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Floristic Diversity and Vegetation Analysis of Some Wadies Northeast of Makkah, Saudi Arabia

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Abstract: The Kingdom of Saudi Arabia is one of the countries with the most biological diversity. The flora of the northeast of Makkah, which included some valleys and the Harrat area (Lava Field), was studied between January 2021 and April 2023. The present work focused on analyzing life forms, habits, and chorotypes. A total of 253 species have been identified, belonging to 161 genera and 46 families. Magnoliopsida (Dicots) has 205 species spread among 131 genera and 40 families. In comparison, Liliopsida (Monocots) has 46 species spread across 29 genera and five families, besides two species belonging to one genus of Gymnosperms (*Ephedra foeminea* and *Ephedra foliata*). The most prominent families in the studied area were Poaceae (37 species), Fabaceae (29 species), and Asteraceae (24 species). The study found six rare species in the flora of Saudi Arabia: *Atriplex farinosa*, *Cyperus rotundus*, *Datura innoxia*, *Kohautia caespitosa*, *Launaea nudicaulis*, and *Plantago ciliata*.
Keywords: Floristic diversity, Vegetation analysis, Flora, Makkah, Saudi Arabia.

1. Introduction

The Kingdom of Saudi Arabia is a vast dry land with an area of about 2,250,000 square kilometers, covering a large area of the Arabian Peninsula. It is characterized by different ecosystems and a diversity of plant species due to the diversity of its climate between the interior and the coast. High humidity combined with more moderate temperatures prevails along the coast, while inland areas are dry and have high temperatures [1, 2]. Saudi Arabia is characterized by the presence of many valleys (the word “wadi” in this article means a non-permanent river) because the Kingdom of Saudi Arabia does not have permanent rivers or lakes. The flow of the valley depends on rainfall. In dry lands, as in Saudi Arabia, valleys represent one of the most prominent desert features affecting plant species distribution [3, 4, 5].

The Floristic diversity in Saudi Arabia is among the richest in the Arabian Peninsula, and its wild plants contain very important genetic resources for crops and medicinal plants [6]. This flora is a mixture of plants from the regions of Asia, Africa, and the Mediterranean. According to [7] these plants include 2250 species belonging to 835 genera and about 142 families. 147 species are classified as "endemic", 721 species are classified as "endangered", and about 22 species are believed to be completely extinct. The number of species has increased from 1,500 to more than 2,300 [8, 9].

The number of wild species found in an area of one square kilometer of the Kingdom of Saudi Arabia is small, especially in the central, eastern, and northern regions, while the northwestern and southwestern regions are characterized by plant density and contain the largest number of species, approximately 70% of the flowering species in these regions. Endemic plant species are relatively few compared to some neighboring countries, such as Yemen and the Sultanate of Oman [10]. Wild plants of Saudi Arabia were studied by many authors [7, 11, 12, 13, 14].

The scarcity of plant species and vegetation in Saudi Arabia is due to overgrazing and some human activities such as urbanization and landfilling according to a study [15, 16] of plant diversity in western Saudi Arabia, therefore, rare plant species must be preserved in their natural environment to preserve biodiversity.

Therophytes are the most common of all life forms in dry areas, accounting for 41%, and are often used for medicinal purposes in addition; it is in a vulnerable system [1]. Native plant diversity is an important component of our terrestrial ecosystems, which plays a vital role in maintaining environmental stability in the region [17].

In a study, 433 plant samples were collected from Makkah, which belong to 44 families, 125 genera, and 184 species. *Calotropis procera* was the most widespread species while *Tribulus arabicus*, *Atriplex farinosa*, *Cyperus rotundus*, *Datura innoxia*, *Rumex spinosus*, *Heliotropium crispum*, *Kohautia caespitosa*, *Launaea nudicaulis*, and *Plantago ciliata* were among the nine rare plant species discovered in the study. Also, they explained that the Poaceae family is the most popular family in Makkah [18].

According to [19] Makkah is positioned between Wadis in Saudi Arabia's western mountainous region. In Makkah, the temperature ranges between 40 and 49° C [20]. Rainfall ranges from 50 to 80 mm per year, with most of the precipitation falling during the winter, resulting in less vegetation cover.

Makkah is known for having a wide variety of flora and many species [21]. The current study includes a survey and identification of the wild plants growing in Some Wadies Northeast of Makkah.

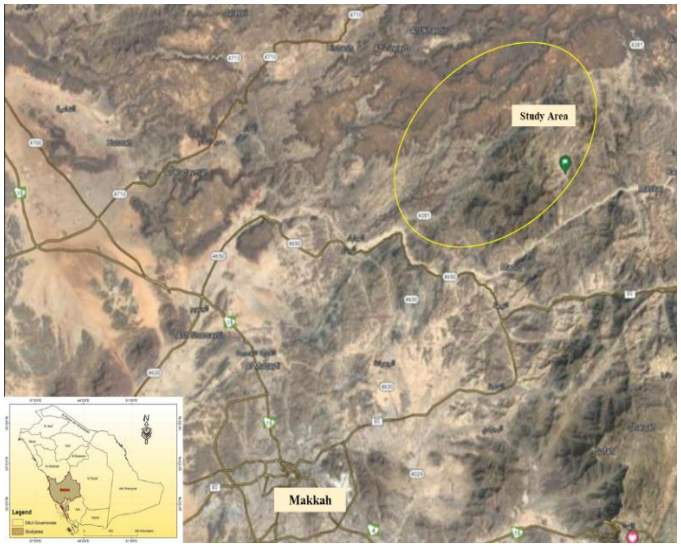

Figure 1: Showing the study area.

Figure 2: Showing some wadies northeast of Makkah (Wadi Bdala, Wadi Al-Hazm).

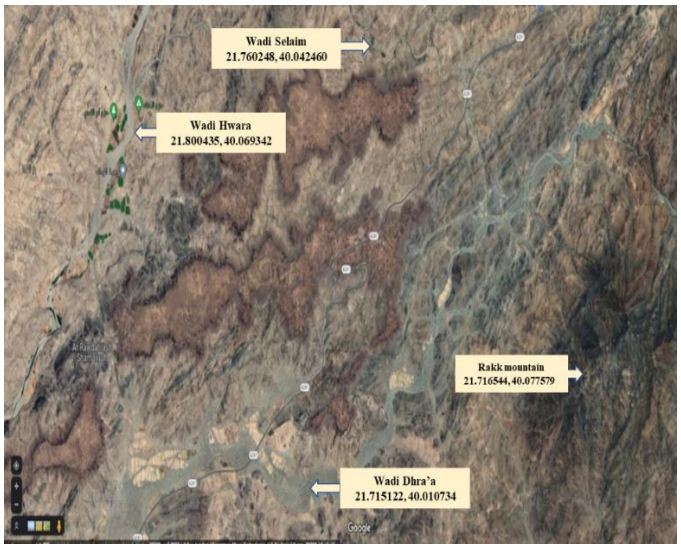

Figure 3: Showing some wadies northeast of Makkah (Wadi Dhra'a, Wadi Selaim, Wadi Hwara).

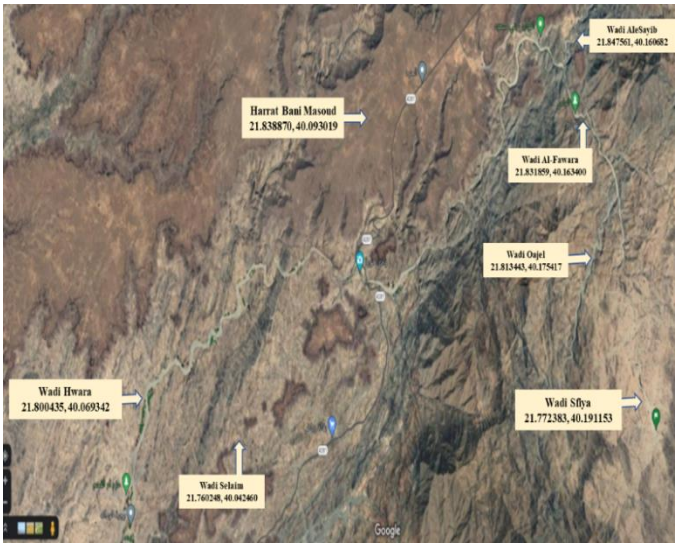

Figure 4: Showing some wadies northeast of Makkah (Selaim, Hwara, Al-Fawara, AleSayib, Oajel, Sfiya) and Harrat Bani Masoud.

2. Materials and methods

2.1. Study area

This study was performed in Some Wadies Northeast of Makkah from January 2021 to April 2023 during the active plant growth period, when most species were expected to be present. The collected plant specimens were identified and named according to [7, 11, 13, 22].

Life forms of species were determined depending on the location of the regenerative buds and the shed parts during the unfavorable season [23]. The floristic categories of the investigated species were made to assign the registered species to world geographical groups according to [24, 25].

Makkah is in Saudi Arabia's westernmost province and on the Arabian Peninsula's westernmost tip. It's located in the valley between Jabal Al-Hijaz, at the crossroads of latitudes 27/19 north and longitude 40/39 east. On the Red Sea shore, it is around 80 kilometers from Jeddah [18]. Makkah is located 80 kilometers (km) west of Jeddah on the Red Sea coast, at 21°26′N and 39°46′E in western Saudi Arabia. Nearly continuous granite and granite gneiss ridges surround it [26].

The study was conducted on the northeast of the city of Makkah about 50-80 km (21.708797, 39.978398) Road number (4281) in the period from January 2022 to April 2023, which included some valleys and wadies Bdala, Al-Hazm, Dhra'a, Selaim, Hwara, Al-Fawara, AleSayib, Oajel, Sfiya, and Harrat area (Lava field) called Harrat Bani Masoud (Almarw) (Table 1).

2.2. Sample identification

Plant species were recorded and photographed with a camera (Galaxy Note 20 Ultra 5G), and then identified using Saudi Arabian flora references [7, 27]. During the unfavorable season, the location of fresh shoots and fallen portions was used to determine the species' life forms [23]. According to [27] a temporal examination of floral classes of species was

used to allocate documented species to worldwide geographical groups.

Life forms of the species were identified according to the Raunkiaer scheme (23). The Chorotypes of the recorded species were determined from [28]. This will help in assessing the rarity forms of these species. The global distribution (i.e., floristic regions) are coded as follows: Cosmopolitan (COSM), Euro-Siberian (ES), Europian (EU), Indian (IN), Irano-Turanian (IT), Mediterranian (ME), Med-Irano-Turanian (MIT), Paneotropic (PAN), Saharo-Arabian (SA), Sudano-Zambezian (SU) and Tropical (TR)

Table 1: Locations in the Study Area of Northeast of Makkah.

No.	Study Area	Location
1	Wadi Bdala	21.672335, 40.076535
2	Wadi Al-Hazm	21.709797, 40.091280
3	Wadi Dhra'a	21.715122, 40.010734
4	Wadi Selaim	21.760248, 40.042460
5	Wadi Hwara	21.800435, 40.069342
6	Wadi Al-Fawara	21.831859, 40.163400
7	Wadi AleSayib	21.847561, 40.160682
8	Wadi Oajel	21.813443, 40.175417
9	Wadi Sfiya	21.772383, 40.191153
10	Harrat Bani Masoud (Almarw)	21.838870, 40.093019

3. Results

This study shows the plant species recorded in different surveyed sectors of some wadies northeast of Makkah. The list includes 253 species belonging to 161 genera and 46 families of phanerogams. Their generic representation is quite variable. However, one family is represented by more than 25 genera (Poaceae), another by 17 genera (Asteraceae); the third most represented family carries about 12 genera (Fabaceae). Eight families are represented by four to nine genera (Lamiaceae with nine genera; Amaranthaceae and Apocynaceae with eight genera; Acanthaceae and Brassicaceae with six genera; Malvaceae and Solanaceae with five genera; and Caryophyllaceae with four genera). Furthermore, 13 families showed a smaller number of genera (two to three genera), and 22 families are represented by a single genus (Table A1).

From the standpoint of species richness within the described families of the region, only one family exceeded 37 species (Poaceae), one family was represented by 29 species (Fabaceae), the third family contained 24 species (Asteraceae), one family was represented by 12 species (Amaranthaceae). Moreover, 16 families showed ten to four species (Aizoaceae and Cucurbitaceae: four, Caryophyllaceae, Cleomaceae, Cyperaceae, and Plantaginaceae: five, Acanthaceae, Euphorbiaceae, Nyctaginaceae, and Zygophyllaceae: seven, Heliotropiaceae: eight, Apocynaceae and Brassicaceae: nine, and Lamiaceae, Malvaceae, and Solanaceae: ten species). As well, three families were represented by three species, seven possessed two species only. Finally, 16 families were represented by a single species (Table A1).

Regarding the growth type, most of the recorded species in this study were perennial plants (160 species or 63.24% of the total recorded species). The second most recorded growth type was the Annuals, which were represented by 93 species (36.76% of the total species) (Table 2, Fig. 5).

Table A1 showed the life form spectra of the recorded species according to the classification of [23] Chamaephytes were the most frequent life form plants constituting 98 species, followed by Therophytes with 90 species and Phanerophytes with 29 species, then geophytes with 22 species, and hemicryptophytes with 12 species with a percentage of 38.74%, 35.57%, 11.46%, 8.70 and 4.74 of the total registered species respectively. Two species were Helophytes (*Bacopa monnieri* and *Veronica anagallis-aquatica*) (Table 2, Fig. 6).

From a phytogeographical point of view, the recorded species in the different sectors of some wadies northeast of Makkah may be classified as mono-regional, bi-regional, or pluriregional taxa. A total of 87 species representing 34.4% of the total number of recorded species were monoregional taxa of different affinities (Table A2, Fig. 8).

The recorded monoregional species fall under six main phytochoria: Sudano-Zambezian taxa (56 species forming 22.1% of recorded species), Saharo-Arabian taxa (19 species forming 7.5% of recorded species) Mediterranean (six species forming 2.4% of recorded species) and Tropical taxa (four species forming 1.6% of recorded species). The last phytochoria was rarely represented in the different sectors of the Wadi with only one species: India (*Senna holosericea*) and Irano-Turanian (*Cyperus squarrosus*) forming 0.4% of the total number of recorded species (Table A2, Fig. 8).

The other 82 species (32.4%) were bi-regional taxa. SA+SU regions were represented by 31 species (12.3%). SU+IN region were represented by 12 species (4.7%). SU+IT region was represented by seven species (2.8%). Both SA+IN and SU+ME regions were represented by six species (2.4%). SA+ME regions were represented by five species (2%). IT+ME region was represented by three species (1.2%). ME+IN, SA+IT, SA+TR, and SU+PAL were represented by two species (0.8%). Only one species was registered to region IT+TR, SU+PAN, TR+ME, and TR+PAL with 0.4%. 57 species representing 22.5% of the recorded species were pluriregional taxa of different affinities (Table A2, Fig. 8).

Table 2: Tubular summary showing the total number of families, genera and species, Habitat (Vegetation type), and life forms of collected plants.

Total number of			Habit			Life forms		
Families	Genera	Species	Type	Number of species	Percentage (%)	Form	No. of species	Percentage (%)
46	161	253	Annual	160	63.24	Ch	98	38.74
			Perennial	93	36.76	Th	90	35.57
						Ph	29	11.46
						G	22	8.70
						He	12	4.74
						H	2	0.79
			Total Number 253		100%	Total Number 253		100%

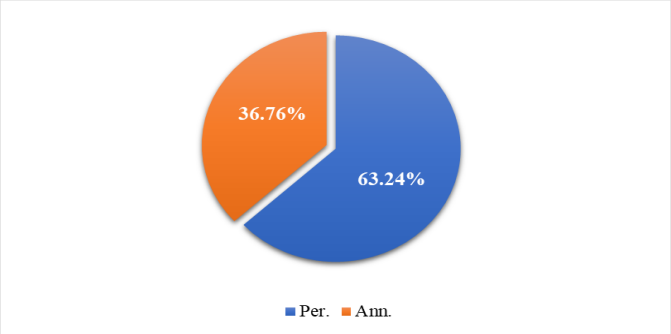

Figure 5: Vegetation type relative spectrum of some wadies northeast of Makkah vegetarian: Ann = annual; Per = perennial.

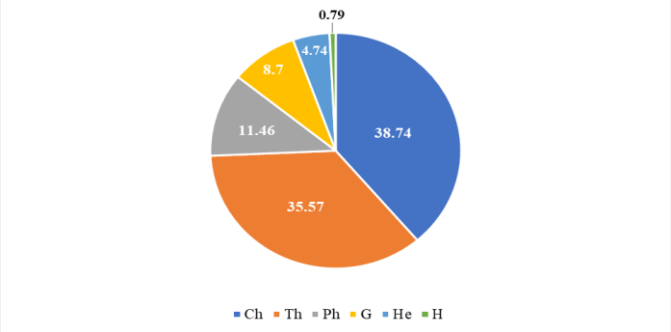

Figure 6: Life form relative spectrum of some wadies northeast of Makkah vegetarian: Ch, Chamaephytes; G, Geophytes; H, Helophytes; He, Hemicryptophytes; Ph, Phanerophytes; Th, Therophytes.

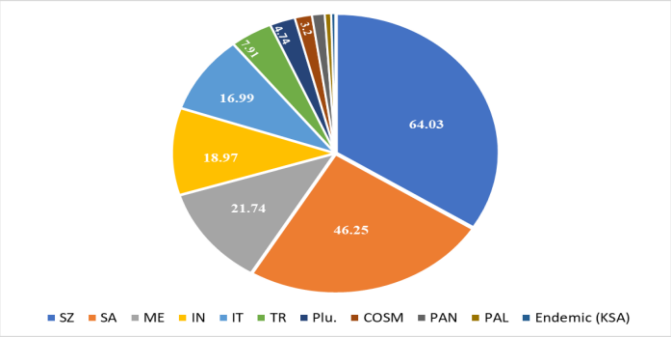

Figure 7: Chorotypes spectrum of some wadies northeast of Makkah: AF, Africa; COSM, Cosmopolitan; IN, India; IT, Irano-Turanian; ME, Mediterranean; PAL: Paleotropical; PAN, Panotropic; Plu., Plurigional; SA, Saharo-Arabian; SI, Asia; SZ, Sudano-Zambezian; and TR, Tropical.

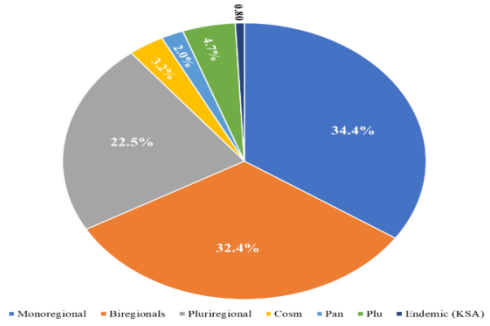

Figure 8: Floristic category spectrum of some wadies northeast of Makkah according to the number of vegetarian regions.

4. Discussion

Saudi Arabia is a country with changing biogeographical regions. It is therefore very rich in plant diversity and special groups at the general level such as *Aloe*, *Caralluma*, and *Vachellia*, or the family level such as Resedaceae, Fabaceae, and Amaranthaceae. Based on new field trips and plant diversity surveys, the number of species recorded in general in the flora of Saudi Arabia is increasing day by day. Evidence of this is the first number of 1,500 species that were recorded in Mujahid between the years 1974-1988. Later, the number increased to 2,300 over about 30 years. This is based on records from the flora of Saudi Arabia [**8, 9, 11**]. This is still largely under-studied and needs further surveys in a wide range of knowledge related to plant diversity.

The importance of the study area from a phytogeographical point of view may be due to the position of Makkah (Hejaz Mountains). This study focused on the flora of some valleys northeast of Mecca, where four combined families (Poaceae, Fabaceae, Asteraceae, Amaranthaceae) contributed approximately two-thirds of the total flora. In terms of floral and plant structure in the study area, the Poaceae and Fabaceae families represent the largest number of species (37 and 29, respectively), and this is consistent with the results of [**1**] and [**18**]. Floristic analysis shows that most plants in the study area are annuals, and that the minority group usually occupies trees. The dominance of members of Poaceae and Fabaceae coincides with the results reported by [**4, 29**].

According to [**30**] The study area is located within the subtropical dry zone, which is characterized by very hot summers and mild winters. The dominant perennial species give the permanent character to the vegetation in each habitat. This is due to the rather low rainfall, which is not enough for many tree plants to appear. On the other hand, when the rainy season is available, it is an opportunity for the emergence of a large number of annuals, which give distinctive features to the vegetation cover [**4, 31, 32**].

The biological spectrum of the study area indicates the dominance of chamaephytes (38%) and therophytes (35%), and this is consistent with the results of [**1**] which does not agree with the results of [**18**], who stated that the most widespread life forms are therophytes. The dominance of chamaephytes and therophytes over other life forms appears to be a response to the hot, dry climate. Therophytes adapt to arid regions and less rainfall because they spend their growth period as dormant seeds [**33**]. These results are consistent with vegetation spectra in desert environments in other regions of Saudi Arabia [**4, 7, 11, 29**], and this result also reflects vegetation spectra in other parts of the Middle East [**34, 35**].

Chronological analysis of the floristic data revealed that the Sudano-Zambezian chorotype forms the major component of the floristic structure in some wadies northeast of Makkah, and this does not agree with the results of [**1, 18**] Who considers that Saharo-Arabia has a greater proportion. The low percentage of endemic species is remarkable. The Arabian Desert region is characterized by a small number of endemic species and genera [**36**]. The Saharo-Arabian species that are restricted in their distribution to the central strip of Saudi

Arabia are more abundant in habitats with more favorable microenvironmental conditions and those that give better protection [37, 38].

Due to the sharp topography of the study area and the importance of these wadies Northeast of Makkah, several microhabitats were recognized, namely wadi beds, slopes, cliffs, and harrat. Each of these habitats supports a special type of vegetation with a characteristic floristic composition and plant cover. The heterogeneity of local topography, edaphic factors, and microclimatic conditions leads to variation in the distributional behavior of the plant associations of the study area. In terms of classification, the vegetation that characterizes the study area can be divided into four vegetation groups. Most of the identified vegetation groups are comparable with those recorded in some other wadis of Saudi Arabia [4, 39] and the Taif region [40, 41].

5. Conclusion

It is expected that further studies on plant diversity will take place, in addition to vegetation and ecophysiology parameters. The vegetation in general and dry ecosystems extremely varies from year to year based on environmental conditions especially rainfall and prevailing temperature.

Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix:

Table A1: Floristic composition in the study area. **Life forms**: Ch, Chamaephytes; G, Geophytes; H, Helophytes; He, Hemicryptophytes; Ph, Phanerophytes; Th, Therophytes. **Habit (Vegetation type)**: Ann, Annual; Per, Perennial. **Chorotypes (Floristic categories)**: AF, Africa; COSM, Cosmopolitan; IN, India; IT, Irano-Turanian; ME, Mediterranean; PAL: Paleotropical; PAN, Panotropic; Plu., Plurigional; SA, Saharo-Arabian; SI, Asia; SZ, Sudano-Zambezian; and TR, Tropical.

Family	Scientific name	Life form	Habit	Chorotype
Acanthaceae	*Blepharis edulis* (Forssk.) Pers.	Ch	Per.	SA+SZ
	Crossandra johanninae Fiori	Ch	Per.	SZ
	Dicliptera paniculata (Forssk.) I.Darbysh.	Ch	Per.	SA+AF+IN+SI+TR
	Ecbolium viride (Forssk.) Alston	Ch	Per.	SZ
	Hypoestes forskaolii (Vahl) Sol. ex Roem. & Schult.	Ch	Per.	SZ
	Ruellia malacosperma Greenman	Ch	Per.	SZ
	Ruellia patula Jacq.	Ch	Per.	SZ
Aizoaceae	*Aizoon canariense* L.	He	Per.	SA+IT+ME+TR
	Sesuvium verrucosum Raf.	Th	Ann.	SZ+IN+IT
	Trianthema crystallina (Forssk.) Vahl	Th	Ann.	SZ
	Trianthema portulacastrum L.	Th	Ann.	SZ
Amaranthaceae	*Achyranthes aspera* L.	G	Per.	SZ
	Aerva javanica (Burm. f.) Juss.	Ch	Per.	SA+SZ+TR
	Aerva lanata (L.) Juss.	Ch	Per.	SA+SZ+TR
	Alternanthera pungens Kunth	Ch	Per.	SU
	Amaranthus albus L.	Th	Ann.	TR
	Amaranthus graecizans L.	Th	Ann.	SA+SZ+TR
	Amaranthus hybridus L.	Th	Ann.	SA+SZ+TR
	Amaranthus viridis L.	Th	Ann.	COSM
	Atriplex farinosa Forssk.	Ch	Per.	SZ+ME
	Chenopodiastrum murale (Lu.) S.Fuentes, Uotila & Borsch	Th	Ann.	IT+ME
	Chenopodium album L.	Th	Ann.	COSM
	Pupalia lappacea (L.) A.Juss.	Ch	Per.	SZ+PAL
Apocynaceae	*Calotropis procera* (Ait.) Ait. f.	Ph	Per.	SA+SZ
	Ceropegia retrospiciens (Ehrenb.) Bruyns	Ch	Per.	SZ
	Cynanchum radians (Forssk.)	Ch	Per.	SA+SZ
	Gomphocarpus sinaicus Boiss.	Ch	Per.	SZ
	Leptadenia arborea (Forssk.) Schweinf.	Ph	Per.	SA
	Leptadenia pyrotechnica (Forssk.)	Ph	Per.	SZ+IN
	Pergularia tomentosa L.	Ch	Per.	SZ
	Periploca visciformis (Vatke) K.Schum.	Ph	Per.	SZ
	Rhazya stricta Decne.	Ch	Per.	SA
Asparagaceae	*Asparagus africanus* Lam.	Ch	Per.	SZ
Asphodelaceae	*Asphodelus fistulosus* L	Th	Ann.	SZ
	Asphodelus tenuifolius Cav.	Th	Ann.	SA+IT+ME+SZ
Asteraceae	*Calendula arvensis* L.	Th	Ann.	SA+ME
	Conyza stricta Willd.	Ch	Per.	SA+IN
	Dicoma schimperi Baill. ex O.Hoffm.	Ch	Per.	SA
	Erigeron bonariensis L.	Th	Ann.	PAN
	Echinops spinosissimus Turra	Ch	Per.	SZ+ME+IT
	Flaveria trinervia	Ch	Per.	SA+SZ+T

	(Spreng.) C.Mohr			R
	Helichrysum glumaceum DC.	Ch	Per.	ME
	Lactuca serriola L.	Ch	Ann.	IT+ME
	Launaea capitata (Spreng.) Dandy	Th	Ann.	SA+SZ+IN
	Launaea intybacea (Jacq.) Beauverd	Th	Ann.	SZ+IN
	Launaea massavensis (Fresen.) Sch.Bip. ex Kuntze	Th	Ann.	SA+SZ
	Launaea nudicaulis (L.) Hook.fil.	Ch	Per.	SA+SZ
	Launaea procumbens (Roxb.) Amin	Ch	Per.	SA
	Osteospermum vaillantii (DC.) Norl.	Ch	Per.	SA+SZ+ME
	Picris babylonica Hand.-Mazz.	Th	Ann.	SA+TR
	Pulicaria crispa Sch.Bip.	Ch	Per.	PAN
	Pulicaria schimperi DC.	Ch	Per.	PAN
	Pulicaria undulata (L.) C.A.Mey.	Ch	Per.	PAN
	Senecio flavus (Decne.) Sch.Bip.	Th	Ann.	SA
	Sonchus oleraceus L.	Th	Ann.	Plu.
	Urospermum picroides (L.) Scop. ex F.W.Schmidt	Th	Ann.	SA+SZ
	Verbesina encelioides (Cav.) Benth. & Hook.fil. ex A.Gray	Th	Ann.	SZ+PAN
	Xanthium spinosum L.	Th	Ann.	COSM
	Xanthium strumarium L.	Th	Ann.	COSM
Boraginaceaa	*Arnebia hispidissima* (Lehm.) DC.	Th	Ann.	SA+SZ+IN
	Trichodesma africanum (L.) R.Br.	Th	Ann.	SA+IN
	Trichodesma ehrenbergii Schweinf. ex Boiss.	Th	Ann.	SZ+ME
Brassicaceae	*Anastatica hierochuntica* L.	Th	Ann.	SA
	Farsetia longisiliqua Decne.	Ch	Per.	SA+SZ
	Farsetia stylosa R. Br. Sehweinf.	Ch	Ann.	SA+SZ+IN
	Morettia canescens Boiss.	Ch	Per.	ME
	Morettia parviflora Boiss.	Ch	Per.	SA+SZ+ME
	Notoceras bicorne (Aiton) Amo	He	Per.	SA+SZ+IN
	Schouwia purpurea (Forssk.) Muschl.	Th	Ann.	SA
	Sisymbrium erysimoides Desf.	Th	Ann.	SA+ME
	Sisymbrium irio L.	Th	Ann.	SA+IN+IT+ME+SZ
Burseraceae	*Commiphora gileadensis* (L.) C.Chr.	Ph	Per.	SZ
Capparaceae	*Capparis spinosa* L.	Ph	Per.	SA+IT+ME+SZ
	Maerua crassifolia Forssk.	Ph	Per.	SA+SZ+IT
	Maerua oblongifolia (Forssk.) A.Rich.	Ph	Per.	SZ
Caryophyllaceae	*Cometes abyssinica* (R.Br.) R.Br.	Ch	Per.	SZ
	Polycarpaea repens (Forssk.) Asch. & Schweinf.	Ch	Per.	SA+SZ+IN
	Polycarpaea robbairea (Kuntze) Greuter & Burdet	He	Per.	SA+SZ+ME
	Polycarpon tetraphyllum (L.) L.	Th	Ann.	SA+IT+ME+SZ
	Spergularia diandra (Guss.) Boiss.	Th	Ann.	Plu.
Cleomaceae	*Cleome brachycarpa* M.Vahl ex Triana & Planch.	Ch	Per.	SZ+IT
	Cleome paradoxa R.Br.	Ch	Per.	SZ
	Cleome scaposa DC.	He	Per.	SZ+IN
	Dipterygium glaucum Decne.	Ch	Per.	SZ+IN
	Thulinella chrysantha (Decne.) Roalson & J.C.Hall	Th	Ann.	SZ+IT
Convolvulaceae	*Convolvulus hystrix* Vahl	Ch	Per.	SZ+ME
	Seddera virgata Hochst. & Steud. ex Hochst.	Ch	Per.	SZ
Corbichoniaceae	*Corbichonia decumbens* (Forssk.) Exell	Th	Ann.	SZ+IN+TR
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	He	Per.	Plu.
	Cucumis melo L.	Th	Ann.	SA
	Cucumis prophetarum L.	Th	Ann.	SA+IN
	Momordica balsamina L.	Th	Ann.	SZ
Cyperaceae	*Cyperus articulatus* L.	G	Per.	SZ
	Cyperus laevigatus L.	G	Per.	SA+IT+ME+SZ
	Cyperus rotundus L.	G	Per.	Plu.
	Cyperus schimperianus Spreng.	G	Per.	SZ
	Cyperus squarrosus L.	Th	Ann.	IT
Ephedraceae	*Ephedra foeminea* Forssk.	Ch	Per.	SA+SZ
	Ephedra foliata Boiss. ex C.A.Mey.	Ch	Per.	SA+IN
Euphorbiaceae	*Chrozophora oblongifolia* (Delile) A.Juss. ex Spreng.	Ch	Per.	SA+SZ
	Chrozophora tinctoria (L.) A.Juss.	Th	Ann.	SA+ME
	Euphorbia arabica Hochst. & Steud. ex T.Anderson	Th	Ann.	SA+IT+ME+SZ
	Euphorbia granulata	Th	Ann.	SA+IT+

	Forssk.			ME+SZ
	Euphorbia hirta L.	Th	Ann.	Plu.
	Euphorbia serpens Kunth	Th	Ann,	SA
	Ricinus communis L.	Ph	Per.	TR
Fabaceae	*Argyrolobium arabicum* (Decne.) Jaub. & Spach	Th	Ann.	SZ
	Astragalus atropilosulus (Hochst.) Bunge	Ch	Per.	SZ
	Astragalus eremophilus Boiss.	Th	Ann.	SA+SZ
	Colutea istria Mill.	Ph	Per.	SA
	Crotalaria microphylla Vahl	Th	Ann.	SZ
	Crotalaria senegalensis (Pers.) Bacle ex DC.	Th	Ann.	SZ
	Cyamopsis senegalensis Guill. & Perr.	Th	Ann.	SZ
	Delonix elata (L.) Gamble	Ph	Per.	SA+SZ
	Indigofera arabica Jaub. & Spach	He	Per.	SZ+IN
	Indigofera spiniflora Hochst. ex Boiss.	Ch	Per.	SZ
	Indigofera spinosa Forssk.	Ch	Per.	SZ
	Senegalia asak (Forssk.) Kyal. & Boatwr.	Ph	Per.	SA+SZ
	Senegalia hamulosa (Benth.) Boatwr.	Ph	Per.	SA+SZ
	Senegalia laeta (R.Br. ex Benth.) Seigler & Ebinger	Ph	Per.	SA+SZ
	Senegalia mellifera (Benth.) Seigler & Ebinger	Ph	Per.	SA+SZ
	Senna alexandrina Miller	Ch	Per.	ME+IN
	Senna holosericea (Fresen.) Greuter	Ch	Per.	IN
	Senna italica Miller	Ch	Per.	SZ
	Taverniera aegyptiaca Boiss.	Ch	Per.	SA+ME
	Tephrosia desertorum Scheele	Th	Ann.	SZ
	Tephrosia nubica (Boiss.) Baker	Ch	Per.	SA+SZ
	Tephrosia purpurea (L.) Pers.	Th	Ann.	SA+SZ
	Vachellia abyssinica (Hochst. ex Benth.) Kyal. & Boatwr.	Ph	Per.	SZ
	Vachellia etbaica (Schweinf.) Kyal. & Boatwr.	Ph	Per.	SZ
	Vachellia flava (Forssk.) Kyal. & Boatwr.	Ph	Per.	SA+SZ
	Vachellia gerrardii (Benth.) P.J.H.Hurter	Ph	Per.	SZ+IT
	Vachellia oerfota (Forssk.) Kyal. & Boatwr.	Ph	Per.	SZ+IT
	Vachellia seyal (Delile) P.J.H.Hurte	Ph	Per.	SZ
	Vachellia tortilis (Forssk.) Galasso & Banfi	Ph	Per.	SZ
Gisekiaceae	*Gisekia pharnaceoides* L.	Th	Ann.	SA+SZ+IN
Heliotropiaceae	*Heliotropium aegyptiacum* Lehm.	Ch	Per.	SZ
	Heliotropium arbainense Fresen.	Ch	Per.	SA+SZ+ME
	Heliotropium bacciferum Forssk.	Ch	Per.	SA+IT
	Heliotropium curassavicum L.	Ch	Per.	PAN
	Heliotropium digynum (Forssk.) Asch. ex C.Chr.	Ch	Per.	SA+SZ
	Heliotropium europaeum L.	Th	Ann.	SA+SZ+IN
	Heliotropium longiflorum (A.DC.) Jaubert & Spach	Ch	Per.	SZ
	Heliotropium pterocarpum (DC. & A.DC.) Hochst. & Steud. ex Bunge	Ch	Ann.	SZ
Lamiaceae	*Lavandula coronopifolia* Poir.	Ch	Per.	SZ+ME+IT
	Lavandula pubescens Decne.	Ch	Per.	SA+SZ
	Nepeta deflersiana Schweinf. ex Hedge	Ch	Per.	SU
	Ocimum forsskaolii Benth.	Ch	Per.	SU
	Otostegia fruticosa (Forssk.) Schweinf. ex Penzig	Ch	Per.	SA+SZ
	Plectranthus asirensis J.R.I.Wood	Ch	Per.	Endemic (KSA)
	Pleudia aegyptiaca (L.) M.Will, N.Schmalz & Class.-Bockh.	Ch	Per.	SA+SZ
	Premna resinosa (Hochst.) Schauer	Ph	Per.	SA+SZ+IN
	Salvia spinosa subsp. *spinosa*	Ch	Per.	ME
	Teucrium polium L.	Ch	Per.	SA+IT+ME
Loranthaceae	*Phragmanthera austroarabica* A.G.Mill. & J.A.Nyberg	Ch	Per.	Endemic (KSA)
Lythraceae	*Ammannia baccifera* L.	Th	Ann.	Plu.
Malvaceae	*Abutilon bidentatum* Hochst. ex A.Rich.	Ph	Per.	SZ+IN
	Abutilon fruticosum Guill. &	Ph	Per.	SZ

	Perr.			
	Abutilon hirtum (Lamk.) Sweet+SU	Ch	Per.	SZ+IT
	Abutilon pannosum (G.Forst.) Schltdl.	Ph	Per.	SZ+SA+IN+ME
	Corchorus depressus (L.) Stocks)	Ch	Per.	SA+ IN+ IT+ SZ
	Corchorus tridens L.	Th	Ann.	SA+ IN+ IT+ SZ
	Hibiscus micranthus L.fil.	Ch	Per.	SU+IN
	Malva parviflora L.	Th	Ann.	SA+IN+IT+ ME
	Triumfetta flavescens Hochst. ex A.Rich	Ch	Per.	SA+SZ+TR
	Triumfetta heterocarpa Sprague & Hitchc.	Ch	Per.	SA+SZ
Menispermaceae	*Cocculus pendulus* (J.R.Forst. & G.Forst.) Diels	Ph	Per.	SZ+IT
Nyctaginaceae	*Boerhavia coccinea* Mill.	Th	Ann.	SZ
	Boerhavia diffusa L.	Th	Ann.	SZ+IT
	Boerhavia elegans Choisy	Ch	Per.	SA
	Boerhavia repens L.	Th	Ann.	SZ
	Commicarpus grandiflorus (A.Rich.) Standl.	He	Per.	SZ+IN
	Commicarpus helenae (Schult.) Meikle	Ch	Per.	SA+IT+ ME+SZ
	Commicarpus plumbagineus (Cav.) Standl.	Ch	Per.	SA+SZ+TR
Orobanchaceae	*Lindenbergia indica* (L.) Vatke	Th	Ann.	SA+ IN+ IT+ SZ
	Scrophularaiaceae			
Papaveraceae	*Argemone ochroleuca* Sweet	Th	Ann.	IT+TR
Phyllanthaceae	*Andrachne aspera* Spreng.	Ch	Per.	SA+TR
	Andrachne telephioides L.	Ch	Per.	TR+ME
Plantaginaceae	*Bacopa monnieri* (L.) Pennell	H	Per.	TR
	Kickxia pseudoscoparia V.A.W .Sm. & D.A.Sutton	Ch	Per.	SA
	Plantago ciliata Desf.	Ch	Per	SA+IT+ ME+SZ
	Schweinfurthia pterosperma (A.Rich.) A.Br.	Th	Ann.	SA+ SZ
	Veronica anagallis-aquatica L.	H	Per.	COSM
Poaceae	*Aristida adscensionis* L.	Th	Ann.	SA+ SZ
	Cenchrus ciliaris L.	G	Per.	Plu.
	Cenchrus divisus (J.F.Gmel.) Verloove, Govaerts & Buttler	G	Per.	SZ
	Cenchrus setigerus Spreng. ex Steud.	G	Per.	SA+SZ
	Chloris barbata Sw.	He	Per.	SA+SZ+ ME
	Chloris gayana Kunth	G	Per.	Plu.
	Chloris virgata Sw.	Th	Ann.	SZ
	Chrysopogon plumulosus Hochst.	G	Per.	SZ
	Cynodon dactylon (L.) Pers.	G	Per.	COSM
	Dactyloctenium aegyptium (L.) Willd.	Th	Ann.	TR
	Dactyloctenium scindicum Boiss.	G	Per.	SZ+ IN+IT
	Dichanthium annulatum (Forssk.) Stapf	He	Per.	Plu.
	Dichanthium foveolatum (Delile) Roberty	G	Per.	Plu.
	Digitaria ciliaris (Retz.) Koeler	Th	Ann.	SZ+ IN+IT
	Eleusine indica (L.) Gaertn	Th	Ann.	SZ
	Eragrostis barrelieri Daveau	Th	Ann.	SZ+IN
	Eragrostis papposa (Roem. & Schult.) Steud.	G	Per.	SA+IN
	Hyparrhenia hirta (L.) Stapf	G	Per.	SA+ME
	Panicum turgidum Forssk.	G	Per.	SA+ IN+IT+ME+SZ
	Panicum repens L.	He	Per.	SZ
	Pennisetum villosum Fresen.	G	Per.	SZ
	Phragmites australis (Cav.) Trin. ex Steud.	He	Per.	Plu.
	Polypogon monspeliensis (L.) Desf.	Th	Ann.	SA+IT+ME
	Rostraria pumila (Desf.) Tzvelev	Th	Ann.	SA+IN+ ME
	Schismus barbatus (L.) Thell.	Th	Ann.	Plu.
	Setaria viridis (L.) P.Beauv.	Th	Ann.	SA
	Setaria verticillata (L.) P.Beauv.	Th	Ann.	SA
	Sorghum bicolor (L.) Moench	Th	Ann.	COSM
	Sporobolus ioclados (Nees ex Trin.) Nees	G	Per.	SA+IN+IT+ ME
	Stipa capillata L.	G	Per.	SA
	Stipa tenacissima L.	G	Per.	SA+SZ
	Stipellula capensis (Thunb.) Röser & Hamasha	Th	Ann.	ME+IN
	Stipagrostis ciliata (Desf.) De Winter	G	Per.	SA+ IN+ME+SZ
	Stipagrostis hirtigluma (Steud. ex	Th	Ann.	SZ+IN

	Trin. & Rupr.) De Winter			
	Stipagrostis raddiana (Savi) De Winter	G	Per.	SZ+ME
	Tetrapogon cenchriformis (A.Rich.) Clayton	Th	Ann.	SZ
	Tragus racemosus (L.) All.	Th	Ann.	SA
Polygalaceae	*Polygala erioptera* DC.	Th	Ann.	SA+IN
	Polygala negevensis Danin	Ch	Per.	ME
Polygonaceae	*Rumex vesicarius* L.	Th	Ann.	SA+IN+ME+SZ
Portulacaceae	*Portulaca oleracea* L.	Th	Ann.	COSM
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	Ph	Per.	SA+SZ
Resedaceae	*Caylusea hexagyna* (Forssk.) M.L.Green	Th	Ann.	SZ+ME+IT
	Ochradenus baccatus Delile	Ch	Per.	SA+SZ
Rubiaceae	*Kohautia caespitosa* Schnizl.	Th	Ann.	SZ
	Oldenlandia capensis L.f.	Th	Ann.	ME
Scrophulariaceae	*Anticharis arabica* Steud. & Hochst. ex Endl.	Th	Ann.	SZ
Solanaceae	*Datura innoxia* Mill	Ch	Per.	SU+PAL
	Hyoscyamus desertorum (Asch. ex Boiss.) Täckh.	Th	Ann.	ME
	Lycium shawii Roem. & Schult.	Ch	Per.	SA+SZ+IT
	Solanum coagulans Forssk.	Ch	Per.	SZ+ME
	Solanum forsskalii Dunal	Ch	Per.	SZ+IN
	Solanum incanum L.	Ch	Per.	SZ
	Solanum nigrum L.	Th	Ann.	SA+SZ
	Solanum schimperianum Hochst.	Ch	Per.	SZ
	Solanum villosum Mill.	Ch	Per.	IT+ME
	Withania somnifera (L.) Dunal	Ch	Per.	SA+IT+ME+SZ+TR
Tamaricaceae	*Tamarix aphylla* (L.) Karst.	Ph	Per.	SA
Typhaceae	*Typha domingensis* Pers.	Ch	Per.	TR+PAL
Urticaceae	*Forsskaolea tenacissima* L.	Ch	Per.	SA+SZ
	Parietaria alsinifolia Delile	Th	Ann.	SA
	Urtica pilulifera L.	Th	Ann.	SZ+ME
Verbenaceae	*Chascanum marrubiifolium* Fenzl ex Walp.	Ch	Per.	SZ+IN
Zygophyllac eae	*Fagonia bruguieri* DC.	Ch	Per.	SA+IN+IT+ME+SZ
	Fagonia indica Burnm. f.	Ch	Per.	SA+IT
	Fagonia olivieri DC.	Ch	Per.	SA+IN+ME
	Tetraena simplex (L.) Beier & Thulin	He	Per.	SA+IN+ME+SZ
	Tribulus macropterus Boiss.	Th	Ann.	SA
	Tribulus pentandrus Forssk.	Ch	Per.	SZ
	Tribulus terrestris L.	Th	Ann.	SA+IN+IT+ME+SZ

Table A2: Chorotype the total and percentage of taxa.

Chorotypes	Number of species	Percentage (%)
Monoregional		
IN	1	0.4
IT	1	0.4
ME	6	2.4
SA	19	7.5
SU	56	22.1
TR	4	1.6
Total	87	34.4
Biregionals		
IT+ME	3	1.2
IT+TR	1	0.4
ME+IN	2	0.8
SA+IN	6	2.4
SA+IT	2	0.8
SA+ME	5	2%
SA+TR	2	0.8
SA+SU	31	12.3
SU+IN	12	4.7
SU+IT	7	2.8
SU+ME	6	2.4
SU+PAN	1	0.4
SU+PAL	2	0.8
TR+ME	1	0.4
TR+PAL	1	0.4
Total	82	32.4
Pluriregional		
SA+IN+ME	2	0.8
SA+IT+ME	2	0.8
SA+SU+IN	8	3.2
SA+SU+ IT	2	0.8
SA+SU+ME	5	2
SA+SU+TR	7	2.8
SU+ IN+IT	3	1.2
SU+ IN+TR	1	0.4
SU+ME+IT	3	1.2
SA+IN+IT+ ME	2	0.8
SA+ IN+ IT+ SU	3	1.2
SA+ IN+ME+SU	4	1.6
SA+IT+ME+TR	1	0.4
SA+IT+ ME+SU	8	3.2
SA+ AF+IN+SI+TR	1	0.4
SA+ IN+IT+ME+SU	4	1.6
SA+IT+ME+SU+TR	1	0.4
Total	57	22.5
Cosm	8	3.20
Pan	5	2

Plu	12	4.70
Total	25	9.9
Endemic (KSA)	2	0.80

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