



## Floristic Diversity of Jeddah: An Arid Desert, Western Region of Saudi Arabia

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**T**HIS STUDY was conducted in the arid deserts of Jeddah Governorate in the western region of Saudi Arabia. The main objective is to determine the floristic composition of the area, including an explanation of its different life forms and the chorology of the recorded species. A total of 107 taxa belonging to 77 genera in 31 families of the Angiospermae were recorded. Fabaceae and Poaceae account for approximately 31.8% of the recorded species in the study area. The data also reflect a high degree of monotypic, where 42% of the recorded families were represented by a single species, and 76.6% of the genera were monotypic. Perennial species dominated the plant cover with 62%, defining the character of the vegetation, while annuals were represented by about 38%. The most common lifeforms were therophytes and chamaephytes. Chronological analysis of the floristic data revealed that the biregionalSaharo-Arabian–Sudanianchorotypeis the most dominant in the Jeddah area (18.7%), followed by the two monoregionalSudanian and Saharo-Arabian chorotypes (12.1 and 11.2%, respectively). The results also showed the predominance of biregional taxa (38.32%) over the other phytogeographical elements followed by the monoregionaltaxa (28.97%). The IUCN Red List includes 17 of the species recorded in this study in the least concern category. The current study's findings could be useful for the conservation and management of the study area.

**Keywords:** Chorology, Flora, Life-form, Saudi Arabia, Threatened Species.

### Introduction

The Kingdom of Saudi Arabia (KSA) is a vast arid land covering an area of about 2,250,000 km<sup>2</sup>, which constitutes a large part of the Arabian Peninsula. It is characterized by high ecosystems and plant species diversity. The floristic diversity of Saudi Arabia is the richest in the Arabian Peninsula and encompasses valuable genetic resources of medicinal plants and crops (Atiqur et al., 2004; Abdel Khalik, 2013). Flora of Saudi Arabia encompasses 2250 species belonging to 835 genera and 142 families. According to Collenette 1999, 147 species are endemic, 721 species are endangered, and about 22 species are believed to be extinct. Endemism in Saudi Arabia is insignificant as compared tonear by countries such as Oman and

Yamen (Thomas, 2011). It is worth mentioning that Southwestern regions are characterized by dense vegetation, having the greatest number of species (Collenette, 1999; Thomas, 2011). As floristic surveys are the prerequisites for the conservation of plant species diversity, therefore, it is important to examine the status of floristic diversity to provide appropriate guidelines for developing an effective system of conservation and management. Many studies on the flora of Saudi Arabia have been carried out either on a general scale or limited to certain regions or ecosystems. There have been few attempts to comprehensively analyze and describe floristic diversity in the deserts of KSA. The present study involves a survey and identification of the wild plant species growing in Jeddah deserts in the western region of Saudi Arabia, to determine

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the floristic composition, including a breakdown of its different life forms and chorology of the recorded species. Jeddah is characterized by an arid climate with a hot temperature, usually approaching 50°C or more. It retains its warm temperature in winter, ranging from 15°C to 28°C. Summer temperatures are extremely hot, ranging from 35°C to 48°C. Up until the 1970s, Jeddah was reported to receive an annual average rain of 65.3mm, however, due to the effects of climate change, Jeddah now receives no more than 55 mm of rain per year (Motasim, 2018), but it frequently experiences sudden floods, such as the two major floods in 2009 and 2011 (Belhaj, 2018). The recent anthropogenic disturbance exerted by local inhabitants in Jeddah imposes the necessity for conservation action to ensure the sustainable utilization and management of wild plants in the study area. Research and analysis of the status of floristic diversity are very important as prerequisites for the conservation of plant species, as they provide proper guidelines for developing an effective system of conservation and management. Data from the current study may serve as a valuable reference for appropriate conservation and management of the study area.

## Materials and Methods

### Study area

Jeddah is in western Saudi Arabia on the Red Sea coastal plain between the Hijaz Mountain and the Red Sea. Table 1 shows climate data collected from the General Authority for Meteorology and Environmental Protection in Jeddah Governorate for the mean rate from 2017 to 2020.

### Plant collection and species identification

The first author G.S. Aljedaani carried out the field collections through intensive field surveys of the wild plant communities in the study area. The selected sites were observed for 2 years (Spring 2019 to Winter 2020). During the visits, the stands were surveyed, and the data were recorded, during 2020. Twenty sites were selected in the Jeddah desert (Fig. 1). At each site, sampling stands were located randomly by using the Relève method (Muller-Dombois & Ellenberg, 1974). When selecting each site and stand, habitat uniformity and a reasonable degree of plant cover homogeneity was insured (Fig. 1). The plant species were identified and named according to available literature

(Collenette, 1999; Chaudhary, 2001; Boulos, 2009). Plant lifeforms and duration were defined. Phytogeographical affinities of the recorded species were determined (Zohary, 1966; Zohary, 1972). Herbarium specimens were prepared and stored in the herbarium of the Biology Department, College of Science, University of Jeddah, and others were given as gifts to the national herbarium in the Ministry of Environment, Water, and Agriculture in Saudi Arabia.

## Results

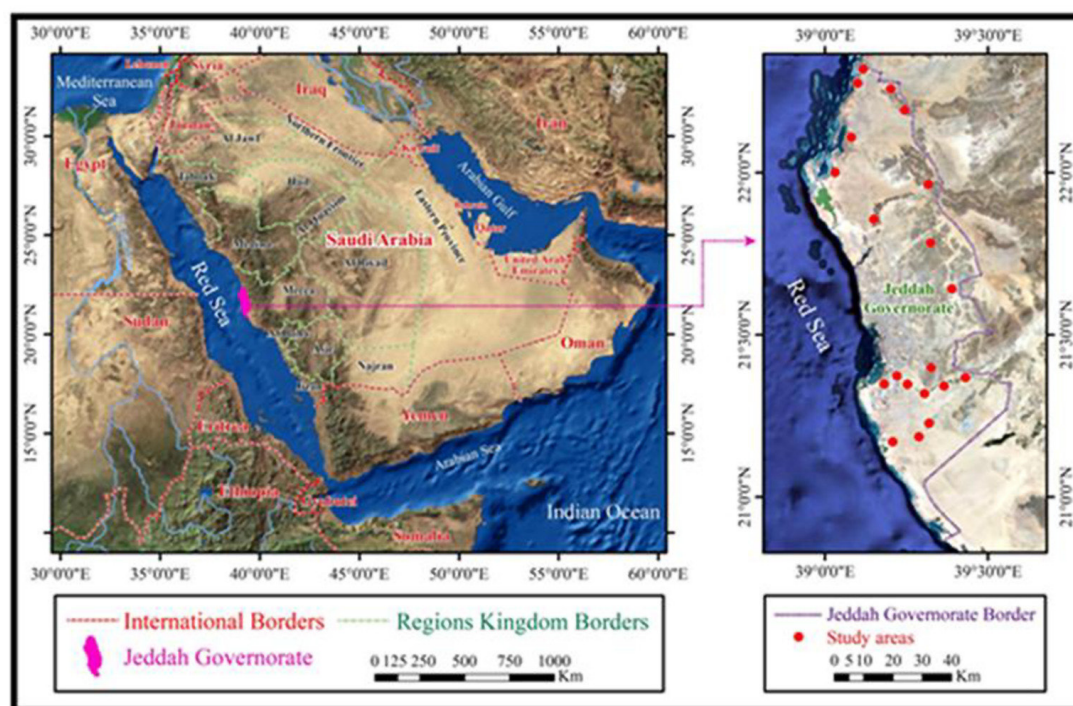
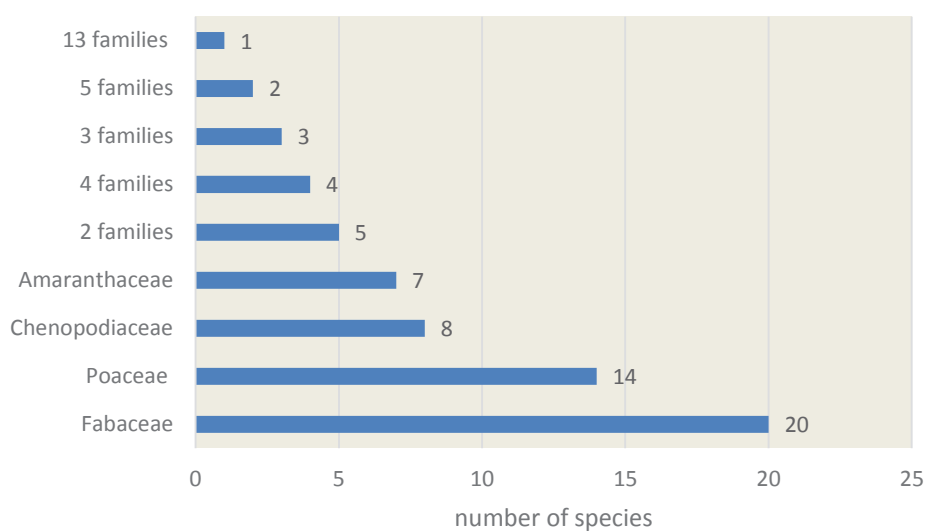
### Floristic composition

A total of 107 species belonging to 31 families of Angiospermae were recorded in the Jeddah area and shown in Fig. 2. Two of these families dominate the flora of the study area as they were the most species-rich families: Fabaceae (20 species = 18.70%) and Poaceae (14 species = 13.09%). Chenopodiaceae was represented by 8 species (7.48%), Amaranthaceae was represented by 7 species (6.55%), Zygophyllaceae was represented by 5 species (4.67%), and Apocynaceae was represented by 5 species (4.67%). Boraginaceae, Capparaceae, Cleomaceae, and Convolvulaceae were represented by 4 species each (3.74%). While Asteraceae, Cyperaceae, and Malvaceae were represented by 3 species each (2.80%). Five families: Acanthaceae, Aizoaceae, Brassicaceae, Caryophyllaceae, and Solanaceae were represented by 2 species each (1.87%). Meanwhile, only one species from each of the 13 families was represented (0.93%). This may reflect the high taxonomic diversity in the study area. The low ratios of species/genera and genera/families estimated for total species (1.39 and 2.48, respectively) indicate high taxonomic diversity in the study area. It is noteworthy to mention that *Amaranthus* was the largest genus, represented by six species. Other genera with the greater number of species (three species each) were *Heliotropium*, *Chenopodium*, *Suaeda*, *Cleome*, *Cyperus*, and *Indigofera*. Only one species is near-endemic (*Taverniera aegyptiaca* Boiss.).

Most of the species recorded during this study were perennials with 66 species (61.68%) of the total surveyed species, while annual plants were represented by 41 species (38.32%) (Tables 2, 3).

**TABLE 1.** Average climate data rates during (2017–2020) from the General Authority for Meteorology and Environmental Protection in Jeddah Governorate

| Year | Temperature (°C) |      |      | Relative Humidity (%) |      |      | Max Rainfall (Mm/year) |
|------|------------------|------|------|-----------------------|------|------|------------------------|
|      | Max              | Min  | Mean | Max                   | Min  | Mean |                        |
| 2017 | 48.8             | 16.6 | 22.5 | 100.0                 | 16.0 | 55.0 | 17.0                   |
| 2018 | 47.4             | 17.4 | 22.7 | 90.0                  | 15.0 | 54.0 | 26.0                   |
| 2019 | 48.2             | 16.0 | 22.5 | 92.0                  | 15.0 | 53.0 | 30.0                   |
| 2020 | 46.4             | 15.0 | 21.6 | 95.0                  | 11.0 | 52.0 | 16.0                   |

**Fig. 1.** Map showing the location of the study area of Jeddah and indicating the sampling sites (red)**Fig. 2.** Histogram of the floristic structure of 31 families recorded in Jeddah

**TABLE 2. List of plant species surveyed in the Jeddah area and their families, duration, life form, and chorology**

| Family          | Species   | Life-form | Duration  | Chorology |
|-----------------|---|-----------|-----------|-----------|
| Acanthaceae     | <i>Avicennia marina</i> (Forssk.) Vierh.                                | Ph        | perennial | SA        |
|                 | <i>Blepharis edulis</i> Pers.   | Ch        | perennial | SA+IT     |
| Aizoaceae       | <i>Aizoon canariense</i> L.   | Th        | annual    | SA+SU     |
|                 | <i>Sesuvium verrucosum</i> Raf.   | H         | perennial | NEO       |
|                 | <i>Aerva javanica</i> (Burm.f.) Juss. ex Schult.                        | Ch        | perennial | SA+SZ     |
|                 | <i>Amaranthus albus</i> L.  | Th        | annual    | COSM      |
|                 | <i>Amaranthus graecizans</i> L.   | Th        | annual    | COSM      |
| Amaranthaceae   | <i>Amaranthus hybridus</i> L.   | Th        | annual    | COSM      |
|                 | <i>Amaranthus retroflexus</i> L.  | Th        | annual    | COSM      |
|                 | <i>Amaranthus spinosus</i> L.   | Th        | annual    | NEO       |
|                 | <i>Amaranthus viridis</i> L.  | Th        | annual    | COSM      |
| Amaryllidaceae  | <i>Pancratium tortuosum</i> Herb.                                       | G         | perennial | ME        |
|                 | <i>Calotropis procera</i> (Aiton) W.T.Aiton                             | Ph        | perennial | SA+SU     |
|                 | <i>Cynanchum boveanum</i> subsp. <i>nubicum</i> (Decne.) Khanum & Liede | H         | perennial | PAN       |
| Apocynaceae     | <i>Leptadenia pyrotechnica</i> (Forssk.) Decne.                         | Ph        | perennial | PAN       |
|                 | <i>Odontanthera radians</i> Forssk.                                     | Ch        | perennial | SU        |
|                 | <i>Rhazya stricta</i> Decne.  | Ch        | perennial | SA+SU     |
| Asparagaceae    | <i>Dipcadi erythraeum</i> Webb & Berthel.                               | G         | perennial | SA        |
|                 | <i>Launaea nudicaulis</i> Hook.f.                                       | H         | perennial | SA        |
| Asteraceae      | <i>Launaea procumbens</i> (Roxb.) Amin                                  | H         | annual    | SA        |
|                 | <i>Sonchus oleraceus</i> L.   | Th        | annual    | ME+IT+ ES |
|                 | <i>Arnebia hispidissima</i> DC.   | Th        | annual    | SA+SU     |
| Boraginaceae    | <i>Heliotropium longiflorum</i> Hochst. & Steud.                        | H         | perennial | SA+SU     |
|                 | <i>Heliotropium pterocarpum</i> Hockst. & Steud. ex Bunge               | Th        | annual    | SA+SU     |
|                 | <i>Heliotropium ramosissimum</i> Sieber ex DC.                          | H         | perennial | IT        |
| Brassicaceae    | <i>Anastatica hierochuntica</i> L.                                      | Th        | annual    | SA        |
|                 | <i>Farsetia stylosa</i> R.Br.   | Ch        | perennial | SA+SZ     |
|                 | <i>Cadaba glandulosa</i> Forssk.  | Ph        | perennial | IT        |
| Capparaceae     | <i>Capparis decidua</i> Edgew   | Ph        | perennial | SA+SU     |
|                 | <i>Maerua crassifolia</i> Forssk.                                       | Ph        | perennial | SA+SU     |
|                 | <i>Maerua oblongifolia</i> A. Rich.                                     | Ph        | perennial | SU        |
| Caryophyllaceae | <i>Polycarpaea repens</i> Asch. & Schweinf. ex Asch.                    | H         | perennial | SU        |
|                 | <i>Polycarpaea robbairea</i> (Kuntze) Greuter & Burdet                  | Th        | annual    | SA+SU     |
|                 | <i>Chenopodium album</i> L.   | Th        | annual    | COSM      |
|                 | <i>Chenopodium glaucum</i>  | Th        | annual    | COSM      |
|                 | <i>Chenopodium murale</i> L.  | Th        | annual    | COSM      |
| Chenopodiaceae  | <i>Halopeplis perfoliata</i> Bunge ex Schweinf. & Asch.                 | Ch        | perennial | ME+IT     |
|                 | <i>Salsola imbricata</i> Forssk. ex J.F. Gmeli.                         | Ch        | perennial | SA+SZ     |
|                 | <i>Suaeda aegyptiaca</i> (Hasselq.)Zohary                               | Ch        | perennial | SA        |
|                 | <i>Suaeda monoica</i> Forssk.   | Ch        | perennial | SU        |
|                 | <i>Suaeda vermiculata</i> J.F.Gmelin                                    | Ch        | perennial | SA+SZ     |

TABLE 2. Cont.

| Family         | Species  | Life-form | Duration  | Chorology    |
|----------------|--|-----------|-----------|--------------|
| Cleomaceae     | <i>Cleome brachycarpa</i> Vahl ex DC.                                    | Th        | annual    | IT+SS+SZ     |
|                | <i>Cleome gynandra</i> L.  | Th        | annual    | PAN          |
|                | <i>Cleome viscosa</i> L.   | Th        | annual    | PAN          |
|                | <i>Dipterygium glaucum</i> Decne.  | Ch        | perennial | SA+SU        |
|                | <i>Convolvulus hystrix</i> Vahl  | Ch        | perennial | SA+SU        |
| Convolvulaceae | <i>Convolvulus prostratus</i> Forssk.                                    | H         | perennial | SS           |
|                | <i>Cressa cretica</i> L.   | H         | perennial | ME+IT        |
|                | <i>Distimake semisagittus</i> (Griseb. ex Peter) A.R.Simões & Staples    | H         | perennial | SU           |
| Cucurbitaceae  | <i>Citrullus colocynthis</i> (L.) Schrad.                                | H         | perennial | SA+ME+IT+SZ  |
|                | <i>Cyperus conglomeratus</i> Rottb.                                      | H         | perennial | SA           |
| Cyperaceae     | <i>Cyperus conglomeratus</i> var. <i>effusus</i> (Rottb.) Coss. & Durand | H         | perennial | SA           |
|                | <i>Cyperus jeminicus</i> Rottb.  | H         | perennial | SU           |
| Euphorbiaceae  | <i>Euphorbia granulata</i> Forssk.                                       | Th        | annual    | SA+ME+IT     |
|                | <i>Argyrolobium arabicum</i> (Decne.) Jaub. & Spach                      | Th        | annual    | SS+SZ        |
| Fabaceae       | <i>Astragalus atropilosulus</i> (Hochst.) Bunge                          | Ch        | perennial | SZ           |
|                | <i>Astragalus vogellii</i> Sieber  | Th        | annual    | SA           |
|                | <i>Crotalaria microphylla</i> Vahl                                       | Th        | annual    | SA+SU        |
|                | <i>Indigofera articulata</i> Gouan                                       | Ph        | perennial | PAN          |
|                | <i>Indigofera oblongifolia</i> Forssk.                                   | Ch        | perennial | SS+SZ        |
|                | <i>Indigofera spinosa</i> Forssk.  | Th        | annual    | ME           |
|                | <i>Lotus schimperii</i> Steud. ex Boiss.                                 | Th        | annual    | SA+SU        |
|                | <i>Parkinsonia aculeata</i> L.   | Ph        | perennial | NEO          |
|                | <i>Prosopis juliflora</i> (Sw.) DC.                                      | Ph        | perennial | SA           |
|                | <i>Rhynchosia schimperii</i> Hochst. ex Boiss.                           | H         | perennial | PAN          |
|                | <i>Senna alexandrina</i> Mill.   | H         | perennial | SS+SZ        |
|                | <i>Senna italica</i> Mill.   | Ch        | perennial | SU           |
|                | <i>Senna italica</i> subsp. <i>micrantha</i> (Brenan) Lock               | Ch        | perennial | SU           |
|                | <i>Taverniera aegyptiaca</i> Boiss.                                      | Ch        | perennial | Near endemic |
|                | <i>Taverniera lappacea</i> DC.   | Ch        | perennial | SU           |
|                | <i>Tephrosia desertorum</i> Scheele                                      | Ch        | perennial | SU           |
|                | <i>Tephrosia purpurea</i> (L.) Pers.                                     | Ch        | perennial | SA + S-Z     |
|                | <i>Vachellia flava</i> (Forssk.) Kyal. & Boatwr.                         | Ph        | perennial | SA+SU        |
|                | <i>Vachellia oerfata</i> Forsk Schweinf.                                 | Ph        | perennial | SA+SU        |
|                | <i>Abutilon pannosum</i> (G.Forst.) Schltdl                              | Ch        | perennial | PAL          |
| Malvaceae      | <i>Corchorus depressus</i> Stocks  | Ch        | perennial | SA+ME        |
|                | <i>Malva parviflora</i> L.   | Th        | annual    | ME+IT        |
| Nyctaginaceae  | <i>Boerhavia diffusa</i> L.  | Ch        | perennial | COSM         |
| Pedaliaceae    | <i>Pedaliium murex</i> L.  | H         | perennial | PAN          |
| Plumbaginaceae | <i>Limonium axillare</i> Kuntze  | Ch        | perennial | SA+SU        |



TABLE 2. Cont.

| Family         | Species   | Life-form | Duration  | Chorology   |
|----------------|---|-----------|-----------|-------------|
| Poaceae        | <i>Aeluropus lagopoides</i> (L.) Thwaites       | G         | perennial | ME+SS+IT+SZ |
|                | <i>Aristida adscensionis</i> L.                 | Th        | annual    | SA+SU       |
|                | <i>Cenchrus ciliaris</i> L.                     | H         | perennial | SA          |
|                | <i>Chloris barbata</i> SW.                      | H         | perennial | SU          |
|                | <i>Cynodon dactylon</i> (L.) Pers.              | G         | perennial | COSM        |
|                | <i>Dactyloctenium aegyptium</i> (L.) Willd.     | Th        | annual    | PAN         |
|                | <i>Echinochloa colonum</i> (L.) Link            | Th        | annual    | PAN         |
|                | <i>Eleusine indica</i> (L.) Gaertn.             | Th        | annual    | PAL         |
|                | <i>Eragrostisbarrelieri</i> Daveau              | Th        | annual    | SA+ME+IT+SZ |
|                | <i>Eragrostisciliaris</i> (L.) R.Br.            | Th        | annual    | SA+ME+IT+SZ |
|                | <i>Panicum turgidum</i> Forssk.                 | G         | perennial | SS+SZ       |
|                | <i>Rostraria pumila</i> (Desf.) Tzvelev         | Th        | annual    | SA+IT       |
|                | <i>Stipagrostis plumosa</i> Munro ex T.Anderson | H         | perennial | IT+SA       |
|                | <i>Tragus racemosus</i> (L.) All.               | Th        | annual    | SA+SU       |
| Portulacaceae  | <i>Portulaca oleracea</i> L.                    | Th        | annual    | COSM        |
| Resedaceae     | <i>Caylusea hexagyna</i> M.L.Green              | Th        | annual    | SS+SZ       |
| Rhamnaceae     | <i>Ziziphus spina-christi</i> (L.) Desf.        | Ph        | perennial | SA+SU       |
| Rubiaceae      | <i>Kohautia caespitosa</i> Schnizl.             | Th        | annual    | SU          |
| Salvadoraceae  | <i>Salvadora persica</i> L.                     | Ph        | perennial | SA+ME+IT+SZ |
| Solanaceae     | <i>Lycium shawii</i> Roem. & Schult.            | Ph        | perennial | SA+SZ       |
|                | <i>Solanum nigrum</i> L.                        | H         | annual    | ME+IT       |
| Tamaricaceae   | <i>Tamarix aphylla</i> H.Karst.                 | Ph        | perennial | SA+SZ       |
| Zygophyllaceae | <i>Fagonia indica</i> Burm.f.                   | Ch        | perennial | SA          |
|                | <i>Tetraena alba</i> (L.f.) Beier & Thulin      | Ch        | perennial | SA+SU       |
|                | <i>Tetraena simplex</i> (L.) Beier & Thulin     | Th        | annual    | SS + SZ     |
|                | <i>Tribulus pentandrus</i> Forssk.              | Th        | annual    | SU          |
|                | <i>Tribulus terrestris</i> L.                   | Th        | annual    | ME+IT+ES    |

Life form: Ch: Chamaephyte, G: Geophyte, H: Hemicyptophyte, Ph: Phanerophyte, Th: Therophyte - Chorology (Floristic categories): SA: Saharo-Arabian; ME: Mediterranean; IR-TR: Irano-Turanian; SU: Sudanian; ES: Euro-Siberian; SZ: Sudano-Zambezian; EU: Euro-Siberean, COSM: Cosmopolitan, PAN: Pantropical, NEO: Neotropical, and PAL: Paleotropical.

TABLE 3. Tabular summary showing the total number of families, genera and species, growth types, and life forms of recorded plants

| Total number of |        |         | Growth type |                   |                | Life forms |                   |                |
|-----------------|--------|---------|-------------|-------------------|----------------|------------|-------------------|----------------|
| Families        | Genera | Species | Type        | Number of species | Percentage (%) | Form       | Number of species | Percentage (%) |
| 31              | 77     | 107     | Perennial   | 66                | 61.68          | Ph         | 16                | 14.95          |
|                 |        |         |             |                   |                | Ch         | 26                | 24.30          |
|                 |        |         | Annual      | 41                | 38.32          | H          | 21                | 19.63          |
|                 |        |         |             |                   |                | G          | 5                 | 4.67           |
|                 |        |         | Total       | 107               | 100            | Th         | 39                | 36.45          |
|                 |        |         |             |                   |                | Total      | 107               | 100            |

### Life-form

Five different life forms have been recorded in the present study. Classes of the plant life forms along the study area indicated that Therophytes were the most frequent life form (39 species = 36.45%), followed up by Chamaephytes (26 species = 24.30%), Hemicryptophytes (21 species = 19.63%), Phanerophytes (16 species = 14.95%), and Geophytes with (5 species = 4.67%) (Table 2, Fig. 3).

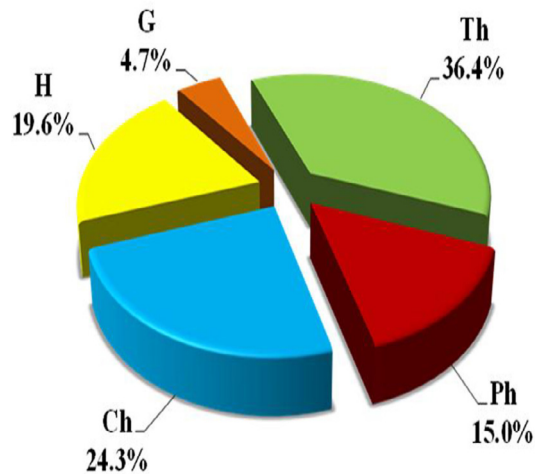


Fig. 3. Life form spectrum of plant species surveyed in Jeddah

### Chorology

Chronological analysis of the 107 plant species surveyed in the present study categorized them into eight phytogeographical groups: monoregional, biregional, pluriregional, cosmopolitan, pantropical, neotropical, near-endemic, and paleotropical (Fig. 4). A total of 31 species representing 28.97% of the total number of surveyed species were monoregional taxa of various affinities. The recorded monoregional elements fall under six main chorotypes (Table 3): Sudanian taxa (13 species forming 12.15% of monoregional species), Saharo-Arabian taxa (11 species forming 11.21% of monoregional species). Two Mediterranean and two Irano-Turanian taxa were recorded in the study area, representing 1.87% of the monoregional flora for each of them. The last two chorotypes Sudano-Zambezian and Saharo-Sindian have rarely been represented in the study area with just one species for each, forming 0.93% of the total number of the recorded monoregional plant species. The biregional elements were the most (41 species = 38.32%) among the recorded

species in the study area with various affinities. The recorded biregional elements include six major chorotype types: the Saharo-Arabian/Sudanian chorotype has the highest share of species (20 species), representing 18.69% of the biregional surveyed flora, followed by the Saharo-Arabian/Sudano-Zambezian region, represented by 7 species (6.54%). While the lowest share of species was recorded for the Saharo-Arabian/Mediterranean region with one species (0.93%). The pluriregional elements were represented by a total of 9 species (8.41%) of various affinities. These pluriregional species include five major chorotype types: The Saharo-Arabian/Mediterranean/Irano-Turanian/Sudano-Zambezian chorotype has the highest share (4 species forming 3.74% of recorded pluriregional species), followed by the Euro-Siberian/Mediterranean/Irano-Turanian (2 species forming 1.87% of recorded pluriregional species). While the lowest share of species was recorded for the Irano-Turanian/Saharo-Sindian/Sudano-Zambezian, Saharo-Arabian/Mediterranean/Irano-Turanian, and Mediterranean/Saharo-Sindian/Irano-Turanian/Sudano-Zambezian (each is represented by one species forming 0.93% of recorded pluriregional species). The remaining 26 species were distributed among cosmopolitan (11 species = 10.28%), pantropical (9 species = 8.41%), neotropical (3 species = 2.81%), palaeotropical (2 species = 1.87%), and only one species is near-endemic (*Taverniera aegyptiaca* = 0.93%) chorotypes (Table 4, Fig. 4).

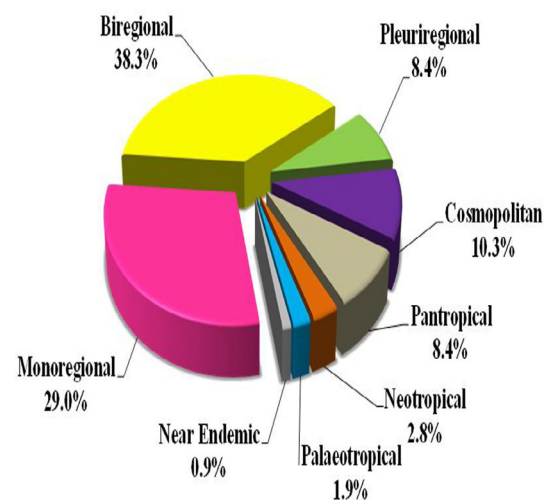


Fig. 4. Phytogeographical analysis of the surveyed species in Jeddah

**TABLE 4. The number of recorded species belonging to the main floristic categories and their relevant percent**

| Phytochoria          | Number of species | Percentage (%) |
|----------------------|-------------------|----------------|
| Monoregional         |                   |                |
| SU                   | 13                | 12.15          |
| SA                   | 12                | 11.21          |
| ME                   | 2                 | 1.87           |
| IT                   | 2                 | 1.87           |
| SZ                   | 1                 | 0.93           |
| SS                   | 1                 | 0.93           |
| Total                | 31                | 28.97          |
| Biregional           |                   |                |
| SA+SU                | 20                | 18.69          |
| SA+SZ                | 7                 | 6.54           |
| SS+SZ                | 6                 | 5.61           |
| ME+IT                | 4                 | 3.74           |
| SA+IT                | 3                 | 2.81           |
| SA+ME                | 1                 | 0.93           |
| Total                | 41                | 38.32          |
| Pleuriregional       |                   |                |
| SA+ME+IT+SZ          | 4                 | 3.74           |
| ES+ME+IT             | 2                 | 1.87           |
| IT+SS+SZ             | 1                 | 0.93           |
| SA+ME+IT             | 1                 | 0.93           |
| ME+SS+IT+SZ          | 1                 | 0.93           |
| Total                | 9                 | 8.41           |
| Cosmopolitan (COSM)  | 11                | 10.28          |
| Pantropical (PAN)    | 9                 | 8.41           |
| Neotropical (NEO)    | 3                 | 2.81           |
| Palaeotropical (PAL) | 2                 | 1.87           |
| Near-Endemic (NE)    | 1                 | 0.93           |

SU: Sudanian, SA: Saharo-Arabian, ME: Mediterranean, IT: Irano-Turanian, SZ: Sudano-Zambian, SS: Saharo-Sindian, COSM: Cosmopolitan, PAN: Pantropical, NEO: Neotropical, PAL: Palaeotropical, NE: Near-Endemic.

#### *Globally threatened taxa*

The plant species recorded in this study were checked with the IUCN list (International Union for Conservation of Nature and Natural Resources). The IUCN Red List Categories and Criteria are meant to be a simple and broadly understood system for classifying species at great threat of extinction on a global scale. Species are classified into nine categories: not evaluated, data deficient, least concerned, near threatened, vulnerable, endangered, critically endangered, extinct in the wild, and extinct. Results shown in Table 4 reveal that 17 of the species recorded in this study are incorporated into the IUCN Red List (IUCN, 2021). All of them are included in the least concern category. The least concern taxon indicates that it

was evaluated against the criteria and is not entitled to be critically endangered, endangered, vulnerable, or near threatened. Widespread and abundant taxa are involved in this category. It is to be noted that the global taxon assessments are the ones to be meant in the IUCN Red List Categories and Criteria. It must be known that a global category for a particular taxon may not be the same as a regional or national category. It is also notable that the current population trend is decreasing for only one species *A. marina*. Populations of 9 species are globally stable (Table 5). *A. lagopoides* and *P. laceracea* populations are stable in the Mediterranean. The population trend is unknown for 5 species (Table 5). According to the IUCN List, 3 species are not evaluated: *S. verrucosum*, *O. radians*, and *H. perfoliata*.



**TABLE 5. Status of globally threatened taxa as checked with the IUCN Red List Status's**

| Species  | Status | Population trend                        | Last assessed    |
|--|--------|---|------------------|
| <i>Avicennia marina</i> (Forssk.) Vierh.           | LC     | decreasing                              | 7 March 2008     |
| <i>Leptadenia pyrotechnica</i> (Forssk.)<br>Decne. | LC     | Unknown- global                         | 14 January 2020  |
| <i>Capparis decidua</i> Edgew                      | LC     | Stable- global                          | 29 January 2020  |
| <i>Maerua crassifolia</i> Forssk.                  | LC     | Unknown -global                         | 30 January 2020  |
| <i>Cressa cretica</i> L.                           | LC     | Unknown -global                         | 29 March 2019    |
| <i>Cyperus conglomeratus</i> Rottb.                | LC     | Stable- global                          | 24 December 2017 |
| <i>Indigofera oblongifolia</i> Forssk.             | LC     | Stable- global                          | 22 July 2010     |
| <i>Lotus schimperii</i> Steud. ex Boiss.           | LC     | Stable- global                          | 9 September 2010 |
| <i>Parkinsonia aculeata</i> L.                     | LC     | Stable- global                          | 12 June 2018     |
| <i>Senna alexandrina</i> Mill.                     | LC     | Stable- global                          | 12 June 2018     |
| <i>Aeluropus lagopoides</i> (L.) Thwaites          | LC     | Stable- Mediterranean                   | 10 February 2009 |
| <i>Cenchrus ciliaris</i> L.                        | LC     | Stable- global                          | 21 February 2017 |
| <i>Eleusine indica</i> (L.) Gaertn.                | LC     | Stable- global                          | 1 July 2014      |
| <i>Portulaca oleracea</i> L.                       | LC     | Stable- Mediterranean                   | 13 February 2009 |
| <i>Lycium shawii</i> Roem. & Schult.               | LC     | Unknown -global                         | 15 January 2020  |
| <i>Salvadora persica</i> L.                        | LC     | Stable- global                          | 12 June 2018     |
| <i>Tribulus terrestris</i> L.                      | LC     | Unknown- scope of assessment<br>Europe- | 31 March 2014    |

LC: Least Concern, NE: Not Evaluated.

## Discussion

In the present study, a floristic survey of vascular plant species from the Jeddah area includes 107 species belonging to 77 genera and 31 families. The floristic analysis of the Jeddah area showed that Fabaceae (20 species) and Poaceae (14 species), were the richest families, constituting the majority of plant species (31.8%). Similar results were obtained in different regions of Saudi Arabia by Alatar et al. (2012) in Al-Jufair wadi, Fakhry & AlAnazi (2017) in the Al Dissah area, Abbas et al. (2020) in Jabal Fayfa, and Al-Sodany et al. (2020) in the Western Mountains of Taif. These results are also confirmed by those of AlNafie (2008) and Collenette (1999) for the flora of Saudi Arabia, where Poaceae, Fabaceae, and Asteraceae were reported to constitute the main bulk of plant species in Saudi Arabia. It is worth notable that among the floristic composition of Saudi Arabia, few families are floristically rich. This may be attributed to the efficient seed dispersal capabilities and migration efficiency, in addition to their wide ecological amplitude of tolerance (Abbas et al., 2020).

The current study showed that the floristic

composition of Jeddah exhibited a high degree of monotypic. Amongst 31 families recorded, 13 families (41.9%) were represented by only one species. These findings are confirmed by the results of Thomas (2011, who reported the presence of 33 monotypic families (25.19%) of the total number of families recorded in the whole flora of Saudi Arabia. Taxonomic diversity in the study area is indicated by the ratios of species/genera and genera/families estimated for total species (1.39 and 2.48, respectively) recorded in the present study, a ratio less than 2.68 which was documented by AlNafie (2008) in the total area of Saudi Arabia. Similar results were also obtained by Abbas et al. (2020), where taxonomic diversity in Jabal Fayfa was 1.42 (341/240) species per genus. Fakhry & AlAnazi (2017) also recorded similar results for the Al-Dissah area in the Tabuk region, where species/genera and genera/families were 1.03 and 2.03, respectively.

The present study reveals that perennial species dominated the plant cover defining the character of the vegetation. About 62% of the recorded flora is represented by perennial species, while annuals were represented by about 38%. This trend matches the finding of many

studies in different regions of Saudi Arabia, such as Alfarhan et al. (2005) and Abbas et al. (2020). Other studies especially those which were carried on in wadis of Saudi Arabia show a considerable increase in the percentage of annual species, such as Abdel Khalik et al. (2013), Osman et al. (2014), and Fakhry & AlAnazi (2017). As the life form of desert plants is closely linked with rainfall (Zohary, 1973), so the dominance of perennials in the Jeddah desert area could be attributed to the low rainfall, which is not enough for the growth of many annual species.

Chronological analysis of the floristic data revealed that the biregional Saharo-Arabian–Sudanian chorotype (18.7%) forms the major component of the floristic structure in the Jeddah area, followed by the two monoregional Sudanian and Saharo-Arabian chorotypes (12.1 and 11.2%, respectively). The results also showed the predominance of biregional taxa (38.32%) over the other phytogeographical elements followed by the monoregional (28.97%). Similarly, the dominance of Saharo-Arabian and Sudanian elements was also reported in the Khulais region, west Saudi Arabia (Alsherif et al., 2013), and in the Al Soada region southwestern Saudi Arabia (Seraj, 2014). While in the Alaqan area in the Tabuk region, northwest Saudi Arabia, most plant species belong to Saharo-Arabian, Irano-Turanian, and Sudanian regions (Moawad, 2016). Despite the high number of plant species recorded in the study area, the proportion of endemism is too little. Only a single species (0.93%) is near-endemic (*T. aegyptiaca*). The low percentage of endemic species and genera in the Saharo-Arabian region is mentioned by Wickens (Wickens, 1978) and Boulos (Boulos, 1997).

The plant species of the Jeddah area were checked with the international IUCN list. Seven of the recorded species in the study area are incorporated into the IUCN Red List of Threatened Species (IUCN, 2021). All of them are included in the least concern category. The population trend is stable for 11 species, and unknown for 5 other species. The current population trend is decreasing for only one species *Avicennia marina*. This is a very common, widespread species. Species-specific dieback was observed by Duke et al. (2005) in Queensland, northeastern Australia affecting 30km<sup>2</sup> of mangrove in five separate estuaries.

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Between 1980 and 2000 Duke et al. (2007) reported a 16% loss in the region. Overall, there was an average of 0.8% habitat decline per year within the distribution of the *A. marina* (Duke et al., 2007).

## Conclusions

The results of the current study may provide a valuable reference for appropriate conservation and management of the Jeddah region in west Saudi Arabia. This study shows a considerably high floristic diversity of the study area. The recorded plant species are subjected to drought (due to lack of rainfall) and overgrazing as well as urbanization, which in turn led to disturbance in their native habitats. There is an urgent need to conserve the floristic diversity of the study area by protecting native habitats as well as the establishment of national parks to recover these plants for conserving genetic and species diversity from being lost.

*Appendix A:* Photos of some species recorded in the study area

*Conflicts of interest:* The authors declare no conflict of interest.

*Authors' contributions:* Conceptualization, A.F., and GH.A.; methodology, A.F., and GH.A.; formal analysis, A.F.; investigation, A.F., and GH.A.; writing, A.F. and GH.A.; supervision, A.F.; funding acquisition, GH.A. All authors have read and agreed to the published version of the manuscript.

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## التنوع النباتي في جدة: منطقة صحراوية جافة غرب المملكة العربية السعودية

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أجريت هذه الدراسة في الصحاري الجافة في محافظة جدة في المنطقة الغربية من المملكة العربية السعودية. وتهدف إلى دراسة التنوع النباتي في المنطقة، بما في ذلك أشكال الحياة المختلفة للأنواع النباتية المسجلة، والمناطق الفلورية التابعة لها. وقد تم تسجيل 107 نوع نباتي تنتمي إلى 77 جنس و 31 فصيلة نباتية من كاسيات البذور. وتضم الفصيلتين النجيلية والبقولية العدد الأكبر (31.8%) من الأنواع المسجلة بمنطقة الدراسة. وتوضح النتائج درجة عالية من النمط الأحادي، حيث تم تمثيل (42%) من العائلات المسجلة بنوع نباتي واحد فقط، وكان 76.6% من الأجناس أيضا أحادية النمط. هيمنت الأنواع المعمرة على الغطاء النباتي (62%)، في حين تم تمثيل الأنواع الحولية بحوالي 38%. كما لوحظ أن الشجيرات هي أكثر أشكال الحياة شيوعا في صحاري جدة. وأوضحت النتائج أيضا أن النمط الصحراوي العربي- السوداني ثنائي المنطقة هو النمط الأكثر هيمنة في منطقة جدة (18.7%)، يليه النمط السوداني أحادي المنطقة و الصحراوي العربي (12.1% و 11.2% على التوالي). وأظهرت النتائج أيضا غلبة الأنواع ثنائية المنطقة (38.32%) على العناصر الجغرافية النباتية الأخرى تليها الأنواع الأحادية (28.97%). ومن الجدير بالذكر أن 17 نوعا نباتيا من الأنواع المسجلة في هذه الدراسة قد تم تسجيلها في القائمة الحمراء للاتحاد الدولي لحفظ الطبيعة، في الفئة الأقل إثارة للقلق. وقد توفر المعلومات المستقاة من الدراسة الحالية مرجعا قيما لحفظ وإدارة منطقة الدراسة بشكل مناسب.