

## PLANT DIVERSITY IN KING SALMAN PARK IN RIYADH, SAUDI ARABIA

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**Abstract.** King Salman National Park is located about 22 km north of Riyadh city (Saudi Arabia) and has an area of 340000 m<sup>2</sup>. The park is one of the important parks in Riyadh and the Kingdom of Saudi Arabia. This study aims to determine the floristic structure and plant diversity, informing policymakers and conservationists about this protected area. Fifteen sites of the national park, cultivated and non-cultivated, were selected. Density, frequency and diversity indices were evaluated. Twenty species were recorded in the park, including eight species of phanerophyte (40%), followed by seven species of chamaephytes (35%), three species of therophyte (15%) and two species of hemicryptophytes (10%). Rhamnaceae were dominated in the national park with one species (*Ziziphus spina-cristi*) which had the greatest ecological importance in all areas under study (44.77%). Small sandy hills have the highest diversity among all studied sites. Decreasing the effect of visitors and climate change by creating protected areas in the park could increase plant diversity in the park under study.

**Keywords:** *King Salman National Park, biodiversity, species richness, vegetation*

### Introduction

Saudi Arabia covers a huge area of the Arabian Peninsula, it is located in the Middle East in South Asia at 25 degrees north latitude and 45 degrees east longitude. It covers an area of 2.25 million km<sup>2</sup>. Saudi Arabia is characterised by a semi-arid to arid climate with hot days, cold nights, and extremely low annual rainfall. Drought-resistant plant species are widely spread in Saudi Arabia, distinguished from plants in non-dry conditions at the morphological, anatomical, and physiological levels. Promoting the conservation of these species could maintain water agriculture used in the world. Plant diversity is essential to human survival, economic well-being, ecosystem function and stability (Singh et al., 2019). Local plant species are more vulnerable to human activity pressures and natural changes, posing a greater danger of extinction. To promote the conservation of these species, in situ conservation measures must be implemented, and the establishment of National parks is the most efficient and cost-effective technique. (Coelho et al., 2020; Abeli et al., 2020). The United Nations Environment Program (2001) reported that habitat destruction, overexploitation, pollution, and species introduction are the main causes of biodiversity loss. These disturbances have been considered an important factor in structuring societies and determining plant dynamics diversity at the local and regional levels (Wilcove et al., 1998; Suratman, 2012; Kehoe et al., 2021). The climate zones favourable for plants will alter, and species diversity will be significantly threatened as a result of climate change. Climate change's impact on species has become a hot topic in studying global species spatial patterns (Tian and

Jiang, 2015). Therefore, regular plant diversity monitoring and high maintenance requirements of national parks are crucial. Plants are keys to life on earth and main components of all ecosystems. Despite their importance, plant diversity is threatened not only by climate change but also by human activities (FAO, 2019).

In vegetation cover management operations, the information from the quantitative inventory will provide a valuable reference for assessing desert ecosystems and improving our knowledge in identifying ecologically beneficial species of particular interest, thus defining conservation efforts to sustain plant biodiversity. For example, the all-taxa biodiversity inventory (ATBI) can help to determine the nature and distribution of biodiversity in the area being managed, in addition to the quantitative analysis studies that could give resources for a wide range of species (Cannon et al., 1998). A study made by El-Sheikh et al., 2013, showed the progressive succession varying among the different habitat types in Thumamah Nature Park, which was an attempt to explain the vegetation dynamics after 30 years of conservation. The escarpment and the rocky upland habitats reflect the relationship between altitude, edaphic factors, and the type of vegetation units in each habitat type after excluding the human impact. A different study talked about regeneration, density, and diversity of woody vegetation in Awash National Park in Ethiopia. They found that only *Acacia senegal*, the park's major tree species, exhibited a higher capability for regeneration (Mekonnen, 2009). As a result, if the park's surviving vegetation is to be protected, appropriate management interventions, such as avoiding human intrusion, are required for Awash National Park. The quantitative analysis study of Khadimnagar National Park of Bangladesh described the diversity of plant species (trees, shrubs and herbs) and the structure and composition of the national park, which give them the ability to assess the plant diversity and provide sustainable management strategies to the protected area (Sobuj and Rahman, 2011).

Several new wildlife-protected areas have been established in Saudi Arabia over the last three decades (SA). The number of national parks, newly constituted nature reserves, wildlife sanctuaries, protected landscapes and biosphere reserves have expanded. Saudi Arabia now includes 16 protected areas and 12 national parks (Abuzinada, 2003). King Salman national Park is in Banban, north of Riyadh. It is one of the most important parks in Riyadh.

Moreover, it was opened in March of 2016 and is intended for visitors from inside and outside the country. This study aims to determine this national park's floristic structure and plant diversity, informing policymakers and conservationists about this protected area. As a result, appropriate steps would be taken to preserve and enhance its diversity.

## Materials and methods

### *The study area*

The King Salman Wilderness Park is located in Banban, 22 km from the city of Riyadh, on a land area of more than 3.400.000 m<sup>2</sup> in the northwest corner of King Khalid International Airport. Numerous valleys separated by ridges dissect the small hills. The soil ranges from clay loams to sandy on the hills. The desert climate prevails in Riyadh, where the national park is located. Climate is hot and dry. June and July are the hottest, and December and January are the coolest. During the year, there is virtually no rainfall, the average annual temperature is 26.2 °C and the precipitation is about 5 mm per year (*Fig. 1*). The study was carried out through a total of 15 sample plots in all three areas, each area had five plots, 10 m × 10 m sample plots were nested within

each plot. Overall, the first five sites have represented the slope of the valley habitat. The middle five sites represented the depressions habitat. And the last five sites represented the small sandy hill habitat (*Fig. 2*).

### ***Plants identification***

Samples were taken from King Salman Wilderness Park, in which this study was carried out in the fall-spring season of 2022 (April/2022). In this field study, some tools were used to obtain these samples. These materials used in field work include plastic bags, scissors, pen, label tapes and a notebook to record the number of species in the study areas. Species were identified in the study site, King Salman Park and confirmed in the herbarium of the plant and microbiology department at King Saud University. The numbers of these species in each site were counted. The analytical characteristics such as abundance, density, relative density, frequency, relative frequency, abundance, relative dominance and Importance Value Index (IVI) were calculated through (Shukla and Chandel, 2000) and (Zhigila et al., 2015). Shannon- Wiener diversity index for trees and herbs species and Simpson's index for all species were also calculated (Michael, 1990).

### ***Data analyses***

The data acquired were analyzed quantitatively. The analytical characters used were density, relative density, frequency, relative frequency, abundance, relative abundance cover, importance value, Simpson's index, and Shannon wiener index.

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied} \times \text{Quadrats area}} \quad (\text{Eq.1})$$

$$\text{Relative Density} = \frac{\text{Number of individuals of one species}}{\text{Total number of all individuals counted}} \times 100 \quad (\text{Eq.2})$$

$$\text{Frequency} = \frac{\text{Number of quadrats in which the species occurs}}{\text{Total number of quadrats sampled}} \quad (\text{Eq.3})$$

$$\text{Relative Frequency} = \frac{\text{Frequency of one species}}{\text{Total frequency of all species}} \times 100 \quad (\text{Eq.4})$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which the species occurred}} \quad (\text{Eq.5})$$

$$\text{Relative Abundance} = \frac{\text{The abundance of one species}}{\text{Total of all species counted}} \times 100 \quad (\text{Eq.6})$$

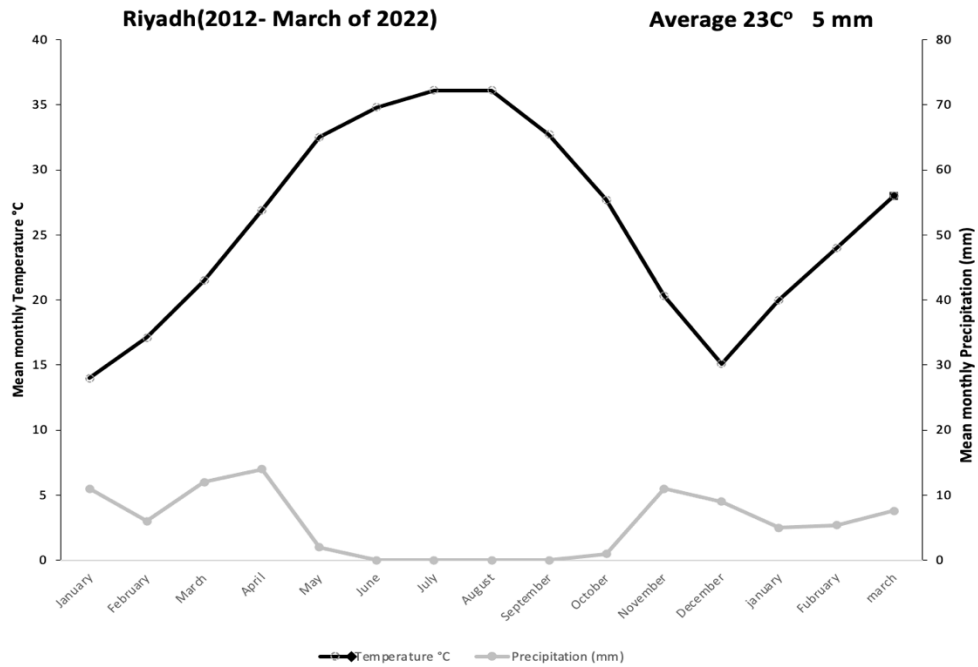
$$\text{Importance value index} = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Abundance} \quad (\text{Eq.7})$$

$$\text{Simpson diversity index (C)} = \sum_{i=1}^s p_i^2 \quad (\text{Eq.8})$$

The value of C ranges between 0 and 1. With this index, 0 represents infinite diversity and 1 no diversity.

$$\text{Shannon-Wiener index (H)} = - \sum_{i=1}^s p_i \text{Log } p_i \quad (\text{Eq.9})$$

where  $P_i = \frac{\text{Number of individuals of one species}}{\text{Total number of individuals in the samples}} \times 100$  or relative sp. abundance.



**Figure 1.** Average of 2012- March of 22. Mean monthly temperature (°C) and mean monthly precipitation (mm) in King Salman Wilderness Park, Riyadh according to King Khalid international airport station



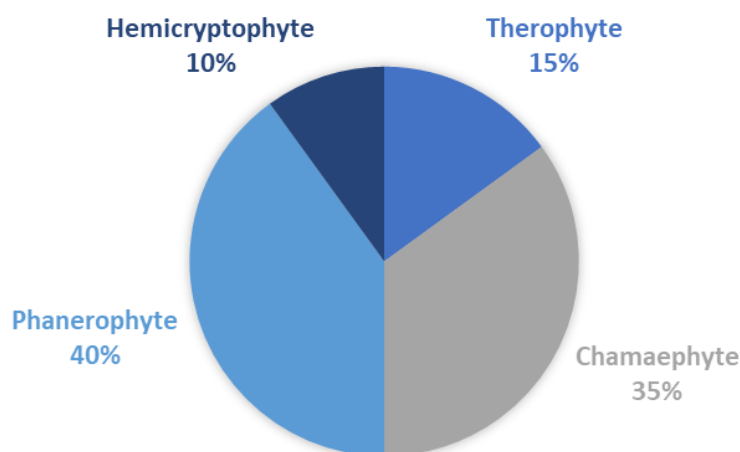
**Figure 2.** Study area map showing the whole map of Saudi Arabia with focus on the study area. And showing the distribution of the studied Sites in the study area. Sites 1, 2, 3, 4, 5 show Slope of valley habitat. Sites 6, 7, 8, 9, 10 show Depressions habitat. Sites 11, 12, 13, 14, 15 show Small sandy hill habitat

## Results and discussion

Trees and herbs were mainly accrued in King Salman National Park. A species' high important value index (IVI) indicates its dominance and ecological success, as well as its good regeneration power and bigger ecological amplitude, as well as those plants that require monitoring management. In contrast, species classed as low require substantial conservation efforts.

### *Floristic diversity and composition of plants species*

Floral diversity refers to the variety of plants that exist at a given time. In the present study, the cultivated and non-cultivated plants were recorded in March-April at 2022. Twenty taxa, including eight species of phanerophyte (40%), followed by seven species of chamaephytes (35%), three species of therophyte (15%) and two species of hemicryptophytes (10%) were recorded (*Fig. 3*). Phanerophyte is the most represented life form in the national park. The majority of conifer and dicot tree species, as well as numerous palm and cycad species, and tree ferns, come under phanerophyte (Niklas, 2008).

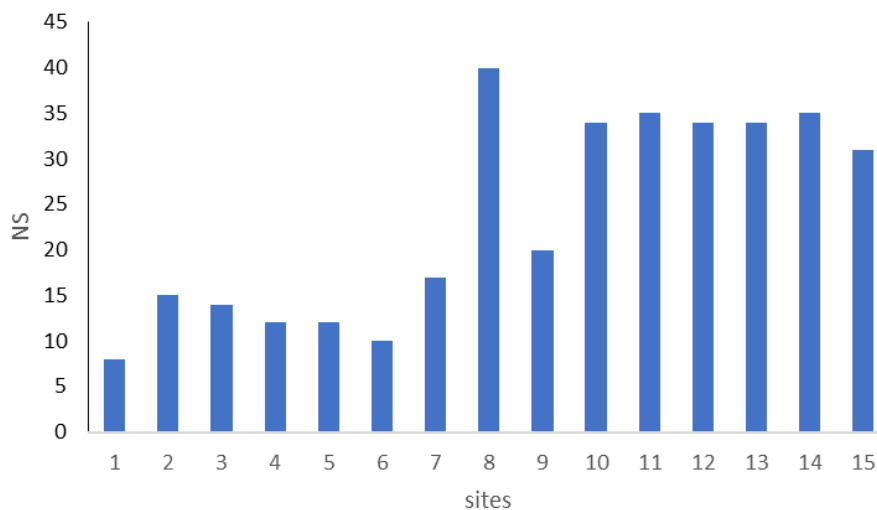


**Figure 3.** Life-form spectrum of the recorded species in the study area

In more detail, eight species of trees under five families were identified. Mimosaceae containing three species followed by Caesalpiaceae (two species), Fabaceae, Tamaricaceae, Rhamnaceae had the same number of species (one species each) (*Table A1* in the *Appendix*). Moreover, 11 species of shrubs and sub-shrubs under eight families were identified. The family Poaceae, Asteraceae, and Brassicaceae containing two species each, followed by Resedaceae, Polygonaceae, Chenopodiaceae, Boraginaceae, and Malvaceae (one species each). These plant families are widely distributed in Saudi Arabia, especially in the middle region at late winter and the beginning of spring (Migahid, 1996; Chaudhary, 1999). And known to be resistant to drought climate in the desert ecosystem (Maraghni et al., 2019; Akande et al., 2019; Ricks, 1992). They are able to colonize wide spaces and create microsites for the germination and establishment of numerous other species beneath their canopies because of their high germinability, accelerated growth rates during the early stages, and tolerance to high radiation levels (Bedair et al., 2020). However, due to the high impact of the pressure of human trampling on the land which is the major issue of plant diversity declined (Pescott and Stewart, 2014). Rhamnaceae were dominated in the

national park with one species (*Ziziphus spina-cristi*) which had the most ecological importance in all studied areas (44.77%). The ecological and economic importance of *Ziziphus spina-cristi* is considerable (Zhao et al., 2021). With their thick root structure that stabilizes the soil and protects it from erosion, *Ziziphus spina-cristi* plays a vital role in soil conservation. The firm wood is useful for turning and manufacturing agricultural implements, firewood, and high-quality charcoal, while the leaves provide fodder for cattle. Based on the importance of the *Ziziphus spina-cristi*, King Salman national park emphasises sowing this tree in all park areas. The second dominant family was Caesalpiniaceae represented by *Parkinsonia aculeata* which is one of the alpine plant species and widely disturbed trees or shrubs in hot climates which would affect negatively in native plant diversity (Calvo-Alvarado et al., 2022). Due to its thorns it develops dense, impenetrable woods that ruin meadows, clog rivers, and prevent livestock drinking (van Klinken et al., 2009). It was frequently marketed as a forage, hedge, or decorative tree with the ability to endure the driest, saltiest, and most waterlogged environments.

*Sorghum halepense* and *Pulicaria crispa* (3.11%) had less ecological importance. *Sorghum halepense* L. is a common and noxious herb that is spreading around the world. It showed less abundance in the park, but it spreads quickly and will compete with native species diversity (Travlos et al., 2019). Therefore, the national park maintenance should increase the species spread control (Fig. 4).



**Figure 4.** Number of all organisms of given species (NS) at each site under study

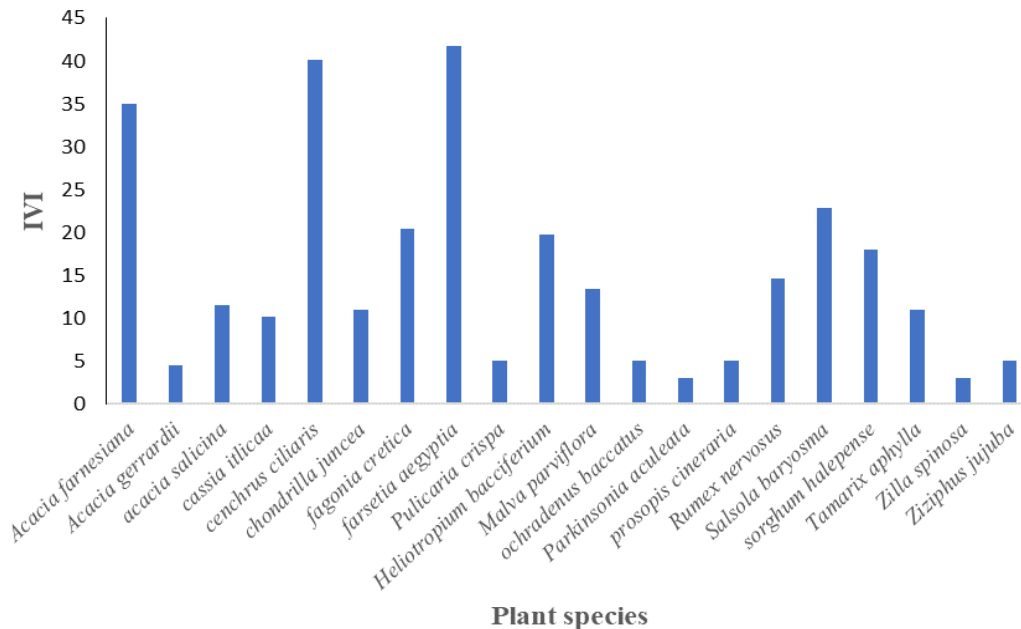
### Habitat diversity

The habitat types in King Salman National Park were divided into three types, the slope of the valley (1, 2, 3, 4 and 5 site), depressions (6, 7, 8, 9 and 10 site) and small sandy hill (11, 12, 13, 14 and 15 site) (Fig. 2). The slope of the valley habitat indicates the species' lowest degree of relative evenness, which is confirmed by the high Simson index, illustrating that 4-5 species were dominated in this site (Table A3). In the second habitat of the study (depressions), the degree of relative evenness of the species was high only in the ninth site compared with other sites in the same habitat. However, the small sandy hill habitat showed the highest diversity and regular distribution at all sites (11, 12, 13, 14 and 15) (Table A3), far from visitors and the nature of rocky soil. This



confirms that repeated use of the same sites by the visitors trampled the vegetation and soil (Bar, 2017), eventually resulting in harm that could cause plant diversity loss (Pescott and Stewart, 2014). Encouraging visitors to use the places designated for picnics and walking paths could help to increase or protect plant diversity and improve ecosystem stability in the national park.

Also, the climate change has tangible impact on the vegetation of National Parks (Scherrer and Pickering, 2001; Jahani and Saffariha, 2021). Due to the drought seasons during last ten years (Fig. 1), some important species such as *Acacia spp.* had low relative abundance (Fig. 5).



**Figure 5.** Importance value index (IVI) of plant species at the 15 sites in King Salman National Park

## Conclusion

- *Ziziphus spina-cristi* dominate the King Salman National Park plants community. Increasing species diversity in the current park could elevate the ecosystem stability in each site.
- The small plant diversity species in the study area could be related to two main factors, the pressure of national park visitors and climate change. Therefore, this study would like to draw attention to the importance of increasing plant diversity in the parks and decreasing the effect of visitors by creating some protected areas in the park.

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## APPENDIX

**Table A1.** Nomenclature and life form of plant species at the 15 sites in King Salman National Park

Family	Scientific name	Common name	Life form
<i>Mimosaceae</i>	<i>Acacia farnesiana</i>		Ph
<i>Mimosaceae</i>	<i>Acacia gerrardii</i>	AlGhaf	Ph
<i>Mimosaceae</i>	<i>Acacia salicina</i>		Ph
<i>Caesalpinaceae</i>	<i>Senna italica</i>	AlAshrik	Ch
<i>Caesalpinaceae</i>	<i>Parkinsonia aculeata</i>		Ph
<i>Fabaceae</i>	<i>Prosopis cineraria</i>		Ph
<i>Tamaricaceae</i>	<i>Tamarix aphylla</i>	AlAthel	Ph
<i>Rhamnaceae</i>	<i>Ziziphus spina-cristi</i>	AlSeder	Ph
<i>Poaceae</i>	<i>Cenchrus ciliaris</i>		Ch
<i>Poaceae</i>	<i>Sorghum halepense</i>		He
<i>Asteraceae</i>	<i>Pulicaria crispa</i>	AlJuthjath	Ch
<i>Asteraceae</i>	<i>Chondrilla juncea</i>		He
<i>Brassicaceae</i>	<i>Zilla spinosa</i>	AlZilla	Th
<i>Brassicaceae</i>	<i>Farsetia aegyptia</i>	AlJurba	Ch
<i>Resedaceae</i>	<i>Ochradenus baccatus</i>	AlKurda	Ph
<i>Polygonaceae</i>	<i>Rumex vesicarius</i>	AlHumeedh	Th
<i>Chenopodiaceae</i>	<i>Salsola baryosma</i>	Salsola	Ch
<i>Boraginaceae</i>	<i>Heliotropium crispum</i>	AlRumram	Ch
<i>Malvaceae</i>	<i>Malva parviflora</i>	AlKhobeeza	Th
<i>Zygophyllaceae</i>	<i>Fagonia cretica</i>		Ch

The life forms are: Th therophyte, Ch chamaephyte, Ph phanerophyte, He hemicyrptophyte

**Table A2.** The occurrence and importance value index (IVI) of plant species at the 15 sites in King Salman National Park

Scientific name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	T	M	RD	RF	RA	IVI
<i>Acacia farnesiana</i>	3	0	1	4	4	0	0	0	0	0	12	9	6	10	4	53	3.53	1.86	10.00	9.82	21.68
<i>Acacia gerrardii</i>	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0.13	0.66	2.22	1.67	4.55
<i>Acacia salicina</i>	2	5	1	0	2	0	0	0	0	0	0	0	0	0	0	10	0.67	3.31	4.44	4.17	11.92
<i>Cassia itlicaa</i>	1	2	1	1	1	0	1	0	0	0	0	0	0	0	0	7	0.47	1.74	6.67	1.94	10.35
<i>Cenchrus ciliaris</i>	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0.13	0.66	1.11	3.33	5.11
<i>Chondrilla juncea</i>	0	0	0	0	0	0	0	0	0	0	6	4	3	7	3	23	1.53	7.62	5.56	7.67	20.84
<i>Fagonia cretica</i>	0	0	0	0	0	0	0	1	0	0	2	4	2	1	2	12	0.80	3.98	6.67	3.33	13.98
<i>Farsetia aegyptia</i>	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0.13	0.66	1.11	3.33	5.11
<i>Pulicaria crispa</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.07	0.33	1.11	1.67	3.11
<i>Heliotropium bacciferium</i>	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0.13	0.66	1.11	3.33	5.11
<i>Malva parviflora</i>	0	0	0	0	0	0	0	1	0	1	2	0	1	6	3	14	0.93	4.64	6.67	3.89	15.19
<i>Ochradenus baccatus</i>	0	0	0	0	0	0	0	0	0	0	2	6	9	8	3	28	1.87	9.28	5.56	9.33	24.17
<i>Parkinsonia aculeata</i>	1	7	9	2	2	3	5	7	12	16	0	0	0	0	0	64	4.27	21.20	11.11	10.67	42.98
<i>Prosopis cineraria</i>	0	0	0	0	0	0	0	0	0	0	4	3	2	0	0	9	0.60	2.98	3.33	5.00	11.32
<i>Rumex nervosus</i>	·	·	0	0	0	0	0	0	0	0	3	4	6	2	5	20	1.33	6.63	5.56	6.67	18.85
<i>Salsola baryosma</i>	0	0	0	0	0	0	0	0	0	0	0	0	3	1	5	9	0.60	2.98	3.33	5.00	11.32
<i>Sorghum halepense</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.07	0.33	1.11	1.67	3.11
<i>Tamarix aphylla</i>	0	0	0	0	0	2	5	12	0	1	2	0	1	0	1	24	1.60	7.95	7.78	5.71	21.44
<i>Zilla spinosa</i>	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0.13	0.66	1.11	3.33	5.11
<i>Ziziphus spina-cristi</i>	1	0	2	4	3	4	6	12	8	14	2	4	1	0	5	66	4.40	21.86	14.44	8.46	44.77
Total	8	15	14	12	12	10	17	40	20	34	35	34	34	35	31	-	-	100	100	100	300
Mean	0.4	0.8	0.7	0.6	0.6	0.5	0.9	2	1	1.7	1.8	1.7	1.7	1.8	1.6						

T: total, M: mean, RD: relative density, RF: relative frequency. RA: relative abundance. IVI: important value index

**Table A3.** Plant diversity measurement in the study area

Sites	S	N	d	J'	H'(log10)	Lambda'	Habitat
1	5	8	1.924	0.928	0.6489	0.1429	Slope of valley
2	4	15	1.108	0.8447	0.5086	0.3048	
3	5	14	1.516	0.7006	0.4897	0.4066	
4	5	12	1.61	0.8979	0.6276	0.197	
5	5	12	1.61	0.9426	0.6589	0.1667	
6	4	10	1.303	0.9232	0.5558	0.2222	Depressions
7	4	17	1.059	0.9046	0.5446	0.2574	
8	9	40	2.169	0.798	0.7615	0.2	
9	2	20	0.3338	0.971	0.2923	0.4947	
10	5	34	1.134	0.6798	0.4752	0.3779	
11	9	35	2.25	0.8855	0.845	0.1597	Small sandy hill
12	7	34	1.701	0.9657	0.8161	0.139	
13	10	34	2.552	0.8846	0.8846	0.1319	
14	7	35	1.688	0.8665	0.7323	0.1849	
15	9	31	2.33	0.9615	0.9175	9.892E-2	
F	7.448**			0.575	10.322**	3.746*	
P value	0.008			0.578	0.002	0.054	

S = species number. N = individual numbers of species. J = species richness  $\hat{H}$  = Shannon Wiener index. Lambda' = Simpson dominance. GPS = Global Positioning System position of the sampling sites. F and P value calculated according to ANOVA one-way. \* =  $\leq 0.05$ , \*\* =  $\leq 0.001$ , \*\*\* =  $\leq 0.001$

**Table A4.** The habitats of study samples and their locations

Sites	GPS	Habitat
1	25.011818, 46.595993	Slope of valley
2	25.012051, 46.597034	
3	25.011298, 46.595172	
4	25.011851, 46.596629	
5	25.010914, 46.596563	
6	25.003241, 46.598145	Depressions
7	25.001173, 46.595776	
8	25.001242, 46.595896	
9	25.000570, 46.597005	
10	25.001262, 46.599238	
11	25.001252, 46.601240	Small sandy hill
12	25.002657, 46.603266	
13	25.002099, 46.605138	
14	25.000526, 46.604654	
15	24.999432, 46.603563	