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Floristic Composition, Diversity, and Vegetation Structure in Wadi Al-Quwayiyah, Riyadh Region, Saudi Arabia

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Abstract: Wadi Al-Quwayiyah, Riyadh Region, Saudi Arabya is one of the most important Wadis of the Kingdom. The current study aimed to determine floristic composition, the structure of the vegetation, and species distribution at four different plant communities in Wadi Al-Quwayiyah, Riyadh Region, Saudi Arabia, and highlighting the ecological factors that affect species distribution. The study revealed forty-two plant species belonging to 21 families were collected and found to be dispersed over four different plant communities*: Acacia tortilis, Leptadenia pyrotechnica, Zizuphus nummularia,* and *Acacia gerradii*. Leguminosae and Brassicaceae were the dominant families, and therophytes and chamaephytes and were predominant life forms, which demonstrate a typical desert life-form. Soil texture, organic matter content, Na, CaCO3, Cl, Ca, Mg, pH and EC were the primary parameters affecting the occurrence of plants. Perennials accounted for 28 of the total reported species in this survey about 66.7% of the listed species. Annuals, on the other hand, accounted for 14 species (33.3%).

Keywords: : Flora; Vegetation; Wadi Al-Quwayiyah; Saudi Arabia.

Introduction

The variety of wild plants is a vital component of our terrestrial habitats and is crucial in preserving the ecological balance and coherence of the area (Abdel Khalik *et al*., 2017). The Kingdom of Saudi Arabia is a huge arid land with an area of about 2,250,000 km2 covering the major part of the Arabian Peninsula, characterized by different ecosystems and diversity of plant species (Abdel Khalik *et al*., 2013). It lies around longitudes 34º 400´ E and 55º 450´ E and between latitudes 15º 450´ N and 34º 350´ N (Alzamel, 2021, 2022). Although Saudi Arabia lacks perennial lakes or rivers, "Wadis" are common throughout the region (Osman *et al*., 2014). One of the most prevalent desert landforms are "wadis," which include physiographic irregularities that explain the accompanying differences in species distribution (Kassas & Girgis, 1964). In addition, the wadi's vegetation is not very consistent, and changes annually based on humidity conditions (Siddiqui & Al Harbi, 1995). The occurrence of life forms has a strong correlation to landform and topography (Osman *et al*., 2014; Wickens, 1978; Orshan, 1986). Additionally, the development, growth, regeneration, and distribution pattern of plant communities in wadis are influenced by human activity, geography, and physiographic position (Shaltout & El-Sheikh, 2003; Alatar *et al*., 2012). Because of this, Saudi Arabia has a very diverse range of plants, particularly in the southwest, which flourishes in natural forests. These differences can be seen in the unique vegetation zones, biological habitats, and diverse flora across the region (Alzamel, 2022; Fadl *et al*., 2015). The Saudi Arabian flora has been detailed in numerous earlier investigations (Migahid, 1978, Chaudhary, 1999). Collenette (1999) provided illustrations of Saudi Arabia's flora. The flora and vegetation analysis of Wadi Ar'ar were detailed by Osman *et al*. (2014). Furthermore, Chaudhary & Al-Jowaid (2013) wrote a book named Under Vegetation of the Kingdom of Saudi Arabia. Mossa (1987) asserts that Saudi Arabia is endowed with a diverse array of flora, including a substantial quantity of trees, shrubs, and therapeutic herbs (Alzamel, 2022). In Saudi Arabia, there are over 2285 different plant species in the flora. While 500 species coexist in restricted locations, about 656 species live in small groups. Additionally, some 100 species have been identified as

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vulnerable (Al-Farhan, 2011). These records offer reliable information regarding the distribution of these species in addition to serving as a crucial baseline for the floristic elements. As far as we are aware, nevertheless, not many research have examined the relationship between floristic composition and habitat diversity in the Wadi Al-Quwayiyah area and vegetation analysis.

Thus, the goal of the current study was aimed to analyze the species floristic composition, life-form, chorotype, and vegetation structure of Wadi Al-Quwayiyah. Also, to identify the plant communities of the different habitats in the study region; and evaluate the influence of edaphic conditions on the vegetation distribution.

Materials and methods

Study area.

Quwayiyah is a city in the Riyadh region located 180 km west of Riyadh, at latitude 05 24 and longitude 40 41. It is a major stopping point on the Riyadh-Makkah highway, bordered to the north by Dawadmi Governorate and Marat Center, to the south by Wadi Al-Dawasir Governorate, to the east by Al-Hariq Governorate, Al-Muzahimiyah Governorate and Al-Aflaj Governorate, and to the west by Afif Governorate, with an area of 550,580 km^2 (Figure 1).

Climate

Temperature

The climate of Saudi Arabia is primarily dry and hot. There are two types of climates that affect it: Mediterranean and Monsoon. The southern region is impacted by the monsoon climate, whereas the climate of the Mediterranean affects the northern part. The study area has a typically hot summer climate, with highs of 41°C to 46°C during the summer months of June-September and lows of 24°C. In contrast, the average maximum temperature in the winter months of December- February is at least 18°C, and the average minimum temperature in January is at least 13°C. As a result, the study area's vegetation cover, including perennials that are subjected to severe temperature fluctuations is impacted by daily and seasonal temperature variations. This effect is also evident in the viability of seeds and the longevity of annual plant species (Figure 2).

Rainfall

Like other arid regions with a desert climate, the study region has rain on a restricted number of days each year never more than 15 days and very seldom more than 25 days. Rainfall seldom occurs in April and often starts in November and lasts through March. The year 2018 saw the most rainfall (170.6 mm), while the year 2017 saw the least amount (59.7 mm) (Figure 3).

Relative humidity

Precipitation and humidity percentage are directly correlated, while temperature and humidity are inversely correlated—the more the temperature, the less the humidity. The average monthly humidity changes significantly throughout the year. Astronomically, the atmosphere's relative humidity increases with rainfall rates; the maximum relative humidity values are found in December and January when average humidity levels range from 52.40% to 53.45%. June, July, and August have the lowest relative humidity rates, which range from 16.15 to 18.45% (Figure 4).

Soil analysis

To construct a composite sample, three soil samples were taken from each stand at an extent of 50 cm. The hydrometer method was used to determine the texture of the soil. The entire amount of organic matter was calculated using the "Loss on Ignition" method at 550 ºC. A soil water extract (1:5) was made by dissolving 100 g of air-dried soil in 500 ml of distilled water in order to measure pH and electrical conductivity (EC). The following procedures (Allen, 1989; Ryan et al., 2001) were used to test the soil nutrient components (K, Na, Mg, $CaCO_3$, Ca, HCO_3, and Cl).

Data analysis

COSTAT software for Windows version (4.6) was used to statistically assess all demographic data, and SPSS for Windows version (25), one-way analysis of variance, was utilized to evaluate the significance of differences.

Results

Fourty two plant species from 21 families are recorded in Wadi Al-Quwayiyah. According to the floristic composition analysis, the family Brassicaceae (six species, 14.28%) and the family Leguminosae (seven species, 16.6%) are the two most abundant,13 families were represented by one species (Table 7, Figure 5). According to the vegetation type, (66.7%) of the reported species in this survey were perennials (28 plant species), followed by (33.3 %) were annuals (14 plant species). Based on Raunkiaer's 1937 classification, three life forms were found. Therophytes, which represent 50% of the documented life forms (21 species), were the most common, followed by chamaephytes (11 species, 26.2%) and phanerophytes (10 species, 23.8%) (Tables 7, Figure 5). 42 plant species are found in four plant communities, according to a survey conducted at numerous locations in the Wadi Al-Quwayiyah area: *Acacia tortilis*, *Leptadenia pyrotechnica*, *Zizuphus nummularia*, *and Acacia gerradii* (Tables 1-4).

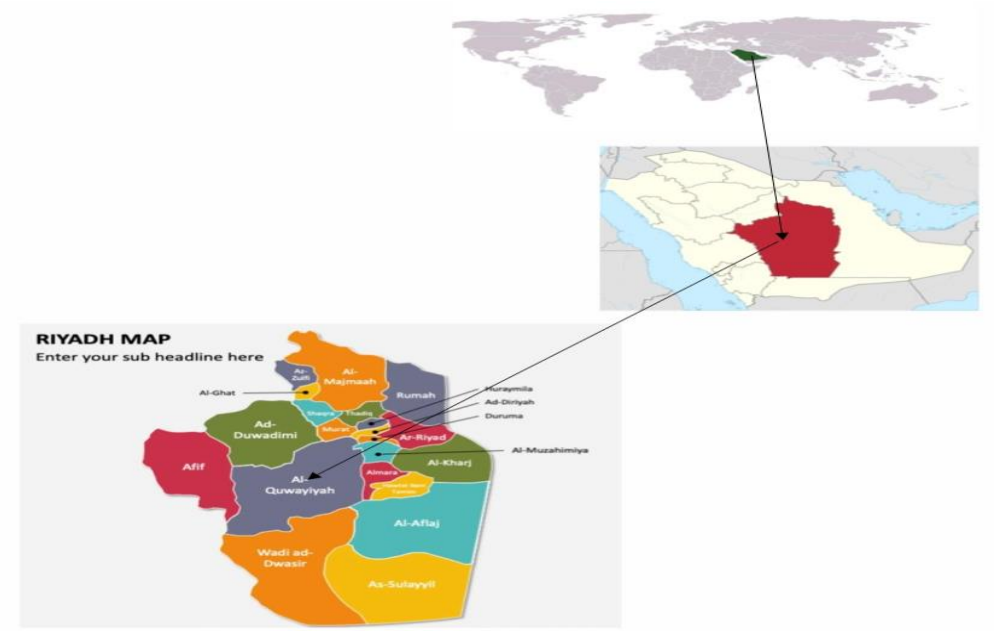

Figure 1: Map of Saudi Arabia showing the study area's location (Wadi Al-Quwayiyah region)

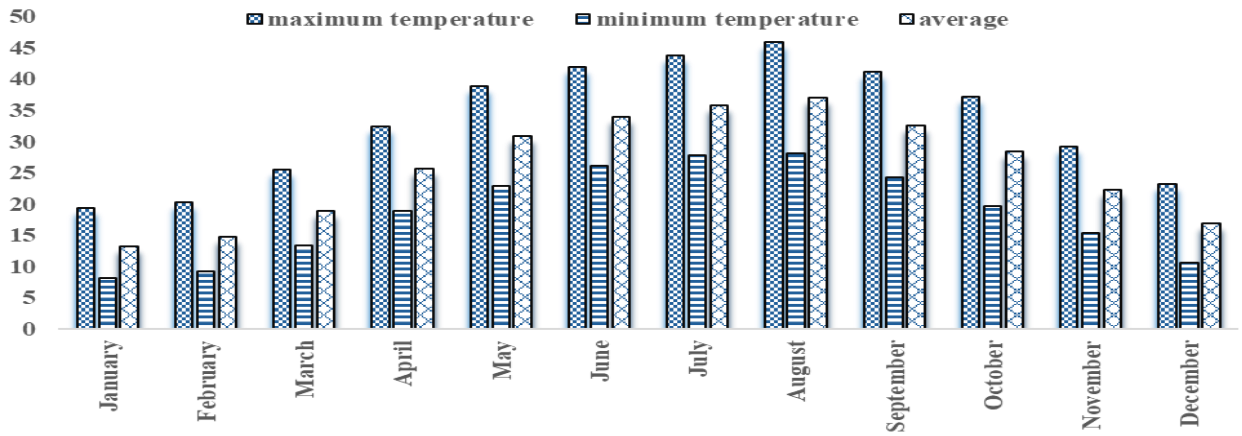

Figure 2: The average monthly minimum and maximum temperatures (from 2014 to 2023) during a period of ten years.

Figure 3: Average yearly rainfall (mm) in the Wadi Al-Quwayiyah area over the previous ten years.

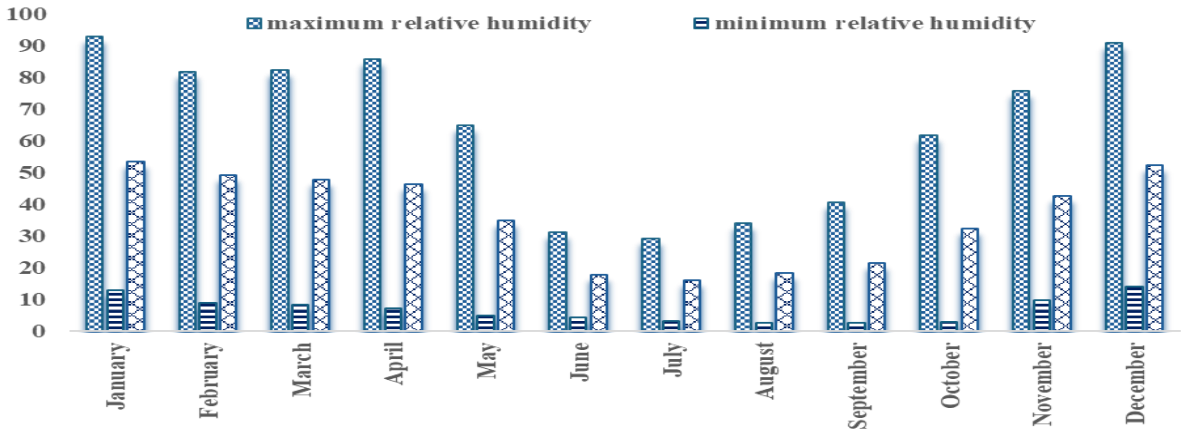

Figure 4: The average monthly relative humidity, including lowest and maximum, for a ten-year period (2014 - 2023).

Table 1: Plant characteristics of a community of *Acacia tortilis* in Wadi Al-Quwayiyah region

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Acacia tortilis	1.4	85	20.11	17.7	15.6	16.5	49.8
Acacia gerradii	1.2	80	19.8	15.19	14.7	16.2	46.09
Prosopis juliflora	1.01	79	17.9	12.8	14.5	14.7	41.9
Rhazya stricta	0.98	70	16.5	12.4	12.9	13.5	38.8
Anvilea gercinii	0.88	68	13.1	11.13	12.5	10.7	34.33
Senna italica	0.85	64	12.7	10.76	10.7	10.44	31.9
Zilla spinosa	0.81	57	11.6	10.26	10.20	9.5	29.9
Zygophyllumpropinquum	0.78	40	10.01	9.8	9.7	8.2	27.8
Total	7.9	543	121.7	100	100	100	300

Table 2: Plant characteristics of a community of *Leptadenia pyrotechnica* in Wadi Al-Quwayiyah region

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Leptadenia pyrotechnicm	1.3	92	11.33	19.70	36	23.9	79.6
Prosopis juliflora	1.01	62	10.9	15.3	24.3	23	62.6
Ochradenus baccatus	0.92	24	9.7	13.9	9.4	20.4	43.7
Trichodesma africanm	0.90	20	8.5	13.6	7.8	17.9	39.3
Astragalus dactylocarpus	0.88	19	4.1	13.3	7.4	8.6	29.3
Scrophularia deserti	0.81	15	1.1	12.2	5.8	2.3	2.3
Aerva javanica	5.50	13	0.95	7.5	5.1	2	14.6
Thymus bovei	0.53	10	0.81	5.3	3.9	1.7	10.9
Total	6.6	255	47.39	100	100	100	300

Table 3: Plant characteristics of a community of *Zizuphus nummularia* in Wadi Al-Quwayiyah region

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Zizuphus nummularia	1.8	88	40.13	22.5	31.3	20.3	47.10
Acacia gerradii	1.3	65	31.13	16.2	23.1	15.7	55
Acacia tortilis	0.99	40	29.80	13.3	14.2	15	42.50
Citrullus colocynthis	0.84	31	22.01	10.5	11.04	11.15	32.6
Cleome glauescens	0.78	21	19.72	9.7	7.4	9.9	27
Helionthemum sancti	0.70	11	18.1	8.7	3.9	9.1	21.70
Ricinus communis	0.69	9	15.2	8.6	3.2	7.7	19.50
Trichodesma africanm	0.58	8	11.3	7.2	2.8	5.7	15.7
Zilla spinosa	0.40	8	10.02	5	2.8	5.08	12.8
Total	8	281	197.5	100	100	100	300

Table 4: Plant characteristics of a community of *Acacia gerradii* in Wadi Al-Quwayiyah region

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Acacia gerradii	0.35	80	13.5	18.43	15.91	15.83	50.17
Acacia enhrenbergiana	0.30	79	13.1	15.79	15.71	15.63	64.86
Pulicaria undulata	0.30	78	12.4	15.79	15.51	14.54	45.84
Cenchrus ciliaris	0.29	71	12.1	15.27	15.12	14.19	43.58
Alhagi graecorum	0.24	70	10.8	12.64	13.92	13.84	40.40
Pergularia tomentosa	0.22	65	11.6	11.58	12.93	13.6	38.11
Calotropis procera	0.20	60	10.8	10.53	11.9	12.67	35.10
Total	1.9	503	85.30	100	100	100	300

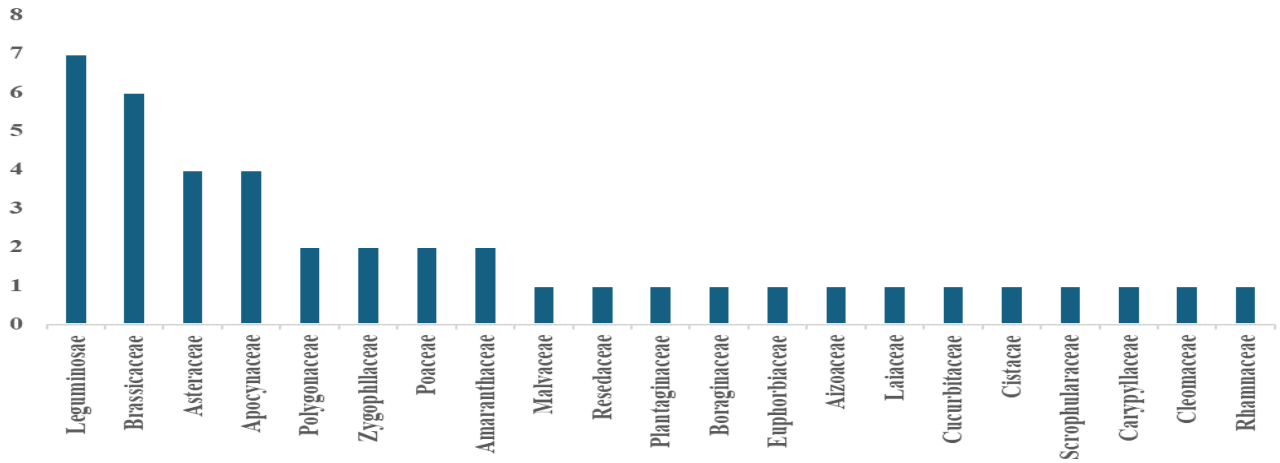

Figure 5: Histogram showing the percentage of the species in each of 21 families recorded in the surveyed Wadi Al-Ouwavivah.

Table 7: A list of the species recorded in the study area with their families, vegetation type, life form and floristic categories.

Families	Species	Life forms	Habit	I	II	III	IV
Apocynaceae	*Leptadenia pyrotechnica*	Ph	Per	-	79.6	-	-
	Calotropis procera	Ph	Per	-	-	-	35.10
	Pergularia tomentosa	Ch	Per	-	-	-	38.11
	Rhazya strica	Ch	Per	38.8	-	-	-
Polygonaceae	*Rumex vesicarius*	Th	Ann	-	-	-	-
	Emex spinosa	Th	Ann	-	-	-	-
Asteraceae	*Spinosissimus turra*	Th	Per	-	-	-	-
	Tortuosissima bois	Th	Per	-	-	-	-
	Pulicaria undulata	Ch	Per	-	-	-	45.84
	Anvillea garcinii	Ch	Per	34.33	-	-	-
Brassicaceae	*Zilla spinosa*	Ch	Ann	29.9	-	12.8	-
	Diplotaxis acris	Th	Ann	-	-	-	-
	Cakile arabica	Th	Ann	-	-	-	-
	Sisymbrium irio	Th	Ann	-	-	-	-
	Morettia canescens	Th	Ann	-	-	-	-
	Schouwia purpurea	Th	Ann	-	-	-	-
Leguminosae	*Prosopis juliflora*	Ph	Per	41.9	62.6	-	-
	Alhagi graecorum	Ph	Per	-	-	-	40.40
	Senna italica	Ch	Per	31.9	-	-	-
	Acacia tortilis	Ph	Per	49.8	-	42.50	-
	Astragalus dactylocarpus	Th	Per	-	29.3	-	-
	Acacia gerrardii	Ph	Per	46.09	-	55	50.17
	Acacia ehrenbergiana	Ph	Per	-	-	-	64.86
Poaceae	*Cenchrus ciliaris*	Th	Per	-	-	-	43.58
	Eragrostis barrelieri	Th	Ann				
Zygophllaceae	*Fagonia bruguieri*	Th	Per	-	-	-	-
	Zygophyllum propinquum	Ch	Per	27.8	-	-	-
Malvaceae	*Malva parviflora*	Th	Ann	-	-	-	-
Resedaceae	*Ochradenus baccatus*	Ch	Per	-	43.7	-	-
Plantaginaceae	*Plantago albicans*	Th	Ann	-	-	-	-
Boraginaceae	*Trichodesma africanm*	Th	Per	-	39.3	15.7	-
Amaranthaceae	*Aerva javanica*	Ch	Per	-	14.6	-	-
	Salsola jordanicola	Th	Ann	-	-	-	-
Euphorbiaceae	*Ricinus communis*	Ph	Per	-	-	19.50	-
Aizoaceae	*Arizona Canarinsa*	Th	Ann				
Laiaceae	*Thymus bovei*	Th	Per	-	10.9	-	-
Cucurbitaceae	*Citrullus colocynthis*	Ph	Per	-	-	32.6	-
Cistacae	*Helionthemum sancti*	Ch	Per	-	-	21.70	-
Scrophulariaceae	*Scrophularia deserti*	Ch	Per	-	2.3	-	-
Carypyllaceae	*Gymnocarpos sclerocehalus*	Th	Ann	-	-	-	-
Cleomaceae	*Cleome glauescens*	Th	Per	-	-	27	-
Rhamnaceae	*Zizuphus nummularia*	Ph	Per	-	-	47.10	-

The different plant communities in the research area reflect differences in environmental parameters such habitat, availability of moisture, and altitudinal factors. Consequently, Wadi Al-Quwayiyah's four plant communities are distinguished and categorized according to the dominating species within them (Tables 1-4).

Eight plant species constitute the *Acacia tortilis* community. With a rating of 49.8, *Acacia tortilis* was the highest, followed by

Acacia gerradii, which co-dominated with a value of 46.09. Spread across low rocky hills, this community is characterized by vast, hard sandy soil (Table 1).

The community of *Leptadenia pyrotechnica* was identified by eight plant species. With a value of 79.6, *Leptadenia pyrotechnicm* was the highest, followed by *Prosopis juliflora* with a value of 62.6. This community extends widely along low, rocky hills with rigorous sandy soil. (Table 2).

Nine plant species made up the *Zizuphus nummularia* community. With a rating of 55, *Acacia gerradii* was the highest, followed by *Zizuphus nummularia*, which had a value of 47.10. This community extends widely along low, rocky hills with rigorous sandy soil. (Table 3).

Seven plant species were found in the *Acacia gerradii*

community. *Acacia enhrenbergiana* had the highest value (64.86) whereas *Acacia gerradii* had the co-dominant value (50.17). *Acacia gerradii* community extends widely on hard sandy soil among low rocky hills (Table 4).

A loamy soil with 41.1% sand, 31.1% silt, and 27.8% clay is habitat to the *Acacia tortilis* population (Table 7). It also exhibits the lowest contents of HCO_3, PH, and EC values and a comparatively high amount of Mg, K, Cl, and Ca (Table 5).

Table 5: Physical characteristics of the soil of plant communities of *Acacia tortilis* (I), *Leptadenia pyrotechnica* (II), *Zizuphus nummularia* (III) and *Acacia gerradii* (IV)

Community	Texture class	Sand %	Silt %	Clay %
I	Loam	41.1	31.1	27.8
II	Loam	40.30	30.9	28.8
III	Loam	38.5	31.5	30
IV	Loam	42.4	30.7	26.9

Table 6: Chemical characteristics of the soil of plant communities of *Acacia tortilis (I), Leptadenia pyrotechnica (II), Zizuphus nummularia (III) and Acacia gerradii (IV)*

	C1	HCO_3	CO_3	K	Na	Mg	Ca	E	PH	O.M	$CaCO_3$%
I	3.1	1.9	0	0.7	0.6	5.9	12.8	1.2	7.10	0.72	12.9
II	2.01	2.3	0	0.9	0.7	6.1	12.9	1.5	7.25	0.69	13.4
III	1.5	2.7	0	0.6	0.5	4.1	11.11	1.4	7.22	0.74	13.7
IV	1.8	2.9	0	0.6	0.8	3.6	10.2	1.6	7.27	0.68	13.9

The *Leptadenia pyrotechnica* community is found in sand-loamy soil that has 28.8% clay, 30.9% silt, and 40.3% sand. It is also distinguished by having the highest Ca, K, and Mg levels (Table 6).

The *Zizuphus nummularia* community grows on a sand loamy soil that is thirty percent clay, thirty one percent silt, and thirty eight percent sand (Table 5). Furthermore, it has the lowest levels of Na, K, and Cl and a comparatively high concentration of $CaCO_3$, PH, and O.M values (Table 6).

The *Acacia gerradii* community grows on a sand loamy soil that has 26.9% clay, 30.7 silt, and 42.4% sand. It is also distinguished by having the highest contents of $CaCO_3$, HCO_3, Na, PH and EC values, while the lowest of K, and Mg. Because the topography in the research area is comparable, there isn't a noticeable variation between the soil constituents (Tables 5 and 6).

Discussion

Saudi Arabia is a large country on the Arabian Peninsula with a variety of climates and habitats. The two most significant variables influencing the species identification and the development of plant communities everywhere are soil properties and climate (Alzamel, 2021). Climate is primarily influenced by natural forces, which clearly contribute to the research region overall vegetation appearance (Migahid, 1996). The investigation of the floristic composition in this research revealed that the family Leguminosae, which is represented by the greatest number of species, is the most prevalent in the studied area. Another huge family, the Asteraceae has five species represented, and the Brassicaceae has six species. Of the twenty-one families included in the study, thirteen (62%) had one species per family, including the Amaranthaceae, Rhamnaceae, Laiaceae, Malvaceae, and Resedaceae. Of the largest plant families, only a few numbers of species are able to adapt and survive, while other species face extinction. This characteristic is found frequently in desert plants and is believed to be a sign of xeric climate adaptation (Abdel Khalik, 2017). The floristic analysis of the current research reveals that majority of plants in the study region are perennials while the minority group is in the tree. The results of Al-Turki & Al-Qlayan (2003), Alatar *et al*. (2012), and Fadel et al. (2015) are consistent with the dominance of Leguminosae and Asteraceae members. This may be the result of the fact that few of these plant species are able to withstand and adapt to the extreme environments in these regions (El-Ghanim *et al*., 2010; Al-Sherif *et al*., 2013; Alzamel, 2021). Topography and landform have a significant impact on the distribution of plant life forms in dry climates (Orshan, 1986; Shaltout *et al*., 2010). Variations in soil properties could be the cause of the variations in species composition among habitat types (Al-Mefarrej, 2012; Fadel *et al*., 2015). The study region is located in the subtropical dry zone, which has extremely hot summers and mild winters. According to Walter *et al*. (1975), the dominant perennial species provide the plant cover with permanent character in each habitat. This may be because there hasn't been enough rain for many annuals to appear due to the short rainy period. Therophytes and chamaephytes appear to be dominant due to a hot, dry climate, as well as interference from

humans and other animals. Because therophytes complete their vegetative stage in seed form, they are adapted to the lack of rainfall and region dryness (Asri 2003; Abdel khalik *et al*. 2013). These findings correspond with the vegetation spectra found in other Saudi Arabian desert ecosystems (Al-Turki & Al-Qlayan, 2003; El Ghanem *et al*., 2010; Alatar *et al*., 2012). Four distinct vegetation communities made up the Wadi Al-Quwayiyah region's vegetation: *Acacia tortilis*, *Leptadenia pyrotechnica*, *Zizuphus nummularia*, and *Acacia gerradii*.

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