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Floristic composition and vegetation analysis in Wadi AlFurayshah region, Saudi Arabia

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Abstract:
The present study aimed to determine floristic composition, vegetation cover of different communities in Wadi AlFurayshah, Saudi Arabia, and highlighting the ecological factors that affect species distribution. A total of 26 plant species were collected and identified to be distributed among four plant communities: *Ziziphus nummularia*, *Panicum turegidum*, *Acacia gerardii*, and *Haloxylon salicornicum*. The main factors influencing plant presence were soil texture, $CaCO_3$, Na, Mg, Ca, Cl, EC, pH and organic matter content. The majority of the registered species in this survey were perennials with 16 of the total recorded species (61.54%), followed by annuals by 10 species (38.46%).

Keywords: Vegetation; Flora; Wadi AlFurayshah; Saudi Arabia.

Introduction

With an area of approximately 2,250,000 km^2, the Kingdom of Saudi Arabia is the Arabian Peninsula's largest arid land. It is approximately located between latitudes 15º 450´ N and 34º 350´ N and between longitudes 34º 400´ E and 55º 450´ E (Alzamel, 2021). “Wadis" are one of the most common desert landforms, with physiographic irregularities that account for the corresponding variations in species distribution (Kassas & Girgis, 1964). The distribution of life forms is strongly related to topography and landform (Zohary, 1973; Orshan, 1986). Furthermore, the wadi's vegetation is not relatively stable and varies from year to year depending on humidity levels (Siddiqui & Al-Harbi, 1995). Furthermore, geographical location, physiographic position, and human influence all have an impact on the establishment, growth, regeneration, and distribution pattern of plant communities in wadis (Shaltout & El-Sheikh, 2003; Alatar *et al*., 2012). This explains the high plant diversity in Saudi Arabia, especially in the southwestern region, which is covered with natural forests. These variations are reflected in the country distinctive ecological habitats, vegetation zones and, as a result, rich flora. It has a diverse range of ecosystems and species diversity, particularly in the southwest (Fadl *et al*., 2015). Several reports on the country's Flora have been published, the most comprehensive being two Floras (the first written by Mighaid (1974) and published four times, the last in 1996, and the other is the three-volume Flora written by Mighaid (1974) and published three times (1999, 2000, 2001). Moreover, a book was written by (Chaudhary & Al-Jowaid, 2013) titled under vegetation of the kingdom of Saudi Arabia. According to (Mossa, 1987), the Kingdom of Saudi Arabia is gifted with a wide range of flora, consisting of a large number of shrubs, trees, and medicinal herbs. Saudi Arabia's flora contains approximately 2285 plant species. Approximately 656 species live in small populations, while 500 species coexist in restricted areas. Moreover, around 100 species have been recorded as endangered (Al-Farhan, 2011). These records not only provide an important baseline for the floristic elements, but they also provide authoritative information about the distribution of these species. However, to our knowledge, few studies have dealt with vegetation analysis in relation to floristic composition and habitat variation in Wadi AlFurayshah region.

The current study aims to investigate vegetation structure and some environmental conditions that influence their distribution in fenced areas of Wadi AlFurayshah. Furthermore, this study may take into account the first monitoring of vegetation cover in this version area.

Materials and methods

Study area

Wadi AlFurayshah is located in the Southeast of Al-Muzahimiyah Governorate. It is a large valley surrounded by sand from the west and south. From the north are the Saqouriyah Mountains, from the east is the city of Riyadh, and at its western end is the Nasah Governorate. In the valley grows *Acacia gerrardii* and perennials, especially: *Haloxylon salicornicum*,

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Pulicaria undulata, *Panicum turegidum*, and *Ziziphus nummularia*. The valley is located about 65 km southwest of the city of Riyadh, and about 30 km southeast of Al-Muzahimiyah Governorate (Figure 1).

Figure 1: Map of Saudi Arabia showing the study area.

Climate

Temperature

The climate of the study area is generally considered hot in summer, where the maximum temperature in the summer months (June, July, August) ranges from 41°C to 47 °C and the minimum temperature is 25 °C, while in winter (December, January, February) the average maximum temperature is not less than 20 °C while the average minimum temperature is at least 8 °C in January. Thus, the seasonal and daily variation in temperature affects vegetation cover in the study area, including perennials where plants are exposed to large temperature fluctuations, and this effect is also shown significantly on the life of annuals plant species, and the vitality of seeds (Table 1).

Table 1: Monthly mean minimum and maximum temperature (average for 10 years, 2012 - 2021).

Month	Maximum temperature	Minimum temperature	Average
January	19.8	8.1	13.95
February	22	9.1	15.55
March	28	14.9	21.45
April	32.2	17.9	25.05
May	38.8	22.1	30.45
June	41.8	26	33.9
July	46.1	31.5	38.8
August	47	31.8	39.4
September	43.3	24.1	33.7
October	34.8	19.2	27
November	30	17.6	23.8
December	24	10.2	17.1

Relative humidity

The average monthly humidity varies greatly between the months of the year, and there is an inverse relationship between temperature and humidity, the higher the temperature, the lower the humidity, and a direct relationship between precipitation and the percentage of humidity astronomy, the higher the rainfall rate, the higher the humidity in the atmosphere, the highest rates of relative humidity are recorded in December and January where the average humidity ranges between 51.35% and 52.45%. The lowest relative humidity rates are in June, July, and August, ranging from 14.56 to 18.45% (Table 2).

Table 2: Monthly mean minimum and maximum relative humidity (average for 10 years, 2012 - 2021).

Month	Maximum relative humidity	Minimum relative humidity	Average
January	93.1	11.8	52.45
February	88.2	8.8	48.5
March	87.4	6.9	47.15
April	85.1	5.8	45.45
May	50.1	3.9	27
June	33.2	4.7	18.45
July	27.9	3.4	15.6
August	26.1	3.2	14.65
September	29.4	5.1	17.52
October	39.5	5.3	22.4
November	40.1	9.7	24.9
December	89.9	12.8	51.35

Rainfall

Rainfall in the study area falls on a limited number of days during the year not exceeding 15 days and rarely more than 25 days, like other dry areas located within the desert climate. Rainfall usually begins in the November months until March and rarely in April. The highest amount of rainfall was recorded in 2018 with 170.1 mm, and the lowest amount of rainfall was 59.3 mm in 2017 (Figure 2).

Winds

The winds are strong in March to June, reaching speeds between 6 meters and 11 meters per second, and these

winds contribute to the encroachment of sand from the exposed areas in the study area.

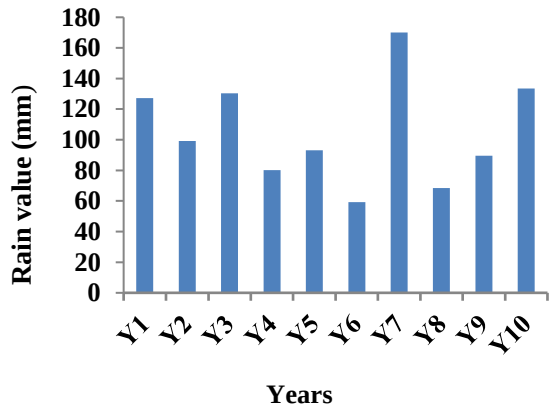

Figure 2: Mean annual rainfall (mm) in last ten years in Wadi AlFurayshah region

Soil analysis

Three soil samples were collected at a depth of 50 cm from each stand and mixed to form a composite sample. The soil texture was determined using the hydrometer method (Day 1965). Total organic matter was determined based on the "Loss on Ignition" method at 550 ºC. To estimate pH and electrical conductivity (EC), a soil water extract (1:5) was prepared by dissolving 100 g air-dried soil in 500 ml distilled water. Soil nutrient elements (Ca, K, Na, Mg, HCO_3, $CaCO_3$, and Cl) were measured following the methods described by (Allen, 1989; Ryan *et al*., 2001).

All edaphic variables were statistically evaluated using COSTAT software for Windows version (4.6), and one-way analysis of variance was used to determine the significance of differences using SPSS for Windows version (25).

Results

Wadi Al-Furayshah is represented by 26 Plant Species related to 14 families (Table 2). Asteraceae (Six species 23%). Poaceae (Four species 15 %). Eight families were represented by one species (Table 2). With respect to the vegetation type, (61.53%) of the reported species in this survey were perennials (16 plant species), followed by (38.46.8%) were annuals (10 plant species). According to the classification of Raunkiaer 1937 three life forms were recorded, the most numerous life forms were chamaephytes (46.11 % 12 species), followed by therophytes (11 species 42.3 %) and phanerophytes (3 species 11.5 %) (Tables 3).

The survey of many sites in Wadi AlFurayshah region revealed the presence of 26 plant species in four plant communities; four plant communities: *Ziziphus nummularia*, *Panicum turegidum*, *Acacia gerardii*, and *Haloxylon salicornicum* (Tables 4-7). The study area's various plant communities reflect variations in environmental conditions such as habitat, altitudinal factors, and moisture availability. As a result, four plant communities are identified and arranged in Wadi AlFurayshah based on their dominant species (Tables 4-7).

Table 3: Floristic composition and mean of the importance values (out of 300) of the recorded species in the four plant communities of the study area.

Families	Species	Life forms	Habit	I	II	III	IV
Apiacea	*Anisosciadium lanatum*	Ch	Ann	-	-	-	-
Apocynacea	*Rhazya stricta*	Ch	Per	-	35.57	24.49	8.42
	Calotropis procera	Ch	Per	94.28	-	24.06	-
Asteraceae	*Artemisia monosperma*	Ch	Per	-	-	-	75.69
	Launaea capitata	Th	Ann	-	-	-	-
	Picris babylonica	Th	Ann	-	-	-	-
	Pulicaria undulata	Th	Per	28.81	-	-	15.35
	Rhanterium eppaposum	Ch	Per	-	-	-	-
	Artemisia sieberi	Ch	Per	32.14	-	-	-
Boraginaceae	*Heliotropium bacciferum*	Ch	Per	7.34	-	-	-
Brassicaceae	*Horwoodia dicksoniae*	Th	Ann	-	-	-	-
	Zilla spinosa	Ch	Per	-	30.97	-	-
Chenopodiaceae	*Haloxylon salicornicum*	Ch	Per	-	-	107.83	-
Cucurbitaceae	*Citrullus colocynthis*	Th	Per	-	-	24.54	-
Malvaceae	*Malva parviflora*	Th	Ann	-	-	-	-
Mimosaceae	*Acacia ehrenbergiana*	Ph	Per	-	-	43.26	22.90
	Acacia gerrardii	Ph	Per	100	-	-	-
Neuradaceae	*Neurada procumbens*	Th	Ann	-	-	-	-
Papilionaceae	*Astragalus spinosus*	Ch	Per	11.28	20.73	-	-
	Medicago laciniata	Th	Ann	-	-	-	-
Plantaginaceae	*Plantago albicans*	Th	Ann	-	-	-	-
Poaceae	*Stipagrostis plumosa*	Th	Per	-	-	-	7.25
	Panicum turegidum	Ch	Per	-	131.1	-	-
	Stipagrostis drarii	Th	Per	-	41.63	48.8	-
	Pennisetum divisum	Ch	Per	26.16	0	0	-
Rhamnaceae	*Ziziphus nummularia*	Ph	Per	-	42.52	28.14	172.3

Acacia gerrardii community was characterized by seven plant species. *Acacia gerrardii* was the highest with value (72) and the co-dominated one was *Calotropis procera* with a value (63). This community is widely spread on wide hard sandy soil among low rocky hills (Table 4).

Panicum turegidum community was characterized by six plant species. *Panicum turegidum* was the highest with a value (89) and the co-dominated one was *Ziziphus nummularia* with value (55). This community is widely spread on wide hard sandy soil among low rocky hills (Table 5).

Haloxylon salicornicum community was characterized by six plant species. *Haloxylon salicornicum* was the highest with value (71) and the co-dominated one was *Acacia ehrenbergiana* with value (24). This community is widely spread on wide hard sandy soil among low rocky hills (Table 6).

Ziziphus nummularia community was characterized by six plant species. *Ziziphus nummularia* was the highest with a value (99) and the co-dominated one was *Artemisia monosperma* with value (81). This community is widely spread on wide hard sandy soil among low rocky hills (Table 7).

Table 4: plant characteristics of a community *Acacia gerrardii* in Wadi AlFurayshah.

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Acacia gerrardii	0.11	72	7.9	31.42	31.57	36.89	100
Calotropis procera	0.15	63	5.1	42.85	27.63	23.80	94.28
Pulicaria undulata	0.021	34	1.70	6	14.91	7.9	28.81
Artemisia sieberi	0.033	21	2.9	9.4	9.21	13.53	32.14
Pennisetum divisum	0.022	23	2.1	6.28	10.08	9.80	26.16
Astragalus spinosus	0.004	9	1.33	1.14	3.94	6	11.28
Heliotropium bacciferum	0.01	6	0.4	2.85	2.63	1.86	7.34
Total	0.35	228	21.43	100	100	100	300

Table 5: plant characteristics of a community *Panicum turegidum in* Wadi AlFurayshah

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Panicum turegidum	28	89	18.91	34.14	30.78	66.18	131.1
Ziziphus nummularia	0.017	55	0.81	20.79	18.96	2.83	42.52
Stipagrostis drarii	0.003	31	7.08	3.65	10.68	27.30	41.63
Rhazya stricta	0.016	45	0.16	19.51	15.51	0.56	35.57
Zilla spinosa	0.010	41	1.33	12.19	14.13	4.65	30.97
Astragalus spinosus	0.008	29	0.28	9.75	10	0.98	20.73
Total	0.082	290	28.57	100	100	100	300

Table 6: plant characteristics of a community *Haloxylon salicornicum* in Wadi AlFurayshah

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Haloxylon salicornicum	0.090	71	9.9	19.27	42.51	46.06	107.83
Stipagrostis drarii	0.059	21	4.98	12.34	12.57	23.17	48.8
Acacia ehrenbergiana	0.079	24	2.60	16.52	14.37	12.37	43.26
Ziziphus nummularia	0.075	19	0.19	15.89	11.37	0.88	28.14
Citrullus colocynthis	0.070	8	1.10	14.64	4.79	5.11	24.54
Rhazya stricta	0.049	13	1.39	10.25	7.78	6.46	24.49
Calotropis procera	0.056	11	1.22	11.71	6.58	5.77	24.06
Total	0.478	167	21.49	100	100	100	300

Acacia gerrardii community occurs on loamy soil with sand percent (47.05 %), silt (31.90 %), and clay (21.05 %). The plant cover percentage is about 37% on fine-textured sandy soil. In addition, it is characterized by a relatively high content of Na, K and Ca and the lowest $CaCO_3$. *Panicum turegidum community* occurs on sand loamy soil with sand percent (45.90 %), silt (31.20 %) and clay (22.90 %).In addition, it is characterized by the highest contents of HCO_3, K and pH, while the lowest of Cl and O.M. *Haloxylon salicornicum community* occurs on a sand loamy soil with sand percent (40.11 %), silt (34.50 %), and clay (25.39 %).In addition, it is characterized by the highest contents of EC and OM, while the lowest of Na, Mg and PH. *Ziziphus*

nummularia community occurs on a sand loamy soil with sand percent (44.89 %), silt (33.12 %) and clay (21.99 %).In addition, it is characterized by the highest contents of Cl, CO_3, Na, Mg, Ca, PH and $CaCO_3$, while the lowest of K, O.M and HCO_3.The absence of a clear difference between the soil elements due to the similarity of the topography in the study area (Table 8 &9).

Table 7: Plant characteristics of a community *Ziziphus nummularia* in Wadi AlFurayshah

Species	Density	Frequency %	Coverage %	Relative density %	Relative frequency %	Relative coverage %	Values of importance
Ziziphus nummularia	0.041	99	21.31	48.23	38.82	85.27	172.30
Artemisia monosperma	0.03	81	2.61	35.29	31.67	8.64	75.69
Acacia ehrenbergiana	0.009	30	0.14	10.58	11.76	0.56	22.90
Pulicaria undulata	0.002	20	1.29	2.35	7.84	5.16	15.35
Stipagrostis plumosa	0.002	15	0.05	1.176	5.88	0.20	7.25
Rhazya Stricta	0.002	15	0.049	2.35	5.88	0.19	8.42
Total	0.085	255	24.99	100	100	100	300

Table 8: Physical properties of the soil of plant communities of *Ziziphus nummularia* **(I)**, *Panicum turegidum* (**II**), *Acacia gerrardii* (**III**) and *Haloxylon salicornicum* (**IV**)

Community	Texture class	Sand %	Silt %	Clay %
I	Loam	47.05	31.90	21.05
II	Loam	45.90	31.20	22.90
III	Loam	40.11	34.50	25.39
IV	Loam	44.89	33.12	21.99

Table 9: Chemical properties of the soil of plant communities of *Ziziphus nummularia* **(I)**, *Panicum turegidum* (**II**), *Acacia gerrardii* (**III**) and *Haloxylon salicornicum* (**IV**)

	$C1^-$	HCO_3^{2-}	CO_3^{-2}	K^+	Na^+	Mg^{+2}	Ca^{+2}	EC	PH	O.M	$CaCO_3$%
I	2.9	2.3	0	0.77	0.81	5.1	10.3	1.5	7.31	0.69	5.41
II	2.88	3.1	0	0.9	0.78	6.5	8.1	1.7	7.4	0.66	6.89
III	3.1	2.88	0.09	0.7	0.6	5	9.01	1.9	7.21	0.90	7.1
IV	3.9	1.77	0.2	0.5	0.9	7	10.6	1.7	7.4	0.66	9.2

Discussion

In terms of floristic and vegetation composition in the studied area, Asteraceae and Poaceae (are represented by the highest number of species (6 and 4, respectively). A floristic analysis shows that all of the plants species in the study area are perennials. The dominance of Poaceae and Asteraceae members is in line with the findings of Al-Turki & Al-Qlayan (2003); Alatar *et al.*, (2012) and Fadel *et al*. 2015. Furthermore, many families were recorded with only one species per family. This could be because few of these plant species can cope with and adapt to the harsh conditions in these areas (El-Ghanim *et al*., 2010; Al-Sherif *et al*., 2013; Alzamel, 2021). The distribution of plant life forms in arid regions is strongly influenced by topography and landform (Orshan, 1986; Shaltout *et al*., 2010). The differences in species composition among habitat types may be attributed to differences in soil characteristics (Al-Mefarrej, 2012; Fadel *et al*., 2015). According to Walter *et al.*, (1975), the study area is located in the subtropical dry zone, which has very hot summers and mild winters. The dominant perennial species provide the plant cover with permanent character in each habitat. This could be attributed to the relatively short rainfall, which is insufficient for the appearance of many annuals. The dominance of chamaephytes and therophytes seems to be a response to the hot dry climate and human and animal interference. Therophytes are adapted to the dryness of the region and shortage of rainfall because they spend their vegetative period in seed form (Asri 2003; Abdel khalik *et al*. 2013). These results are congruent with the spectra of vegetation in the desert habitats in other parts of Saudi Arabia (Al-Turki & Al-Qlayan, 2003; El-Ghanem *et al*., 2010; Alatar *et al*., 2012). Saudi Arabia encompasses a large portion of the Arabian Peninsula, with a variety of environments and climates. Climate and soil characteristics are the most important determinants of species identification and plant community growth in any region (Alzamel, 2021). The vegetation of Wadi AlFurayshah region fell into four different vegetation communities dominated by *Ziziphus nummularia*, *Panicum turegidum*, *Acacia gerrardii* and *Haloxylon salicornicum*.

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