Floristic and ecological studies on the plant cover of Wadi Al Rummah, Qassim Region, Saudi Arabia

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Abstract

Floristic composition, plant diversity and edaphic characteristics were examined in 9 sampling sites representing linear systematic series of locations along Wadi Al Rummah, Qassim Region, Saudi Arabia. 45 quadrats (5 quadrats per site) were analysed covering various geomorphological landforms in upstream, midstream and downstream locations. In these quadrats, 5 vegetation characteristics, 6 ecological parameters and 11 edaphic variables were investigated. A total of 59 plant species belonging to 43 genera and 21 families were recorded from the various sites examined. 57 % of these plants are Therophytes and Saharo-Arabian elements (66%) form the dominant component of the floristic composition of the Wadi. Upon the application of TWINSPAN and CCA bioplots, the floristic composition, floristic characteristics and edaphic variables can be aggregated into three distinct groups, and plant communities at the downstream sites showed distinct features.

Keywords: TWINSPAN, CCA, edaphic characteristics, Raunkiaer life forms, linear systematic series of locations.

INTRODUCTION

The vegetation cover of Wadis (shallow usually sharply defined depressions) may be considered among the main centers of biodiversity in desert habitats. These Wadis are home to pastoral communities utilizing the area as rangelands for camels, goats and sheep (Briggs et al. 1993), good indicators of biodiversity support capacity (Ali et al. 2000), and are the prime focus for conservation managements in desert habitats (Ghabbour and Mikhail 1993).

In Saudi Arabia, several floristic and ecological studies have been published on Wadi vegetation e.g. Wadi Al Ammaria (El Ghenam 2006, Al Yemeni 2001), Wadi Al Jufair (Al Atar et al. 2012), Wadi Al Argy (Farrag 2012), Wadi Al Noman (Abdel Khalik et al. 2013), Wadi El Ghayl (Fahmy and Hassan 2005), and Wadi Talha (Al Wadie 2002).

Wadi Al Rummah (Wadi Ar Rummah), in spite of being the longest and the largest Wadi in the Arabian Peninsula (Surhone et al. 2010, Ugayl 1998), no previous studies were encountered to assess its ecology and floristic characteristics.

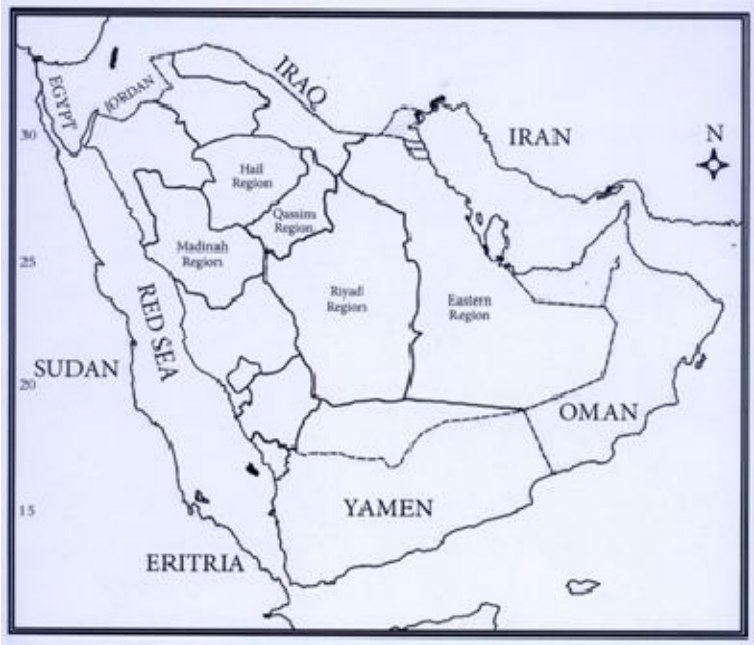
Wadi Al Rummah, although consists of a network of complex tributaries which are situated east of Madina Region, South of Hail Region, and North-west of Riyadh Region, the basin of the wadi is located mostly in Qassim Region.

The aim of the present study is to elucidate the floristic composition, plant diversity and soil characteristics of Wadi Al Rummah in Qassim Region via linear systematic series of locations in an attempt to establish an ecological study (from source to estuary) for future sustainable utilization of the natural resources of this Wadi in Qassim Region.

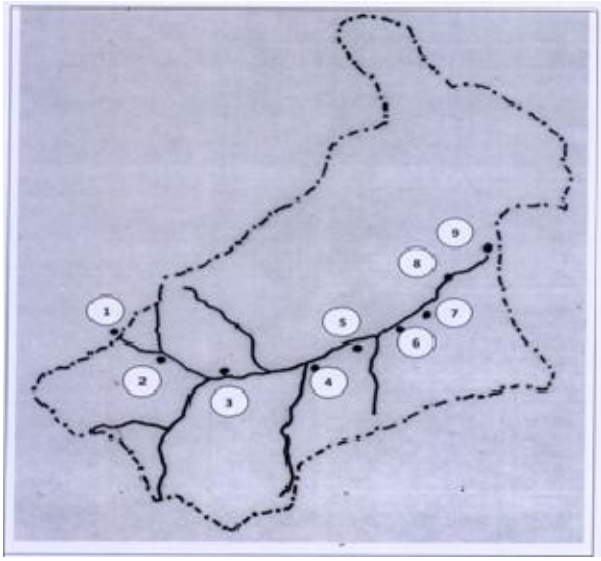
Study area

Wadi Al Rummah is the most important geomorphologic phenomena in Najd Plateau (Ugayl 1998, Surhone et al. 2010), occupying vast areas representing diverse ecological habitat.

Wadi Al Rummah arises from the outskirts of Medina



Map 1. Location of Qassim Region in Saudi Arabia



Map 2. Sampling sites along Wadi Al Rummah, Qassim Region, Saudi Arabia. (1= Al Baith,2= Uglat Al Suqoor, 3= Ata, 4= Al Gesoma, 5= Al Rass, 6= Al Badia, 7= Onasiza, 8= Al Rakia, 9= Al Bandaria).

Region at the eastern slopes of Al Abyad Mountains and the foothills of the nearby “Harat”. It heads towards the north-east connecting to several tributaries from the north and the south, till it is blocked by the encroaching sand dunes of “Nfood” Al Thwairat of the ad- Dahna desert near the village of Bandariah, south of the Asyah in Qassim Region (maps 1 and 2).

Wadi Al Rummah is the largest and longest Wadi of the Arabian Peninsula and stretches for about 600 kilometers from the source to estuary. It collects and

discharges run-off water across a network of complex tributaries, but the basin of the Wadi is located mostly in Qassim Region.

In Qassim Region, the boundaries of the Wadi become more obvious and exhibit a meandering manner with various widths.

MATERIAL AND METHODS

1. Sampling sites:

A total of 9 sampling sites along the main channel of Wadi Al Rummah in Qassim Region were investigated. These sites represent linear systematic series of locations every 50-70 kilometers, along the Wadi and cover an area of about 500 kilometers from Al Baieth village (41° 56' N, 26° 05' E) at the point where the Wadi enters Qassim Region, and north-east till Al Bandaria village (44°15' N, 26°66' E) where the wadi is blocked by the encroaching sand dunes.

2. Vegetation sampling:

The sampling of the vegetation was conducted in the period from mid February 2012 to the end of May 2012. This period in Qassim Region represents the optimum growing and flowering seasons for most plant species.

Five randomly selected quadrates (10 X 10 m) were examined at each site, covering various geomorphologic landforms (rocky and sandy slopes, beds, plateau, and edges). In all the 45 quadrates studied, vegetation sampling involved quantitative and qualitative listing of all plant species present at each of the sample plots.

3. Vegetation characteristics:

Three vegetation characteristics (frequency, density and abundance) were examined from the floristic composition, whereas six ecological parameters were analysed for the 9 sites examined along Wadi Al Rummah. These parameters which include total number of species per site (N) species richness (S), index of biodiversity (I), α-diversity, Simpson's index (D) and Simpson's index of biodiversity (1-D), were calculated mainly as outlined by Brower and Zar (1977).

4. Taxonomic studies:

All plant species encountered within the various 45 quadrates in all geomorphologic landforms were identified and named according to Boulos (2002, 2000, 1999), Chaudhary (2001, 2000, 1989, 1419), Chaudhary and Al Jowaid (1999), Collenette (1985), and Migahid (1990, 1989, 1988, 1978). Voucher specimens of these species were collected, pressed, mounted, compared with already identified specimens in local herbaria, and deposited at Faculty of Science and Arts at Alrass (Qassim University), and Faculty of Microbiology and Botany Herbarium, King Suad University.

All plant species studied, were classified according to their growth habits, and Raunkiaer's life forms system (Raunkiaer 1934) was used. The percentage composition of each of these life form categories were calculated. The chorotype of each species was also cited according to Wickens (1978), Zohary (1973).

5. Soil analysis:

Five soil samples were collected from the different landforms to the depth of 50 cm and mixed together in a composite soil sample for each site. For each composite soil sample, eleven physio-chemical characteristics were determined e.g. electrical conductivity (EC), total dissolved solids (TDS), hydrogen ion concentration (pH), organic matters (OM), soluble anions ($Co3^{2-}$, $HCO3^{-}$, Cl), and soluble cations ($Ca2^{+}$, $Mg2^{+}$, Na^{+} , K^{+}). These edaphic parameters were calculated according to Black (1965) and Chapman and Pratt (1961).

6. Data analysis:

The vegetation data matrix (9 sites and 55 species) was classified using Two-way-indicator Species Analysis (TWINSPAN), (Hill 1979). The vegetation data and edaphic characteristics were analyzed together by canonical correspondence analysis (CCA) using CANOCO for windows version 4.5 (ter Braak and Smilauer 2002).

RESULTS

1. Floristic diversity:

A total of (59) plant species belonging to (43) genera and (21) families were recorded from the various sites examined. In table (1) a list of these plant species (arranged according to their families), life-form, chorotypes, frequency, density and abundance were outlined. The most highly represented families are the Brassicaceae (8 species), the Chenopodiaceae (7 species) and the Asteraceae (6 species).

According to Raunkiaer's method, the plant life form classes along Wadi Al Rummah indicated the clear dominance of Therophytes (57 %) and Chamaephytes (33%). The Chorological studies, showed a great variation in the phyto-geographical distribution of the plant species of the Wadi. However, Saharo-Arabian elements (66%), form the major component of the floristic composition of the Wadi.

Among the species encountered in the Wadi, Haloxylon salicornicum has the highest frequency (10%), followed by Pulicaria undulata (6.67%) and Malva

Table 1. List of species recorded in the study area with their families, life form, Chorotypes, frequency, density and abundance. (Th = Therophytes, H= Hemicryptophytes, G= Geophytes, Ch= Chamaephytes, Ph= Phanerophytes, P= Parasites), (COSM= Cosmopolitan, SA= Saharo-Arabian, SM= Sahalian Somali- Masai, ME= Mediterranean, IT= Irano-Turanian, SU= Sudano-Zambezian).

Families and Species	Life form	Chorotype	Frequency	Density	Abundance
Aizoaceae					
Gisekia pharnaceoides L.	Th	COSM	2.6	0.2	0.05
Asclepediaceae					
Calotropis procera	Ch	SA- SM	0.7	0.01	0.01
Asphodelaceae					
Asphodellus fisulosus L.,	G	ME	2.59	17.9	5.69
Asteriaceae					
Anthemis pseudocotula Boiss.	Th	IT	0.7	0.1	0.03
Centaurea sinaica DC.	Th	ME	1.5	0.3	0.08
Launaea angustifolia (Desf.) Kuntze	Ch	ME, SA	1.5	0.1	0.04
Launaea capitata (Spreng.) Dandy	Th	ME, SU, IT	3.7	1.2	0.39
Pulicarpia undulata (L.) C.A. Mey	Ch	SA, SU	6.67	12.9	4.11
Scorzonera intricata	G	ME	1.5	0.1	0.04
Boraginaceae					
Arnebia decumbens (Vent.) Coss. & Kralik.	Th	SA,SU, IT	0.7	0.01	0.01
Gastrocotyle hispida (Forssk.) Bunge	Th	IT, SA	2.6	0.1	0.03
Heliotropium arbainense Fresen.	Ch	SA, SM	0.7	0.01	0.10
Heliotropium bacciferum Forssk.	Ch	SA, SM	2.6	0.30	0.10
Brassicaceae					
Eremobium aegyptiacum (Spreng.) Asch.	Th	SA	2.6	6.9	2.91
Erucaria crassifolia (Forssk.) Del.	Th	ME	1.5	2.3	0.73
Faresetia aegyptia Turr.	Ch	SA	0.7	0.01	0.01
Farsetia longisilqua Decene	Ch	SU	4.07	4.0	1.29
Lepidium aucheri Boiss.	Th	ME	0.37	0.8	0.26
Morettia canescens Boiss.	Th	SA, SU	1.5	0.1	0.03
Savignya parviflora (Del.) Webb. in Giorn.	Th	SA	2.6	1.3	0.42
Zilla spinosa (Turr.) Prantl.	Th	SA	2.22	0.4	0.12
Caryophyllaceae					
Paronychia chlorothyrsa	Th	SA	1.48	7.2	2.29
Polycarpaea repens (Forssk.) Asch. & Sch.	Th	SA, SU	2.22	1.1	0.33
Polycarpaea robbairea (Kuntze) Greuter & Burdet.	Th	ME	1.5	1.7	0.54
Silene aegyptiaca (L.) L.f.	Th	ME	0.7	0.01	0.01
Chenopodiaceae					
Atriplex leucoclada Boiss.	Th	SA, IT	1.48	1.6	0.51
Bassia muricata (L.) Asch.	Th	SA, IT	2.6	18.8	6.0
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	Ch	IT, SU	10.0	12.5	3.95
Salsola imbricate Forssk.	Ch	SA, SU	1.5	0.4	0.12
Suaeda monoica Forssk.	Ch	SU	1.5	4.2	1.37
Suaeda vermiculata Forssk.	Ch	SA	0.7	0.2	0.06
Suaeda fruticosa	Ch	SU, SA	1.48	0.3	0.11
Cleomaceae					
Cleome amblyocarpa Barratte & Murb.	Ch	SA, SU	2.6	0.2	0.05
Cucurbitaceae					
Citrullus colocynthis (L.) Schard.	H	SA, ME	2.59	0.8	0.25
Euphorbiaceae					
Euphorbia aegyptiaca Boiss.	Ch	SA	0.7	0.01	0.01
Euphorbia retusa Forssk.	Th	SA	0.7	0.1	0.01

Table 1 continues

	Euphorbia terracina L.	Ch	M	1.5	0.1	0.04
Geranaceae						
	Erodium laciniatum (Cav.) Willd.	Th	M	1.48	0.2	0.07
Leguminaceae						
	Astragalus schimperi Boiss.	Th	SA	3.33	1.2	0.37
	Lotus halophilus Boiss. & Spruner.	Th	ME, SA	2.22	1.2	0.37
	Trigonella stellata Forssk.	Th	IT, SA	4.44	9.5	3.01
Malvaceae						
	Malva parviflora L.	Th	ME, IT	5.19	0.4	0.13
	Malva aegyptia L.	Th	SA,	0.7	0.1	0.01
Neuradaceae						
	Neurada procumbens L.	Th	SA	1.48	0.7	0.22
Orobanchaceae						
	Cistanche violacea (Desf.) Beck.	P	ME, SA	0.7	0.1	0.02
Plantagonaceae						
	Plantago ciliate Desf.	Th	IT, SA	1.48	1.8	0.57
	Plantago cylindrical Forssk.	Th	SA	4.82	3.0	0.95
	Plantago ovata Forssk.	Th	IT, SA	2.6	1.0	0.31
Poaceae						
	Schismus baratus	Th	IT, ME,SA	3.33	16.0	50.77
	Stipagrostis obtusa	Th	SA,SU, IT	2.6	0.9	0.28
Polygonaceae						
	Emex spinosa (L.) Campd.	Th	IT, ME,SA	4.07	3.9	1.24
Scrophyllariaceae						
	Kickxia acerbiana	Ch	S	0.7	0.1	0.01
Tamaricaceae						
	Tamarix nilotica (Ehrenb.) Bunge.	Ph	SA	1.5	0.1	0.02
Zygophyllaceae						
	Fagonia indica Burm.f.	Ch	IT, SA	0.7	0.1	0.01
	Fagonia Arabica L.	Ch	S	0.7	0.01	0.01
	Tribulus teristris	Th	ME, SU, IT	0.7	0.1	0.02
	Zygophyllum coccineum L.	Ch	SA	1.85	0.8	0.25

parviflora (5.19%), whereas with respect to density and abundance, P. undulate (12.9 and 4.11) takes the lead over H. salicornicum (12.5 and 3.95) and M. parviflora (0.4 and 0.13) respectively. The total number of species (N), species richness (S), index of biodiversity (I), Simpson's index (D), Simpson's index of biodiversity(1-D), α - diversity of the 9 sited investigated are shown in table 2.

2. edaphic characteristics:

The edaphic characteristics of the different sites in Wadi Al Rummah are presented in table 3. The physio-chemical analysis of the soil samples, showed a considerable variation among soil characteristics of the different sites investigated. Soils collected from the neighbouring upstream sites (site -1 and site -2), showed the lowest and highest values of (EC) and (TDS) respectively. Site -1 showed the highest values of bicarbonates (HCO3 -) and Potassium (K+), and the lowest values of Chlorides (Cl-), Calcium (Ca2+) and Sodium (Na+), whereas, site-2 showed the highest values for Chlorides (Cl-) and Sodium (Na+), and the lowest values for bicarbonates (HCO3 -).

3. Sites grouping:

The application of TWINSPAN to the vegetation data matrix (9 sites and 59 species) indicated four main vegetation groups at level three and three vegetation groups at level 2 (Figure 1). These three major plant communities groups are: Group (A): includes site 3, Group (B): includes sites (1, 2, 4, 5 & 6), Group (C): includes sites(8 & 9).

Table 2. Total number of species (N), Species Richness (S), index of biodiversity (I), Simpson's index (D) , Simpson's index of biodiversity (1-D), α- diversity of the various sites along Wadi Al- Rummah .

Site number and name	N	S	I	D	1-D	α- diversity
site.1 (Al Baith)	232	18	0.174	0.47	0.53	3.60
site.2 (Oglat Alsougoor)	561	32	0.075	0.53	0.47	6.40
site.3 (Ata)	644	16	0.027	0.76	0.24	3.20
site.4 (Algesoma)	115	7	0.017	0.91	0.09	1.40
site.5 (Alrass)	1171	27	0.041	0.68	0.32	5.40
site.6 (Al badia)	1398	37	0.164	0.49	0.51	7.40
site.7 (Onasiza)	981	45	0.046	0.47	0.53	9.00
site.8 (Al Rakia)	473	47	0.143	0.31	0.69	9.40
site.9 (Al Bandaria)	8565	43	0.025	0.73	0.27	8.60

Table 3. Physio- chemical characteristics of soil in the different sites along Wadi Al Rummah, Qassim Region

Location	EC dS/m	TDS	pH	OM%	CO_3^{-2}	HCO^3	Cl-	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}
site.1 (Al Baith)	0.34	217.6	8.55	0.47	0.26	2.17	0.52	69.0	12.0	7.17	1.85
site.2 (Oglat Alsougoor)	31.60	20224.0	8.00	0.77	0.18	1.21	53.0	168.0	16.5	105.3	0.62
site.3 (Ata)	8.80	5638.4	7.86	0.64	0.27	1.59	10.89	212.0	12.0	53.39	1.56
site.4 (Algesoma)	1.21	774.4	8.52	0.86	0.20	1.67	1.36	242.0	102.0	19.35	0.64
site.5 (Alrass)	1.14	729.6	8.41	0.86	0.18	1.46	0.59	147.0	11.0	11.55	0.75
site.6 (Al badia)	2.30	1472.0	8.51	0.69	0.17	1.21	0.71	172.0	5.0	14.1	0.35
site.7 (Onasiza)	2.20	1408.0	8.10	0.65	0.10	1.22	1.81	202.0	30.0	18.91	0.90
site.8 (Al Rakia)	0.75	480.0	8.30	0.33	0.30	1.87	0.57	132.0	20.0	4.57	0.41
site.9 (Al Bandaria)	0.82	524.8	8.60	0.45	0.27	2.01	0.93	90.0	20.0	9.39	0.43

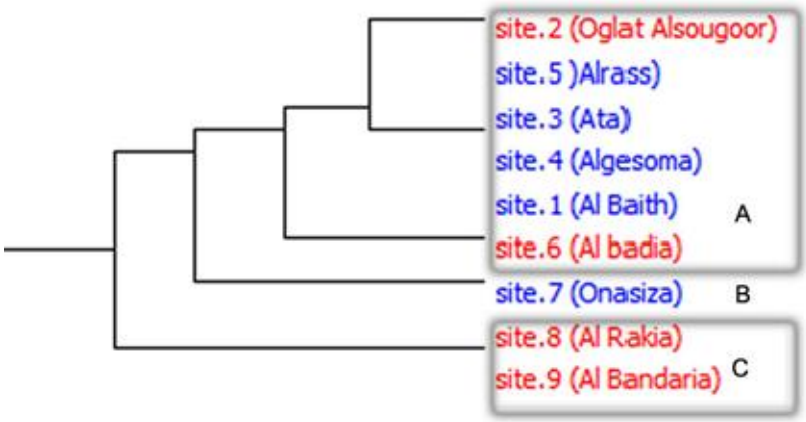


Figure 1. A dendrogram illustrating the presence of three groups of sites (at level 2), using (TWINSPAN) analysis for the 9 sites examined at Wadi Al Rummah, Qassim Region, Saudi Arabia

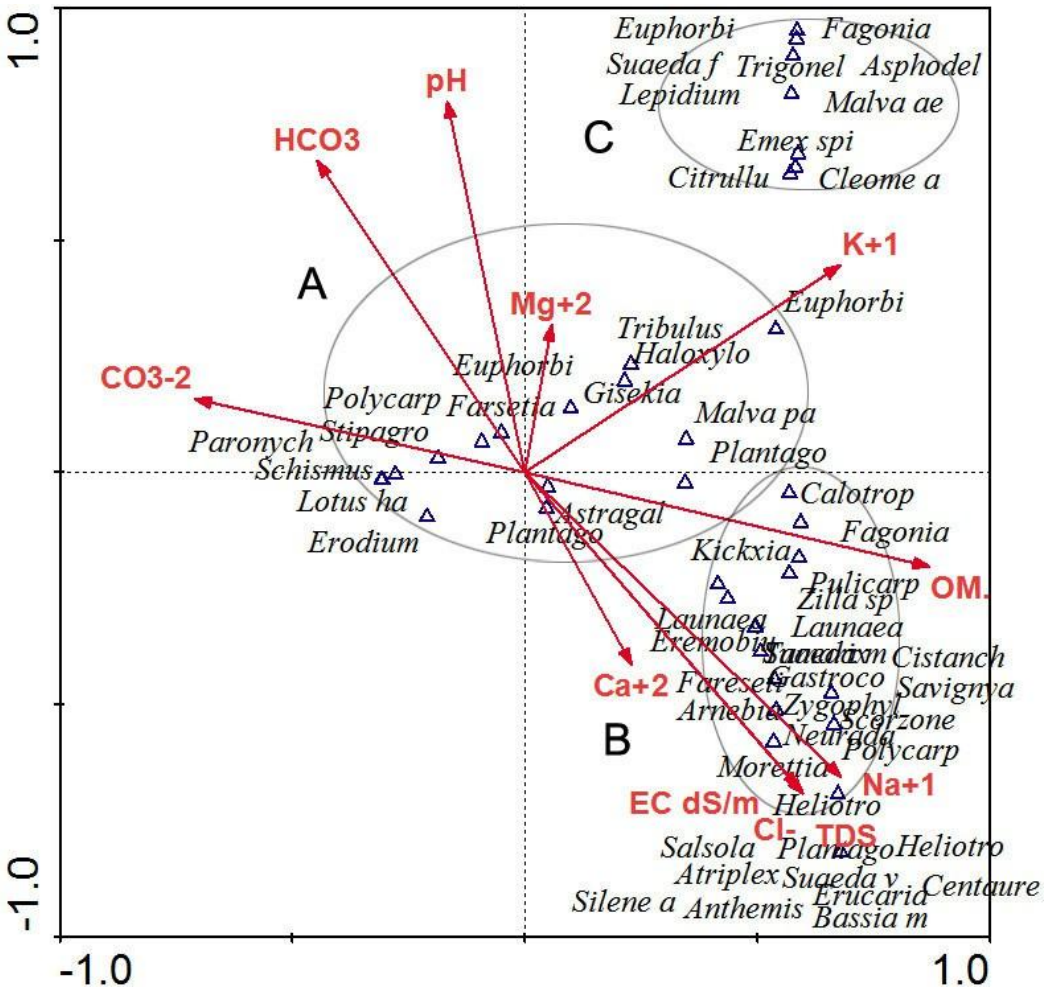


Figure 2. (CCA) biplot of axis 1 and axis 2, with environmental variables (arrows), and the abundant species represented by the first seven letters (Complete names of the species are shown in table 1) of Wadi Al Rummah, Qassim Region, Saudi Arabia.

4. Plant cover- edaphic characteristics:

The application of CCA to the vegetation data matrix (9 sites and 11 edaphic variables) indicated three vegetation groups (Figure 2).

Group (A): located at the centre of the CCA plot, which means that they have no significant effect of any environmental variables.

Group (B): showed strong and significant correlation with (OM), (Na^{+}) and (TDS), whereas (Ca^{+2}) showed a weaker correlation. This group of vegetation aggregate on the lower right of axis 1.

Group (C): showed strong positive correlation with (PH) and (HCO^{3}-), and exhibits complete separation and isolation from the other groups. This group of vegetation aggregate on the upper right of axis 1.

5 Plant cover- sites relationships:

The application of CCA to the vegetation data matrix (9 sites and 6 floristic characteristics) indicated three main groups of sites (Figure 3).

Group (A): which includes sites (1, 2 & 8), showed strong and significant correlation with (1-D), α - diversity and (I). It was noticed that site (1) has a high score of axis 2 which is positively associated with (I). This group is located at the upper left of axis 1.

Group (B): which includes sites (3, 4, 5 & 7), showed strong and significant correlation with (D). It was noticed that (I) is strongly related to axis 2. This group is located on the lower left of axis 2.

Group (C): which includes sites (6 & 9), showed strong negative correlation with (1-D), (α- diversity) and

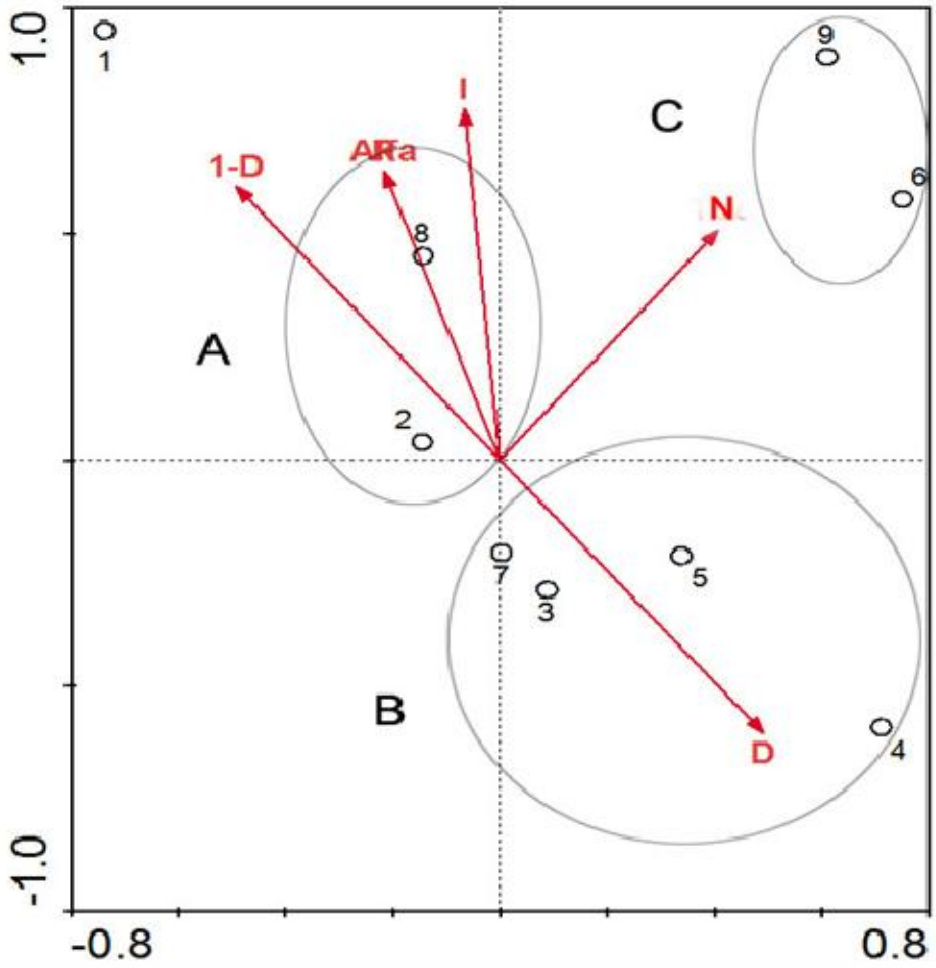


Figure 3. A (CCA) biplot of axis 1 and axis 2, with seven floristic characteristics (arrows), and the nine sites examined at Wadi Al Rummal, Qassim Region, Saudi Arabia.

(I), and exhibited complete separation from the other sites. This group is located on the upper right of axis 1.

DISCUSSION AND CONCLUSIONS

A total of 59 plant species belonging to 21 families were recorded from the various sites examined at the different geomorphologic landscapes of Wadi Al Rummah. Compared to the floristic composition of other desert ecosystems of inland Wadis in Saudi Arabia, the quantity of species recorded in this study is within the range, since 57 species, 75 species and 30 species were recorded in Wadi Al-Jufair (At Atar *et al.* 2012), Wadi Al Argy (Farra 2012), and Wadi Talha (Al Wadi 2002) respectively. However, the floristic composition of these Wadis, vary with respect to the dominant plant families. In the present study, members of the families Brassicaceae dominate the floristic composition of Wadi Al – Rummah, whereas in Wadi Al Jufair (Al Attar *et al.* 2012), Wadi Al Argy (Farrag 2012) and Wadi Talha (Wadie 2002), the families Poaceae, Asteraceae and Solanaceae are the dominant families respectively. Such qualitative variation may be attributed to edaphic factors within these wadis.

Various methods were encountered to investigate the floristic composition and ecology of Wadis in Saudi Arabia. For Wadi Al Noman (Abdel Khalik *et al.* 2013), Wadi Al Jufair (Al Attar *et al.* 2012) and Wadi Al Argy (Farrag 2012),the plant communities of these Wadis were investigated via studying different landform features in various cites, without evaluating the trends of change from source to estuary of these Wadis. However, in the present study, the plant communities were studied in upstream, midstream and downstream sites of Wadi Al Rummah, and in each cite, plant sampling was carried out in all landform features available.

Various grouping were used using (TWINSPAN and CCA) for the various parameters studied, in an attempt to

construct a clear idea on the plant cover and edaphic characteristics of the Wadi. Three groups of sites and plant communities were recognized, and plant communities at the down stream sites showed distinct pattern, whereas the interaction of edaphic variables need further studies.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the generous financial support provided by the Deanship of Scientific Research (SABIC grant no. 1095), Qassim University.

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