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Vegetation Analysis of Some Desert Rangelands in United Arab Emirates

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Abstract: The present study deals with the vegetation analysis of some desert rangelands in United Arab Emirates (UAE). 615 stands were selected to represent the variations in 3 major types of habitat in 7 locations in this country. In each stand the present species were recorded and their cover was estimated by line-intercept method (m/100m) and a composite soil sample was collected. 97 species belong to 91 genera and 29 families were recorded. The application of TWINSPAN classification technique on the cover estimates of the 97 species recorded in 615 stands led to the recognition of ten vegetation groups at the level six of classification; These groups are named after the first two dominant species as follows: *Prosopis cineraria - Cyperus conglomerates*, *Acacia tortilis* ssp. *tortilis - Arnebia hispidissima, Cornulaca monacantha - Haloxylon salicornicum, Acacia tortilis* ssp. *tortilis - Tephrosia purpurea, Acacia tortilis* ssp. *tortilis - Euphorbia larica, Haloxylon salicornicum - Acacia tortilis* ssp. *tortilis, Cornulaca monacantha - Arthrocnemum macrostachyum, Calotropis procera - Acacia tortilis* ssp. *tortilis, Tribulus terrestris - Rhazya stricta* and *Acacia tortilis* ssp. *tortilis - Dipterygium glaucum.* Result of ordination using DECORANA indicates a reasonable segregation among these groups along the ordination axis 1 and 2. The communities characterized by *Acacia tortilis* ssp. *tortilis* represent the climax stage of the vegetation in the study area. The effects of environmental factors and human impacts on species diversity and abundance of these communities were assessed.

Key words: Desert vegetation · Rangelands · *Acacia* · Diversity · Ordination · UAE

INTRODUCTION

Little attention has been paid for the evaluation of current status of natural rangelands and their plants in UAE [1-3]. In addition, visual observation indicated that many habitats in UAE are subjected to over-grazing [4-6]. Satchell [7] briefly presented notes on the different habitats of the UAE, while Satchell *et al.* [8] indicated that the land classification of UAE being the basis of a stratified scheme for vegetation sampling. El-Ghonemy [4] described the climate, topography and soil of Al-Ain Oasis and gave a short account of the main plant communities with a detailed description of the monocotyledons taxa. Recently, Mousa [9] analyzed the vegetation of rangelands in the UAE.

The present study analyses the vegetation structure, physical components and land-use in the rangeland ecosystems in seven locations representing the seven emirates of UAE: Hili (Abu Dhabi), Biat (Ajman), Hatta (Dubai), Madam (Sharjah), Digdaga (Ras Al-Khimah), Masafi (Fujairah) and Falaj Al-Muala (Umm Al-Quwain). The main objectives are determining the floristic composition of the different locations and habitats and identifying the main plant communities using the multivariate analysis. This study focuses our attention towards the species diversity of the rangelands in UAE.

Study Area: The study area lies between latitude 23° and 25° N and longitude 54° and 56 ° E. Semi-mobile dunes are the dominant visual feature, with a relatively high water table resulting in evaporative crusts in many depressions. The sands remain fairly well demarcated between the coastal oolitics and the inland Aeolian [10]. Low rainfall and high temperatures characterize the climate of the UAE. Temperature rises up to 49°C in July, while it can be as low as 5°C in January, though this is rare on the coast because of the moderating influence of the sea. Most precipitation occurs between December and April, annual precipitation ranges between 87.3 and 180 mm, the range varied from year to anther [11].

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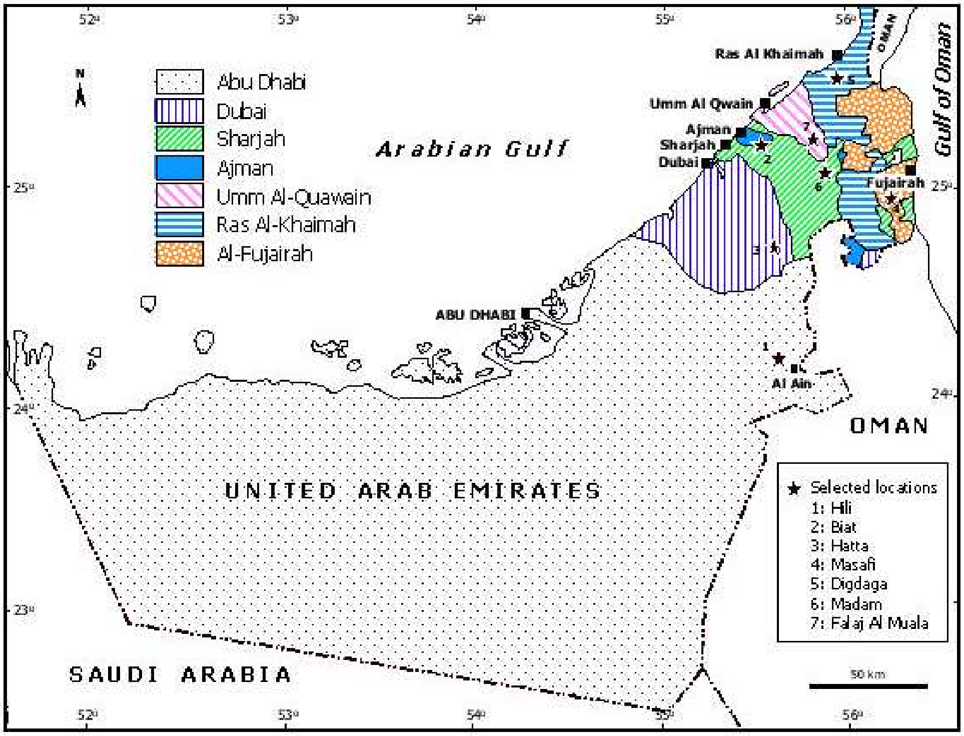


Fig. 1: Location map of the United Arab Emirates showing the 7 studied locations

MATERIALS AND METHODS

Six-hundred and fifiten stands each of 20x20 m, which approximates the minimal area of the prevailing plant communities, were selected so as to represent the physiographic and physiognomic variation in 7 locations represent the 7 emirates: Hili (Abu-Dhabi), Hatta (Dubai), Madam (Sharjah), Digdaga (Ras Al-Khimah), Biat (Ajman), Masafi (Fujairah) and Falaj Al-Muala (Umm Al-Quwain) (Fig. 1). The main haitats are sand formations, inland plains and mountains. In each stand the present species were recorded. Nomenclature was according to Western [5], Mandaville [12] and Jongbloed [13]. Plant cover was estimated quantitatively by line-intercept method [14].

TWINSPAN and DECORANA were applied to the matrix of cover estimates of 97 species in 615 stands according to the computer programme of Hill [15,16]. Species richness (SR) of each vegetation group was calculated as the average number of species per stand. Species turnover (ST) (beta diversity) was calculated as the ratio between the total number of species recorded in a certain vegetation cluster and its alpha-diversity [17]. Shannon-Wiener index ($H' = -\sum P_i \log P_i$) for the relative evenness and Simpson index ($C = \sum Pi^2$) for the relative concentration of dominance were calculated for each vegetation group on the basis of relative cover (pi) of species [18]. A composite soil sample was collected from each sampled stand. Soil texture was determined by the Bouyoucous hydrometer method, organic matter by loss-on-ignition at 450°C and calcium carbonate using calcimeter. Soil-water extracts at 1: 5 were prepared for the determination of soil salinity (as EC) and soil reaction (pH) using conductivity- and pH-meters. Soil extracts of 5 gm air-dried soil samples were prepared using 2.5% v/v glacial acetic acid for determining P, K, Ca, Na and Mg. Flame photometer was used for estimating K, Ca and Na, Molybdenum blue and Indo-phenol blue methods for the determination of P and N. Total nitrogen was estimated by the Micro-Kjeldahl method [19,20].

The probable environmental significance of DECORANA axes was investigated by the simple linear correlation analysis and the forward selection of stepwise multiple regression. ANOVA test was applied to assess the significance of variation in community and soil variables in relation to the vegetation clusters. *These techniques were according to SPSS software* [21].

RESULTS

Ten vegetation groups (VG) were generated at the level six of TWINSPAN; the results of applications of DECORANA indicated a reasonable segregation among these groups (Fig. 2). These groups are named after the first two dominant species (Table 1). The groups that inhabit the sand formations include VG 1 which has the highest species richness (10.0 species stand^{-1}); VG 7 of the lowest number of species (6 species), relative evenness (1.6) and total cover (3.4 m100 m^{-1}); and VG 9 that has the lowest relative concentration of dominance (3.5) but the highest species number (74 species) and total cover (109.4 m100 m^{-1}) (Table 2). On the other hand, the groups that characterize the mountains include VG 3 of the lowest species turnover (1.1); VG 4 of the highest relative evenness (2.5); and VG 5 which has the lowest species richness (2.9 species stand^{-1}) but the highest species turnover (21.1). In addition, VG 6 which inhabits the sand plains has the highest relative concentration of dominance (4.9).

Soils of the vegetation groups that characterize the sand formations include that of VG 1 which has the lowest calcium carbonate (18.7%) and calcium (74.2); VG 2 that has the lowest sand (73.1%), but the highest fine fractions (26.9%); VG 7 which has the highest sodium (17.1 meql^{-1}), but the lowest pH (7.4), phosphorus (0.4 meql^{1}) and magnesium (8 meql^{-1}); VG 9 of the highest pH (8.2) and phosphorus (1.3 meql^{-1}),but the lowest EC (0.3 mS cm^{-1}) and sodium (11.1 meql^{-1}); and VG 10 that has the highest potassium (14.2 meql^{-1}) (Table 3). On the other hand, soils of the groups that inhabit the mountains include that of

Table 1: Characters of the 10 vegetation groups (VG) derived after the application of TWINSPAN. Pr: presence percentage of species, SF: Sand formations, MO: Mountains and SP: Sand plains

VG	stands	First dominant species	Pr	Second dominant species	Pr	Hab
1	85	*Prosopis cineraria*	92.0	*Cyperus conglomeratus*	92.0	SF
2	125	*Acacia tortilis* ssp. *Tortilis*	80.0	*Arnebia hispidissima*	80.0	SF
3	20	*Cornulaca monacantha*	80.0	*Haloxylon salicornicum*	75.0	MO
4	20	*Acacia tortilis* ssp. *Tortilis*	80.0	*Tephrosia purpurea*	80.0	MO
5	21	*Acacia tortilis* ssp. *Tortilis*	100.0	*Euphorbia larica*	50.0	MO
6	60	*Haloxylon salicornicum*	100.0	*Acacia tortilis* ssp. *tortilis*	100.0	SP
7	15	*Cornulaca monacantha*	66.0	*Arthrocnemum macrostachyum*	66.0	SF
8	62	*Calotropis procera*	88.7	*Acacia tortilis* ssp. *tortilis*	80.6	SP
9	96	*Tribulus terrestris*	100.0	*Rhazya stricta*	93.7	SF
10	111	*Acacia tortilis* ssp. *Tortilis*	90.1	*Dipterygium glaucum*	81.1	SF

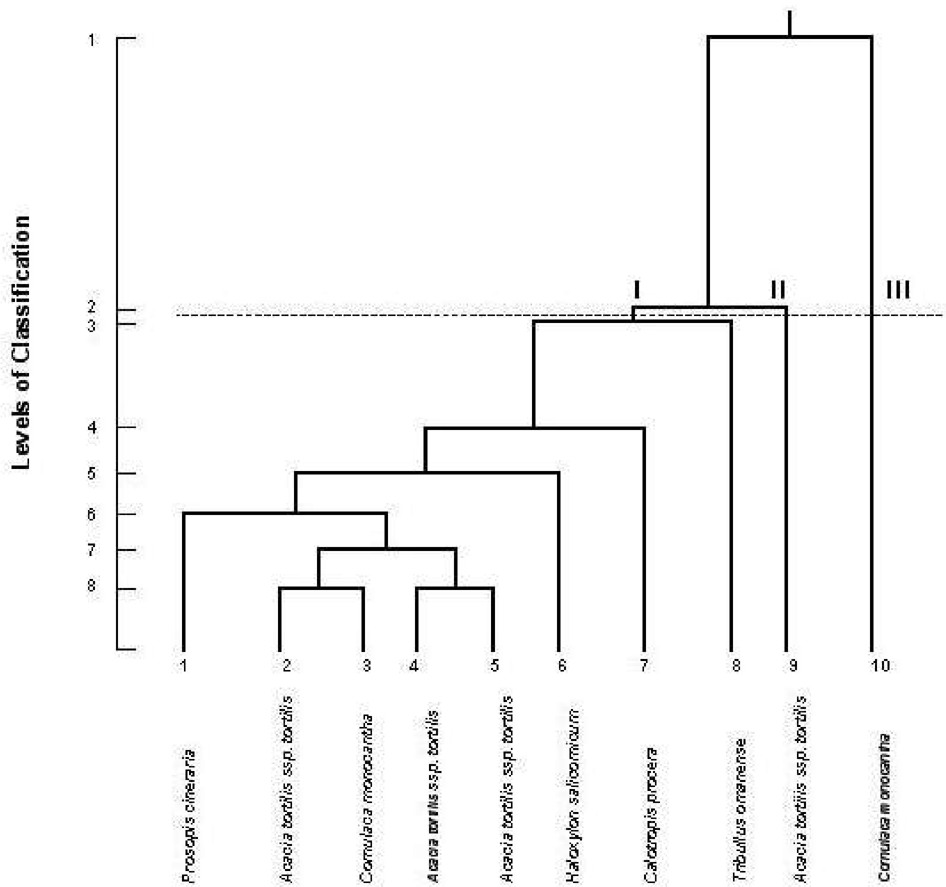
Table 2: Variation in some plant community attributes of the 10 vegetation groups generated after the application of TWINSPAN (1-10). SN: species Number, SR: species richness, ST: species turnover, RE: relative evenness, RC: relative concentration of dominance and TC: total cover. P-values are according to one–way ANOVA

Community attribute	1	2	3	4	5	6	7	8	9	10	P
S N	47	36	32	17	36	23	6	28	74	51	<0.001
SR	10.0	6.3	5.4	5.6	2.9	6.2	8.0	4.3	8.0	6.0	<0.01
ST	7.8	7.9	1.1	8.0	21.1	7.4	4.5	6.0	3.3	4.8	<0.001
RE	2.2	1.8	1.9	2.5	1.7	1.6	1.6	1.9	1.8	2.2	<0.01
RC	3.7	4.1	4.0	4.0	3.6	4.9	3.9	3.8	3.5	3.8	<0.01
TC (m100 m^{-1})	36.4	24.6	25.8	17.5	25.3	35.1	3.4	35.2	109.4	49.2	<0.001

Table 3: Variation in some soil characters of the 10 vegetation groups generated after the application of TWINSPAN. P-values are according to one–way ANOVA.

Soil characters	1	2	3	4	5	6	7	8	9	10	p
pH	7.6	8.0	7.7	7.5	7.8	7.9	7.4	8.1	8.2	7.6	<0.05
EC (mS^{-1})	0.4	0.7	0.6	1.0	1.4	0.5	0.8	1.1	0.3	0.9	<0.05
Ca CO_3%	18.7	20.5	25.8	49.0	62.0	41.0	60.0	20.5	25.8	25.8	<0.05
OM%	3.2	2.5	1.7	2.0	5.0	2.3	2.0	2.5	1.8	1.9	<0.05
Sand%	80.2	73.1	79.1	78.7	85.1	90.2	85.2	74.1	85.1	78.7	<0.01
Fine frac.%	18.8	26.9	20.9	21.3	14.9	9.8	14.8	25.9	20.9	21.3	<0.05
Ca Meql^{-1}	74.2	77.2	78.2	87.2	84.5	78.2	81.1	87.2	86.2	84.2	<0.05
Na Meql^{-1}	15.1	14.2	13.2	12.1	14.1	16.1	17.1	13.2	11.1	14.1	<0.05
K Meql^{-1}	10.1	11.2	11.9	13.2	14.2	7.2	9.5	11.9	13.2	14.2	<0.05
N Meql^{-1}	1.2	1.1	0.7	1.0	1.4	1.6	1.5	0.8	0.9	1.3	<0.05
P Meql^{-1}	0.7	0.5	0.6	1.1	0.8	0.5	0.4	0.6	1.3	1.2	<0.05
Mg Meql^{-1}	12.5	11.4	10.5	8.8	12.5	8.4	8.0	11.9	13.2	8.7	<0.05

TWINSPAN



DECORANA

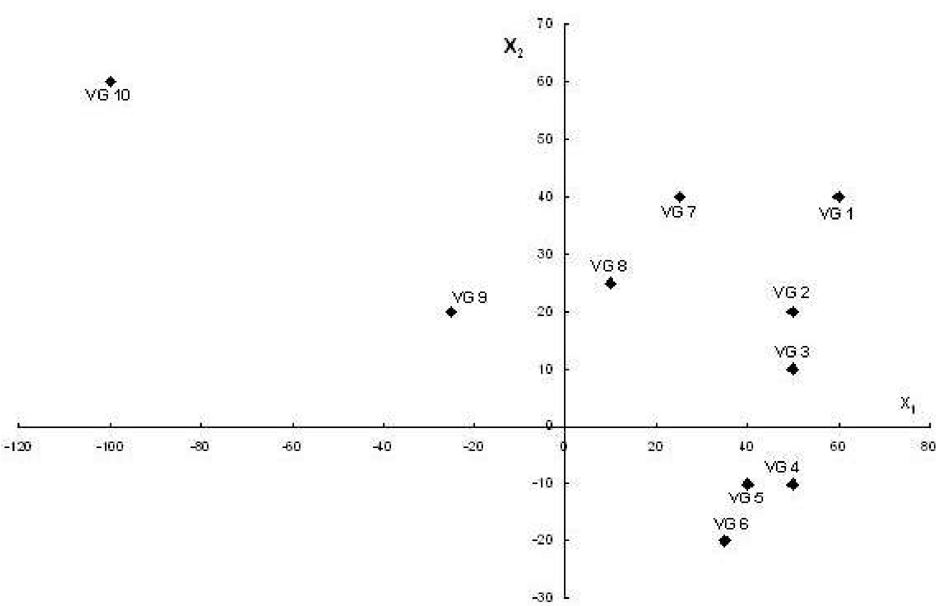


Fig. 2: The relationship between the ten vegetation groups segregated after the application of TWINSPAN classification technique and their centroides on the first and second axes of DECORANA

Table 4: Stepwise multiple regressions (forward selection) of the DECORANA axes 1 and 2 on the soil variables. r = simple linear correlation coefficient

Step	Variable entered	Partial R^2	Model R^2	F	r
DECORANA Axis 1					
1	EC	0.092	0.100	12.40*	0.31***
2	Mg	0.031	0.210	7.20	0.22**
3	K	0.022	0.250	4.10	0.15*
4	P	0.022	0.280	3.30	0.14*
DECORANA Axis 2					
1	EC	0.020	0.080	17.50*	0.28***
2	Mg	0.010	0.110	5.10	0.16**

Table 5: Pairs of community and soil variables with significant simple linear correlations

Pair of variables		r	p
Organic matter	X Species turnover	0.88	<0.001
	X Total cover	0.39	<0.01
Nitrogen	X Species turnover	0.64	<0.001
	X Total cover	0.52	<0.01
Phosphorous	X Total cover	0.43	<0.01

VG. 3 which has the lowest organic matter (1.7%) and nitrogen (0.7 meql^{-1}); VG 5 that has the highest EC (1.4 mS cm^{-1}), calcium carbonate (62%), organic matter (5%) and potassium (14.2 meql^{-1}). In addition, those of the sand plains include VG 6 which has the highest sand (90.2%) and nitrogen (1.6 meql^{-1}), but the lowest fine fractions (9.8%) and potassium (7.2 meql^{-1}); and G 8 that has the highest value of calcium (87.2 meql^{-1}).

The environmental significance of the DECORANA axes 1 and 2 was investigated by simple linear correlation (r) and stepwise multiple regression (Table 4). The soil variables that correlate positively with axis 1 are EC (r = 0.31), magnesium (r = 0.22), potassium (r = 0.15) and phosphorus (r = 0.14). The soil variables which contribute significantly to the regression model of this axis are EC and magnesium (they explain only about 21 % of the total variation along this axis 1). Axis 2 correlates significantly with EC (r = 0.28) and magnesium (r = 0.16). The soil variables of significant contribution to the regression model of axis two are salinity and magnesium (explain about 11% of the total variation along this axis).

The correlation between soil characters and community variables indicated that organic matter, nitrogen and phosphorus have significant positive correlations with species turnover and total cover (Table 5).

DISCUSSION

In the area of the present study, ten vegetation groups are generated after the application of two way indicator species analysis (TWINSPAN) to the cover estimate of 97 species in 615 stands. The application of detrended correspondence analysis (DCA) to the same set of data supports the distinction between the 10 vegetation groups. Some groups are dominated by prominent component of native range flora such as those dominated by Prosopis cineraria and Acacia tortilis ssp. tortilis). The groups dominated by Acacia trees represent the climax stage of the xerophytic vegetation in Gulf region [22,23]. Acacia tortilis ssp. tortilis has a wide distribution in the all the shrublands of the Arabian desert [24]. Some of these groups are comparable to those identified in the central and eastern Arabia [23,25].

The groups characterized by Haloxylon salicornicum covers thousands of square kilometers of the eastern Saudi Arabia [12]. It is an important camel grazing plant during summer and fall where annual and grasses are not available, it also provides a good firewood. Cyperus conglomerates, that characterized one of the vegetation groups in the present study, tolerates disturbed ground and sometimes colonizes clean– graded sites. It provides a useful cover against wind erosion, livestock graze it and sometimes it may be very abundant and virtually the only available forage [12,25]. Posepis cineraria inhabits the sand plains, dunes and wadi banks. This plant is common and widespread in the north eastern part of the country. It is a good fodder plant and shade tree in barren sandy desert and plays a major role in the reforestation schemes of the UAE western region. Seed, pods and young leaves are eaten by Bedouin and wood are used for fuel and construction. In Arabia, the natural distribution of Posepis cineraria is limited to the UAE and Oman [13].

Vesey–Fitzgerald [26] classed the whole group of perennials in the eastern Arabia as halophytes which vegetate during the hot dry months on subsoil moisture.

This case is represented in the present study by the groups dominated by Halocnemum salicornium and Arthrocnemum macrostachym. No doubt that the species that characterize the other groups are not strictly halophytes which contrasted with the Vesey–Fitzgerald's generalization.

On a relative scale, the present study indicates that the sand formations seem to be of higher species diversity (in terms of total number of species and species richness) and abundance (in terms of total cover) than the mountains. No doubt, under the harsh conditions of very hot and dry conditions, sand formation keep more moisture than the mountains of skeletal soil (most of them are exposed rocks).

Among the 20 soil variables estimated in the present study; salinity, Mg, K and P are the factors of environmental significance along the DCA ordination axes. But these factors contributed not more than 28 % of the total variation along axis one and 11 % along axis two. This means that other factors, not included in this analysis, are more effective. No doubt, some physical factors of anthropogenic nature (e.g. overgrazing and overcutting of woody plants) play an important role. Approximately 60 % of the Arabian rangelands is degraded mainly due to overgrazing and overcutting [27].

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