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Floristic composition and vegetation analysis in Hail region north of central Saudi Arabia

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Floristic composition; Vegetation analysis; Desert; Hail region; Saudi Arabia

Abstract In this study, 19 sites representing different habitats in Hail region were regularly visited for two years, in each site 2–5 stands were selected for investigating floristic composition and vegetation types in the area. A total of 124 species representing 34 families were recorded. The family Asteraceae is represented by the highest number of species (21 species) followed by the Poaceae (17 species) and the Brassicaceae (10 species) whereas, 15 families including Acanthaceae, Convolvulaceae, Moraceae, Nyctaginaceae and Primulaceae, are represented by a single species each. Chronological analysis of the vegetation in the area revealed the domination of Saharo-Sindian elements in the wild vegetations and of weedy species in the cultivated plots. Therophytes and chamaephytes are the dominating life forms of the vegetation spectra; therophytes represent 49.20% and chamaephytes represent 29.00% of the total species in the study area. Application of TWINISPAN and DECORANA classification and ordination techniques to the data produced seven vegetation groups. Ruderal habitats comprised two small groups A and F dominated by Phragmites australis and Imperata cylindrical (A), Euphorbia peplus and Sisymbrium irio (F), respectively. Two vegetation groups (B and G) have been recognized in the mountains and slopes dominated by Launaea mucronata, Trigonella stellata (B) and Ficus palmate and Fagonia bruguieri (G). Other two groups (C and E) inhabit the desert and mountainous wadies; these are represented by Gymnocarpos

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decandrus and Ochradenus baccatus (C) and Senecio glaucus subsp. coronopifolius and Rumex equisetiforme (E). On the other hand, one group (D) inhabits the cultivated plots and is represented by Plantago albicans and Rumex vesicarius, the last group also includes species restricted to the sand dune habitat of the Al-Nafud desert north of Hail city and represented by Calligonum polygonoides and Halyxolon salicornicum. The vegetation analysis indicated the invasion of Hail Flora by some foreign weeds such as Solanum nigrum, Lactuca serriola and Amaranthus lividus. The presence of these weeds points out the need to monitor the vegetation change in Hail region, and also other regions of Saudi Arabia, in order to elucidate the human impact on the wild plants diversity as human activities change with the fast development in the kingdom.

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1. Introduction

Saudi Arabia (Lat. 32° 34'N-16° 83'N, Long. 34° 36'E-56'E) is a vast arid desert with an area of about 2250,000 sq kms covering the major part of the Arabian Peninsula. Accordingly, xerophytic vegetation makes up the prominent features of the plant life in the kingdom (Zahran, 1982). Several reports have been published on the Flora of the country, the most comprehensive are two Floras; the first was written by Mighaid in 1974 and published four times, the last in 1996 (Mighaid, 1996) and the other is the three volume Flora written by Chaudhary (1999, 2000, 2001). Other publications on the Flora of Saudi Arabia include the illustrated flowers of Saudi Arabia by Collenette (1999) and a number of reports on regional on certain parts of the Kingdom. The Middle part of Saudi Arabia, has received attention regarding its floristic survey. Al-Turki (1997) published a check list on the Flora of Al-Qassim region comprising a total of 450 wild and cultivated species of flowering plants belonging to 257 genera and 62 families. Al-Turki and Al-Olayan (2003) published synoptic analysis of the Flora of Hail reveals that 338 wild plants representing 221 genera spread over 61 families in Hail region. Studies on the Al-Aushazia Sabkha vegetation in Al-Qassim region was also described by Al-Huquial and Al-Turki (2006).

A number of ecological studies have been published on the vegetation of Saudi Arabia. Zahran (1982, 1983) wrote an introduction to the plant ecology and vegetation types in the country. Some other reports have dealt with the vegetation types in certain regions of the kingdom particularly in the Hijaz and Aseer regions. Batanouny (1979) described the vegetation types in the Jeddah-Makkah road, Batanouny and Baeshain (1983) described vegetation types in the Al-Madinah-Badr road across the Hijaz Mountains and Fayed and Zayed (1999) reported on the vegetation along Makkah-Taif road. More detailed studies was carried out on the vegetation change in relation to elevation in the Aseer mountains (Abulfatih, 1992) and on vegetation analysis and species diversity in the central Hijaz mountains (Abd-El-Ghani, 1993, 1997) and Wadi El-Ghayl in Aseer mountains (Fahmy and Hassan, 2005). Studies on the vegetation environment relationship in the mountainous Taif area (80-100 km south east of Makkah), indicated that soil water table and salinity cause discontinuities of vegetation in the area (Abdel-Fattah and Ali, 2005). In the central part of Saudi Arabia, the Raudhas vegetation was analyzed by Shaltout and Madi (1996). The floristic account of Raudhat Khuraim in the central province was also reported by Al-Farhan (2001). In addition, comparative ecological studies were also conducted by Al-Ghanim (2002) on the natural vegetation in the Riyadh region. However, few

studies have dealt with vegetation analysis and species diversity Saudi Arabia.

Hail region, covers the northern part of the central Najd plateau (Fig. 1), it comprises diverse ecosystems that provide interesting aspects for vegetation and species diversity investigations. The study by Al-Turki and Al-Olayan (2003) represent a comprehensive contribution to the Flora of the region, whereas the recent study by Sharawy and Alshammari (2008) represents a contribution to the poisonous plants in the Aja Mountains, North of Hail. However, to our knowledge no studies have dealt with the vegetation analysis in relation to the florestic composition and habitat variation in the region. The aim of the present work is to study the vegetation in the Hail province in terms of species composition, life form, diversity and vegetation types (groups) in relation to habitat change in the study area. Multivariate techniques and species diversity indices have been used to differentiate vegetation groups and to assess the relation between the vegetation types in the study area.

2. The study area

The Hail region is found in the northern central part of Saudi Arabia and extends between 25° 29'N and 38° 42'E (Fig. 1B). It covers an area of 118,322 sq km and represents 6% of the total area of the kingdom of Saudi Arabia. Hail is bordered to the north by Al-Jouf and the Northern Frontier regions, to the west by Tabouk and Al-Madinah regions, to the south by Al-Qassim and to the east by the Central and Eastern regions. The study area includes the town of Hail and extends to the west, north and south. It covers the major part of the Aja mountain chains that includes Ugdah and Jubbah areas and extends north to Al-Khuttah and further North West to cover part of An-Nafud Al-Kabir sand dune desert and South West to Gazzala. The study area also covers the Wadies in the western parts of Salma mountains to the east of Hail town and also several gardens and orchards in Hail town and Al-Khuttah farms (Fig. 1B).

2.1. Topography and geomorphology

Hail region is characterized by its variation in topography and geomorphology. According to Chapman (1978) the area belongs to the Arabian shield and the great An-Nafud (Nafud Al-Kabir), which is connected by Dahma, to the Rub Al-Khali to the south of Saudi Arabia. The great An-Nafud, which represents a principal part of Hail region, is a very large depression filled up with masses of sand and covers an area of almost 64,000 sq km. One striking aspect of this great body

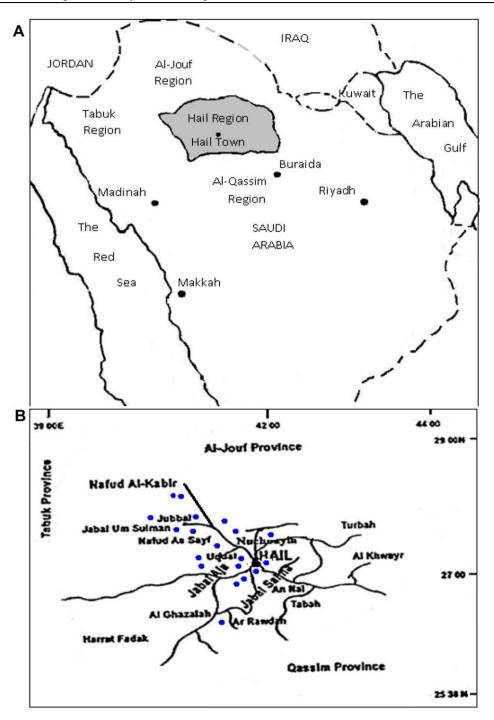


Figure 1 Map of Saudi Arabia showing Hail region (A) and the sampled sites in the study area on Hail Province (B). Adapted from Al-Turki and Al-Olayan (2003).

of sand is the lack of oases of sand and rivers system. The mountain chains; Jabal Aja (100 km long and 25–30 km wide) to the west of Hail town and Jabal Salma (60 km long and 13 km wide) to the east are granite rocks formation (Fig. 1B). The Arabian shield extends to steep wadies and hills characterized by its limestone sand. The primary source of sand is the large granite mass intrusive igneous rock underlying the Arabian Shield. However, the sand that we see in form of sand sheets and sand dunes appears to be of secondary or more usually tertiary origins from Paleozoic and Mesozoic

sand stones. Cultivation is the main activity in the Hail region but the cultivated areas are only about 92,000 hectares, which represents a small fraction of the total area of Hail region.

2.2. Climate

The climate of Saudi Arabia is generally hot and dry. It is affected by two climatic types, namely: Monsoon and Mediterranean. The Monsoon climate affects the southern part while the northern part is affected by Mediterranean climate. The weather

Table 1 The list of 124 species recorded in 57 stands in 19 sites in the study areas and their distribution in seven vegetation groupsusing the TWINISPAN analysis.

Ser.	Species	А	В	С	D	Е	F	G	P (%)
01	Abutilon pannosum (G. Forst.) Schltdl.		18.2						11.1
02	Acacia ehrenbergiana Hayne	14.3				12.5			22.2
03	Acacia tortilis subsp. raddiana (Savi) Brenan	14.3	36.4	38.5	20.0				44.4
04	Aerva javanica (Burm.f.) Juss.			7.7					11.1
05	Aizoon canariense L.			7.7		12.5			22.2
06	Alternanthera sessilis (L.) DC.					2.5			11.1
07	Amaranthus lividus L.					2.5			11.1
08	Anagallis arvensis L.					2.5			11.1
09	Andrachne aspera Spreng.	20.6	18.2	7.7	20.0				22.2
10	Anthemis melampodina subsp. deserti (Boiss.) Eig.	28.6	10.0	7.7	20.0				44.4
11	Artemisia judaica L.		42.9	38.5	40.0				22.2
12	Artemisia monosperma Delile		10.2		40.0				11.1 22.2
13 14	Asclepias fruticosa L. Asphodelous fiscidulus Boiss.		18.2	7.7 15.4					11.1
14	Astragalus sieberi DC.			7.7					11.1
16	Astragalus shelen DC. Astragalus spinosus (Forssk.) Muschl.		45.5	23.8					22.2
17	Avena barbata Pott		- J.J	7.7	20.0				22.2
18	Avena fatua L.			/./	20.0	2.5			11.1
19	Bassia eriophora (Schrad.) Asch.			7.7		2.5			22.2
20	Bassia muricata (L.) Asch.			15.4					11.1
21	Blepharis ciliaris (L.) B.L. Burtt.		36.4			12.5			22.2
22	Boerhavia diffusa L.					15.0			11.1
23	Brassica tournefortii Gouan					12.5	2.5		22.2
24	Calendula arvensis L.			7.7		12.5			22.2
25	Calligonum polygonoides L.			23.8		80.0			22.2
26	Capsella bursa-pastoris (L.) Medik.					2.5			11.1
27	Cenchrus ciliaris L.					2.5			11.1
28	Chenopodium murale L.					5.0			11.1
29	Citrulus colocynthis (L.) Schrad.		18.2	46.2	20.0				33.3
30	Cleome amblyocarpa Barratte						33.8		11.1
31	Convolvulus arvensis L.	14.2				2.5			11.1
32	Conyza bonariensis (L.) Cronquist.	14.3	10.0	15 4		2.5			11.1
33 34	Cynodon dactylon (L.) Pers. Datura innoxia Mill.		10.0	15.4 7.7		2.5	0.5		33.3 22.2
34 35	Dichanthium annulatum (Forssk.) Stapf.		27.3	7.7			0.5		22.2
36	Diplotaxis acris (Forssk.) Boiss.		10.0	/./					11.1
37	Diplotaxis daris (Forssk.) Boiss.		10.0	23.8	20.0				22.2
38	Echinops spinosus L.		10.0	20.0	60.0				22.2
39	<i>Ephedra alata</i> Decne.							50.0	11.1
40	Eragrostis cilianensis (All.) F.T. Hubb.					0.5			11.1
41	Erodium cicutarium (L.) L'Her		10.0	15.4	20.0		1.0		44.4
42	Erodium glaucophyllum (L.) L'Her			3.8					11.1
43	Erodium laciniatum (Cav.) Willd.					37.5	0.5		22.2
44	Eruca sativa Mill.						0.5		11.1
45	Euphorbia granulata Forssk.					37.5			11.1
46	Euphorbia peplus L.						100		11.1
47	Euphorbia retusa Forssk.	28.6	10.0						22.2
48	Fagonia bruguieri DC.	14.3						100	22.2
49	Fagonia cretica L.		18.2			12.5	o -		22.2
50	Farsetia aegyptia Turra		7.7	72.7		37.5	0.5	100	44.4
51	Ficus palmata Forssk.					27 5		100	11.1
52 53	Flaveria trinervia (Spreng.) Mohr Forsskaolea tenacissima L.			38.5		37.5 2.5			11.1 22.2
53 54	Gymnocarpos decandrus Forssk.			38.5 53.8		2.5			22.2 11.1
54 55	<i>Gymnocarpos aecanarus</i> Foissk. <i>Gypsophila capillaris</i> (Forssk.) C. Chr.			38.5					11.1
56	Halyxolon salicornicum (Moq.) Bunge			50.5	46.2	80.0			22.2
57	Helianthemum lippii (L.) Dum. Cours		18.2		10.2	50.0	0.5		22.2
58	Heliotropium arbainense Frense.		10.2	15.4			0.0		11.1
59	Heliotropium bacciferum Forssk.			15.4					11.1
	Heliotropium ramosissimum (Lehm.) Sieb.		3.8	63.6		12.5			33.3
60	neuoropium rumosissimum (Lenni.) Sico.		5.0	05.0		12.5			55.5

Sec. Species A B C D E F G P(%) 63 Improvem (Forcels) Ed.). Recevel. 1.0 - - 1.1 64 Improvem (Forcels) Ed.). Recevel. 1.0 - - 1.1 65 Improvem (Forcels) Ed.). Recevel. 8.7 2.7.3 8.5 - - 1.1 66 Immovem morenaux (Forcels). Unschlut. 8.5.7 27.3 8.6 - - 3.3 67 Infanto morenaux (Forcels). Unschlut. 27.3 - - 3.3 70 Macken anceptifak (L). Hads. 27.3 - 1.2 - 3.3 71 Macken anceptifak (L). Hads. 27.3 - 1.2 - 2.3 - 1.1 73 Macken bracelfak (L). Machen. 27.3 - 4.2 - 2.2 3.3 - 1.1 74 Macken bracelfak (L). Machen. 27.3 - - 2.2 3.3 - 1.1	Table	1 (continued)								
63 Imperate cylindrica (L.) Raeasch. 1.0 21.3 15.4 22.2 65 Lautea servica L. 0.5 1.1 66 Launea merchniz (FOrsk.) Muschl. 8.7.3 35.5 22.2 67 Launea merchniz (FOrsk.) Muschl. 8.7.3 35.5 21.3 67 Launea merchniz (FOrsk.) Muschl. 14.3 27.3 35.5 11.1 67 Launea merchniz (FOrsk.) Muschl. 14.3 27.3 46.2 4.0 33.3 71 Metha fongfloid () Hols. 28.6 10.0 12.5 33.3 73 Meentin fongfloid () Hols. 27.3 46.2 30.3 31.1 74 Mothespecificat (Creass) Muschl. 27.3 46.2 33.3 31.1 75 Motta' fongfloid () Hols. 27.3 46.2 33.3 31.1 76 Orderadems becanta Delite 7.7 33.3 33.3 33.3 78 Pariateria distriffidi Delite 15.4 11.1 11.1 77 11.1 </th <th>Ser.</th> <th>Species</th> <th>А</th> <th>В</th> <th>С</th> <th>D</th> <th>Е</th> <th>F</th> <th>G</th> <th>P (%)</th>	Ser.	Species	А	В	С	D	Е	F	G	P (%)
64 Kolepinia linearis Pall. 27.3 15.4 22.2 Lananea marcana (Forsk) Muschl. 85.7 27.3 38.5 2.5 44.4 Lananea marcana (Forsk) Muschl. 85.7 27.3 38.5 2.5 44.4 Lananea marcana (Forsk) Muschl. 14.3 27.3 7.7 33.3 Marca parema L. 23.3 7.7 33.3 11.1 Marca parema L. 23.3 11.1 33.3 31.1 Marca parema L. 23.8 2.5 33.3 31.3 Moretha longificia (L) Husb. 23.8 5.0 33.3 33.3 Moretha longificia (Forsk) L. M. Johnst. 27.3 46.2 2.2 2.3 11.1 Naracia resis (Forsk), Asch. 23.8 37.5 31.3 33.3 33.3 Proprimari alsofificia (Valh) J. Macbr. 23.8 37.5 33.3 31.1 Proprimari alsofificia (Valh) J. Macbr. 23.8 37.5 33.3 31.1 Proprimari alsofificia (Valh) J. Macbr. 23.8 37.5 11.1 <td>62</td> <td>Iflago spicata (Forssk.) Sch.Bip.</td> <td></td> <td></td> <td></td> <td></td> <td>0.5</td> <td></td> <td></td> <td>11.1</td>	62	Iflago spicata (Forssk.) Sch.Bip.					0.5			11.1
65 Lainea meriona (Forks) Musch. 8.5 2.5 11.1 67 Laumach melical (L.) Hock, F. 8.6 22.2 101 Laumach and consorphilo Poir. 27.3 8.6 22.2 102 Lycium Shoril Roem. and Schult. 14.3 27.3 46.2 4.0 33.3 111 Lycium Shoril Roem. and Schult. 25.6 10.0 12.5 33.3 111 Macha forgifold (.) Huds. 33.3 13.1 33.3 13.1 13 Macenbryanthemm forskaoli Hochat. 26.6 10.0 12.5 33.3 13.1 15 Moretia professe, Closek, Nikuda 22.8 33.3 13.1 16 Obrindems baccaus Delile 23.4 46.2 22.2 10 16 Pararychia arbita functional Biolis 15.4 13.1 13.3 13.1 17 Nanghia desarratian Biolis 15.4 13.1 13.1 18 Pararychia arbita functional Biolis 12.5 22.2 13.1 11.1 Pararychia arbi	63		1.0							11.1
66 Lanaeae macronata (Forsk) Muschl. 85.7 27.3 38.5 2.5 44.4 7 Lamanda corronfpilie Poir. 27.3 1.1 70 Lyciam showii Roem. and Schult. 14.3 27.3 7.7 33.3 71 Marta parente 1. 33.3 11.1 70 Lyciam showii Roem. and Schult. 14.3 27.3 6.2 4.0 33.3 11.1 71 Marta parente 1. 33.3 11.1 33.3 11.1 71 Marta parente fores A. 28.6 10.0 12.5 33.3 73 Marta parente fores A. 28.6 10.0 33.3 11.1 71 Marta parenta fores A. 27.3 46.2 22.2 22.2 73 Toria transki fores A. Soch. 11.1 7.5 11.1 71 Narra's transki fores A. Soch. 13.3 13.3 13.3 71 Narra's transki fores A. Soch. 13.3 13.3 13.3 71 Narra's transki fores A. Soch. 13.				27.3	15.4					
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70 Lyckinn shawi Roem, and Schut. 14.3 27.3 7.7 33.3 71 Marka portifiera L. 27.3 46.2 33.3 11.1 72 Merch long/fold (L) Huds. 27.3 12.5 33.3 11.1 73 Merch long/fold (L) Huds. 27.3 12.5 33.3 13.3 74 Moltkings gravedem (Forsk.) I. M. Johnst. 28.8 50.0 33.3 31.1 75 Moretin adminiful Delbip DC. 27.3 46.2 22.2 22.2 70 Olgemeris Infolda (Vah) J.F. Mach. 13.4 11.1 11.1 11.1 76 Parietzin adminiful Delbie 15.4 11.1 11.1 76 Parietzin adminiful Delbie 12.5 22.2 22.2 76 Pronzychia arbite adminiful Delbie 12.5 22.2 11.1 77 Parietzin Comentus L. 14.3 11.1 11.1 78 Pronzychia arbite adminiful Delbie 11.1 11.1 11.1 78 Pronzychia arbite adminiful Delbie 12.5 22.2 22.2 78 Pronzychia				27.3			27.5			
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73 Mescenbry/ministraming forsekatil Inchest. 28.6 10.0 1.2.5 33.3 33.3 74 Motkings citual (Forssk) 1 M. Johnst. 27.3 28.5 5.0 33.3 11.1 75 Morettia philacanea (Delile) DC. 28.5 5.0 33.3 11.1 76 Narptias graveolas (Forssk) Niklund 23.8 31.1 11.1 76 Orkindems baccanus Delile 27.3 46.2 22.2 76 Orkindems baccanus Delile 15.4 11.1 78 Parietaria abinfolia Delile 15.4 11.1 78 Parietaria abinfolia Delile 16.2 22.2 78 Paronychia destortriam Boiss. 18.2 11.1 78 Paronychia destortriam Boiss. 18.2 11.1 79 Paratoga obicas L 10.0 23.5 33.8 70 Plantago orpholic Boiss. 10.0 37.5 22.2 78 Plantago orpholic Boiss. 10.0 37.5 11.1 79 Plantago orpholic Boiss.				27.5	40.2		4.0	33.3		
74 Molkkopsis cititata (Forsk.) I.M. Johnst. 27.3 11.1 75 Moretin philacan (Chellie) DC. 38.5 5.0 33.3 13.3 76 Nargins gravelens (Forsk.) Wikhund 23.8 11.1 11.1 78 Ochrademus baccatus Dellie 27.3 46.2 22.2 79 Oligomeris lanifolia (Valii) J.F. Macbr. 27.3 46.2 11.1 78 Paretin adsinfolia Dellie 15.4 11.1 79 Oligomeris lanifolia (Valii) J.F. Macbr. 23.8 37.5 33.3 33.3 80 Paretin adsinfolia Dellie 15.4 11.1 11.1 81 Parenychia arabica (L.) DC. 23.8 37.5 33.3 33.3 82 Parotychia developtiom Boiss. 10.0 37.5 22.2 11.1 85 Phoenis dactylifera L. 10.0 37.5 33.8 22.2 91 Polynogom monspeliensis (Cav) Trinces Steud 10.0 37.5 33.8 22.2 91 Polynogom monspeliensis (L.) Desf. 37.5 11.1 11.1 92 Polycona primoso Dellie			28.6	10.0			12.5			
76 Namping provolous (Forsak.) Walkind 23.8 11.1 78 Outgradenus haccoans Delile 27.3 46.2 22.2 79 Oligomeris inifolia (Vali) J.F. Macbr. 37.5 11.1 81 Paronychia actorizam Boiss. 12.3 37.5 33.3 33.3 82 Paronychia desorizam Boiss. 18.2 7.7 22.2 37.5 33.3 33.3 83 Pennischia desorizam Boiss. 18.2 11.1 12.5 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 22.2 21.1 11.1 25.5 33.8 22.2.2 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1	74			27.3						11.1
77Nitrair tensor (Forsk). Asch. 33.3 11.1 77 Objeomeris linifolia (Vahl) J.F. Macbr. 37.5 11.1 80 Parietaria alsinifolia Delile 15.4 11.1 81 Paromychia arobica (L) DC. 23.8 37.5 33.3 81 Paromychia arobica (L) DC. 23.8 37.5 33.3 82 Persitentia dising (L) F. Gmel.) Herard 42.9 7.7 22.2 84 Pergularia tomentusa L. 14.3 11.1 87 Pergularia tomentusa L. 10.0 37.5 22.2 86 Phoentik daerliffera L. 10.0 37.5 22.2 87 Plantago arbitras L. 10.0 37.5 11.1 97 Plantago arbitras L. 10.0 37.5 11.1 98 Plantago arbitras L. 10.0 37.5 11.1 99 Polygogan mappelienska (L), Desf. 37.5 11.1 91 Polygogan mappelienska (L), Desf. 37.5 11.1 97 Reised arphinosa Delile 23.8 11.1 98 Rume verivarine L. 27.3 7.0 33.3 99 Saloal inbricata subsp. gaenula (Maire) Boulus 7.7 2.5 31.4 97 Rum reparation Olive 42.9 45.5 5.4 25.0 22.2 100 Sarigary parvinou (Delile) Webb 36.4 11.1 11.1 100 Sarigary parvinou (Delile) Webb 36.4 11.1 105 Seneti flama (Guss) Boiss.	75	Morettia philaeana (Delile) DC.			38.5		5.0	33.3		33.3
78 Ochradenus baccatus Delile 27.3 46.2 22.2 70 Offgomus finifold (Whih J.F. Mucht. 37.5 33.3 33.3 81 Paronychia arabica (L.) DC. 23.8 37.5 33.3 33.3 82 Paronychia desorrorium Boiss. 18.2 11.1 83 Paronychia desorrorium Boiss. 18.2 11.1 84 Perguiatri tamentus L. 14.3 11.1 85 Phonix dactylifera L. 10.0 37.5 22.2 87 Plattago albicas L. 10.0 37.5 22.2 87 Plattago arbicas Se Boiss. 10.0 37.5 11.1 89 Plattago arbicas L. 10.0 37.5 11.1 90 Polypogno marguicityfora Sn. 2.5 33.8 22.2 91 Polypogno marguicityfora Sn. 2.5 15.4 22.2 92 Portuca olaraca L. 37.5 11.1 93 Pulcaria undulata (L.) C.A. Mey. 45.5 15.4 23.8 94 Reschardta tingtima (L.) Roth 14.3 11.1 95 Robas olaria undulata (L.) C.A. Mey. 27.3 7.5.0 33.3 95 Robas olaria undulata (L.) C.A. Mey. 27.3 7.5.1					23.8					
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80 Paricuria disinglifia Dellie 15.4 11.1 81 Paronychia arabica (L.) DC. 23.8 37.5 33.3 33.3 82 Paronychia deisortorium Boiss. 18.2 11.1 83 Permisterium divisum (J.F. Gmel.) Henrard 42.9 7.7 22.2 84 Perguineria untentina L. 1.3 11.1 85 Phoneix dactylifera L. 1.0 12.5 22.2 87 Patatogo ablicas L. 1.0 12.5 22.2 88 Plantago orbits alst Silforme Sm. 10.0 37.5 22.2 91 Polygonam onspeleirus (L.) Dest. 37.5 11.1 92 Polygonam onspeleirus (L.) Dest. 37.5 11.1 93 Pulicaria undulata (L.) C.M. Mey. 45.5 15.4 22.0 94 Reindrafu miginana (L.) Roth 14.3 11.1 11.1 95 Reischardia tingitana (L.) C.M. Mey. 27.3 7.5.0 33.3 33.3 97 Rhus tripartia (Ueria) Grande 27.3 7.5.0 33.3 33.3 98 Salobia inbricatas ubsp. geatula (Maire) B				27.3		46.2				
81 Paronychia desortorium Boiss. 23.8 37.5 33.3 33.3 82 Paronychia desortorium Boiss. 18.2 11.1 84 Pergularia tomentusa L. 14.3 11.1 87 Phonemistica dactylifera L. 10.0 12.5 22.2 86 Phonganites austrafis (Cav.) Trinex Steud 75.0 11.1 11.1 87 Plantago othicans L. 10.0 37.5 22.2 88 Plantago othicans L. 10.0 37.5 11.1 99 Polysogon mongelefensis (L.) Dest. 37.5 11.1 91 Polynogon mongelefensis (L.) Dest. 37.5 11.1 92 Portulace oleracea L. 37.5 11.1 93 Pullicaria undulata (L.) CA. Mey. 45.5 15.4 22.2 94 Reichardia tingtiana (L.) Roth 14.3 11.1 11.1 95 Resoda pruinosa Delile 23.8 11.1 11.1 95 Robio inbrietat subp. genetial (Maire) Boulus 7.7 2.5 22.2 96 Runtex vesicarias L. 11.1 11.1 11.1					15.4		37.5			
82 Paranychia desorariam Boiss. 18.2 11.1 83 Permiseum divisam (J.F. Gmcl.) Henrard 42.9 7.7 22.2 84 Pergularia tomentusa L. 14.3 11.1 85 Phoenix dact/lifera L. 1.0 12.5 22.2 84 Pergularia tomentusa L. 1.0 12.5 22.2 87 Plantago atta tomentusa L. 10.0 37.5 22.2 87 Plantago atta forssk. 10.0 37.5 22.2 87 Plantago atta Forssk. 40.0 11.1 89 Polyogon monspeliensis (L.) Desf. 37.5 11.1 91 Polyogon monspeliensis (L.) Desf. 37.5 11.1 92 Partulaca oleracea L. 37.5 11.1 93 Pulicaria undulata (L.) C.A. Mey. 45.5 15.4 22.0 94 Reichardia tingitana (L.) Roth 14.3 11.1 95 Rutarum equastifica (Maire) Boulus 7.7 2.5 22.2 98 Rumex vesicarius L. 27.3 7.50 33.3 33.3 99 Saliola intridra Multa		0					27.5	22.2		
83 Perniserum divisum (J.F. Gmel.) Henrard 42.9 7.7 22.2 84 Pergularia tomentusa L. 14.3 11.1 87 Pheneix dacriffera L. 1.0 12.5 22.2 88 Phragmites australis (Cav.) Trinex Steud 7.0 11.1 12.5 22.2 88 Plantage origo ablicens L. 10.0 37.5 22.2 89 Plantage origo origo Forsk. 10.0 37.5 11.1 90 Polygonum equisetiforme Sm. 2.5 33.8 22.2 91 Polygonum equisetiforme Sm. 2.5 13.4 22.2 92 Portulace oleraced L. 37.5 11.1 93 Publicaria undiatata (L.) Desf. 37.5 11.1 94 Reichardia inigitama (L.) Roth 14.3 23.8 22.0 94 Reichardia inigitama subsp. gaetula (Maire) Boulus 7.7 2.5 22.2 98 Salsa imbricata subsp. gaetula (Maire) Boulus 7.7 2.5 22.2 98 Salsa imbricata subsp. gaetula (Maire) Boulus 7.7 2.5 22.2 99 Salsa imbrica				18.2	23.0		57.5	55.5		
84 Pergularia tomentasa L. 14.3 1.1 85 Phoenix dactylifera L. 1.0 12.5 22.2 86 Prizagniles australis (Cav.) Trinex Steud 75.0 11.1 87 Plantago citysiofes Boiss. 10.0 37.5 22.2 87 Plantago citysiofes Boiss. 10.0 37.5 11.1 89 Plantago citysiofes Boiss. 10.0 37.5 11.1 90 Polygoon monspellensis (L.) Desf. 37.5 11.1 91 Polygoon monspellensis (L.) CA. Mey. 45.5 15.4 22.2 94 Reichardia tingitana (L.) Roth 14.3 11.1 22.5 33.3 97 Rhus tripartita (Ucia) Grande 27.3 75.0 33.3 33.3 97 Rhus tripartita (Ucia) Grande 27.3 75.0 33.3 33.3 98 Rumex vesicarias L. 27.3 75.0 33.3 33.3 98 Rumex performating Ubile) Webb 36.4 11.1 11.1 105 Serue o glacus (Ubecne, Sch. Bip. 2.5 11.1 11.1 105					7.7					
85 Phomix decrylifera L. 1.0 12.5 22.2 86 Phragnites australis (Cav.) Tin.ex Steud 75.0 11.1 87 Plantago albicans L. 10.0 37.5 22.2 88 Plantago outs forssk. 10.0 11.1 90 Polypogon monspectensis (L.) Desf. 2.5 33.8 22.2 91 Polypogon monspectensis (L.) Desf. 37.5 11.1 92 Portulaca oleracea L. 37.5 11.1 93 Pulticaria undulata (L.) C.A. Mey. 45.5 15.4 22.2 94 Reichardia trigtinano (L.) Roth 14.3 11.1 11.1 95 Rescha prainosa Delile 27.3 75.0 33.3 33.3 97 Runex vesicarius L. 27.3 75.0 33.3 33.3 97 Raise insbirbardus subsp. gentula (Maire) Boulus 7.7 2.5 11.1 105 Senecio glaucus subsp. coronopifolius (Maire) C. Alexander 10.0 35.8 22.2 108 Silen initica wiris (L.) Thell. 28.6 11.1 11.1 105 Senecio glaucus subsp			14.3	12.9	,.,					
86 Phragmits (Cav.) Trin.ex Steud 75.0 11.1 87 Plantago adbicans L. 10.0 37.5 22.2 87 Plantago ortysoldes Boiss. 10.0 11.1 89 Plantago ortysoldes Boiss. 10.0 11.1 89 Plantago ortat Forssk. 40.0 11.1 89 Polypogon monspelensis (L.) Desf. 37.5 11.1 97 Polypogon monspelensis (L.) Desf. 37.5 11.1 98 Polypogon monspelensis (L.) CA. Mey. 45.5 15.4 22.2 94 Reichardia tingitana (L.) Roth 14.3 11.1 11.1 95 Resed pruinosa Debile 23.8 11.1 96 Rhantarum epaposum Olive 42.9 45.5 15.4 25.0 22.2 98 Rumex vesicarius L. 27.3 75.0 33.3 33.3 33.3 99 Salsola imbricata subsp. genenia (Maire) Boulus 7.7 2.5 11.1 101 Scherein farus (Decne.) Sch.Bip. 2.5 11.1 102 Senecio glaucus subsp. coronopfolius (Maire) C. Alexander 7.7 11.1<							12.5			
88 Planago crypsoides Boiss. 10.0 11.1 89 Plantago ovata Forssk. 40.0 11.1 89 Polypogon monspeliensis (L.) Desf. 37.5 33.8 22.2 91 Polypogon monspeliensis (L.) Desf. 37.5 11.1 92 Portulaca oleracea L. 37.5 11.1 93 Pulicaria undiulta (L.) CA. Mey. 45.5 15.4 22.2 94 Reichardia tingitama (L.) Roth 14.3 11.1 95 Resed pruinosa Delile 23.8 11.1 96 Rhantarum epaposam Olive 42.9 45.5 15.4 25.0 22.2 98 Runex vesicarius L. 27.3 75.0 33.3 33.3 99 Salsola imbricata subsp. gaetula (Maire) Boulus 7.7 2.5 22.2 101 Schismus barbatus (L.) Thell. 28.6 11.1 11 101 Schismus barbatus (L.) Thell. 28.6 11.1 11 103 Senecio glaucus subsp. coronopifolius (Maire) C. Alexander 10.0 37.5 11.1 105 Stetaria verticillata (L.) P. Beauv.		Phragmites australis (Cav.) Trin.ex Steud								
89 Plantago ovita Forsk. 40.0 11.1 90 Polygoum equisetiforme Sn. 2.5 33.8 22.2 1 Polygoum equisetiforme Sn. 37.5 11.1 92 Polygoum mongelinesis (L.) Desf. 37.5 11.1 93 Pulicaria undulata (L.) CA. Mey. 45.5 15.4 22.2 4 Reichardia ingitana (L.) Roth 14.3 11.1 95 Reseda prainosa Delile 23.8 11.1 96 Rhatrarum equasosam Olive 42.9 45.5 15.4 25.0 22.2 98 Rules triparitia (Ucria) Grande 15.4 25.0 22.2 22 99 Saloia inbricata subsp. gaetula (Maire) Boulus 7.7 2.5 21.1 11 101 Schiegnaya parvilora (Delile) Webb 36.4 11.1 11 102 Senecio flarus (Decne.) Sch.Bip. 2.5 11.1 103 Selencia viridis (L.) P.Beauv. 37.5 11.1 104 Setaria viridis (L.) P.Beauv. 37.5 11.1 105 Setaria viridis (L.) P.Beauv. 37.5 11.1	87	Plantago albicans L.		10.0			37.5			22.2
90 Polygonum equiseitforme Sm. 2.5 33.8 22.2 91 Polypogon monxpellensis (L.) Desf. 37.5 11.1 92 Portulaca oleracea L. 37.5 11.1 93 Pulicaria undulata (L.) CA. Mey. 45.5 15.4 22.2 94 Reichardia tingitana (L.) Roth 14.3 11.1 22.2 94 Reichardia tingitana (L.) Roth 14.3 11.1 96 Rhontarum epaposum Olive 42.9 45.5 15.4 23.0 97 Rhunex vesicarius L. 27.3 75.0 33.3 33.3 97 Ramex vesicarius L. 27.3 75.0 33.3 33.3 98 Salsola imbricata subsp. gaetula (Maire) Boulus 7.7 2.5 22.2 100 Sarignya parvilora (Decine, Sch.Bip. 2.5 11.1 101 Schismus barbarus (L.) Thell. 28.6 11.1 102 Senecio flacus usbps, coronopifolius (Maire) C. Alexander 10.0 35.8 22.2 104 Seneric Wirklis (L.) P. Beauv. 37.5 11.1 11.1 105 Setaria vericiill				10.0						
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94Reichardia tingitana (L.) Rot14.311.195Reseda pruinosa Delile23.811.196Rhuntarum epaposum Olive42.945.515.433.397Rhus tripartia (Ucria) Grande15.425.022.298Rumex vesicarius L.27.375.033.333.399Salsola imbricata subsp. gaetula (Maire) Boulus7.72.522.2100Savignya parulora (Delile) Webb36.411.1111Senecio flavus (Decne.) Sch.Bip.2.511.1102Senecio glaucus subsp. coronopifolius (Maire) C. Alexander10.035.822.2104Senna italica Mill.7.711.111.1105Setaria verticillata (L.) P.Beauv.37.511.1106Setaria viridis (L.) P.Beauv.37.511.1107Silene linearis Decne.12.511.1108Silene villosa Forsk.33.311.1109Sitypa capensis Thunb.42.910.022.2114Tamarix nilotica (Ehrenb.) Bunge1.011.1115Telephium sphaerospernum Boiss.33.311.1116Thenedia trindar Forssk.7.740.022.2117Tribudus terrestris L.7.711.1118Trichodesma africanum (L.) R. Br.23.812.522.2119Trigourospernum auriculatum (Boiss.) Rech.f.10.011.1122Zila spinosa (L.) Prantl10.02.511.1123 <td></td> <td></td> <td></td> <td>45.5</td> <td>15.4</td> <td></td> <td>37.5</td> <td></td> <td></td> <td></td>				45.5	15.4		37.5			
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 Table 2
 Life form spectra of the recorded species in the study area according to Raunkiaer's (1937) classification.

Life form	No. of species	% of collected species		
Therophytes	61	49.20		
Chamaephytes	36	29.00		
Hemicryptophytes	14	11.29		
Phanerophytes and	11	8.87		
Nano-phanerophytes				
Hydrophytes and Helophytes	1	0.80		
Geophytes	1	0.80		

Table 3	The chronological analysis of the collected species
according	to Wickens (1978) and Zohary (1983).

Number of species	Percentage
29	23.4
25	20.2
2	1.62
1	0.81
1	0.81
48	38.7
4	3.22
7	5.65
29	23.4
5	4.23
3	2.42
5	4.23
11	8.87
28	22.58
	29 25 2 1 1 48 4 7 29 5 3 5 11

system in the Hail regions is general arid to extra arid. It is influenced by two main pressures, namely Siberian high in winter and tropical low in summer months. According to the records of Hail metrological station for the period 1998-2006, the study area is characterized by a mean minimum temperature of 10.8 °C in January and a mean maximum temperature of 34.1 °C in August with an annual mean temperature of 25.6 °C. The rainfall in the region is erratic and irregular; it is mainly winter fall, the high precipitation occurs in November (32.0 mm/day) and the average annual rainfall is 104.4 mm/day, however in the summer months no rain has been detected. The relative humidity is extremely low in summer as it reached 15.0% in July and relatively high January (53.0%); the mean annual average is 31.0%. The average annual wind velocity in the study area is 68.4 km/h and the mean number of stormy days may reach 25 per year, storms are more frequent in the spring from the North East direction. The rate of evaporation in the area is generally low; it ranges between 6.6 mm in January and 8.7 mm in November.

3. Materials and methods

Nineteen sites in the study region, representing different habitats, were regularly visited from October 2005 to May 2007. These sites are in or around Hail town, Ugdah, El-Nafud, Gebel Aja and Jubba (Fig. 1B). In each site, 2–5 stands were randomly selected for this investigation. In each stand; quadrates of $10 \times 10 \text{ m}^2$ in the desert area were used. In the urban and cultivated plots areas quadrates of $5 \times 5 \text{ m}^2$ and $1 \times 1 \text{ m}^2$ were respectively, used. Cover, abundance and presence values of the specie were calculated in the examined quadrates. The collected plant specimens were identified and named according to Collenette (1999), Cope (1985) Mighaid (1996) and Chaudhary

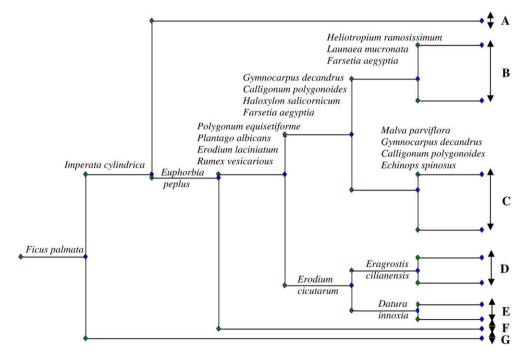


Figure 2 The dendrogram illustrating the presence of seven vegetation groups using TWINSPAN analysis of 57 sampled stands in the study area.

(1999, 2000, 2001). Voucher specimens are deposited in the Science Department, Faculty of Science, Hail University.

A floristic data matrix of the 57 stands and 124 species was prepared after the removal of more than unicate species occurring at a single stand. A chronological analysis of the floristic categories of species was made to assign the recorded species to World geographical groups according to Wickens (1978) and Zohary (1983). For the vegetation analysis, the two way indicator species analysis (TWINISPAN; Hill, 1979) based on species with frequency of more than 5% in at least two sites in the study area. In addition, the Detrended Correspondence Analysis (DCA), which is an indirect gradient analysis technique that plots sites against axes, based on species composition

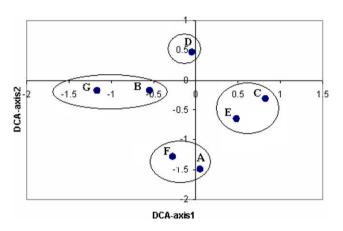


Figure 3 DCA ordination of the seven vegetation groups identified using TWINSPAN analysis of the 57 sampled stands in the study area.

and abundance was employed using the CANOCO software version 3.12 (Ter Braak, 1994) was also used for classification and ordination of plant vegetation. Both types of vegetation analysis were conducted using the CAP (2002) Community Analysis Package. In addition, species richness (alpha diversity) was calculated as the average number of species per site in the study area and species diversity, that measures the species turnover between different areas, was determined according to Magurran (2003). According to Magurran (2003) also, the Shanon-Wiener and Simpson indices were also calculated, in addition to these indices, the recurrence index that reflects species distribution in the different habitats in the study area in five groups was also calculated.

4. Results

The final list of 124 species that were recorded in at least two sites in the study area, represent 34 families of flowering plants (Table 1); 15 families are only represented by one species; examples include Acanthaceae, Convolvulaceae, Moraceae, Nyctaginaceae and Primulaceae. The large family Compositae (Asteraceae) is represented by 21 species while the grass family Graminae (Poaceae) and Cruciferae (Brassicaceae) are represented by 17 and 10 species, respectively. The life form spectra of the recorded species in the study area according to Raunkiaer's (1937) classification are given in Table 2. The therophytes are the dominating life form in the study area amounting to 49.20% of the collected species. Chamaephytes were represented by 36 species (29.00% of the total species) while hemicryptophytes were represented by 14 species (11.29% of the total species). Geophytes and Hydrophytes are each represented by only one species (Asphodelus tenuifolius and Phragmites australis), respectively.

Table 4 Characteristics of the seven vegetation groups derived after the application of TWINSPAN on the 57 stands in Hail area. VG: vegetation group; N: number of stands; NS: number of species per group; RU: ruderals, CP: cultivated plots, WA: wadies, MA: mountainous area and SD: sand dunes.

VG	Ν	NS	Habita	ts				Species richness	Shannon index	Simpson index
			RU	СР	WA	MA	SD			
A	3	3	100					3.0	1.1	3.0
В	19	57			100	54.5		16.2	6.2	41.7
С	18	63	30.8		73.8	15.4	80	15.5	6.0	45.6
D	8	52	37.5	62.5				15.8	3.5	26.0
Е	5	19	100					8.8	2.5	11.8
F	3	2	100					2.0	0.7	2.0
G	2	3			100			2.5	0.8	2.1

Table 5 A list of the two most dominant species in the seven TWINSPAN groups and the percentage of their presence (P) in the sites of the study area (species).

VG.	1st Dominant	P (%)	2nd Dominant	P (%)
A	Phragmites australis	100	Imperata cylindrica	100
В	Launaea mucronata	85.7	Trigonella stellata	57.1
С	Gymnocarpos decandrus	53.8	Ochradenus baccatus	42.6
D	Plantago albicans	75	Rumex vesicarius	75
Е	Senecio glaucus subsp. coronopifolius	35.8	Polygonum equisetiforme	33.8
F	Euphorbia peplus	100	Sisymbrium irio	100
G	Ficus palmata	100	Fagonia bruguieri	100

The chronological analysis of species in the study area (Table 3) revealed that mono-regional species representing 23.4% of the total species. The Sahro-Sindian elements are dominating as mono-regional elements with a species number of 25 representing 20.2% of the total species. Bi-regional elements amount to 48 species representing 38.7% of total number of species; the Sahro-Sindian and the Sudano-Zambezian elements together are represented by 29 species that represent 23.4% of the total species. Meanwhile pluri-regional elements are presented by 28 species representing 22.58% of the total species. The floristic composition of the study area also includes 11 Cosmopolitan species, 5 pantropic species and three Palaeotropic species (Table 3).

The application of TWINSPAN on the cover and presence estimates of the 124 species, recorded in the 57 sampled stands, in the Hail region indicated the recognition of seven vegetation groups (Fig. 2). The application of DCA on the same set of data indicated a reasonable aggregation of these groups along the ordination plane of axes 1 and 2 (Fig. 3). The characteristics of these seven vegetation groups and the presence and number of species per each group and their vegetation type are given in Table 4; this table also includes the values of species richness, Shanon's index and Simpson's index. The two most common species in each group and the percentage of their occurrence in the seven groups are listed in Table 5. Two groups have been found most common in the ruderal habitats, these are groups A and F dominated by P. australis, Imperata cylindrical (A) and Euphorbia peplus and Sisymbrium irio (F), respectively. Two other vegetation groups (B and G) have been recognized in the mountains and slopes dominated by Launaea mucronata and Trigonella stellata (B) and Ficus palmate and Fagonia bruguieri (G). The species in the two groups (C and D) inhabit the desert and mountainous wadies; these are represented by Gymnocarpos decandrus and Ochradenus baccatus (C) and Plantago albicans and Rumex vesicarius (D). On the other hand, one group (E) inhabits the cultivated plots and is represented by Senecio glaucus subsp. coronopifolius and Polygonum equisetiforme. Group B has the highest number of species (52) as well as the highest value of species richness (16.2) as well as the highest Simpson's index (45.6). The two groups C and D also have high values for species rich-

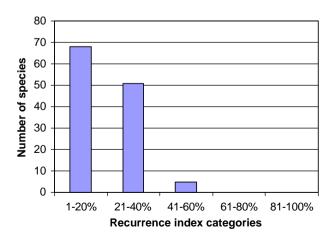


Figure 4 Histogram illustrating the recurrence index distribution of the species collected from the different habitats in the study area of Hail region.

ness, and the Shanon's and Simpson's indices. On the other hand, the groups A, F and G have the low diversity index and also low values for the Shanon's and Simpson's indices (see Tables 4 and 5).

Fig. 4 illustrates the recurrence index distribution of the species from the different habitats in the study area. The highest number of species is 68 in the category 1–20% followed by 51 species in the category 21–40% and only five species in the category 41–60%. However, no species have been assigned to the two categories 61–80% and 80–100%. From this figure, it may be observed that the widely distributed species i.e. species present in all habitats are not represented in these two categories. The presence of the highest number of species (68) in the category 1–20% recurrence index indicates that the majority of species in the study area are restricted to one habitat. Examples of these species include *Abutilon pannosum* (Group B), *Aerva javanica* (Group C), *Amaranthus lividus* (Group E), *Alternanthera sessilis* (Group E) and *Ficus palmata* (group G).

5. Discussion and conclusions

The floristic composition and vegetation features in the Hail area were studied for two years. The floristic composition analysis showed that the family Asteraceae, which is the largest family of angiosperms, is represented by the highest number of species, in the study area. Another large family; the Poaceae is represented by 17 species and the Brassicaceae is represented by 10 species. Meanwhile, 15 families including Primulaceae, Acanthaceae, Convolvulaceae, Moraceae and Nyctaginaceae, are represented by a single species each. A floristic analysis shows that majority of plants in the study area are annuals while the minority group is in the tree. The dominance of members of Asteraceae, Poaceae and Brassicaceae coincides with the findings reported by Al-Turki and Al-Olavan (2003), the only detailed study available on the Flora of Hail region. The most common genera are Euphorbia (Euphorbia), Heliotropium (Boraginaceae) and Plantago (Plantaginaceae) with three species for each family. In the Al-Turki and Al-Olayan (2003) study, Plantago and Astragalus (Fabaceae) were the most common genera in the whole region of Hail.

A number of species from the study area have been identified by Al-Turki and Al-Olayan (2003) as endemic-endangered, such as *Anthemis sheilae* A Ghaloor and TA Al-Turki, *Arabidopsis erysimoides* Hedge and Kit, *Astragalus collenettiae* Hedge and Podl. and *Trisetan'a chaudharyana* Scholz Meanwhile other species such as *Echinops glaberrimus* DC, *E. hystrichoides* Kit Tan, *Ochradenus arahicus* Chaudhary Hille and A.G Miller and *Zygophyllum propinquum Decne.* ssp. *migahidii* (Hadidi) J.'Ibomas and Chaudhary were classified as endemic to Saudi Arabia. However, these species were not encountered in our survey as they are rare and grow only in the region's mountains that house the endemic and rare species, which are often not encountered in ecological studies based on collecting plants from fixed stands in fixed sites in the study area.

The biological spectrum of the study area indicates the prevailing of therophytes (49.2%) and chaemophytes (29.0%). These results also coincide with the findings of Al-Turki and Al-Olayan (2003). The higher number of species recorded in their report might be due to the larger area covered in their survey. The domination of therophytes and chaemophytes in the vegetation spectra of Hail also agrees with the spectra of vegetation in deserts and semi-desert habitats in other parts of Saudi Arabia as described by some other authors (e.g. Abd-El-Ghani, 1997; Fahmy and Hassan, 2005). This picture is also congruent with the vegetation spectra in other parts of the Middle East (Danin and Orchan, 1990; Zahran and Willis, 1992; El-Bana and Al-Mathnani, 2009).

These results showed that Hail region comprises diverse ecosystems and presents very interesting aspects for vegetation studies. The application of TWINSPAN classification techniques to the vegetation data produced seven groups and the application of DECORANA to the same data showed resemblances among some of these groups. The two groups A and F, which covers the moist and ruderal areas as indicated by the domination of P. australis-Imperata cylindrica (A), and E. peplus-S. irio (F), whereas the group E comprises 19 species and characterizes the urban areas in Hail town that includes the species S. glaucus subsp. coronopifolius and P. equisetiforme. Meanwhile, the species in group C, which comprises species dominated by G. decandrus and O. baccatus, as indicator species, are characteristic of the desert plains in the An-Nafud desert coinciding with the results reported by Chaudhary (1983).

The vegetation group B dominated by L. mucronata, T. stellata and group C dominated by G. decandrus and O. baccatus, comprise higher numbers of species (40 and 49, respectively) and together include the most widely distributed elements in the study area. However, group D comprises the highest number of species (52) dominated by P. albicans and R. vesicarius as weedy dominant species for the cultivated plots. This group also includes several intrusive weeds such as Avena fatua, Chenopodium murale, Convolvulus arvensis, Lolium perenne and Polypogon monospeliensis and ruderal elements such as Aizoon canariensis, Anagalis arvensis, P. australis and Salsola imbricata. The elements of this vegetation group show abundance of the introduced ruderal elements and weeds of cultivated plots and indicate the increasing agriculture development in the Hail region.

The two groups B (*L. mucronata–T. stellata*) and G (*F. palmata–F. bruguieri*) characterize the Mountainous areas of Hail region. Group G comprises 40 species that are more common in the mountains slope; *L. mucronata* and *T. stellata* are associated with *Artemisia judaica, Euphorbia retusa, Lycium shawii, Pennisetum divisum, Rhantarum epaposum* and *Stipa capensis* to form the dominant vegetation elements in the mountain slopes. On the other hand, group G comprises only six species; *F. palmata* and *F. bruguieri* are associated with *Ephedra alata* and *Rhus tripartita* and characterize the mountains. These results also agree with the reports of Chaudhary (1983) and add to the contribution to the: Hail Flora as reported by Al-Turki and Al-Olayan (2003).

A glimpse on the floristic composition of these two groups indicates the need to consider the Aja Mountains and their wadies in Hail as a protected area. This area provides all the supplements for the conservation on natural vegetation in a region exposed to increasing agricultural activities. During the past five decades, extensive human activities (livestock grazing, fuel wood cutting and temporary arid land cultivation) have put great pressure on vegetation in all regions of Saudi Arabia and lead to vegetation change. The results of the present study point out the need for further studies on the diverse and changing vegetation of the Hail region. This paper also points out the need for managerial practices to conserve plant diversity in Saudi Arabia.

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