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Flora, Life-forms and Biological Spectrum of Muscat Governorate

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ABSTRACT: The present study evaluated the floristic diversity and biological spectrum of Muscat Governorate, Sultanate of Oman. Heterogeneity of geology, topography and climatic conditions create a diverse array of habitats across the 3,500 km^2 study area, supporting a range of vegetation types. Floristic studies were conducted across 42 sites spread across various habitats such as sand dunes, alluvial plains, gravel plains, wadis, saline dunes, coastal areas, farms and plantations. A total of 264 species belonging to 183 genera and 54 families of angiosperm were documented during sampling the vegetation from different wilayats of the Governorate. Maximum number of species belonged to family Fabaceae (14%), followed by Poaceae (12%), Asteraceae (9%), Apocyanaceae and Convolvulaceae (3.66% each), Boraginaceae, Euphorbiaceae, Zygophylaceae (3% each). The biological spectrum was represented almost equally by therophytes and chamaephytes (30% each), followed by phanerophytes (19%), hemicryptophytes (13%), geophytes (4%), liana (3%), and helophytes (1%). The dominance of therophytes and chamaephytes reveals a thero-chamaephytic phytoclimate for the area. Different habitats are characterized by specific plant assemblages, but some species such as Acacia tortilis, Prosopis cineraria, Tetraena quaterense, Dipterygium gluacum, Aerva javanica, due to their broad ecological tolerance and adaptations, inhabit more than one habitats, while some species are just confined to certain parts of a single habitat.

Keywords: Biological spectrum, Flora, Habitats, Phytoclimate.

الحياة النباتية والطيف البيولوجي لمحافظة مسقط

نيلام شروني

الملخص: هذه الدراسة لتقييم تنوع الحياة النباتية والطيف البيولوجي لمحافظة مسقط ، سلطنة عمان، إن عدم التجانس الجيولوجي وإختلاف سمات سطح الأرض وإختلاف المناخ خلق مجموعة متنوعة من المناطق الطبيعية لمجموعة متنوعة من أنواع النباتات المختلفة في منطقة الدراسة التي امتدت إلى 3500 كلم مربع. لقد تمت دراسة النباتات في 42 موقع بيئي مختلف كالكثبان الرملية ، الكثبان المالحة، المناطق الساحلية والمزارع. وتم رصد 264 نوع من النباتات تنتمي إلى 183 جنس و 54 عائلة من النباتات كاسيات البذور في مختلف ولايات محافظة مسقط. لخصت الدراسة إلى أن أكثر أنواع النباتات تنتمي إلى العائلة البقولية (14%) تتبعها العائلة النجيلية (12%)، العائلة الإستراسيا (9%)، العائلة الدفلية (3.66%)، العائلة المحمودية (3.66%)، العائلة الحمحمية، العائلة الغربيونية والعائلة القديسية (3% لكل عائلة). إن الطيف البيولوجي تمثل تقريبا بالتساوي ما بين (30%) Therophytes و (30%) Chamaephytes ويلي ذلك (19%) Phanerophytes و (13%) Hemicryptophytes و (4%) Geophytes و (3%) Liana و (1%) Helophytes. إن هيمنه therophytes و Chamaephytes تعكس هيمنة هذه المجموعة على المنطقة. إن الموائد (الموطن الطبيعي) المختلفة تتميز بتجميع نباتات محددة إلا أن بعض الأنواع كـ Acacia tortilis و Proposis cineraria و Tetraena quaterense و Dipterygium gluacum و Aerva Javanica تستوطن مناطق مختلفة نسبة لقدرتها على التحمل و التكيف البيئي في حين إن هذه الخاصية لا تتوفر لبعض الأنواع التي تتقيد ببيئة محددة.

الكلمات المفتاحية: الطيف البيولوجي، تنوع النباتات، الموطن الطبيعي و المناخ النباتي.

1. Introduction

Located in the northeast corner of Oman, along the coast running north of the Hajar mountain range, Muscat is the capital city of Oman. Muscat features hot and arid climatic conditions with an average annual rainfall of about 100 millimetres per year [1]. Spanning across an area of 3,500 km^2, Muscat Governorate is comprised of six provinces called wilayats, namely Muttrah, Bawshar, Seeb, Al Amerat, Muscat and Quriyat. Different type of rocks and sediments makes the surface geology of Muscat governorate, which are mixture of samail ophiolite, carbonates, limestones and tertiary sandstones.

The surface sediment materials in general, are dense mixture of clay, gravel, silt, sand, and rock fragments [2,3]. Heterogeneity of geology, topography and climatic conditions create a diverse array of habitats ranging from mud flats, saline dunes, sabkhas, Khawrs, sand dunes, alluvial plains, gravel plains, wadis and Khabrah supporting a range of vegetation types.

Generally, the floristic composition of a region and the biological spectrum, which is the percent representation of the number of species belonging to each life form [4], is influenced by the climate and nature of the substrate material [5] and their distribution is closely associated with the topography of the region [6]. The life forms are manifestations of the total adaptation of their perennating organs [7], and has evolved as a direct response to the prevailing environment [8-10], and are representations of flora adaptations to specific ecological conditions [11] and act as an indicator of nature of existing environmental conditions [12,13]. According to life form's system [7], the harsher the climatic conditions, the more protected are the renewing buds. Arid zones represent harsh environmental conditions [14] and in these extreme habitats, the biological spectrum shifts towards the more protected life-form classes such as therophytes, as they are the only one capable of better survival due to their short vegetative seasons and they survive under unfavourable seasons in the form of seeds. The biological spectra of a typical desert flora is represented mainly by therophytes and chamaephytes [6].

In view of the climate change, with a predicted increase of 1 to 2 °C in the maximum temperature for the entire country of Oman through 2040 [15] and predicted 40% less rainfall for northern coastal area by 2040 [15], Oman is likely to experience a decrease in water resources due to climate change. Oman ranked 28th in terms of in Global Climate Risk Index 2018, the floristic diversity and biological spectrum is expected to be affected. Recent tropical cyclones has also caused substantial damage to the coastal areas like Muscat. With rapid phase of urbanization, infrastructure development and industrialization going on, and Muscat, being the capital city of Oman, the floristic diversity is under threat. Urbanization affects floristic diversity directly through habitat loss and fragmentation and indirectly due to human behavior [16-19]. Being an arid zone ecologically, such zones are fragile, usually highly specialized, with high degree of endemism. Oman has a high percentage of endemics, with 78 plant species being strictly endemic to Oman, 48 species near endemic and 63 species regional endemic to the Arabian Peninsula [20]. Many of these species are rare, threatened, and endangered. A slight change in climatic conditions will cause havoc on these species. The floristic diversity overall in Oman and specially in capital city Muscat is under threat due to its limited water resources, climatic change, population growth and urbanization, thus there is a need to document the total flora, various life forms and species distribution across various habitats. No previous study has highlighted the biological spectrum and plant life forms in this area. Therefore, the present study was conducted to analyse the vegetation of the Muscat Governorate in terms of floristic composition, life-form, and habitat and to prepare a biological spectrum to infer the existing phytoclimate of the area.

2. Materials and Methods

Study area

Muscat Governorate is located in the northeast corner of Oman, latitude 23.5859 °N, and longitude, 58.4059 °E bordered by Gulf of Oman on its north (Figure 1). The western Al Hajar Mountains range dominate the landscape of Muscat. Its area is about 3,500 km^2. Muscat governorate has a hot arid climate, with long and very hot summers and warm winters. Temperature reaches as high as 49 °C in summer. The hottest month is June with an average temperature of 35 °C, January is the coldest month with an average temperature of 21 °C. The Muscat governorate is comprised of six provinces called wilayats, namely Muttrah, Bawshar, Al- Seeb, Al Amerat, Muscat and Quriyat. Samail Ophiolite is mainly exposed around Muscat and Mutrah Wilayat [21], surface geology of Al Amirat is composed of aeolian sand, alluvial fans, dolomite and limestone. Sand, clay and silt are found in Bawsher, with coastal dunes, alluvial sand, silt and Khabrah found in Seeb [2].

A checklist of angiosperm species growing in Muscat Governorate was generated based on the results of four years (2014-2018) intensive study. Field surveys were an important part of the study, regular field surveys were conducted across 42 sites (Figure 1), scattered along different habitats . Specimen of all the species of trees, shrubs, herbs and climbers found in these sites were collected and identified. In the field, the plant species were documented, collected and field notes were taken so as to have information on the plant's habit, leaves, stem and floral parts and habitat. Accession numbers were assigned to each specimen along with locality data.

The specimens were identified using related taxonomic books, [22-26] and compared with herbarium specimens from Herbarium, College of Science, SQU. Life forms of species were evaluated, relying on the location of the regenerative buds and the shed parts during the unfavorable season [7].

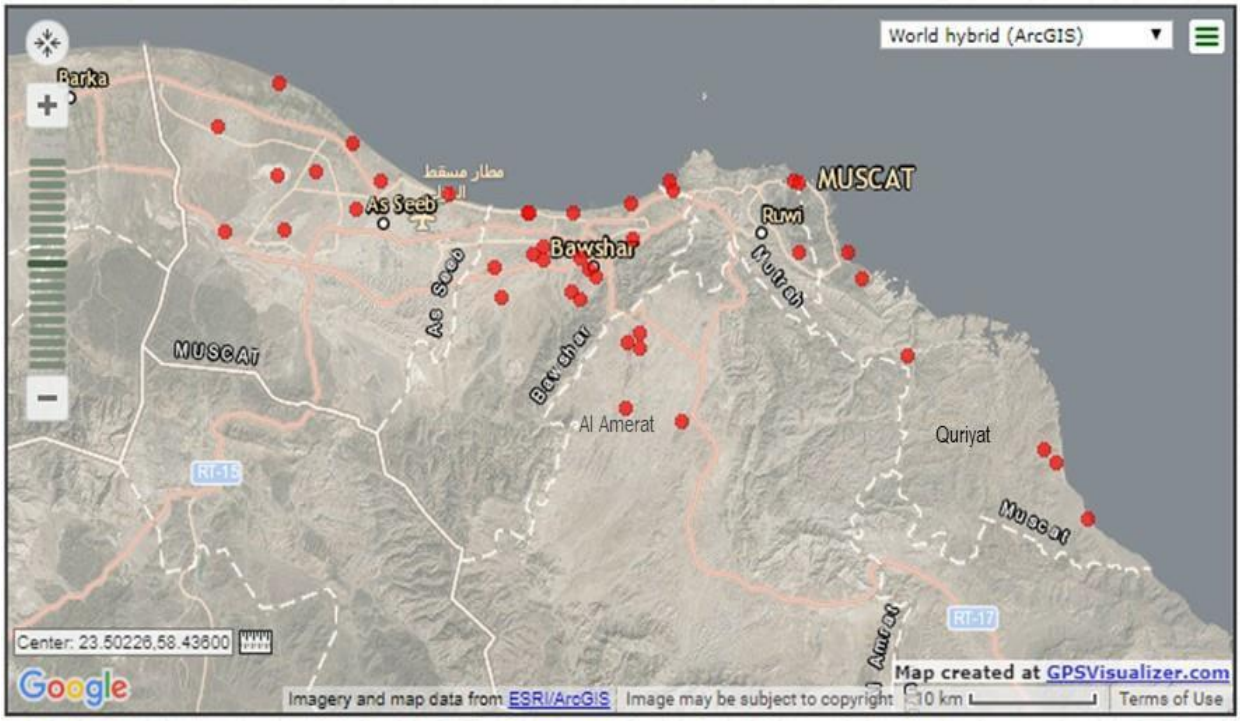

Figure 1. Map of site of collections from Muscat Governorate.

3. Results

A total of 283 species were recorded from different habitats in the Governorate of Muscat, representing 196 genera and 49 families (Table 1). The families with the highest number of species recorded was leguminosae with 42 species (14%).

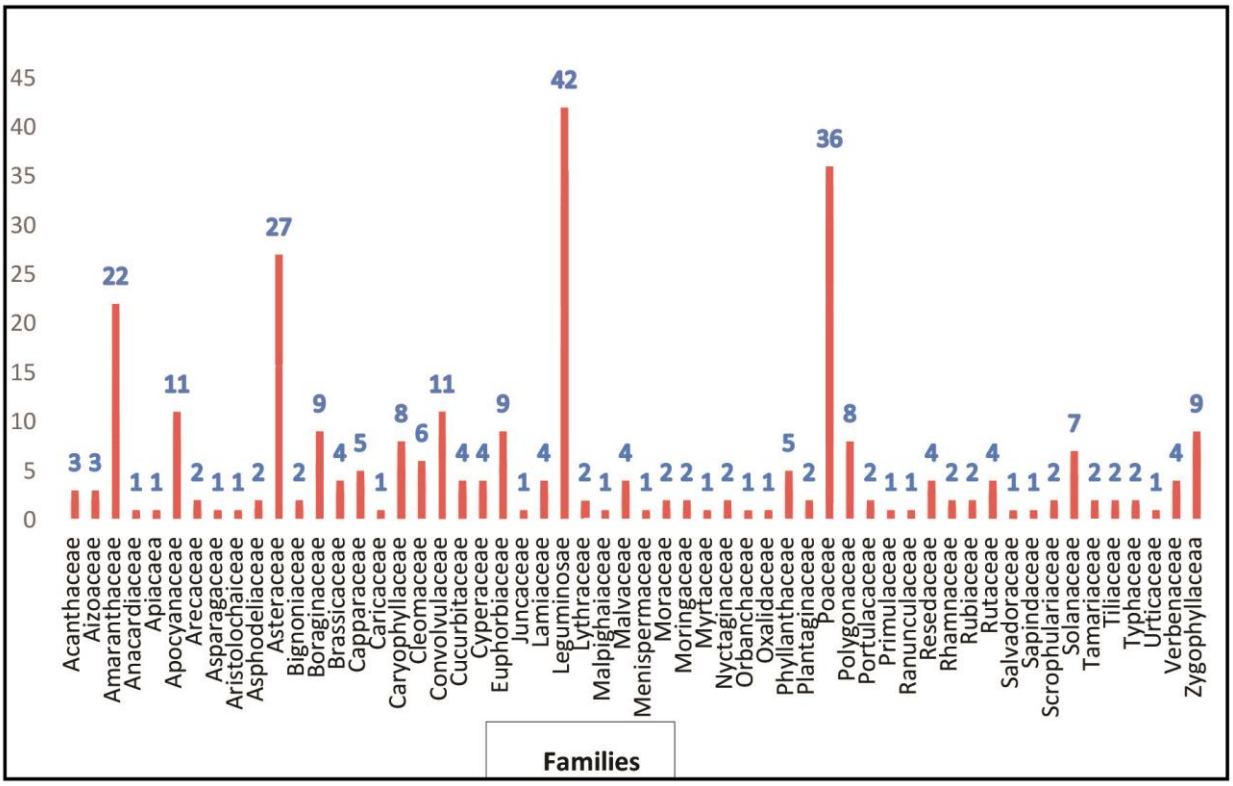

Figure 2. Number of species per family recorded from Muscat Governorate.

Other families represented were Poaceae with 36 species (12%), Asteraceae with 27 species (9%), Apocyanaceae and Convolvulaceae with 11 species each (3.66%), Boraginaceae, Euphorbiaceae, Zygophylaceae with 9 species each (3%), Caryophyllaceae and Polygonaceae with 8 species each (2.6%), Solanaceae with 7 species (2.3%), Cleomaceae with 6 species (2%), followed by Capparaceae and Phyllanthaceae with 5 species each (1.6%), Brassicaceae, Cyperaceae, lamiaceae, Malvaceae and Resedaceae with 4 species each (1.3%) (Figure 2). *Convolvulus* with 6 species was the largest genus in terms of number of species in the study area, followed by *Launea* and *Cleome* with 5 species each.

Figure 3 shows the biological spectrum or the life form spectrum of the given 264 species in the study area. The vegetation of Muscat Governorate showed almost equal percentage of therophytes (30%) and chamaephytes (30%), followed by that of phanerophytes (19%), hemicryptophytes (13%), geophytes (4%), liana (3%), and helophytes (1%). The therophytes and chamaephytes together constitute 60% of the life-forms.

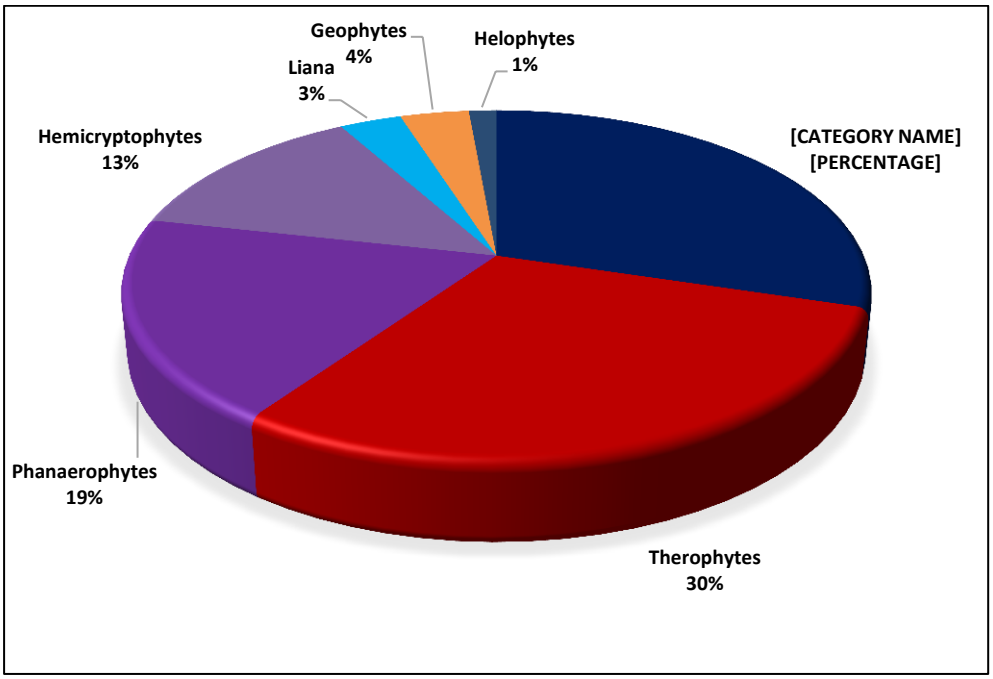

Figure 3. Biological spectrum of life-forms of plant species recorded from Muscat Governorate.

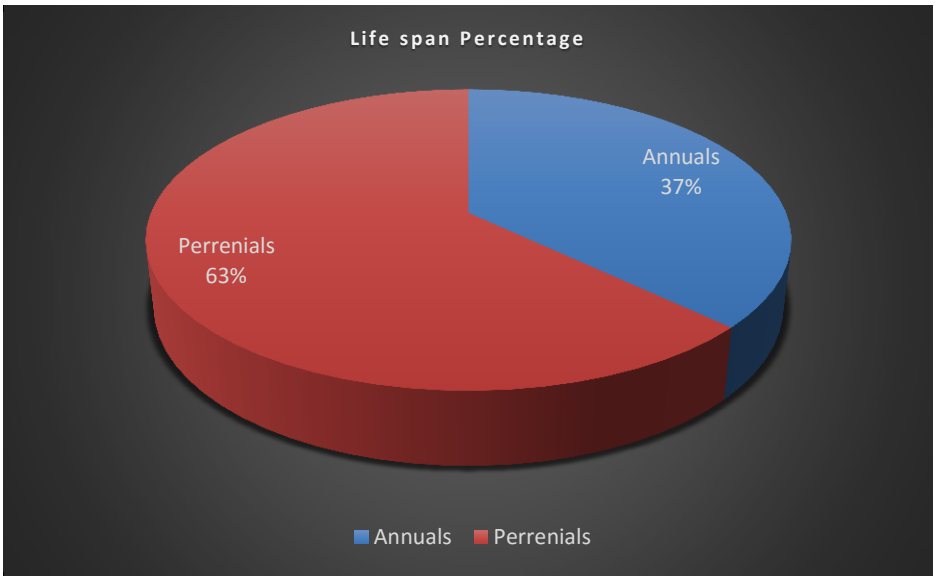

Figure 4. Percentage of the studied species by life-span.

Life span wise, 105 species were annuals (37%) and 159 were perennials (63%), Figure 4. Study of the dominant families in terms of species richness revealed that Fabaceae has high percentage (77%) of perennials and Astereaceae family has high percentage (67%) of annuals.

Distribution studies of the species along varied habitats (Table 1) showed that different habitats are characterized by specific plant assemblages, but some species can be found in more than one habitat.

Gravel and rocky terrain habitat: The highest species density was concentrated in the gravel and rocky terrain habitat (136 species), here the life-form composition is dominated by small trees, woody chamaeophytes and therophytes. Perennial phanaerophytes such as *Acacia tortilis, Prosopis cineraria, Prosopis juliflora* (introduced and naturalized), *Zizyphus spina-christi*, and chamaeophytes such as *Heliotropium bacciferum, Euphorbia larica* are the permanent features of the plant cover in this habitat and therophytes such as *Launea intybatea* and *Cenchrus setigerus* are common.

Alluvial plains and disturbed areas: Here the vegetation is characterized by chamaeophytes such as *Convolvulus virgatus, Fagonia indica, Amaranthus viridus, Tephrosia appollinea, Chrozophora oblongifolia, Pulicaria glutinosa* and therophytes such as *Tribulus terrestris, Tribulus arabica, Cenchus ciliaris, Pennisetum setaceum, Tetreana simplex*. A total of 78 species was found in this zone.

Sand dunes: In dunes, with 55 species, the life-form composition is typical of the desert flora, characterized by low carbonate content substrate. Sand dunes are mainly colonized by chamaeophytes such as *Dipterygium glaucum, Calligonum commosum* and *Cyperus conglomeratus.*

Wadi: In Wadis, the life-form composition is dominated by dense stands of helo-geophytes such as *Phragmatis australis* and *Typha domingensis* in Wadi beds, margins of wadi are colonized mainly by species such as *Acacia tortolis, Prosopis cineraria, Prosopis juliflora*. Annuals such as *Centurea pseudosinaica* and *Plantago ovata* are common on dried wadi beds.

Coastal area with the least number of species (27) are dominated by perennial, low growing halophytic chamaephytes such as *Suaeda aegyptiaca, Sphaerocoma aucheri, Tetraena quaterense and Cornoluca monocantha.* The vegetation stands usually are species poor, as cover of one particular species is frequently seen over a larger area. *Avicenia marina* is a typical mangrove species found in the intertidal zone.

4. Discussion

The floristic data clearly indicate that despite having a dry arid climate, Muscat Governorate is home to a rich diversity of plants and these plant species are very much associated with aridity and drought. Fabaceae, Poaceae and Asteraceae were the dominant families in terms of number of species. These families show high compatibility with arid and semiarid environmental conditions. Similar results were observed in Hema Faid Region of Ha'il Province, Saudi Arabia [27], in Tabuk province, north Saudi Arabia [28], in Hafer Albatin region, northeastern Saudi Arabia [29].

Generally, the vegetation type and the biological spectrum of a given area reflects an apparent relationship to its surrounding environment [30-32]. The biological spectrum in the present study ranged from therophytes, chamaephytes, phanerophytes, hemicryptophytes, geophytes, liana and helophytes. Therophytes and chamaephytes were the dominate forms, the dominance of the therophytes and chamaephytes may be attributed to the hot dry climate, geological factors and the topography [33-35]. Therophytes are associated with a dry climate [36,37], and are characteristics vegetation type of desert flora, as influenced by microclimate and soil conditions [38]. The thero-chamaephytic spectrum has been assiociated with other desert climates observed in the neighbouring countries such as Taif, Saudi Arabia [39], Hail region of Saudi Arabia [40], Wadi Al-Jufair, Saudi Arabia [35], Toor Al-Baha District, Lahej Governorate, Yemen, [41]. Generally, a sparse vegetation cover with scattered small trees, dwarf shrubs and mainly annuals represent a typical desert flora, as the sandy soil of these regions is characterized by low soil organic carbon and low structural stability, a high nutrient leaching and degradation due to erosion [42]. Diverse habitats are zones of microenvironments at local scales, each habitat supporting a characteristic type of vegetation. As the species distribution is generally limited by its ecological amplitude, [43] climate and habitat filtering, generating species pools, [44], where species adjust their metabolism [45] and produce functional traits as result of adaptation to the microclimates found under variable habitats [46]. Analysis of the present study reveals that highest species concentration was found in gravel rocky terrain, here the life-form composition is dominated by small trees, woody chamaeophytes and therophytes. Scattered xerophytic vegetation of dwarf chamaeophytes, perennial herbs, and small trees are features of water limited sand dunes habitat with soils low in organic carbon, phosphorus and low water retaining capacity. Similar results were observed by [47] in Al Kharj region, Saudi Arabia. The psammophytic vegetation of the sand dunes exhibit specific ecological adaptation, sending out long roots to catch hold of the slightest moisture available.

Wadi beds are usually rich floristically [48], where the access to water creates a favourable microclimate and microhabitat, for many species to flourish. The availability of annuals or perennials in a wadi mainly depends on the amount of rainfall received during the year [49]. Perennials helophytic tall grasses are the common representative species in wadis. Similar results were observed in Wadi Hegiya [50].

Halophytic perennial chamaephytes with reduced succulent leaves predominate the coastal vegetation, with mostly chenopodiales and members of Zygophyllaceae being the dominant feature at many coastal locations, similar

results were observed in coastal Area of Al-Uqair, Saudi Arabia [51]. Reduced leaf area is an indicator of severe environmental stress [52]. Reduced leaf area and fleshy leaves, under salinity stress is a common phenomenon associated with most of the coastal halophytes [53]. Under selective pressures at a given habitat, the ecological strategies are limited which results into communities having species with similar functional traits and life form composition [54].

Lying in the arid zone, Oman already suffers from aridity, water paucity and salinity , and being vulnerable to climatic change, with a predicted 1-2 ˚C rise in average temperature over the next 30 years [55], erratic patterns of precipitation and raised sea levels, all these factors are expected to exert considerable physiological constraints and affect biodiversity [56]. In view of the above threats, with high degree of endemism, many threatened species, lack of enough *in situ* protected areas for plant conservation, lack of enough restoration programs, urban sprawl affecting biodiversity, documentation of the species is necessary and important.

Conclusion

The heterogeneity of environmental conditions, surface geology and topography across diverse habitats lead to variation in the distributional pattern of plant species in the studied area. Species were morphologically and physiologically adapted to the varied environmental conditions across different habitats, through selection on their functional traits by environmental filters, generating species pools. Each habitat acts as a microenvironment where specific abiotic stress leads to similar responsive characteristics among the co-existing species, thus similar life-form composition. Based on the work, the phytoclimate of the area, based on Raunkiaer' s system of classification, has been described as thero-chamaephytic phytoclimate.

Table 1. Flora, Life forms, Life span and Habitat of plants recorded from Muscat Governorate. (Names follow APG 1V classification).

Key, Ph : Phanerophyte; Ch: Chamaephyte; He: Hemicryptophyte; Ge: Geophyte; He: Helophytes
Th: Therophyte; Li :Liana; Ann: Annual; Per: Perennial; Coa : Coastal; Al-P : Alluvial plains, roadsides,
Dun: Dunes; Wad : Wadi's; Gr-roc : Gravel, rocky terrain, Mountains; Far : Farms and Plantations.

	Family	Species	Life-form Life span		Habitat					
					Coa	Al-p	Dun	Wad	Gr-	Far
1.	Acanthaceae	*Avicenia marina*	Hl	Per	x					
2.		*Blepharis ciliaris*	Ch	Per					x	
3.		*Ecbolium viride*	Ph	Per				x	x	
4.	Aizoaceae	*Aizoon canariense*	He	Ann		x	x			
5.		*Gisekia pharnaceoides*	He	Ann	x					
6.		*Trianthema portulacatrum*	He	Ann						x
7.	Amaranthaceae	*Achyranthus aspera*	Ch	An/P						x
8.		*Aerva javonica*	Ch	Per		x	x		x	
9.		*Amaranthus graecizans*	Th	Ann		x	x			
10.		*Amaranthus hybridus*	Th	Ann			x			x
11.		*Amaranthus viridus*	Th	Ann		x				x
12.		*Anabasis setifera*	Ch	Per	x	x			x	
13.		*Arthrocnemum*	Ch	Per	x					
14.		*Atriplex farinose*	Ch	Per	x					
15.		*Atriplex leucoclada*	Ch	Per	x					
16.		*Chenopodium album*	Th	Ann		x				x
17.		*Chenopodiastrum murale*	Th	Ann		x				x
18.		*Cornoluca aucheri*	Th	Ann	x					
19.		*Cornoluca monocantha*	Ch	Per	x			x		
20.		*Digera muricata*	Th	Ann						x
21.		*Halothamnus bottae*	Ch	Per		x			x	
22.		*Hamada salicornica*	Ch	Per		x	x		x	

23.		*Pupalia lappacea*	Ch	Per				x	x	
24.		*Salsola drummondii*	Ch	Per	x					
25.		*Caroxylon imbricatum*	Th	Ann	x		x		x	
26.		*Seidlitzia rosmarinus*	Ch	Per	x		x			
27.		*Suaeda aegyptiaca*	Ch	Per	x		x		x	
28.		*Suaeda vermiculata*	Ch	Per	x					
29.	Apiaceae	*Ammi majus*	Th	Ann						x
30.	Apocyanaceae	*Adenium obesum*	Ph	Per					X	
31.		*Calotropis procera*	Ph	Per			x		x	
32.		*Caralluma edulis*	Ch	Per					x	
33.		*Glossonema varians*	He	Ann					x	
34.		*Leptadenia pyrotechnica*	Ph	Per		x	x		x	
35.		*Nerium oleander*	Ph	Per					x	x
36.		*Pentatropis nivalis*	Li	Per		x	x		x	
37.		*Pergularia tomentosa*	Li	Per					x	
38.		*Periploca aphylla*	Ch	Per					x	
39.		*Rhazya stricta*	Ch	Per		x			x	
40.	Arecaceae	*Nanorrhops ritchieana*	Ph	Per					x	
41.		*Phoenix dactylifera*	Ph	Per					x	x
42.	Asparagaceae	*Asparagus racemosus*	Li	Per						
43.	Aristolochiacea	*Aristolochia bracteolata*	Li	Per					x	x
44.	Asphodelaceae	*Aloe inermis*	Ch	Per						x
45.		*Asphodelus tenuifolius*	Ge	Ann			x		x	
46.	Asteraceae	*Ageratum conyzoides*	Th	Ann						x
47.		*Bidens pilosa*	Th/C	Ann				x		x
48.		*Calendula arvensis*	Th	Ann					x	
49.		*Carthamus tinctorius*	Th	Ann						x
50.		*Centaurea puedosinaica*	Th/C	Ann			x		x	
51.		*Conyza bonariensis*	Th	Ann					x	x
52.		*Dyssodia tenuiflora*	Th	Ann				x	x	
53.		*Echinops spinosissimus*	Ch	Per				x	x	
54.		*Eclipta alba*	Th	Ann						x
55.		*Eclipta prostrata*	Th	Ann					x	x
56.		*Flaveria trinervia*	Th	Ann				x		x
57.		*Iphiona aucheri*	Ch	Per		x			x	
58.		*Iphiona horrida*	Ch	Per				x	x	
59.		*Iphiona scabra*	Ch	Per		x			x	
60.		*Launea capitata*	Th	Ann			x		x	
61.		*Launea intybacea*	Th	Ann						x
62.		*Launea massauensis*	Th	Ann					x	
63.		*Launea nudicaulis*	Ch	Per						x
64.		*Launea procumbens*	Ch	Per				x	x	
65.		*Pluchea dioscoridis*	Ch	Per	x					x
66.		*Pulicaria glutinosa*	Ch	Per		x		x	x	
67.		*Pulicaria jaubertii*	Ch	Per		x			x	
68.		*Pulicaria schimperi*	Th	Ann		x				
69.		*Reichardia tingitana*	Th	Ann					x	

70.		*Senecio flavus*	Th	Ann						x
71.		*Sonchus oleraceus*	Th	Ann				x	x	x
72.		*Vernonia cinerea*	Th	Ann					x	
73.	Bignoniaceae	*Tecomella undulata*	Ph	Per					x	
74.	Boraginaceae	*Arnebia hispidissima*	Th	Ann			x		x	
75.		*Echiochilon persicum*	Ch	Per					x	
76.		*Heliotropium bacciferum*	Ch	Per		x	x		x	
77.		*Heliotropium calcareum*	Ch	Per		x	x		x	
78.		*Heliotropium kotschyi*	Ch	Per	x					
79.		*Heliotropium longiflorum*	Ch	Per					x	
80.	Brassicaceae	*Anastatica hierochuntia*	Th	Ann			x		x	
81.		*Diplotaxis harra*	Th	Ann		x				
82.		*Physorrhynchus*	Ch	Per		x		x	x	
83.		*Sisymbrium irio*	Th	Ann				x		
84.	Capparaceae	*Cadaba farinosa*	Ph	Per					x	
85.		*Capparis cartilaginea*	Ph	Per					x	
86.		*Capparis spinosa*	Ph	Per				x	x	
87.		*Capparis decidua*	Ph	Per		x				
88.		*Maerua crassiflolia*	Ph	Per					x	
89.	Caryophyllacea	*Cometes surattensis*	He	Ann					x	
90.		*Herniaria mascatensis*	He	Per		x			x	
91.		*Polycarpaea repens*	He	Per		x	x			
92.		*Silene conoidea*	Th	Ann					x	x
93.		*Silene linearis*	Th	Ann					x	
94.		*Spergula fallax*	He	Ann						x
95.		*Sphaerocoma aucheri*	Ch	Per	x					
96.		*Vaccaria hispanica*	He/	Ann						x
97.	Cleomaceae	*Cleome austroarabica*	Ch	Per				x		
98.		*Cleome brachycarpa*	Ch	Per			x		x	
99.		*Cleome gynandra*	Th	Ann						x
100.		*Cleome rupicola*	Ch	Per				x	x	
101.		*Cleome scaposa*	Th	Ann					x	
102.		*Dipterygium glaucum*	Ch	Per	x	x	x			
103.	Convolvulaceae	*Convolvulus arvensis*	Ch	Per					x	x
14.		*Convolvulus cephalopodus*	Ch	Per			x		x	
105.		*Convolvulus fatmensis*	Ch	Per		x				
106.		*Convolvulus glomeratus*	Ch	Per		x		x	x	
107.		*Convovulus prostratus*	Ch	Per			x	x	x	
108.		*Convovulus virgatus*	Ch	Per		x		x		
109.		*Cressa cretica*	Ch	Per			x			x
110.		*Cuscuta planiflora*	Li	Ann		x		x	x	
111.		*Seddera glomerata*	Ch	Per			x		x	
112.	Cucurbitaceae	*Citrullus colocynthis*	He	Ann				x		
113.		*Corallocarpus epigaeus*	Li	Per					x	
114.		*Cucumis prophetarum*	Li	Ann		x		x		
115.	Cyperaceae	*Cyperus conglomeratus*	Ge	Per			x			
116.		*Cyperus laevigatus*	Ge	Per				x		

117.		*Cyperus rotandus*	Ge	Per			x			x
118.		*Fimbristylis ferruginea*	He	Per				x		
119.	Euphorbiaceae	*Andrachne telephoides*	He	Per					x	
120.		*Chrozophora oblongifolia*	Ch	Per		x			x	x
121.		*Euphorbia arabica*	Th	Ann				x	x	
122.		*Euphorbia hirta*	Th	Ann		x			x	x
123.		*Euphorbia indica*	Th	Ann					x	x
124.		*Euphorbia larica*	Ch	Per		x			x	
125.		*Jatropha integerrima*	Ph	Per		x				
126.		*Ricinus communis*	Ph	Per					x	x
127.	Juncaceae	*Juncus rigidus*	Ge	Per	x			x		
128.	Lamiaceae	*Lavendula subnuda*	Ch	Per				x	x	
129.		*Leucas inflata*	Th	Ann				x	x	
130.		*Ocimum forskaolii*	Ch	Per		x			x	x
131.		*Salvia aegyptiaca*	Ch	Ann				x	x	
132.	Fabaceae	*Acacia ehrenbergiana*	Ph	Per		x			x	
133.		*Acacia nilotica*	Ph	Per					x	
134.		*Acacia tortolis*	Ph	Per			x	x	x	
135.		*Alhagi graecorum*	Ch	Per	x		x			
136.		*Argyrolobium roseum*	He	Ann				x	x	
137.		*Astragalus fatmensis*	He	Ann					x	
138.		*Astragalus tribuloides*	Th	Ann			x	x		
139.		*Astragalus vogelii*	Th	Ann			x			
140.		*Caesalpinea bonduc*	Ch	Per		x				
141.		*Caeslapinea pulcherrima*	Ch	Per		x				
142.		*Crotalaria aegyptiaca*	Ch	Per		x	x		x	
143.		*Crotalaria persica*	Ch	Per			x			
144.		*Hippocrepsis constricta*	Th	Ann		x	x		x	
145.		*Indigofera arabica*	He	Per				x	x	
146.		*Indigofera coerulea*	Ch	Per				x	x	
147.		*Indigofera intricata*	Ch	Per			x	x	x	
148.		*Indigofera oblongifolia*	Ch	Per			x	x	x	
149.		*Lotus garcini*	Ch	Per			x			
150.		*Lotus schimperi*	He	Ann		x			x	
151.		*Medicago sativa*	Ch	Per						x
152.		*Melilotus indicus*	Th	Ann						x
153.		*Prosopis cineraria*	Ph	Per		x	x	x	x	
154.		*Prosopis juliflora*	Ph	Per			x		x	
155.		*Rhynchosia minima*	Li	Per			x			
156.		*Rhynchosia pulverulenta*	Li	Per			x		x	
157.		*Pseudolotus vilosus*	He	Ann						
158.		*Senna holosericea*	Ch	Per		x		x	x	x
159.		*Senna obtusifolia*	Ch	Ann		x				
160.		*Senna italica*	Ch	Per		x				

161.		*Taverniera glabra*	Ch	Per		x			x	
162.		*Taverniera spartea*	Ch	Per	x					
163.		*Tephrosia appollinea*	Ch	Per		x	x		x	
164.		*Tephrosia nubica*	Ch	Per				x	x	
165.		*Tephrosia purpurea*	Ch	Per					x	
166.	Lythraceae	*Ammannia baccifera*	Th	Ann						x
167.		*Lawsonia inermis*	Ph	Per		x		x	x	
168.	Malpighiaceae	*Acridocarpus orientalis*	Ph	Per				x	x	
169.	Malvaceae	*Abutilon fruticosum*	Ch	Per		x				x
170.		*Abutilon pannosum*	Ph	Per		x				x
171.		*Malva parviflora*	Th	Ann			x		x	x
172.	Menispermacae	*Cocculus pendulus*	Li	Per					x	
173.	Moraceae	*Ficus carica*	Ph	Per		x				x
174.		*Ficus cordata*	Ph	Per		x		x		x
175.	Moringaceae	*Moringa peregrina*	Ph	Per		x			x	
176.	Myrtaceae	*Myrtus communis*	Ph	Per		x				
177.	Nyctaginaceae	*Boerhavia diffusa*	Th	Ann		x				x
178.		*Boerhavia elegans*	Ch	Per		x			x	
179.	Orobanchaceae	*Cistanche phelypaea*	Ge-P	Per	x					
180.	Oxalidaceae	*Oxalis corniculata*	Th	Ann						x
181.	Phyllanthaceae	*Andrachne aspera*	He	Per				x	x	
182.		*Andrachne telephoides*	He	Per				x	x	
183.		*Phyllanthus*	Th	Ann						x
184.		*Phyllanthus niruri*	Th	Ann						x
185.		*Phyllanthus rotandifolius*	Th	Ann						x
186.	Plantaginaceae	*Plantago major*	Th	Ann					x	
187.		*Plantago ovata*	Th	Ann					x	
188.	Poaceae	*Aeluropus lagopoides*	He	Per	x					
189.		*Aristada adscensionis*	Th	Ann			x		x	
190.		*Arundo donax*	Ch	Per				x		
191.		*Cenchrus ciliaris*	He	Per		x			x	x
192.		*Cenchrus setigerus*	He	Per						
193.		*Chloris barbata*	Th	Ann			x		x	x
194.		*Chloris gayana*	He	Ann						x
195.		*Chloris virgata*	Th	Ann		x				x
196.		*Cymbopogon*	He	Per				x	x	
197.		*Cynodon dactylon*	Ge	Per		x				x
198.		*Dactyloctenium*	Th	Ann						x
199.		*Desmostachya bipinnata*	Th	Ann		x				
200.		*Dichanthium foveolatum*	He	Per			x			
201.		*Digitaria ciliaris*	Th	Ann						
202.		*Echinochloa colona*	Th	Ann		x				x
203.		*Eragrostis cilianensis*	Th	Ann			x			x
204.		*Halopyrum mucronatum*	Th	Per	x					
205.		*Hyparrhenia hirta*	He	Ann		x	x			

206.		*Lasiurus scindicus*	He	Per		x	x			
207.		*Panicum turgidum*	He	Per			x		x	
208.		*Pennisetum divisum*	He	Per			x			
209.		*Pennisetum setaceum*	He	Per		x		x		
210.		*Phalaris minor*	Th	Ann		x				x
211.		*Phragmites australis*	Hl/Ge	Per				x		
212.		*Saccharum ravennae*	Ch	Per				x		
213.		*Setaria verticillata*	Th	Ann						x
214.		*Sporobolus ioclados*	Ge	Per	x					
215.		*Sporobolus spicatus*	Ge	Per			x	x		x
216.		*Stipagrostis uniplumis*	He	Per				x	x	
217.		Typha domingensis	Hl/Ge					x		
218.	Polygalaceae	*Calligonum comosum*	Ph	Per			x		x	
219.		*Polygala erioptera*	Th	Ann					x	
220.		*Polygala irregularis*	Th	Ann			x			
221.		*Polygala mascatensis*	Ch	Per					x	
222.		*Pteropyrum scoparium*	Ph	Per		x		x		
223.		*Rumex pictus*	Th	Ann			x			
224.		*Rumex vesicarius*	Th	Ann					x	
225.	Portulacaceae	*Portulaca grandiflora*	Th	Ann						x
226.		*Portulaca oleraceae*	Th	Ann						x
227.	Primulaceae	*Anagallis arvensis*	Th	Ann						x
228.	Ranunculaceae	*Ranunculus muricatus*	Th	Ann						x
229.	Resedaceae	*Ochradenus arabicus*	Ch	Per			x	x	x	
230.		*Ochradenus aucheri*	Th	Ann				x	x	
231.		*Oligomeris linifolia*	Th	Ann			x		x	
232.		*Reseda aucheri*	Th	Ann		x			x	
233.	Rhamnaceae	*Ziziphus spina-christi*	Ph	Per		x			x	
234.	Rubiaceae	*Plocama aucheri*	Ch	Per				x	x	
235.	Rutaceae	*Haplophyllum*	Ch	Per		x			x	
236.	Salvadoraceae	*Salvadora persica*	Ph	Per	x		x	x		
237.	Sapindaceae	*Dodonaea viscosa*	Ph	Per					x	
238.	Scrophulariacea	*Schwienfurthia*	Ch	Per		x			x	
239.		*Schwienfurthia*	Th	Ann		x			x	
240.	Solanaceae	*Datura innoxia*	Th	Ann				x		
241.		*Datura metel*	Th	Ann				X	X	X
242.		*Hyoscymus gallagheri*	Ch	Per	x				x	
243.		*Lycium shawii*	Ph	Per		x			x	
244.		*Physalis minima*	Th	Ann						x
245.		*Solanum incanum*	Ch	Per					x	
246.		*Solanum nigrum*	Th	Ann						x

247.	Tamaricaceae	*Tamarix aphylla*	Ph	Per		x	x			
248.		*Tamarix mascatensis*	Ph	Per		x			x	
249.	Tiliaceae	*Corcorus depressus*	He	Per		x	x		x	
250.		*Corcorus trilocularis*	Th	Ann						x
251.	Typhaceae	*Typha domingensis*	Hel	Per				x		
252.		*Typha angustata*	Hel	Per				x		
253.	Urticaceae	*Forsskalea tenacissima*	Th	Ann		x			x	
254.	Verbenaceae	*Lantana camara*	Ch	Per		x				
255.		*Phylla nodiflora*	Ch	Per						x
256.		*Vitex agnus castus*	Ph	Per						x
257.	Zygophyllaceae	*Fagonia bruguieri*	Ch	Per		x	x			
258.		*Fagonia indica*	Ch	Per		x		x		
259.		*Seetzenia lanata*	He	Per			x		x	
260.		*Tribulus arabicus*	He	Per		x	x			
261.		*Tribulus pentandrus*	He	Per			x			
262.		*Tribulus terrestris*	He	Ann		x	x			
263.		*Tetraena* quaterense	Ch	Per	x	x		x	x	
264.		Tetraena *simplex*	He	Ann	x	x			x	

Conflict of interest

The author declares no conflict of interest.

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