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Ecological Studies in the Western Region of Abu Dhabi (United Arab Emirates)

Sabitha Sakkir, Maher Kabshawi, Mohamed Meharibi and Junid N. Shah

Biodiversity Management Sector, Environment Agency-Abu Dhabi, P.O. Box: 45553, Abu Dhabi, UAE

Abstract: Vegetation structure and the threats that can endanger the species richness and diversity were assessed in the western regions of Abu Dhabi Emirate. Five regions were selected to cover the major habitats of the region. Seasonal fluctuations in species richness were assessed. The highest species richness was recordedin Al Marzoum region followed by the Al Haleew regions. Al Marzoum regions attained the highest density of species. Lower species richness in the western regions of Abu Dhabi Emirate could be attributed to low rainfall, poor soil and harsh climatic conditions. Species richnesswas also found to vary significantly across the different habitats studied. The study also confirmed that the vegetation structure remains relatively simple dominated by species tolerant of the harsh climatic conditions and resistant to overgrazing. Communities are dominated by species like *Tetraena qatarense*, *Haloxylon salicornicum, Cyperus conglomeratus* and *Cornulaca monacantha.* It is concluded that, of the different threats that persist, such as harsh climate, poor soil and overgrazing, overgrazing remains the single biggest threat that needs to be controlled effectively. Livestock control could prove very crucial in increasing the vegetation cover and species richness and thus able to restore desert vegetation in the western regions of Abu Dhabi Emirates.

Key words: Species richness · Diversity · Vegetation structure · *Tetraena qatarense* · *Haloxylon salicornicum*

INTRODUCTION

Abu Dhabi, being 77, 700 km^2 on area, is the largest of the emirate comprising the United Arab Emirates. The vegetation in the deserts of Abu Dhabi emirate is known to be sparse due to the extreme environmental factors along with the extreme summer temperature and saline soil. The vegetation comprises of low ground cover rates, densities and diversities. Excessive grazing by camels is recognized as the single greatest threat to the inland desert ecology of UAE [1], due to rapid increase in their numbers. The present survey was conducted in the western region of Abu Dhabi Emirate to assess the species richness, density, vegetation structure and threats.

The vegetation ecology of Abu Dhabi emirate has received limited attention and the literature on the vegetation and ecology was scarce. The situation has begun to change in recent years through the efforts of a number of scientists [2-11]. The significance of study can be gauged from the simple fact that there exists no quantitative data on the vegetation on the western region of the Abu Dhabi Emirate. The vegetation of the Abu Dhabi emirate and a preliminary classification of its plant association were provided by Roshier *et al*. [12]. Western [13] provides an introduction to the vegetation of the Abu Dhabi Island. The effect of vegetation communities from grazing by camels and goats has been investigated in the Baynunah region of Abu Dhabi emirate by Oatham *et al*. [14]. These were rangelands that were heavily overgrazed. Overgrazing, sometimes in catastrophic proportions, is generally perceived as the main cause of vegetation degradation on rangelands [15-19]. In fact, vegetation degradation cannot be triggered through drought alone [20]. With regard to the natural vegetation, over grazing not only lowers the productivity of rangelands, but results in plant species richness and relative abundance [19, 21].

While most of the studies highlight the threat in overgrazing, the focus of this study has been to assess the threat to species richness and diversity in the western region and hence the need for protection from grazing. The study also seeks to analyze whether an extreme case of species extinction exist at this point or is likely in the near future.

Corresponding Author: Sabitha Sakkir, Biodiversity Management Sector, Environment Agency-Abu Dhabi, P.O. Box: 45553, Abu Dhabi, UAE. Tel: (off), +971 2 693 4538. Mob: +971 50 712 9098, Fax: +971 2 4464721.

MATERIALS AND METHODS

The study area is located approximately 180 km North-West of Abu Dhabi Island. Preliminary observations and analysis suggested that vegetation is correlated with geomorphological landforms; for this reason, stratified random sampling method was employed [22, 23] within each of the studied sites. A total of five sites, of different habitat types, were selected randomly in the study area. Of these, two sites were located near the Al Marzoum, (Site 1, GPS coordinates, N23.97783, E054.14168 and Site 2, N 23.94631, E054.19688), one near Al Haleew (Site 3, GPS coordinates, N23.90550, E053.92321) and two near Al Mirfa (Site4, GPS coordinates, N23.95226, E053.56308 and Site5, GPS coordinates, N23.94268, E053.58252) in the western region of Abu Dhabi Emirate (Figure 1).

Data Collection: A quantitative survey of the vegetation was carried out during period 2009-2010. Permanent plots (20mx20m) were set up in each site to carry out detailed vegetation study. The time frame was so chosen that all the four seasons were adequately covered. Furthermore, the study area was also inspected for additional species that were plausibly missed in previous recordings in the sampling plots. Sites were selected based on the type of vegetation communities to understand the species richness and density.

The study area has an arid desert climate with an irregular rainfall, typically between zero to 0.1mm/annum. The mean annual rainfall recorded was about 0.1 mm during the study period from March 2009 to February 2010 During the survey period, maximum temperature observed was around 35.34°C and a minimum temperature observed was 17.68°C [24]. The soil type is of typic torripsamments consociation [25]. Nomenclature of plant species follows that of Brown and Sakkir [26]. Habitats were described according to Brown and Böer [5].

Data Analysis: Numbers are given as mean (± SE). Species diversity and cluster analysis was performed on Bio diversity Pro, whereas One-Way ANOVA test was performed on SPPS Ver. 12. Species richness index (d) indicating the mean number of species per sample [27]

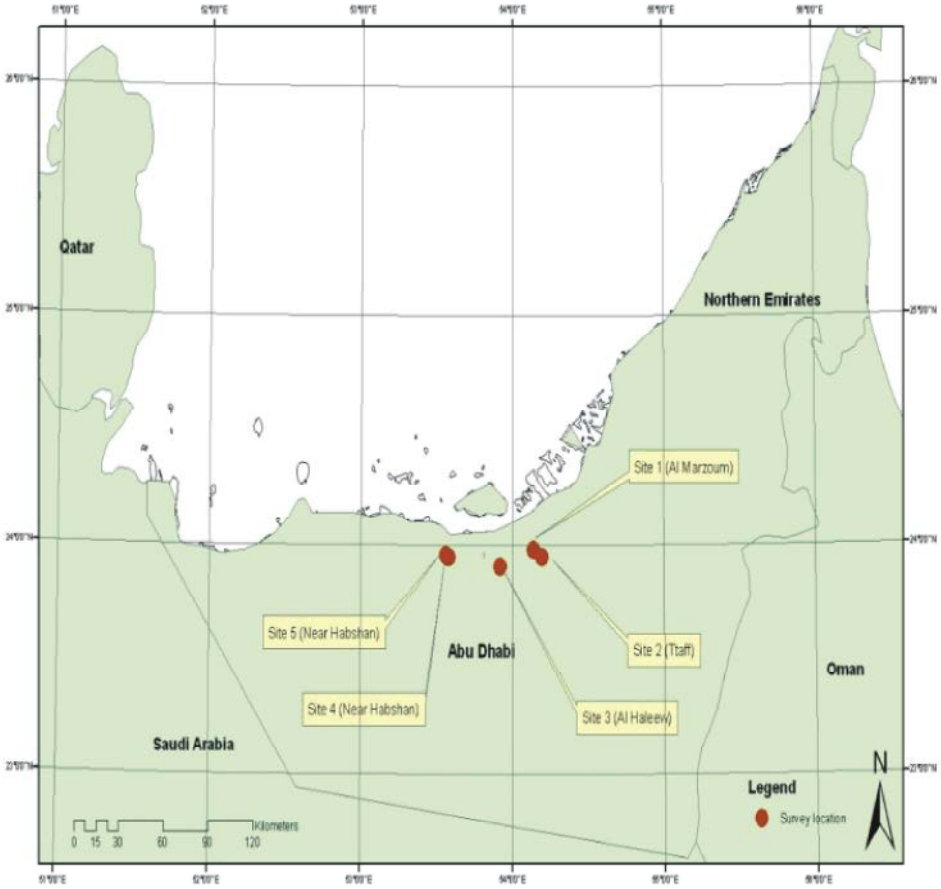

Fig. 1: Map showing the study sites

was calculated as d = S/ÖN, where, S= number of species, N= number of individuals of all species. Equitability or evenness (e = H/log S, where, H= Shannon Wiener's index and S = number of species) was computed following Pielou [28]. The species cover was estimated using Braun-Blanquet cover-abundance scale [29, 30].

Site Description: Site 1 is characterized by two distinct habitat types, the interdunal plains with the dwarf shrub *Caroxylon imbricatum* and the interdunal plains with sabkha. Site 2 is located approximately 6.62 km SE of Site 1. The habitat types identified in this area includes sand sheets and dunes and lithified sand dunes. Site 3 is located around 25km East to Site1 with habitat type of sand sheets and sand dunes. Site 4 and Site 5 is located 59 km West of Site 1. Site 4 and Site 5 are located 2 km apart. In both sites, the habitat type found was sand dunes and sand sheets.

RESULTS

Species Composition and Density: A total of ten species belonging to five different families were recorded in the vegetation quadrants all of which are perennials in the UAE. Highest density of 149.27 was recorded at Site 2 (Table 2), followed by Site 1 having 91.61 Species richness varied significantly across the habitats ($F= 100.36d$ $f= 4$, $p < 0.05$). The results from each site are represented in Table 1.

Species Richness: Highest species richness of 0.511 (± 0.014) was recorded at Site 2 (Table 3), followed by Site 3 having 0.436 (± 0.0.11.). Species richness varied significantly across the habitats ($F= 87.40$, $df= 4$, $p < 0.05$).

DISCUSSION

A variety of factors contribute to the species richness and diversity of plants in a region. Plant species diversity is usually affected by topographic gradients and climatic variations. It is generally observed that areas with high species diversity are found in the middle latitudes, particularly in the tropics because of the congenial climatic, edaphic and biotic factors prevailing there in [31]. Plantspecies diversity is also dependent on the regeneration potential of the various species and the presence of competitors that may either inhibit or promote regeneration. It has also been observed that a change in the habitat variables such as nature of substrate can also influence species diversity. In spite of such generalizations, there exists a commendable density and richness of species in the area under study even under adverse climatic conditions.

Climatic conditions were found to be extreme for most part of the year. The total amount of rainfall was less than 0.1 mm in the year.There were no annual species recorded from the study area. This might be attributed to the poor rainfall received during the study period and the high rate of grazing observed in the study sites. The vegetation community is largely dominated by *Tetraena qatarense* and *Haloxylon salicornicum*. Species like *Cyperus conglomeratus*, *Cornulaca monacantha, Dipterygium glaucum, Fagonia* sp. and *Stipagrostis plumosa* also contributed to the vegetation structure. As expected, the frequency of palatable species like *Dipterygium glaucum, Cyperus conglomeratus and Stipagrostis plumosa* were found to be low in the region.

Higher soil moisture is known to reflect in higher net production of perennial desert vegetation [32]. The present study results also substantiate the above observation. The highest species richness in Site 2 can be attributed to higher soil moisture and nutrients. The presence of *Haloxylon persicum* is also found to provide suitable microhabitat for various fauna. Many experts including Veetas [33] and Brown and Porembski [34, 35], have indicated the importance of microsites created by trees and bushes for plant establishment in natural semiarid ecosystem. The leaves of *Haloxylon persicum* is also able to comb out droplets of water from the atmosphere, which then falls on the ground, thus, favoring the growth of other species. This also could have contributed to the high species richness and high density found in Site 2. The "auto-watering mechanism" of *Haloxylon persicum* could also be anotherfactor [36].

Haloxylon salicornicum was recorded in all the sites studied which show the species ability to tolerate harsh climatic conditions and withstand grazing pressures.In fact, Thalen [37] had found *Haloxylon salicornicum* to be an important source of fodder for livestock all through the year on the Iraqi desert rangelands.

Tetraena qatarense, a native species of Abu Dhabi rangelands, is not suitable for stock grazing and this succulen thalophyte,thus enjoys an extensive distribution across Abu Dhabi and the Middle East [10]. But *Tetraena qatarense*is found to be suitable for camels and that too, in small amounts as it causes"scour" [38]. Munton [38] goes on to suggest that the local dominance of *Tetraena qatarense* in the Wahiba sands may be due to

Table 1: Results from the five different studied sites

Site	Recorded Species	Mean Density (/km^2)	Highest Density (/km^2)	Lowest Density (/km^2)	Dominant Species	Findings
Site 1	*Caroxylon imbricatum*, *Cyperus conglomeratus* *Tetraena qatarense* *Haloxylon salicornium*	91.61(± 4.39 S.E)	99.37(± 10.13 S.E)	84.04(± 7.39 S.E)	*Caroxylon imbricatum*	• The vegetation cover is close to 100%. • There were no major changes in the vegetation pattern during the survey period • The density of plants did not vary significantly across season (F= 0.856, df= 3, p = 0.471)
Site 2	*Haloxylon persicum*, *Haloxylon salicornicum* *Cyperus conglomeratus*, *Caroxylon imbricatum* *Tetraena qatarense*, *Cornulaca monacantha* *Dipterygium glaucum* *Fagonia sp*.	149.27(±8.39)	156.71(±14.54)	143.75(±21.84.)	*Tetraena qatarense*	• The density of plants did not vary significantly across the season (F= 0.153, df = 3, p= 0.927)
Site 3	*Haloxylon salicornicum*, *Tetraena qatarense* *Dipterygium glaucum*, *Stipagrostis plumosa* *Cyperus conglomeratus*	59.01(±5.34)	62.65(±9.88)	55.93(±13.34)	*Tetraena qatarense*	• The density of plants did not vary significantly across the seasons (F= 0.961, df= 3) • Fresh new growths of palatable species like *Cyperus conglomeratus* from rootstocks and *Stipagrostis plumosa* were recorded
Site 4	*Haloxylon salicornicum* *Cyperus conglomeratus*	30.83 (±0.846)	31.25 (±2.36)	30.62 (±2.15)	*Haloxylon salicornicum*	• The area is found to be severely affected by grazing. • The density did not vary significantly across seasons (F= 0.024, df = 3, p = 0.995)
Site 5	*Haloxylon salicornicum* *Cyperus conglomeratus* *Dipterygium glaucum*	33.33 (±1.350)	33.75 (±3.02)	31.25 (±3.20)	*Haloxylon salicornicum*	• The area also has been severely affected by grazing • The density did not vary significantly across seasons (F= 0.150, df = 3, p = 0.929).

Table 2: Seasonal variation in plant density per square kilometer in different sites

Site	Site 1	Site 2	Site 3	Site 4	Site 5
Spring	97.187(±11.421)	150.937(±21.526)	60.312(±13.986)	31.25(±2.362)	31.250(±3.204)
Summer	84.843(±5.038)	143.75(±14.919)	56.25(±9.065)	30.625(±1.470)	33.750(±2.066)
Autumn	84.062(±7.394)	143.75(±21.84)	55.93(±13.354)	30.625(±2.152)	33.750(±3.025)
Winter	99.375(±10.138)	156.718(±14.626)	62.65(±9.9883)	30.937(±1.476)	33.750(±2.859)

Table 3: Species richness (± SE) in each site across seasons

Site	Site 1	Site 2	Site 3	Site 4	Site 5
Spring	0.137(±0.255)	0.507(±0.037)	0.455(±0.019)	0.202(±0.116)	0.060(±0.03)
Summer	0.122(±0.218)	0.508(±0.226)	0.413(±0.020)	0.051(±0.023)	0.065(±0.029)
Autumn	0.124(±0.230)	0.508(±0.039)	0.419(±0.030)	0.051(±0.033)	0.065(±0.042)
Winter	0.131(±0.235)	0.516(±0.024)	0.458(±0.019)	0.125(±0.06)	0.057(±0.027)

overgrazing and elimination of more palatable species. The frequency of typical palatable species like *Cyperus conglomeratus* and *Stipagrostis plumosa* were found to be very low. The dominance of *Tetraena qatarense* in the studied sites also supports this claim.

The effect of grazing in species diversity and density cannot be understated. Interestingly, while overgrazing has adverse effects on plants, moderate grazing is found to have several advantages for both individual plant and plant communities. This observation was supported by the works of Ayyad *et al*., [39]. Thalen [37], who found that the percentage cover of vegetation protected from grazing on desert rangelands increased only after a couple of seasons. This observation has been further substantiated by the study at Baynunah [14] where the vegetation percentage cover was greater inside the enclosure than on the grazed rangelands outside. The results of this study also confirm that if grazing is controlled, the species density and diversity could be increased.

Studies by Thalen [37] also show that heavy grazing over an extended period of time will result in the creation of monospecific stands of those perennial species most able to survive the grazing pressure. The dominant species in Site 1, *Caroxylon imbricatum* is one such species that has survived such grazing pressure.

The heterogeneity of local topography, edaphic factors and micro-climatic conditions explains the variation of the distributional behavior of the plant

associations of the study area. Spatial distribution of plant species and communities over a small geographic area in desert ecosystems is related to heterogeneous topography and landform pattern [40].

In conclusion, from the five sites selected to study the species diversity and vegetation structure in the western region of Abu Dhabi Emirate, it is clear that the vegetation structure still remains simple with species that can withstand harsh climatic conditions and resist grazing, dominating. Site 2's high species richness and diversity could be attributed to *Haloxylon persicum* which provides shade and a microhabitat that helps other species to nuture and grow. No annual species were spotted due to lowrainfall and those that have survived are the ones found unpalatable. Low species richness result from low rainfall, poor soil and harsh climatic condition.

The studies also further conclude that the vegetation across most of the study sites werefound to be severely impacted by livestock grazing. Most of the Abu Dhabi's rangelands are exposed to uncontrolled grazing practices. And as discussed earlier, if grazing pressure were reduced, the current vegetation should produce more visible growth. The availability of water for plant growth is also another significant limiting factor for desert plants and is aggravated by interactions between adverse climatic factors, topography, the poor water holding ability of the substrate and the vegetation. If grazing can be removed from sandy areas, plants such as *Haloxylon salicornicum* could bind the wind-blown sand, forming hummocks and creating a topography with more water - holding potential than flat plains. The presence of camel camps also result in the total extermination of the native flora and therefore the disappearance of hares, spiny-tailed lizards and small rodents. *Tetraena qatatrense* and *Haloxylon salicornicum* were found to be dominant in all the four sites indicating that these plants are most resistant plants to grazing. Livestock control still remains the major means to increase the vegetation cover and species richness and is still considered as the most suitable method to restore desert vegetation in Abu Dhabi.

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