Range Mgmt. & Agroforestry 34 (1) : 88-92, 2013
ISSN 0971-2070

Effect of livestock grazing on plant cover and species diversity in desert rangelands: A case study of Musawar Al Ottoria in Qatar

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Received: 28th May, 2013 Accepted: 20th June, 2013

Abstract
Protection of designated areas within rangelands is widely considered to be the most effective and the practical way to conserve plant diversity and maintain ecosystem composition and structure. Thus, the effect of protection (two levels of grazing) at two sites in a rangeland was monitored: inside Musawar (enclosure), where the protection level is high, and an open area (outside the Musawar) where human and livestock had unrestricted access to ecosystem resources. Total plant cover, plant density, perennial species cover and their contribution were determined inside and outside the Musawar. The findings revealed considerable positive effects of protection on the scored parameters. However, the results emphasized a negative effect of the long term protection on vegetation dynamics. This was observed by the abundance of a very competitive annual species (*Stipa capensis*) and the occurrence of crusts on the soil surface (which may constitute an obstacle to water infiltration and seeds germination) inside Al Musawar. Short term protection followed by light grazing was found more sustainable than long term protection of some degraded rangelands in Qatar.

Key words: Forage, Grazing impacts, Plant cover, Protection, Livestock, Musawar, Rangeland

Introduction

Productivity of rangelands in Qatar has been deteriorating in both quality and quantity due to overgrazing and recurrent droughts. Overgrazing lowers the productivity of ecosystems and reduces the species richness and relative abundance (Boer and Shaukat, 1999; Louhaichi *et al*., 2009, 2012). Today, large parts of the rangelands of the country are suffering from the negative impacts of overgrazing while natural resources have been gradually deteriorating (Assaeed, 1997). Livestock grazing affects more than 90% of the land on the Arabian Peninsula and rangeland degradation takes place (Gallacher and Hill, 2006). Ultimately, a large number of range species have become rare and many have either already disappeared or are on the brink of extinction (Saleh, 2005). The negative trend in the conditions of rangelands was expedited as the traditional grazing system (Hema system) which was based on different grazing deferment and controlled grazing was abandoned (Le Floc'h *et al*., 1999). With the current oil wealth and political stability, facilities have become available for breeding more livestock in rangelands and the grazing pressure on desert rangeland has increased steadily (Oatham *et al*., 1995). Almost all rangelands in Qatar are now grazed continuously without any restriction on grazing intensity or destocking during critical periods. Livestock grazing also leads to a considerable increase in sand movement. Vegetation cover that normally protects the soil from erosion is reduced. In addition to overgrazing by livestock, uprooting of plants and off-road use of vehicles are also among human pressure factors that destroy rangelands.

The degradation of soils and the loss of perennial palatable species, mainly grasses, are two of the direct results driven by the increase in biotic pressure on these fragile ecosystems (Ouled Belgacem *et al*., 2008, 2013; Tarhouni *et al*., 2006). Moreover, drought has become more frequent (Ouled Belgacem and Louhaichi, 2013). Recurrent drought is different from the drought cyclic phenomena known in the region, and could result from a global climatic warming (IPCC, 2007). It may disturb the normal functioning of ecosystems which may also be exacerbated by human induced activities.

In order to reverse or at least alleviate rangeland degradation and the negative impact of the combined effects of overgrazing and drought on pastoral ecosystems in Qatar, the reintroduction of the well known traditional practice 'Hema system' under new management and arrangement could be an effective tool. The purpose of this study is to evaluate the impact of livestock grazing on plant community structure in the desert rangelands located in north-western Al Ottoria in Qatar. Total plant cover, density and species frequency of the herbaceous stratum and woody species between grazed and protected areas were compared.

Materials and Methods

In the framework of the national programme of conservation of plant diversity in Qatar, the Ministry of Environment established 30 fenced areas locally called 'Musawars' in 2004 spread all over the country. Covering an area of 2500 m² each, these Musawars were selected in the landscape depressions (Rodha) and wadis where soils presented relatively high water holding capacity.

Study area: The study was carried out in the Rodha of Al Ottoria in north-western Doha (25° 31' 32'' N and 51° 13' 29'' E). The climate of the site is characterized by high temperatures, hot dry summer winds, comparatively high relative humidity for most part of the year and scant and irregular rainfall (about 77 mm/year). Soils of these landscape depressions vary from sand clay loamy to clay loamy. The natural vegetation belongs to the inland plant communities originally dominated by *Acacia tortilis* and *Ziziphus spina-christi, Lycium shawii* and some perennial grasses such as *Lasiurus hirsutus, Chrysopogon aucheri* and *Cymbopogon parkeri.*

Total annual rainfall at Al Ottoria during the 2004/2005 and 2011-2012 growing seasons were 11.7 and 35.2 mm respectively. In both periods, rainfall was not only lower than the average but also it occurred much later than average which affected negatively the growth of perennials and annual species.

The surrounding area, as everywhere in Qatar, is suffering losses due to desertification including the loss of plant productivity, biodiversity and soil fertility. Improved access to freshwater has allowed the livestock population to increase dramatically. However, the move away from nomadic to a more sedentary lifestyle has also resulted in increased localized grazing pressure. Livestock grazing by camels, sheep and goats above the ecological carrying capacity has resulted in the reduction of many plant species, changing the shrubland to the current relatively barren landscape.

Measurements and data collection: Data collection was made during the 2011/2012 growing season, at two sites located within and adjacent to Al Ottoria Musawar. To study the effect of vegetation protection, three parameters were measured: total plant cover, density and species frequency of the herbaceous stratum and woody species. The quadrat point method (Daget and Poissonet, 1971; Floret, 1988) was used at both stations: inside and outside the Musawar. A total of 8 tapes of 50 m length each were randomly established (4 inside and 4 outside the Musawar). A fine pin was descended to the ground every 25 cm along the tape. Each of the 200 hits per tape was recorded according to the plant species touched. The total plant cover, in each tape, was calculated as: TPC = (n/N)*100 with n: the number of hits of all plant species and N: the total number of hits (200 hits in our case). The specific frequency of presence (SFP) was the number of hits of the specific species: SFPi = (ni/N) * 100 with ni: the number of hits of species i. Hence the SFP is the equivalent of the specific cover of each species. On the other hand, density of perennial species (both herbaceous and woody), per square meter, was determined within five randomly selected 20 m² quadrats for each station. Since measurements of total plant cover and species frequencies were conducted after 2 years of protection (inside the Musawar) (Saleh, 2005), an evaluation of vegetation parameters was made over time.

Data analysis: All data were subjected to analysis of variance (ANOVA) using SPSS 11.5 (SPSS Inc., 2002). Stations (inside or outside the park) were the independent variables whereas total plant cover, species frequency and density were the dependent variables. No transformations were required to meet parametric assumptions for ANOVA.

Results and Discussion

Statistical analysis of total plant cover showed a significant difference between the two treatments in 2012 (Table 1). Total plant cover was higher ($p<0.01$) inside than outside the Musawar (77.3 and 12.67% respectively). Despite the highly significant difference ($p<0.01$) in the contribution of the species, vegetation cover was mainly dominated by annual species and the perennials were few (5-15%). Under open grazing outside the Musawar, the annuals plant species dominated (84%), while the perennials

species became rare (about 5%) (Figure 1). This confirms the common belief of the therophytization phenomenon characterizing plant communities in the dry zones since areas with a high animal density are mostly dominated by annual species (Ouled Belgacem *et al.,* 2013). However, the poor contribution (only 15%) of perennial species inside the protected area (Musawar) after 9 years of protection is low. Compared to what was recorded in 2005 (when it reached more than 78%) after only two years protection, the contribution of perennials was decreased considerably. It is well known that the abundance of annuals is more related to the degree of disturbances and rainfall distribution, whereas the abundance of perennials (in cover and number) is an indicator of a good rangeland condition.

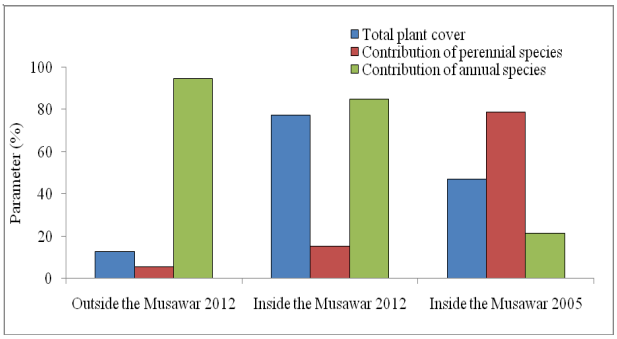

Fig 1. Total plant cover (%) and perennials and annuals species (%) inside and outside the Musawar.

The species cover and density variation were studied (Table 2) in relation to the management tool (protected versus grazed) and protection duration (2 and 9 years). Both indicators were significantly affected (p<0.05) by grazing. The number of species (perennials and annuals) recorded inside was also significantly higher (p<0.05) than outside the Musawar (10 and 6 respectively). Inside the enclosure, statistical analysis of species cover and density showed significant differences for many plants mainly tree and shrub strata such as *Acacia tortilis* and *Lyceum shawii* which disappeared completely from the open grazing site. Some perennial grasses such as *Chrysopogon aucheri* and *Cynodon dactylon* were also either more abundant or scanty in the Musawar. However, regardless of the management technique applied, cover and density of annual species were relatively high inside the Musawar compared to outside the Musawar. *Stipa capensis*, a species with very high dynamics had higher (p<0.05) cover and density inside the Musawar (61% and 260 individuals/ m² respectively) than outside the Musawar.

The results demonstrated that protection significantly increased the total plant cover. Similar results were reported in similar agro-ecological zones earlier (Ayyad and El-Kadi, 1982; Alyemeni and Zayed, 1999; Ouled Belgacem *et al*., 2013; Tastad *et al*., 2010), indicating progressive increase of total vegetation cover in protected areas as compared to grazed areas which are often characterized by the expansion of bare soil. In fact, protection reduces erosion and improves soil structure due to the abundance of litter and other plant debrises (Ouled Belgacem *et al*., 2008). Higher plant cover reduces water losses by evaporation, maintains a favourable microclimate for regeneration of annual herbaceous species and permits the development of perennial herbaceous species (Bryla, 2007).

The data showed that the enclosure led to a significant expansion of perennial herbaceous plant cover at the expense of annual herbaceous species which declined with short term protection. Similar results were reported by Ouled Belgacem *et al*. (2008), who examined protected desert rangeland ecosystem in a two year study in southern Tunisia. The results also agreed with the view of Ouled Belgacem *et al.* (2013), that perennial species cover is an important measure of how vegetation cover recovers after protection. In arid and desert ecosystems, Floret and Pontanier (1982) and Wesstrom and Steen (1993) also reported an expansion of perennials species and decline of annual species in response to protection.

Outside the Musawar, heavy grazing reduced the cover of perennial species (Tarhouni *et al*., 2006). Grazing is generally selective and often leads to the replacement of palatable species by less palatable ones which are less desirable or even worthless (Callaway and Tyler, 1999; Olff and Ritchie, 1998) such as *Heliotropium europaeum* and *Convolvulus cephalopodus*. Moreover, the decline of perennial species (mainly grasses) is considered by several workers to be a good indicator of plant cover degradation. The decrease or even the disappearance of perennial species in relation to the long duration of protection may be attributed to the negative effect of long term protection on the species dynamics. Aged tufts of perennial plants after frequent droughts may lose their vigour and their capacity for seed production compared to annual plants. Results indicated that long term protection had relatively similar negative effects as induced by heavy and continuous grazing. Grass species, such as *Chrysopogon aucheri* and *Stipagrostis obtusa* and other chamephytes such as *Artemisia inculta* and *Teucrium polium* recorded in 2005 disappeared or decreased in cover in 2012. This indicated that they were apparently not tolerant to long term protection and their dynamics were more induced by short term protection or resting followed by moderate grazing.

Table 1. Total plant cover (%) and perennials and annuals species (%) inside and outside the Musawar.

Attribute	Outside the Musawar 2012	Inside the Musawar 2012	*p*	Inside the Musawar 2005
Total plant cover (%)	77.3	12.7	**	47.0
Perennial species (%)	15.1	5.3	**	78.7
Annual species (%)	84.9	94.7	**	21.3

***p < 0.05*

Table 2. Species cover (%) and density (plants/ m²) in inside and outside of Al Ottoria Musawar and their evolution since 2005

Species	Life form	Species cover (%)			Density (plants/ m²)	
		2012		2005*	2012	
		Outside	Inside	Inside	Outside	Inside
Acacia tortilis	P	-	1.67 ± 2.22	-	-	0.0012
Arnebia hispidissima	A	-	0.67 ± 0.5	-	-	-
Artemisia inculta	P	-	-	2	-	-
Bassia muricata	A	5 ± 2.13	1.33 ± 0.31	-	118.2 ± 11.24	36 ± 8.32
Cassia italca	P		-	-	-	0.0024
Chrysopogon aucheri	P	0.33 ± 0.57	1.67 ± 0.57	27	0.14 ± 0.04	0.43 ± 0.18
Citrullus colocynthus	P	-	-	3		-
Convolvulus cephalopodus	P	0.33 ± 0.57	-	-	4 ± 0.56	0.02 ± 0.02
Cymbopogon parkeri	P	-	1.33 ± 0.22	4		-
Cynara cardunculus	A	-	-	-	-	0.03
Cynodon dactylon	P	-	-	-	-	0.34 ± 0.22
Fagonia glutiosa	P	-	5.33 ± 0.70	-	0.02 ± 0.005	0.26 ± 0.18
Francoeria crispa	P	-	1.67 ± 1.15	-	0.01 ± 0.002	0.06 ± 0.68
Helianthemum lippii	P	-	-	-	0.4 ± 0.14	-
Heliotropium europaeum	P	0.67 ± 1.73	-	-	2.6 ± 1.81	-
Lyceum shawii	P	-	-	-	-	0.003
Malva parviflora	A	-	1.33 ± 0.40	-	-	-
Paronychia arabica	A	4.33 ± 1.5	1.33 ± 0.40	2	5 ± 0.1	0.23 ± 0.12
Stipa capensis	A	2 ± 1.88	61 ± 0.35	-	12.6 ± 8.14	260 ± 24.6
Stipagrostis obtusa	P	-	-	1	-	-
Teucrium polium	P	-	-	3	-	-
Trigonella hamosa	A	0	0	5	26.8 ±4.13	20 ± 8.34

*: Saleh (2005), P: perennial, A: annual

Conclusion

Rangelands in Qatar are severely degraded due to the combined effects of overgrazing and harsh environmental conditions. However, it seems that these ecosystems have not lost their resilience and the soil seed bank is still significant. The case study of Al Ottoria Musawar showed the beneficial effect of protection on plant cover dynamics and species diversity. However the results emphasized, on the other side, a negative effect of the long term protection on vegetation dynamics expressed by the abundance of more competitive species and the occurrence of crusts on the soil surface (which may constitute an obstacle to water infiltration and seeds germination). A light grazing is an efficient tool to reactivate the ecosystem functioning. Short term protection followed by light grazing was found more sustainable than long term protection of some degraded rangelands in Qatar.

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