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Effects of open grazing and livestock exclusion on floristic composition and diversity in natural ecosystem of Western Saudi Arabia

Saud L. Al-Rowaily [a,*], Magdy I. El-Bana [b], Dhafer A. Al-Bakre [c], Abdulaziz M. Assaeed [a], Ahmad K. Hegazy [d,e], Mohammed Basharat Ali [a]

[a] Department of Plant Production, King Saud University, PO Box 2460, Riyadh 11451, Saudi Arabia
[b] Department of Botany, Faculty of Science, Port Said University, Egypt
[c] Department of Biology, College of Science, University of Tabuk, Saudi Arabia
[d] Department of Botany and Microbiology, Faculty of Science, Cairo University, Giza 12613, Egypt
[e] Department of Botany and Microbiology, College of Science, King Saud University, Riyadh, Saudi Arabia

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Abstract Livestock grazing is one of the main causes of rangeland degradation in Saudi Arabia. Fencing to exclude grazers is one of the main management practices used to restore vegetation and conserve biodiversity. The main objectives of this study were to investigate the changes in plant diversity and abundance, floristic composition and plant groups of the major life forms in response to thirty-five years of grazing exclosure in western Saudi Arabia. These vegetation attributes and palatability were compared in 30 sampling stands located in the excluded and grazed sites. Our results showed that livestock exclusion significantly increased covers, density and species richness of annuals, grasses, perennial forbs, shrubs and trees. Exclosure enhanced the abundance and richness of palatable species and depressed the development of weedy species. About 66.7% of the recorded species at the excluded site were highly palatable compared to 34.5% at the grazed site. In contrary, about 55.2% unpalatable species were found in the grazed site compared to 25.8% in the protected site. Jaccard's similarity index between the excluded and grazed sites showed lower values of 0.39%, 0.40% and 0.31% at levels of families, genus and species, respectively. The results suggest that establishing livestock exclusion may be a useful sustainable management tool for vegetation restoration and conservation of plant diversity in degraded rangelands of arid regions.

* Corresponding author.
E-mail address: srowaily@ksu.edu.sa (S.L. Al-Rowaily).
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1. Introduction

In arid environments, the concentration of both water and nutrients provides suitable sites for vegetation establishment, and causes the heterogeneous pattern characteristic of vegetation and plant populations (Ludwig and Tongway, 1995; Al-

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Rowaily et al., 2012). Accordingly, the high rates of biomass removal and selective removal of palatable species result in sparse vegetation, reduced resource retention (seeds and litter reserve) and altered proportions of plant life-forms, each of which may respond differently to rainfall (Ludwig et al., 2005). Therefore, the relationship between grazing and vegetation is complex (Lavorel et al., 1997; McIntyre and Lavorel, 2001).

Grazing is the common land-use throughout the arid regions of the world. It has substantial effects on many ecosystem processes and functions, such as nutrient pool and cycling, soil moisture and structure, vegetation composition and productivity (Caldwell et al., 1981; Gao et al., 2007; Garrido et al., 2011; Al-Rowaily et al., 2012). It has generally been concluded that grazers could affect floristic composition and diversity in different ways, depending on the type of grazing animals, intensity of grazing and host plant species (Obeso, 1993; Müller et al., 2000; Bardgett and Wardle, 2010).

Livestock overgrazing is considered as the main cause of rangeland degradation through lowering both the productivity and resilience of host species, reduction of vegetation cover, increase of unpalatable species, decrease of species diversity, and alteration of soil structure and compactness (Kairis et al., 2015; Belgacem et al., 2013; Zhou et al., 2011; El-Keblawy et al., 2009; Keya, 1998; and Mainguet, 1994). Effects of grazing on the plant community and soils are viewed as destructive agents because of the reduction of ground cover, productivity and soil erosion (Al-Rowaily, 1999; Manzano and Návar, 2000; Firincioğlu et al., 2007; Al-Rowaily et al., 2012).

Rangelands of Saudi Arabia are essential terrestrial natural resources with great ecological, economic and social importance due to their crucial role in the development of rural areas. Generally, they support forage for both livestock and wild herbivores; offer the opportunity for outdoor recreational activities and enjoyment of nature (Al-Rowaily, 2003). In addition, they play great ecological role in conserving biodiversity. However, continuous overgrazing threatens the productivity, biodiversity and sustainability of these rangelands, and consequently enhances desertification process (Barth, 1999; Al-Rowaily et al., 2012, 2009; Al-Rowaily,1999), particularly in the absence of a specific policy for the protection and the sustainable management.

Several studies have highlighted the importance of establishing enclosures by fencing as a simple management tool for excluding animal grazing and restoration of degraded rangelands throughout the world (Kumar and Bhandari, 1992; El-Bana et al., 2003; Yeo, 2005; Kröpfl et al., 2013). However, few studies have evaluated such management approach in the rangelands of the Arabian Gulf countries, particularly is Saudi Arabia (Abulfatih et al., 1989; Shaltout et al., 1996; Al-Rowaily, 1999). The response of vegetation abundance and diversity to fencing vary with the period of protection within the same type of vegetation and type of grazing animals (Omar et al., 1990; Omar, 1991; Wu et al., 2009). In the rangelands of Kuwait and United Arab Emirates, short-term protection from grazing for 3–4 years resulted in a significant increase in species abundance and richness compared to low vegetation cover and richness under long-term protection for 10–15 years (Omar et al., 1990; El-Keblawy, 2003). However, Shaltout et al. (1996) reported an increase in vegetation cover and diversity after 11 years of protection in rangelands of Eastern Saudi Arabia. Long-term fencing to exclude large herbivores, in particular, has been adopted as a defense against overgrazing and has become a method used to implement conservation objectives. Comparison of vegetation composition and diversity including species richness and abundance, and plant functional groups in open and fenced areas could reflect the system stability and resilience of the rangelands (Metzger et al., 2005). Such approach can help to guide sustainable management strategies for conserving natural resources and ecosystem goods and services.

Following this management approach, the objectives of this study were to investigate the changes in plant diversity and abundance, floristic composition and plant groups of the major life forms in response to thirty-five years of grazing exclosure in western Saudi Arabia.

2. Materials and methods

2.1. Study area

The study area, the National Wildlife Research Center (NWRC), is located at about 30 km from Taif city, Saudi Arabia (21° 14′ 50″ N, 40° 42′ 30″ E, 1400 m altitude) (Fig. 1). Topography is flat with undulating plateau. The area is subject to continuous livestock grazing by sheep and camels which represent the only human activity that impacts vegetation. An area of about 35 km^2 was fenced in 1986 to prevent livestock grazing. Thirty-five years after fencing, vegetation and flora was surveyed in both the fenced site and in the surrounding open site subject to continuous overgrazing. Unfortunately there are no historical records on the levels of grazing with different animals and their effects on plant community attributes. Uncontrolled numbers of free-ranging camels, sheep and goats continuously grazed in the open site and there was no grazing by either domestic or wildlife animals in the fenced site (M.Z. Islam, personal communication).

The climate is arid with the 30 year average annual rainfall of 180.7 mm (Fig. 2). The rainy season falls between October and May while the summer months remain dry. The mean annual temperature is 22.8 °C, with the coldest mean temperatures (15.4 °C) in January and warmest (29 °C) in August. The study site's soil characteristics are relatively homogeneous with a high proportion of sand (80%) and low organic matter content amounting to 0.44% (Al-Bakre, 2008).

2.2. Field survey and data analysis

A total of 30 sampling stands (20 m × 20 m) were selected to represent the prevailing habitat and community variations inside and outside the exclosure (15 stands for each). Within each stand, five (5 m × 5 m) plots were randomly distributed to estimate plant frequency and density. However, line intercept method (Canfield, 1941) was applied for measuring cover of species using 5 lines of 20 m each, within each stand. The importance value index was calculated as the sum of relative values of density, frequency and cover. Nomenclature of species was according to using Chaudhary (1989, 2000), and Chaudhary and Akram (1987).

We classified the plant community into six functional groups according to their growth forms: annuals, grasses, perennial forbs, shrubs, trees and weeds. The weedy species were defined as those noxious species that are enhanced by