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The effect of grazing exclusion on vegetation characteristics and plant community structure in arid lowland pastures

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Abstract. Rangelands are the mainstay of pastoral livelihoods worldwide. Within rangelands, there are landscape depressions or lowlands characterized by high production potentials with their unique edaphic and hydrologic properties. The purpose of this ongoing research is to evaluate the effect of grazing exclusion on the vegetation characteristics and plant community structure in the arid lowland pastoral ecosystems. Plots were randomly identified within two distinct lowlands in Majidya and Sabha, in the Jordanian Badia. Preliminary results indicate that the total biomass and plant density widely differed between the open grazed and protected areas (P<0.001) in both sites. Total annual dry matter production was 954 kg ha-1 for protected and 151 kg ha-1 for open grazed areas in Majidya and 1749 kg ha-1 for protected and 20 kg ha-1 for open grazed areas in Sabha. The average plant densities in open grazed areas were 29 and 16 plants/m2, compared to 83 and 612 plants/m2 in protected areas in Majidya and Sabha, respectively. These results indicate that plant community structure is greatly affected by livestock grazing and that a site's ability to recover from disturbance over time may be limited. Therefore, carefully planned grazing management is needed to achieve greater rangeland productivity and diversity.

Keywords. Badia – Grazing management – Pasture production – Plant diversity.

Effet de l'exclusion de pâturage sur les caractéristiques de la végétation et la structure de la communauté végétale dans les parcours des zones arides

Résumé. *Les parcours représentent un pilier important des moyens de subsistance pour les communautés pastorales à travers le monde. Au sein des parcours, il existe des zones de dépression ou des terres basses qui ont des propriétés édaphiques et hydrologiques spécifiques. L'objectif de la recherche en cours est d'évaluer l'effet de la protection contre le pâturage sur les caractéristiques de la végétation et la structure de la communauté végétale dans les écosystèmes pastoraux des dépressions dans les zones arides. Des parcelles ont été identifiées au hasard dans deux plaines à Majidya et Sabha, dans la Badia Jordanienne. Les résultats préliminaires montrent que la biomasse totale et la densité des plantes étaient différentes entre les zones protégées et les zones pâturées (P<0.001) au niveau des deux sites. La matière sèche totale produite annuellement a atteint respectivement 954 kg ha^{-1} et 151 kg ha^{-1} pour les zones protégées et les zones pâturées au site de Majidya et les valeurs correspondantes étaient de 1749 kg ha^{-1} et 20 kg ha^{-1} pour le site de Sabha. La densité moyenne des plantes dans les zones pâturées était de 29 et 16 plants/m^2 respectivement à Mjidya et Sabha en comparaison à 83 et 612 plants/m^2 dans les parcelles protégées pour les mêmes sites. Ces résultats montrent que la structure communautaire de la végétation est très affectée par le pâturage et que la capacité des écosystèmes à se remettre des grandes perturbations est limitée dans le temps. Par conséquent, une gestion raisonnée des pâturages est indispensable pour garantir une plus grande productivité et diversité dans les parcours.*

Mots-clés. Badia – Gestion du pâturage – Production pastorale – Diversité des plantes.

I – Introduction

Rangelands cover almost a half of the Earth's land surface (Schimel, 2010). Traditionally, rangelands are a major source of feed for the pastoral livestock production system (Kassahun *et al.,* 2008). Rangelands also provide vital ecological resources that include; nutrient cycling,

filtering of pollution, medicinal herbs, and the preservation of biodiversity for millions of resource-poor agro-pastoral farmers (Louhaichi *et al.,* 2009). However, these rangelands are suffering from the encroachment of cultivations, overgrazing and harsh climatic conditions particularly recurrent droughts. Within these vast areas, lowlands which are broad dry basins exhibit localized high vegetation productivity and unique edaphic and hydrologic properties.

The purpose of this research is to evaluate the effect of short-term grazing on vegetation characteristics and plant community structure within two different lowlands located in the Jordanian Badia, and to provide other options for sustainable development of these key areas.

II – Materials and methods

Two lowland pastures were randomly selected. The sites are located in Majidya (latitude 31° 43′ 48″ longitude 36° 07′ 25.03″ altitude 835 m, long term average annual rainfall = 100 mm, Rainfall of the growing season "begins in November and ends in May" = 134 mm) and Sabha (latitude 32° 17′ 04.2″, longitude 36° 27′ 53.28″ altitude 754.5 m, average annual rainfall = 130 mm, growing season rainfall = 119 mm). Both sites are located in the Jordanian Badia. The main grazing system is the semi-nomadic. In most cases the number of livestock is much higher than the available feed. Grazing periods start usually in late winter and early spring, this leads to reduced cover, resulting in loss of plant reproduction in the next season.

Vegetation sampling took place during the peak standing crop in the spring of 2015. Each lowland pasture site (5 ha total area) had an open grazing and a protected section. In each site ten 1 m × 1 m quadrats were randomly placed to estimate plant biomass, density, and species diversity. Above-ground biomass was harvested by manually clipping plants 2.5 cm above the soil surface within each quadrat. In the lab, clipped plants were oven dried for 72 h at 70°C and then weighed in order to estimate the total dry weight. The percentage of total biomass for above-ground plant parts was estimated on an individual species basis for all species sampled. Plant density was calculated as the number of individuals for each species that were found within a placed quadrat (m^2).

Cover and density were compared among the locations using one-way ANOVA, followed by Duncan test. Differences between means were considered significant if *P* values were <0.05. Comparison of means for vegetation characteristics under grazing and protected treatments was undertaken using a t-test. Means and standard error values were calculated for all comparisons. All computations were carried out in SAS (SAS, 2004).

III – Results and discussion

The optimal use of rangeland resources depends on many factors such as understanding of the changes of seasonal biomass production as affected by climate, grazing management, and proper use management. Productivity (kg ha^{-1}) is a measure of the available herbaceous plant species biomass per surface unit. While, plant density is the number of individuals of each taxon per surface unit. Both measurements represent key indicators for understanding the condition and trend of rangeland resources at the local scale. A proper management scheme is required for the sustainability of these natural resource base. Previous studies have reported that short term protection from grazing have positive effects on productivity (biomass) and biodiversity (species richness) of rangeland ecosystems (Mengistu *et al.,* 2005, Louhaichi *et al.,* 2012).

The total biomass and plant density widely differed between the open grazed and protected areas (*P*<0.001) in both sites. Total annual dry matter production in Majidya was 954 kg ha^{-1} for protected and 151 kg ha^{-1} for open grazed areas (Fig. 1). In Sabha total annual dry matter production was 1,749 kg ha^{-1} for protected and 20 kg ha^{-1} for open grazed areas. Similar results

have been reported within similar landscapes by Louhaichi *et al.* (2012). This is due to the fact that overgrazing has negative impact on biomass production (Abdulatife and Ebro, 2015).

Our results show that the main effect of protection from grazing, the site and their interaction significantly affected the plant density (plant /m^2), total biomass (kg ha^{-1}) and the percent (%) of *Anabasis syriaca* (unpalatable shrub species that invades disturbed land). Plant cover (%) was affected only by protection from grazing and its interaction with the site treatment (P<0.05).

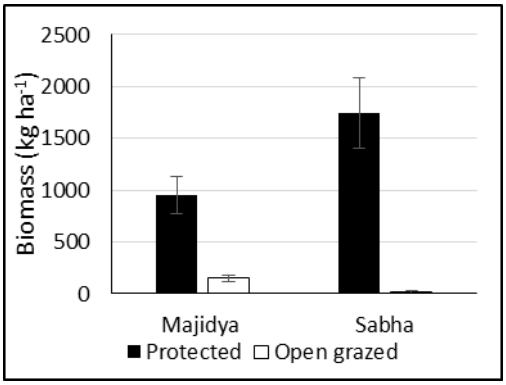

Fig. 1. Total biomass production (kg ha^{-1}) in protected and open grazed sites of two lowland pastures.

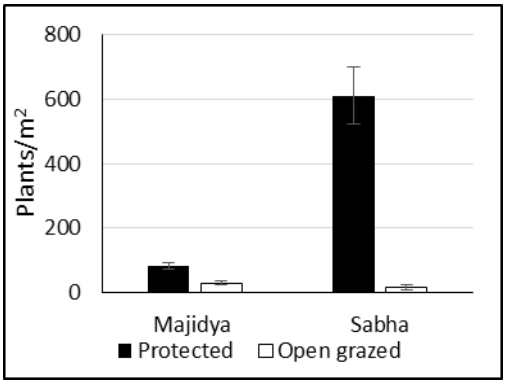

Fig. 2. Plant density (plants/m2) in protected and open grazed sites of two lowland pastures.

The average plant densities in open grazed areas were 29 plants/m^2 in Majidya and 16 plants/m^2 in Sabha. Plant densities increased in protected areas with 83 plants/m^2 in Majidya and 612 plants/m^2 in Sabha (Fig. 2). In the Majidya site, the protection treatment had a significant effect on reducing the percentage (%) of *A. syriaca* from 27% of the total plant cover in open grazed areas to 14% in protected areas.

Table 1. Main family names of species recorded in protected and open grazed areas of Jordan (%)

Family	Protected		Open grazed	
	Annual	Perennial	Annual	Perennial
Poaceae	22	5	13	0
Asteraceae	15	0	7	13
Brassicaceae	10	2	13	0
Caryophyllaceae	0	7	0	13
Fabaceae	5	0	13	0
Amaranthaceae	0	7	0	7
Capparaceae	0	0	0	7
Malvaceae	0	5	0	7
Plantaginaceae	2	5	0	0
Resedaceae	0	0	7	0
Other	8	7	0	0

The plant species composition found in the two lowland pastures represent 15 families mainly (*Poaceae, Asteraceae, Brassicaceae, Caryophyllaceae, and Fabaceae*). Differences between the number of plants that belong to each family in the protected areas and the open grazed areas were observed. In the protected areas, 25% of the species are members of *Poaceae*

family compared to 13% in the open grazed areas. Some species were more abundant in the open grazed areas than the protected areas. Species from *Asteraceae, Brassicaceae*, *Caryophyllaceae*, and *Fabaceae* had respectively 20, 13, 13 and 13% in open grazed areas and 15, 12, 7 and 7% in the protected areas. However, a greater availability of the other species in the protected areas was found (Table 1). Grazing exclusion increased herbaceous species richness mainly that related to annual grasses due to the fact that when overgrazing occur during spring annuals are not able to re-seed. These results showed significant variations in terms of plant biodiversity between protected and open grazed areas. Furthermore, the changes in plant composition resulted from overgrazing can involve the replacement of desirable and palatable plants by unpalatable species such as *A. syriaca* which is an unpalatable invasive shrub. This is illustrated through the state and transition models which explain how rangeland ecosystems response to natural and/or management-induced disturbances (Knapp *et al.,* 2011).

The density of perennials in the open grazing treatments found to be higher than annuals, this may indicate that grazing and reduced perennial biomass is important for perennial establishment.

IV – Conclusions

Lowland pastures have the potential to play an important role in the intensification and diversification of pastoral production system and provide a favorable environment for biodiversity conservation. Results of this research suggest that proper grazing is a potential tool for enhance pasture biodiversity, improve biomass availability and vegetation structure not only to maintain but also to improve range sustainability and enhance productivity. Particularly, lowland pastures, could represent a valuable source of feed for livestock, mainly during the dry season when resources are often limited.

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