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Research article

Effects of community camel and sheep grazing on vegetation cover in Al-Mayla rangeland in northern Saudi Arabia

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Abstract

The present study was conducted to investigate the effects of community camel and sheep grazing on vegetation cover and production at Al-Mayla rangeland enclosure in Arar, northern Saudi Arabia, protected for 40 years. Following a first vegetation sampling conducted in August 2022, two different sites (Artemisia and Atriplex sites) were identified and management plan involving grazing for one month on the Artemisia site by 769 heads of camels and the Atriplex site by 2739 heads of sheep was proposed. Upon pressure from the pastoral community, the number of sheep was increased to 7500 head and the grazing period was reduced to 2 weeks in September 2022. Field data collection was conducted after grazing. Total plant cover and soil surface states, species cover and density, and biomass available for grazing were measured and compared to the situation before introducing animals. Results showed that long-term protection (40 years) had a negative effect on vegetation cover dynamics through the development of more competitive and stress-tolerant low-range value species and hard soil crust which reduces infiltration, emergence of seedlings, and growth of plants. The findings suggested that short-period grazing with a high stocking density of mixed herds of camel and sheep which reduced animal selectivity and improved soil structure is not harmful to vegetation cover and range production and had social implications by allowing the grazing of more herds from the community.

Keywords: Camel, Community, Grazing, Saudi Arabia, Sheep, Vegetation cover

Introduction

The rangelands of Saudi Arabia account for about 73 percent of the total area of the country, forming expansive landscape spanning approximately 146 million hectares (Al-Rowaily *et al*., 2018). These rangelands differ functionally because of differences in the spatial and temporal distribution of climate, soil and vegetation across the country (Chaudhary and Le Houerou, 2006). These important landscapes support a wide diversity of plant and animal communities, provide clean water and air; produce forage and plant cover for livestock and wildlife; and mitigate climate change by storing carbon (Seddon, 2000; Abuzinada, 2003). They also provide forage for livestock, provide genetic material for pharmaceutical products, create opportunities for recreation, and support the livelihood of at least two million people, especially the rural communities (Ouled Belgacem and Njeru, 2022).

For centuries, pastoral nomads were the main users of land in Saudi Arabia. The basic management problem for most pastoralists was that there was rarely enough forage and water in one place to sustain the pastoral community and their livestock year-round and practicing the *Hima* system and migration was the only way they met their livestock feeding needs (Abu-Zanat *et al*., 2005). More recently, the *Hima* system has gradually disappeared due to changes in socioeconomic conditions. In addition, there has been a major shift in the attitudes of pastoralists towards an increasing interest in settling down to benefit from social services such as education for their children.

The productivity of rangelands in Saudi Arabia has been deteriorating in both quality and quantity mainly due to overgrazing and recurrent droughts. Over time, overgrazing has lowered the productivity of rangeland ecosystems and reduced species richness and relative abundance. Today, large parts of the rangelands of the country are suffering from the negative impacts of overgrazing and their natural capacity has been gradually deteriorating. The negative trend in the conditions of rangelands was expedited as the

traditional grazing system (*Hima* system), which was based on varied grazing deferments and controlled grazing, was abandoned. Socioeconomic changes have provided facilities and services that have allowed breeding of more livestock in rangelands thereby increasing steadily the grazing pressure on fragile desert rangeland. There has been marked increase in animal numbers with 59% in the number of sheep; 481% in the number of camels; and 110% in the number of goats between 1981 and 2007 (Ouled Belgacem and Njeru, 2022). Almost all rangelands are now grazed continuously without any rest or restriction on grazing intensity or destocking during critical periods. This has resulted in a situation where more than 60% of the rangeland landscape is considered moderately to severely degraded (Al-Rowaily *et al*., 2018).

In addition to the harsh environment, socioeconomic and institutional constraints have hindered rangeland rehabilitation and limited the success of sustainable management programs that have been implemented in Saudi Arabia (Al-Rowaili *et al.*, 2018). To address the challenges and constraints of the rangeland sector and to ensure environmental sustainability while meeting human needs and economic growth, Saudi Arabia has developed in line with its vision 2030, the national environmental strategy and related sector strategies including national rangeland strategy. Within the framework of the national rangeland strategy, priority range sites located in different regions of Saudi Arabia and representing different rangeland systems are being selected for the implementation of the first phase of grazing management program. Options for sustainable rangeland management will be developed at these sites by piloting and testing different rangeland management technologies and approaches under the leadership of the National Center for Vegetation Cover and Combating Desertification (NCVC) and with the technical support of the Food and Agriculture Organization (FAO) and collaboration of all stakeholders including the pastoral communities. It is within this context that the present study was conducted to investigate the implementation of the grazing management program at Al-Mayla range site in Arar, northern Saudi Arabia.

Materials and Methods

Site description: The study was conducted in the Al-Mayla range site 5 km from Arar city, in the northern borders region of Saudi Arabia. The site which is enclosed and protected since 1982 covers a total area of about 1,467 hectares. The site lies along the valley with hot and dry continental desert Mediterranean climate with mean annual temperature of 29 °C (mean minimum of 15 °C in January and mean maximum of 41 °C in July). The mean annual precipitation is 57 mm with the highest precipitation received in the months of January, February, and March which records a total of 24 mm. The site had silt sand deposits soil with low plasticity and average contents of sand, silt and gravel being 54%, 30%, and 16%, respectively (Hegazy and Alghamdi, 2014). The natural vegetation is dominated by *Artemisia herba-alba*, *Achillea fragrantissima* and *Atriplex leucoclada*.

Study design: Following a relatively heavy rainfall that occurred on 28 April 2022 (27 mm), the vegetation at the protected range site regenerated significantly leading to a request by the local authorities and pastoral community in August 2022 to open the site for controlled grazing in line with the proposed grazing management plan. The NCVC took this opportunity to test and monitor the community grazing management program to gain experience and gather lessons that can support the implementation of the plan across the country. A study was conducted at the site during summer by NCVC and FAO where two blocks representing two grazing vegetation communities (called later Artemisia site and Atriplex site) were identified and targeted for controlled grazing. Measurements were made on 14-15 August 2022 to determine the carrying capacity of the two plant communities to guide the grazing plan, and a second set of measurements were made after the completion of the grazing on 9-10 September 2022 to assess and evaluate the impact of the controlled grazing at the two plant communities. In the second set of measurements, representatives of the pastoral communities were interviewed to capture their experience on community grazing management.

Vegetation sampling was made in the two plant communities: *Artemisia herba-alba* and *Achillea fragrantissima* community which covered an area of 389 ha and *Atriplex leucoclada* community covering 60 ha. The grazing plan was to open the first block which was dominated by the annual spiny vegetation *Carthamus tinctorius* to be grazed by herds of camels while the second block with the *Atriplex leucoclada* was to be grazed by sheep. There was no fence between the blocks and the animals could move between the two areas. Based on the first vegetation cover assessment, the carrying capacities were estimated at 769 heads of camels and 2,739 heads of

sheep for a period of 1 month. However, due to the high grazing demand among the pastoral community, the number of sheep increased to 7000 heads, far above the number planned for and the planned grazing period of 1 month was reduced to only two weeks (14 days).

Measurements and data collection: Within both sites, 3 permanent transects of 50 m were established and sampling points (20 m^2 quadrat) were identified along each transect for collecting data on soil surface condition, plant cover attributes and biomass production. For every sample point, soil and plant cover parameters were determined according to the points-quadrats method described by Daget and Poissonet (1971). Considering that grazing management will be continued at the range site, this experimental design will permit to appreciate the potential of regeneration and the persistence of plant species by monitoring the evolution of some descriptors (global plant cover, species cover, flora richness and the plant density). The state of the soil surface (sand, crust, stones, litter, animal faeces) was studied to monitor and assess changes of soil structure.

At each sampling point (20 m^2 quadrat), annual plants densities were measured by counting species individuals inside the quadrats. However, the density of perennial plants was determined by counting the number of each species tufts within the quadrat. Range biomass production was estimated by clipping the vegetation inside the quadrats for annual species and by clipping half of the potentially palatable biomass (according to the rule of taking half and leaving half) of 10 tufts of each species for perennial vegetation. The total biomass of perennial species was estimated by multiplying the mean available biomass per individual by the density of the species.

***Data analysis*:** Analysis of variance (ANOVA) was used to test differences in total plant cover, species cover, and productivity between plots and animal species grazing, and $P < 0.05$ was used to determine the significance in all tests. Fisher least significant difference at $P = 0.05$ was used for means comparison when the F-test was significant. The statistical analyses were performed using SPSS 26.0 software.

Results and Discussion

***Variation of total plant and soil surface cover*:** Plant cover and soil surface states in the studied rangeland sites before and after the introduction of grazing animals were recorded (Fig 1). The effects of animal grazing technique were highly significant on total plant cover and soil surface elements within and between sites (varying between $0.0013 \leq P \leq 0.0002$). The total vegetation cover showed a higher decrease in the Artemisia site (63%) than in the Atriplex site (43%). Regarding the soil surface states, a considerable decrease in the soil crust was recorded in the Atriplex site, while it was completely broken by the grazing animals in the Artemisia site. Litter cover also increased in both sites, probably due to animal trampling and plant refusal as expected. The composition of animal faeces following grazing was however surprising. In the Artemisia site planned to be grazed by camel herds both camel and sheep faeces were registered. However, in the Atriplex site

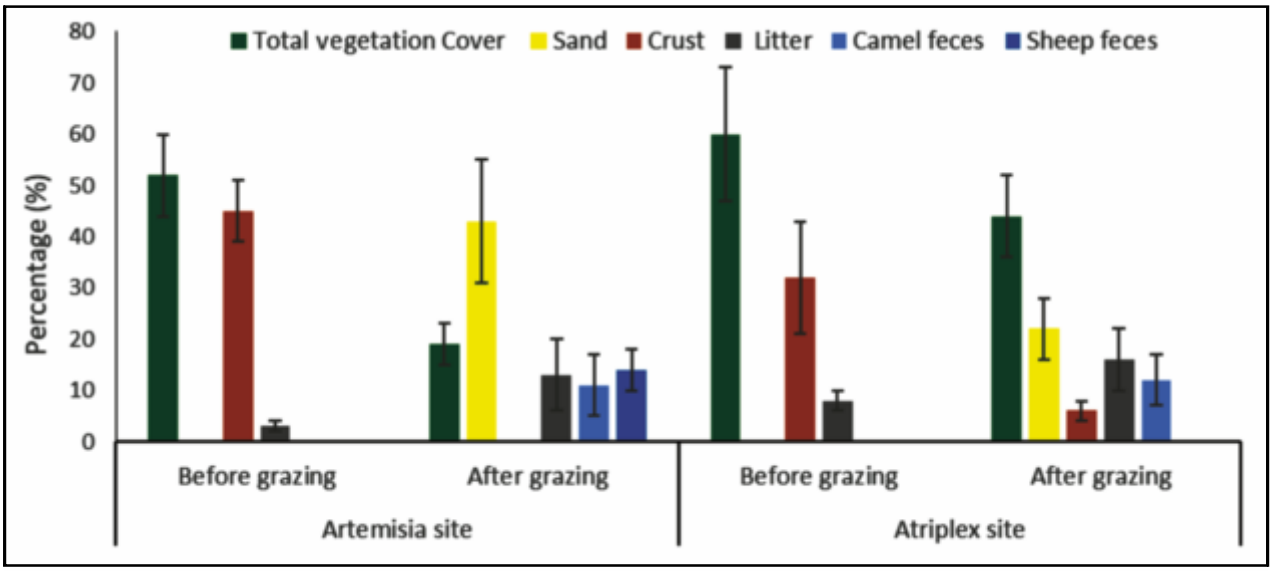

Fig 1. Variation of total plant and soil surface cover (in %) in relation to animal grazing in the studied range sites

which was originally planned to be grazed by sheep herds, only camel faeces were recorded. Since there was no barrier between sites, it seems that both herds moved between the sites to graze by preference.

***Variation of species cover*:** The variability in the species cover both between sites and within each site due to grazing was recorded (Table 1). In Artemisia site, 4 perennial and 5 annual species were registered. Among the perennials, *A. herba-alba* had the highest cover followed by *A. fragrantissima*. The first species was of medium palatability and showed a slight decrease under grazing, while the second species cover remained stable since it was not consumed by both animal species. The rare plants of *A. leucoclada* reduced in vigour or even disappeared after grazing. Among annual species, the spiny plant *Carthamus tinctorius* was dominant before grazing and decreased considerably under the effect of grazing. All the other annuals were fully grazed in spite of their dryness. In the Atriplex site, 9 different species, where 5 were perennial, were registered in the measurement before grazing. The cover of *A. leucoclada* which is well known by its high range value, marked it as the key species of the site. It showed a considerable decrease due to grazing, from 40% to 22%. On the other hand, the unpalatable species such as *Citrullus colocynthis* and *Artemisia scoparia* were relatively favoured by grazing and their specific covers were not decreased if not increased. Annuals were few and fully grazed.

Variation of plant densities: The variation of perennial species as well as the annual spiny plant (*C. tinctorius*) density with grazing in the Artemisia and Atriplex sites was recorded (Table 2). The data revealed the great variability of this parameter according to the applied management mode (camel or sheep grazing) and the original state of the site before grazing. The density of *A. leucoclada*

Table 1. Variation of species cover (%) in relation to animal grazing in the range sites

Species	Artemisia site		Atriplex site	
	Before grazing	After grazing	Before grazing	After grazing
Artemisia herba-alba	16	11	2	2
Atriplex leucoclada	2	0	40	22
Achillea fragrantissima	4	4	11	10
Citrullus colocynthis	1	2	3	8
Artemisia scoparia	0	0	2	2
Total perennials	**23**	**17**	**58**	**44**
Carthamus tinctorius	12	2	1	0
Plantago amplexicaulis	9	0	1	0
Bromus madritensis	5	0	0	0
Erucaria hispanica	1	0	0	0
Phalaris minor	2	0	0	0
Total annuals	**29**	**2**	**2**	**0**

Table 2. Variation of plant density (number of plants/ha) in relation to animal grazing in the range sites

Species	Artemisia site		Atriplex site	
	Before grazing	After grazing	Before grazing	After grazing
Artermisia herba-alba	530	480	200	180
Atriplex leucoclada (small tufts and seedlings)	0	0	12,666	1,750
Atriplex leucoclada (medium size)	0	0	11,666	15,500
Atriplex leucoclada (big tufts)	100	0	8,000	0
Citrullus colocynthus	250	250	300	300
Achillea fragrantissima	3,848	3,750	525	500
Carthamus tinctorius	4,180	1,500	250	100

exceeded 32,200 individuals per hectare before grazing and decreased by 46% to 17,250 after grazing. It seems the very fresh seedlings, were fully grazed before their establishment and thus disappeared due to this early grazing. The plants of other classes of size apparently lost their vigour and thus shifted to the lower class. This explained the disappearance of the big tufts and their conversion to medium or small tufts under the effect of camel grazing. The second species affected by grazing was *C. tinctorius* and its density in the Artemisia site reduced by 65%. This could be beneficial to avoid the invasion of this species on the site due to the big amount of seeds it produces in addition to its competitive behavior towards the main perennial species. The *A. herba-alba* and to a lesser degree *Achillea fragrantissima* were of low palatability and only the dry part could be grazed mainly by sheep and for this reason, the decrease in their densities was not important. As expected no significant changes in the density of *C. colocynthis* before and after introducing grazing animals were observed, due to its toxicity and refusal.

***Variation of palatable biomass*:** The variability in the palatable biomass production of both between sites and within each site due to grazing was also recorded (Fig 2). Analysis of palatable biomass showed that the effect of grazing on biomass production in the two studied sites was highly significant (P= 0.0014)

The considerable decrease of biomass under the effect of grazing was registered in the Atriplex site, where fresh seedlings of the dominant species (*A. leucoclada*) were fully consumed by camel herds. In this site, the biomass was reduced by about 84%. For the Artemisia site, the decrease of palatable biomass was about 75% in relation to grazing. However, in both sites, the carrying capacity was reached and 100% of the available biomass for grazing was used. This certifies that the high number of animals introduced, mainly sheep, was not harmful. The decision to shorten the grazing period following the high number of animals compared to the number previously planned was timely and helped avoid damaging grazing effects.

Indeed, this study was related to animal species' behaviour and preferences. Camel herds were introduced to the Artemisia site started by grazing the competitive annual spiny species (*Carthamus tinctorius*), which was relatively abundant, but they seem they didn't have any preference for the perennial aromatic species and moved to the Atriplex site where green and fresh abundant species were highly palatable. Contrary to camels, sheep didn't prefer to graze *Atriplex leucoclada* due to its sour taste and couldn't stay in the Atriplex site and moved to the Artemisia site to consume dry annuals and dry parts of perennial plants, even those with relatively moderate and low palatability when green. This confirmed the findings of Gihad and El Shaer (1994) that halophytes such as *Atriplex* sp. were more preferred by camel but could impact sheep physiology and behaviour.

This study was also related to the negative effect of long-term protection on vegetation cover and species diversity. This was more visible in the Artemisia site

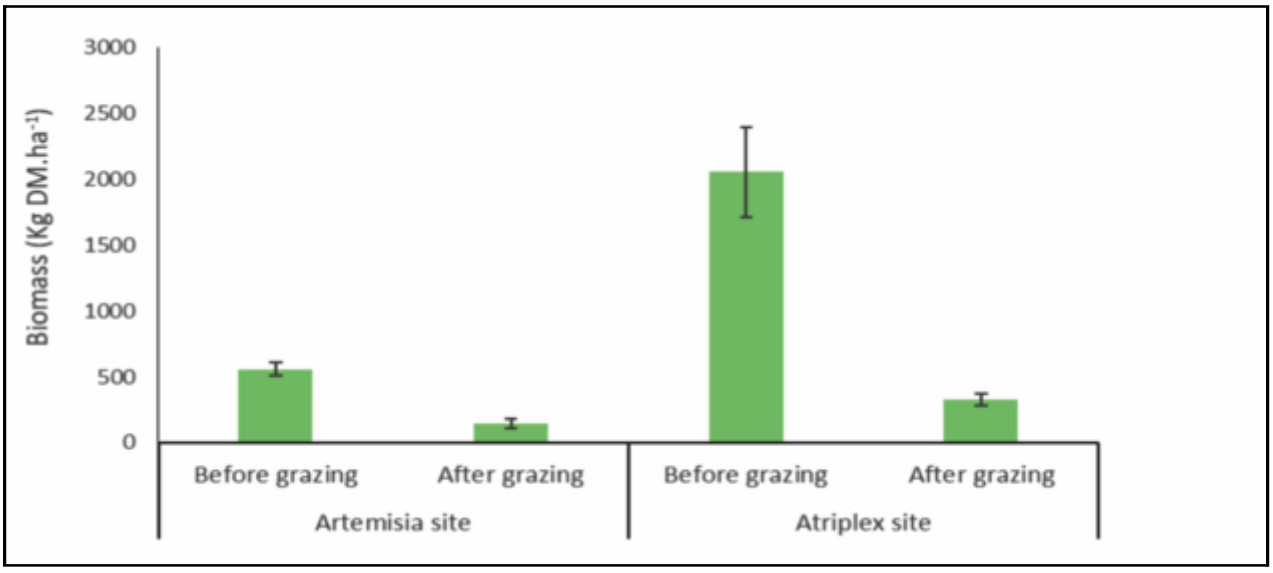

Fig 2. Variation of palatable biomass production (kg dry matter ha^{-1}) in relation to animal grazing in the range sites

where the vegetation cover dynamics were almost blocked by the development and abundance of the strong soil crusts. The crust reduced the rate of infiltration, increased loss of rainwater by runoff and inhibited the germination of seeds, emergence of seedlings, and plant growth (Jeddi and Chaieb, 2010; Ouled Belgacem *et al*., 2019; Chibani *et al*., 2021). For the Al-Mayla site, the beneficial effect of grazing and trampling mainly by sheep on this soil physical obstacle was obvious. Breaking soil crusts improved both soil water and vegetation cover dynamics and restoration (Ouled Belgacem *et al*., 2019). Furthermore, the abundance of *Achillea fragrantissima* and *Carthamus tinctorius* corroborated the results found by Louhaichi *et al*. (2012), Ouled Belgacem *et al*. (2013) and Tarhouni *et al*. (2017), where long-term protection favoured the development of more competitive and stress-tolerant species regardless of their palatability. The significant increase of litter and animal faeces and the disappearance of soil crusts after grazing, improved the organic matter content in the soil, which led to development of the vigour of the adult individuals as well as the good establishment of new seedlings (Ouled Belgacem *et al*., 2006; Tarhouni *et al*., 2007; Louhaichi *et al*., 2021).

Regarding vegetation cover attributes, despite the relative decrease in total vegetation cover and changes in plant species composition, both range sites were in good conditions. Grazing with high stocking density in a very short period enormously reduced the selectivity and protected the high nutritive range species from overgrazing. Although some palatable perennial species such as *Atriplex leucoclada* decreased both in density and in vigour, results showed that grazing did not harm the total biomass available for grazing even if it varied with management practices (Kumawat *et al*., 2022). Study showed that the implemented management plan inspired by the deferred grazing system had important ecological benefits and consequences for ecosystem function as observed earlier (Hickman *et al*., 2004; Gamoun *et al*., 2015; Gosnell *et al*., 2020). It also had important social and economic benefits for the local pastoral community. First, opening an enclosure protected for 40 years presented a gesture for collaboration and shared ownership needed between the local administration (represented here by NCVC) and the pastoral communities. This enhanced their confidence and demonstrated the necessity for sustainable management of the range sites including their rest and short-term protection. Second, due to the high costs of animal feed resources including imported barley, the opening of the site for the short period had substantial savings for the local community. One sheep keeper estimated that he saved as much as 4,000 US$ during this relatively short period of grazing at the opened range site. This will enhance the adoption of this grazing management practice by all involved stakeholders (Dogra *et al*., 2022).

Conclusion

The study showed that long-term protection had a negative effect on vegetation cover dynamics through the development of more competitive and stress-tolerant low-value range species and reduction in infiltration rates, emergence of seedlings, and growth of plants. The findings indicated that short-period grazing with a high stocking density of mixed herds of camel and sheep reduced animal selectivity and improved soil structure, and was not harmful to vegetation cover and range production. This had also social and economic benefits through building of trust and cooperation and saving on animal feeds.

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