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CHANGES OF VEGETATION STRUCTURE AND BIOMASS IN RESPONSE TO THE LIVESTOCK GRAZING IN STEPPE RANGELANDS OF IRAN

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ABSTRACT

This paper provides basic information on the response of steppe rangelands to different grazing regimes in steppe rangelands of Saveh, Iran. Data were collected from four rangelands including: a: Exclosure: for four years, b: Nemati Rangeland: rotation grazing system for six months, c: Chagneh Rangeland: continuous grazing for 6 months and d: Shirali Rangeland: continuous grazing throughout the year. Collected data included species composition, canopy cover percentage, production, and species height. Our results showed that continuous grazing throughout the year had negative effect on species composition and production, as the class-III species formed the main composition of Shirali Rangeland. On the other hand, exclosure for four years increased the canopy cover percentage and production of the species with a positive effect on rangeland. However, grazing management plans should include economic and biological considerations. Consequently, rotation grazing system and observing the grazing capacity could have positive effects on the vegetation and soil of rangelands.

Key words: livestock grazing, vegetation cover, range management, Saveh steppe rangelands, Iran.

INTRODUCTION

In Iran, rangeland ecosystems constitute the main part of renewable natural resources which have an important role in providing livestock ration. Rangeland management under different ecological conditions is not yet fully understood. Studying and understanding the interrelationships of the components of rangeland ecosystems (especially livestock and plant species) are of the most important tools to adopt appropriate administrative measures in rangelands. Effective grazing management requires a comprehensive plan to achieve the best practical use of forage resources. This plan should provide daily, seasonally and annually livestock grazing capacity. In addition to this plan, grazing management and its future administrative decisions should include economic, management, and biological considerations together with their interactions (Vallentine, 1989). Iran's rangelands have been deteriorated severely due to the excessive livestock and the lack of an administrative plan in range management. Hence, it is necessary to do comprehensive studies in order to investigate the response of plant's structure to the grazing especially in arid and semi-arid regions with sensitive and fragile ecosystems. In this regard, the understanding of vegetation response to different grazing intensities is important to facilitate the management of arid and semi-arid regions and also for biological conservation and sustainable use (Hoshino *et al.*, 2009). In arid and semi-arid rangelands, overgrazing is one of the most important destructive factors. Overgrazing has negative effects on rangelands including the increase of unpalatable species and losing canopy cover and biomass (O'connor *et al.*, 2001; Tongway *et al.*, 2003).

The direct effect of livestock grazing includes consumption of the species and soil trampling which can destroy the structure and composition of plant communities. Determination of the correct stocking rate is one of the most important management decisions and should be based upon the proper use of vegetation by grazing animals including livestock and wild life populations, not exclusively based on economic benefits (Van der Westhuizen *et al.*, 2001). Proper distribution of livestock in the rangeland is another important issues in grazing management (Liang *et al.*, 2009). Normally, vegetation biomass, vegetation height and canopy cover percentage are reduced with increasing the grazing intensity (Milchunas *et al.*, 1998). However, the light and moderate grazing intensities can cause an increase in species diversity and plant production in comparison with rangelands under heavy grazing intensity (Huang *et al.*, 2011).

Whereas Huang *et al.* (2011) expressed that although light grazing increases the above-ground biomass, canopy cover and height of the species but from a long-term perspective, moderate grazing can help balance the production of different species and livestock production. Vegetation response to the different grazing

intensities have been investigated in several studies in which the results indicate that overgrazing has caused changes in vegetation structure through increasing non-palatable species (Kraaij & Milton, 2006; Hossienzadeh *et al.*, 2008; Imani *et al.*, 2010). Heidarian *et al.* (2010) reported that intensive grazing of livestock reduced the vegetation cover and changes species composition. Also, it endangered the stability of the rangeland ecosystem through negative changes in soil nutrients. Aghajanloo and Mousavi (2007) studied the effects of a 19-year exclosure on vegetation changes of Zanjan Rangelands and concluded that the composition of class-I species inside the exclosure significantly differed compared to the outside and showed an increase of 280%.

Moreover, the composition of increasers and invasive species inside the exclosure was decreased compared to the grazing area, and the production inside the exclosure was almost doubled. Firinioğlu *et al.* (2007) investigated the effects of exclosure and livestock grazing on rangeland species of Antalya region of Turkey and concluded that exclosure increased the species richness, total vegetation cover, and canopy cover percentage of the forbs and annuals while no significant differences were observed for vegetation cover of the grass and shrub species in the exclosure and grazing area. Derner and Hart (2007) stated that a 29% reduction in shoot biomass under heavy grazing compared to the light grazing during 1991 to 2005 was due to the changes in the composition of plant communities. In a study on grasslands of Kenya, it was expressed that continuous grazing had negative effects on rangelands and plant functional properties. On the other hand, no significant differences were found for biomass between the exclosure for 8 years and the grazing area in the dry season (Kioko *et al.*, 2012).

In steppe rangelands of Saveh, the evidences of changes in plant species composition are observed along the gradients and different grazing managements. The response of different plant species is important to determine the grazing capacity.

MATERIALS AND METHODS

Study areas: The studied steppe rangelands are located 60 km northeast of Saveh, Markazi province between east longitudes of 50° 35' 49" to 50° 49' 11" and north latitudes of 35° 23' 46" to 35° 30' 55". According to the long-term data of Saveh synoptic station, the region receives an average annual rainfall of 200 mm and the average annual temperature is 19 0C. The climate of the region is dry cold based upon Domarten method. The region has an altitude of 1325 m a.s.l with a sandy clay loam soil texture. The studied rangelands were as follows:

1. Nemati Rangeland: The mentioned area is considered as a summer rangeland. The dominant vegetation type is *Artemisia sieberi –Salsola laricina*. The rangeland is used for six months as the livestock entry to and exit from rangeland would be respectively, in early November and mid-May. This rangeland has been under a rotation grazing system for 10 years. The grazing intensity is moderate.
2. Chaganeh Rangeland: This rangeland is also considered as a summer rangeland with a dominant vegetation type of *Artemisia sieberi –Salsola laricina*. The rangeland is used for more than six months as the livestock entry to and exit from rangeland would be respectively, in early November and mid-May. A continuous grazing system is implemented here during the grazing season.
3. Shirali Rangeland: it is grazed continuously all the year with an intensive grazing intensity. *Noaea mucronata-Cousinia cylindracea* is identified as the dominant vegetation type.
4. The exclosure area (control): it is located in Nemati Rangeland with an area of one ha. This area has been under exclosure since 2007.

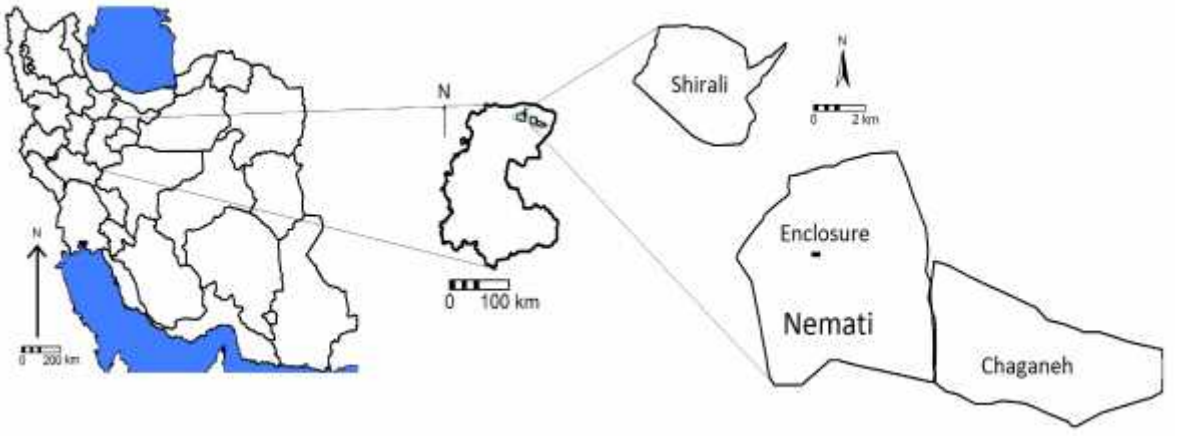

Figure 1. The locations of the study area

Methodology*:* To study various vegetation parameters in each Range Management Plan, a reference area was selected and with coordination of local ranchers, it was tried to prevent livestock grazing in these areas until early June (the end of growing season). In the next step, sampling was carried out by random-systematic method in reference areas. A total of 60 plots (2 m^2) were established along four transects of 400 m length with 100 m intervals. However, in Shirali and exclosure site, the number and intervals of the plots and transects were less depending on the surface area of the region. Canopy cover percentage, density, and height of the species were measured in each plot. The production was measured by clip-and-weight method for 25% of randomly selected plots. The production was also estimated for the other plots by a regression equation between canopy cover (percent) and production (kg ha^{-1}).It was estimated only for the species used by livestock. All data collected from the sites were analyzed by SAS software, followed by one-way analysis of variance and mean comparisons were performed by Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Vegetation Cover*:* The percentage of vegetation cover is presented in Table 1. The species that had less than 0.1% canopy cover were removed from the table. According to this table, canopy cover of the most species like *Dendrostellera lessertii*, *Astragalus gossypinus* and *Anderachne rotundifolia* showed no significant differences among the study areas ($p>0.05$). Significant differences were observed for dominant species of the study area namely *Salsola laricina*, *Artemisia sieberi* and *Stipa hohenackeriana* ($p<0.001$), as the highest percentage of canopy cover in exclosure area was recorded for the mentioned species. In Shirali Rangeland, in which continuous grazing with a high grazing intensity is occurred during the year, the species of *Salsola laricina* and *Artemisia sieberi* were completely removed. Also, some species, including *Acanthophyllum sp*., *Noaea mucronata* and *Scariola orientalis* in Shirali Rangeland had higher canopy cover than the other areas ($p<0.001$ and $p<0.005$).

Table 1. The changes of canopy cover percentage under different grazing managements (exclosure for 4 years, Nemati: rotation grazing system for six month, Chaganeh: continuous grazing system for six month, Shirali: continuous grazing system for all the year).

Palatability Category	Species	Canopy Cover (%)				
		Exclosure	Nemati	Chaganeh	Shirali	P
I	*Salsola laricina*	9.50	5.1	2.00	0.01	**
II	*Artemisia sieberi*	6.31	6.20	3.00	0.00	**
III	*Acanthophyllum sp.*	0.00	0.01	0.16	0.48	*
II	*Stipa hohenackeriana*	4.72	1.40	0.55	0.37	**
II	*Noaea mucronata*	0.00	0.19	0.08	0.98	**
II	*Dendrostellera lessertii*	0.11	0.12	0.18	0.00	NS
III	*Astragalus gossypinus*	0.16	0.11	0.06	0.68	NS
III	*Andrachne rotundifolia*	0.00	0.01	0.12	0.24	NS
II	*Stachys inflata*	0.34	0.15	0.00	0.00	NS
III	*Cousinia cylindracea*	0.50	0.25	0.10	0.81	*
I	*Poa sinaica*	0.26	0.16	0.00	0.00	NS
II	*Allium scabriscapum*	0.15	0.01	0.00	0.00	**
II	*Phlomis olivieri*	0.17	0.00	0.00	0.00	NS
II	*Scariola orientalis*	0.00	0.09	0.05	0.37	**
III	*Gundelia tornefortii*	0.00	0.00	0.00	0.34	**
III	*Echinops sp.*	0.00	0.00	0.00	0.15	**
III	*Peganum harmala*	0.00	0.00	0.00	1.15	**
III	*Lounaea acanthodes*	0.00	0.00	0.00	0.25	**
III	*Carex stenophylla*	0.00	0.56	1.52	2.58	**
II	*Muscari tenuiflorum*	0.56	0.00	0.00	0.00	**

Significant: * $p<0.05$, ** $p<0.01$ and NS: No Significant

The palatability of the species was reduced by passing from the exclosure area towards Shirali Rangeland. In other words, palatable species were replaced by non-palatable species, as the average canopy cover percentage of palatable species were 9.87% and 0.01% in the exclosure area and in Shirali Rangeland, respectively ($p<0.01$) (Fig. 2, a). Moreover, a considerable percentage of the canopy cover (1.15) in Shirali Rangeland was allocated to non-palatable species, like *Peganum harmala* while the average canopy cover percentage of non-palatable species were 4.15% and 0.75 in Shirali Rangeland and in the exclosure area, respectively ($p<0.01$) (Fig.2, c).

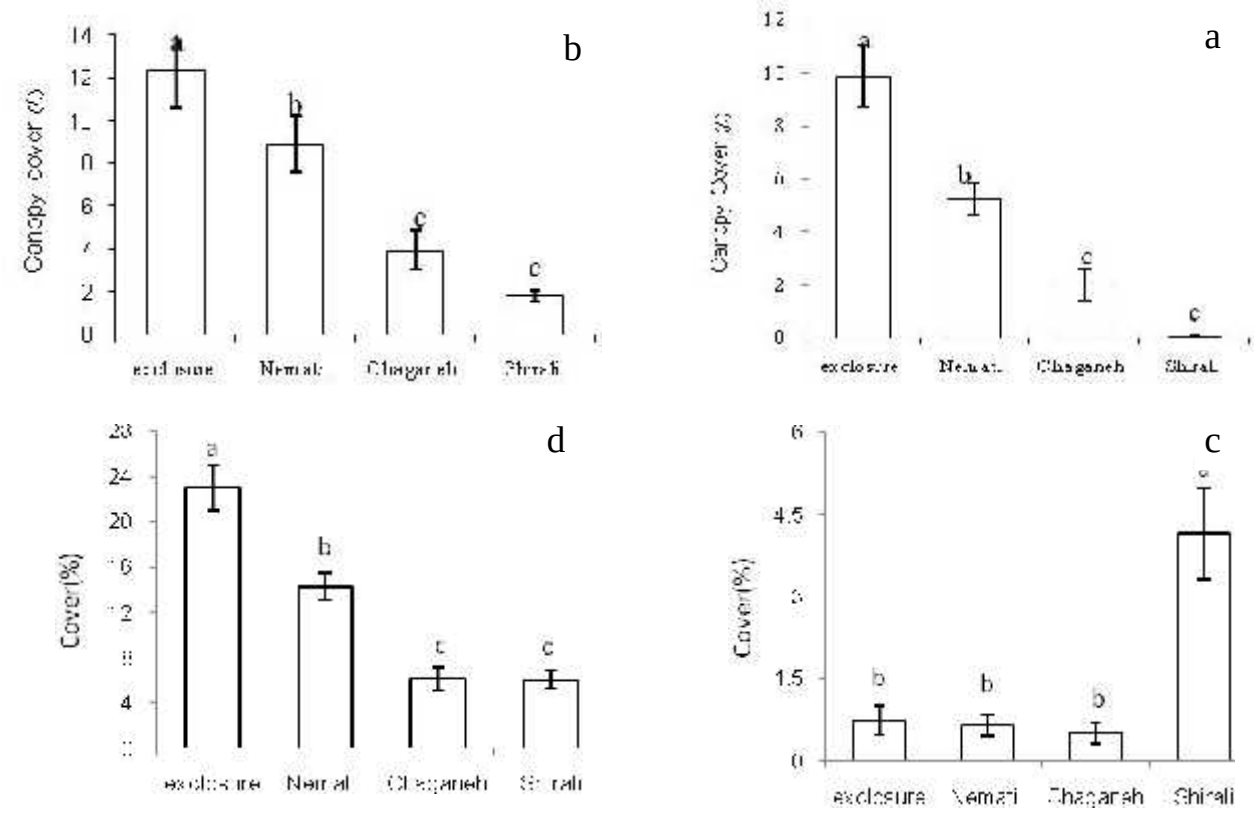

Figure 2. Mean (±SE) canopy coverage (%) of class I (a), class II (b), class III (c) and total of the perennials (d)

Production: The production of the major species was calculated from regression equation made between the percentage of canopy cover and production (Table 1).

Results showed that total production was significantly reduced by passing from the exclosure of the reference area to Shirali region. As is clear from Figure 3, the production of the exclosure is 7 times more than that of Shirali region. The same trend was observed for Chaganeh region. In other words, although the canopy cover percentage of Chaganeh was approximately equal to that of Shirali region, the production calculated for Chaganeh was two times more than that of Shirali region. However, the mentioned difference was not significant. It should be noted that the estimated production for Shirali region was calculated from class-II species, while in other areas, the estimated production was related to *Salsola laricina*, as a class I species.

Table 2. The estimating equations of production from vegetation data based on double sampling

Sites	Species	Production Estimated Equation	R^2 (%)
Exclosure (Control)	*Salsola laricina*	Y=1.41+4.12 X	0.85
	Artemisia sieberi	Y=-1.41+2.65 X	0.89
	Stipa hohenackeriana	Y=-9.5+5 X	0.92
	Cousinia cylindracea	Y=0.21+3.05 X	0.82
Nemati	*Salsola laricina*	Y=-6.3+4.6 X	0.83
	Artemisia sieberi	Y=3.06+2.52 X	0.97
	Stipa hohenackeriana	Y=1.53+1.61 X	0.77
Chaganeh	*Salsola laricina*	Y=1.55+3.39 X	0.91
	Artemisia sieberi	Y=1.54+2.41 X	0.89
	Stipa hohenackeriana	Y=0.62+2.48 X	0.74
Shirali	*Noaea mucronata*	Y=-0.73+4.3 X	0.72
	Stipa hohenackeriana	Y=-0.93+2.45 X	0.92
	Cousinia cylindracea	Y=4.8+3.2 X	0.84
	Scariola orientalis	Y=0.38+4.38 X	0.88

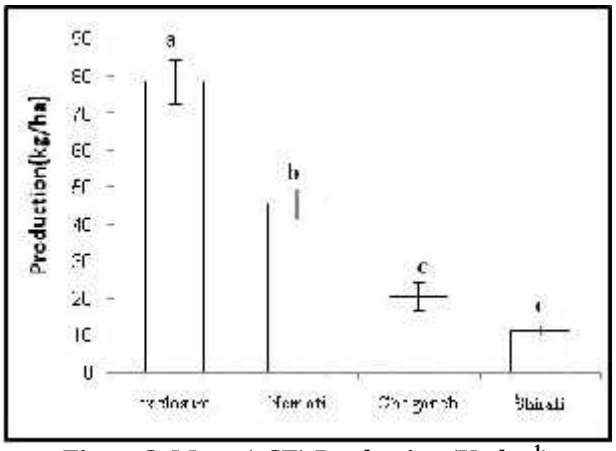

Figure 3. Mean (±SE) Production (Kg ha^{-1})

According to the results, significant differences were observed for production and canopy cover percentage as a response to the exclosure treatment in the studied steppe rangeland for 4 years. In other words, exclosure could increase the canopy cover percentage of class-I and palatable species. In contrast, the canopy cover percentage of class-III and non-palatable species was reduced. The increase of total canopy cover percentage inside the exclosure is consistent with studies that showed the positive effects of exclosure on these parameters (Belsky, 1992; Brown & Al-Mazrooei, 2003). This increment may be due to the improved soil conditions (temperature, moisture, and nutrient cycles). In contrast, heavy grazing with no comprehensive plan in steppe rangelands caused changes in vegetation composition and structure. Continuous and heavy grazing could cause a reduction in canopy cover percentage and biomass production. It is in consistence with the results of (Yong-Zhong *et al.*, 2005)

They reported that due to the livestock trampling, the soil surface was exposed to erosion and soil fertility was reduced and affected the quantity and quality of vegetation. Klimesova *et al.* (2008), and Zheng *et al.* (2011) also noted that biomass, canopy cover percentage and height were significantly reduced by increasing grazing intensity. As seen from Table 3, these parameters were also decreased for dominant species of the region.

The presence of the species, including *Peganum harmala*, *Lounaea acanthodes* and *Gundelia tornefortii* in a rangeland grazed continuously with heavy grazing intensity represents non-normative utilization of these rangelands which coincided with results of the study performed by Hossienzadeh *et al.* (2008). The diversity and composition of plant communities may be strongly influenced by management practices in response to the livestock grazing.

Grazing systems are tools that allow managers to control the number of livestock and also the duration of the grazing period, so that the performance of livestock and plant will remain at the optimum with a satisfactory level of vegetation composition (Hickman *et al.*, 2004). In Nemati Rangeland, rotation grazing system and moderate grazing intensity gave the opportunity to plant species for revival in the rest periods and this leads to decrease the negative effect of livestock concentration in a distinct part of the rangeland because of rotative grazing. In practice, managements such as exclosure and rotation grazing system are considered as the solutions for plant revegetation against continuous grazing (Liang *et al.*, 2009). The same result was reported by Eaton *et al.* (2011). They showed that a higher dry matter production and higher average weight of cattle were obtained under rotation grazing system compared to continuous grazing.

On the other hand, although Nemati Rangeland is under rotation grazing system from November to May, our results indicate that the presence of livestock from early March to mid May would negatively affect the growth and production of the main species.

The response of dominant species to grazing

***Salsola laricina*:** It is a shrub that at the time of livestock entry to the region is in seeding stage. It receives much attention from livestock at this time which the leaves are dry. According to Table 3, the highest canopy cover percentage and production of this species were occurred in the exclosure area. Contrary to FRWO (1999), our results indicated that *Salsola laricina* had been totally removed from the species composition of this rangeland except for a few stands. The results also showed that grazing stimulation was one of the factors which affected the increase of height in *Salsola laricina* ; in other words, the plant's height in Nemati and Chaganeh Rangelands was higher than that of the exclosure region ($p<0.001$).

Artemisia sieberi: As can be seen from table 3, the production and plant height of this species in Nemati Rangeland is higher than the others, and shows that grazing stimulation has had a positive effect on *Artemisia sieberi***.** A higher grazing intensity (in Chaganeh Rangeland) reduced the percentage of canopy cover, production, and height of the species. Also, intensive grazing eliminated *Salsola laricina* from Shirali Rangeland.

Stipa hohenackeriana: This perennial grass is of utmost importance in arid and semi-arid regions in view of livestock feeding. It appeared in all study areas but the percentage of the canopy cover, height and production were reduced by passing from the exclosure area to Shirali Rangeland, as its height were 48.84 + 2.43 (mean±se) and 12.7 + 1.4 cm in the exclosure area and in Shirali Rangeland, respectively. The average of the maximum canopy cover was 4.71 + 0.81 % in the exclosure area.

Table 3. Changes of canopy cover percentage under different grazing managements

Factor	Species	Sites			
		Exclosure	**Nemati**	**Chaganeh**	**Shirali**
canopy cover(%)	*Salsola laricina*	9.5 ±1.1 a	5.1 ±0.58 b	2.01 ±0.6 c	0.01 ±0.005 d
	Artemisia sieberi	6.3 ±1.8 a	6.22 ±1.1 ab	3 ±0.9 b	0
	Stipa hohenackeriana	4.71 ±0.81 a	1.39 ±0.39 b	0.55 ±0.1 b	0.27 ±0.1 b
production (kg/ha)	*Salsola laricina*	40.66 ±4.88 a	22.51 ±2.1 b	11.48 ±3.2 c	0
	Artemisia sieberi	15.99 ±4.3 a	17.78 ±3.1 a	7.57 ±2.32 b	0
	Stipa hohenackeriana	16.14 ±3.8 a	5.27 ±1.47 b	1.79 ±0.45 b	0.69 ±0.23 b
height (cm)	*Salsola laricina*	5.15 ±0.33 b	8.84 ±1.07 a	6.92 ±0.63 b	0
	Artemisia sieberi	16.22 ±1.14 ab	17.37 ±1.86 a	14.5 ±0.69 b	0
	Stipa hohenackeriana	48.84 ±2.43 a	41.78 ±4.07 a	31 ±3.6 b	12.7 ±1.4 c

Note: Values represent means±SE (standard error). The different letters mean significant differences ($p<0.05$)

According to Table 3, the forage production of *Stipa hohenackeriana* and *Salsola laricina* in exclosure were 3 and 2 times more than that of Nemati Rangeland, respectively. While Kioko *et al.* (2012) in semi-arid rangelands of Kenya found no significant changes for biomass between the dry season grazing area and the area excluded from livestock grazing for eight years. This result clearly indicates that implementing grazing license (mid November to mid March) would positively affect the plant revegetation. The same result was reported by Mushtaque *et al.* (2010) that for getting more forage, Setaria sphacelata should be harvested up to three months and delaying in harvest give the highest dry matter. However, the mentioned period had no negative effects on forage production of *Artemisia Sieberi* because of the leaves containing secondary compounds in the growing season as an inhibitory factor for livestock consumption. In Chaganeh Rangeland, the entry of livestock into the rangeland is mid November while its exit is from late May to mid June and this is when the plants are in the peak of the growth and seeding stage is recorded for *Stipa hohenackeriana*.

In Chaganeh Rangeland, in addition to livestock grazing for six months, grazing intensity was more than that of Nemati Rangeland, which negatively affected the production, canopy cover percentage, and the height of the species. However, in terms of vegetation composition, no significant differences were observed for Chaganeh Rangeland compared to Nemati Rangeland and exclosure. Vegetation composition just significantly differed in Shirali Rangeland with continuous grazing system, as *Artemisia sieberi* and *Salsola laricina* were totally removed from the rangeland. However, according to FRWO (1999), the mentioned species were as a part of the composition. Jeddi and Chaieb (2010) studied the steppe rangelands of Tanzania and concluded that continuous grazing resulted in decrease of the canopy cover percentage of *Artemisia sieberi* as its canopy cover percentage were 6.2% and 1.6% in a six-year exclosure and outside the exclosure, respectively. Our results indicated that although moderate grazing intensity (Nemati Rangeland) had no significant effects on canopy cover percentage and the production of *Artemisia sieberi*, relatively heavy grazing (Chaganeh Rangeland) and continuous grazing (Shirali) significantly decreased its canopy cover percentage.

Generally, this study showed that poor management of livestock grazing in arid steppe rangelands could lead to the increase of the frequency of non-palatable species in vegetation communities. If the degradation of the rangelands is continued, it will be a threat to livestock production and ecological issues.

Conclusion: Steppe rangelands are ecologically fragile. Continuous grazing causes a significant reduction in total vegetation cover, production, and the change of the vegetation composition. The changes observed in different treatments showed that basic and fundamental conservation together with preventing livestock grazing would result in increase of the plant revegetation and production. Grazing management plans should include economic and biological considerations. Therefore, soil and vegetation of the rangelands should be conserved through providing appropriate facilities and implementing rotation grazing systems as well as observing the grazing capacity and grazing season.

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