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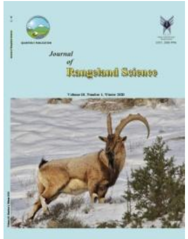

Research and Full Length Article:

Effects of Intermediated-Term Grazing Rest on the Vegetation Characteristics of Steppe Rangelands

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Abstract. The effects of grazing rest on rangelands are different in different climates and knowledge of these effects is necessary to apply a correct management. For this purpose, this study was carried out on the Vegetation Cover (VC) and Forage Production (FP) of range species as a model of steppe rangelands of Iran at the Nir Range Research Station in Yazd province, Iran. In the study area, different grazing intensities were applied until the end of the grazing season of 2006 and thereafter, the whole area was under exclusion. VC and FP were measured in each of the experimental plots once in May 2007 and again seven years later in May 2014. The results of vegetation data analysis in 2007 showed that the heavy grazing intensity applied in the past caused the reduced vegetation cover and forage production of two desirable species i.e. *Salsola rigida* and *Stipa barbata* as well as increased vegetation cover and forage production of *Launaea acanthodes* and increased forage production of *Scariola orientalis* as undesirable species. The results of vegetation data analysis in 2014 showed that the lowest VC and FP of *S. rigida* were recorded in the experimental plots under heavy grazing intensity. In other experimental plots, there was no significant difference in VC and FP of this species ($p>0.05$). There was no significant difference of VC and FP in other species and total species in different experimental plots ($p>0.05$). Thus, during the 7-year rest period, although the negative effect of grazing on *S. barbata* is resolved, it remains on *S. rigida* and the resulting degradation is not completely compensated during this period and needs more time. Therefore, *S. barbata* showed a better resistance to grazing as compared with *S. rigida*. According to the results, if steppe rangelands are grazed heavily in the short-term, an intermediated-term grazing rest could improve the vegetation to the previous state.

Key words: Grazing intensity, Percent vegetation cover, Forage production, *Stipa barbata*, *Salsola rigida*

Introduction

Rangelands, as a part of renewable natural resources, are considered as one of the main components of sustainable development in each country. Continuous use of rangelands requires precise knowledge and principled exploitation. Rest from grazing is applied to allow vegetation recovery. Rest is often used for one year as a part of many grazing systems; however, the intermediate term (five to ten years) to long term (more than ten years) rest is applied in some areas based on the assumption that it can improve ecosystem properties (Davies *et al.*, 2014). The effects of resting on rangelands and preventing the entry of livestock into the arena have always been the subject of attention by rangeland researchers. The effects of grazing rest on rangelands in different climates and with a different management history are not the same; therefore, knowledge of these effects seems necessary to apply the correct management. Some researchers have mentioned the negative effects of not harvesting rangeland species (Manier & Hobbs, 2006; Holechek *et al.*, 2006, 2010). For example, Fox and Eddlemen (2003) stated that after a 30-year period of livestock grazing exclusion, the perennial grass cover declined 1.5%. In contrast, some results indicated that grazing exclusion was an effective measure to keep up the community stability and improve the above ground vegetation growth (Mata-González *et al.*, 2007; Mofidi *et al.*, 2013; Yan and Lu, 2015). Grazing exclusion could improve vegetation composition and soil quality parameters due to the absence of grazing in degraded rangelands of Iran (Mofidi *et al.*, 2013). Also, grazing exclusion enhances the abundance, species diversity, and production of palatable species, and declines the development of unpalatable species (Baghestani Maybodi *et al.*, 2006; Belgacem *et al.*, 2013; Kairis *et al.*, 2015). On the other hand, Sigcha *et al.* (2018) reported a clear influence of grazing exclusion on soil properties and plant community composition and structure; however, no influence was found on species diversity. In semi-steppe areas where climate conditions are relatively stable, the improvement of vegetation characteristics seems more likely in a shorter period. The change in semi-steppe rangelands of Zharf, Khorasan province, Iran was reported to be 6.4% during a four-year period (Kashki, 2015). Effect of exclusion on vegetation characteristics of the semi-steppe rangelands of Semirom, Esfahan in Iran were investigated by Moradi and Mofidi (2012). The results indicated that vegetation cover and production of various life forms inside the exclusion increased significantly compared to the no grazing site. So, vegetation changes in arid areas are very slow and make the observation of vegetation change difficult (Cody, 2000; Guo, 2004; Lawley *et al.*, 2013) and determination of trend of vegetation cover, composition and diversity is challenging, especially in arid lands (Van der Merwe *et al.*, 2016). Therefore, a long period is required to detect the real trends of annual variability such as high variation of annual production and grazing on the trend of range vegetation condition and dynamics in arid lands (Sharp *et al.*, 1990; Yorks *et al.*, 1992).

Given the above literature review, it is clear that the effects of exclusion and different grazing intensities on rangelands differ depending on climate and grazing management history. Therefore, knowledge of these effects seems necessary to apply management. This research was aimed to investigate the effects of grazing rest on the vegetation of steppe rangelands under different grazing intensities to answer this question whether a seven-year rest under different grazing intensities is adequate to reach the potential of steppe rangelands or not. It is obvious that the data and results obtained from this research could be applicable as an executive instruction in the future management of a large part of the steppe rangelands of Iran.

Materials and Methods

Study area

This study was carried out at the Nir rangeland research station located in Taft, Yazd province, Iran. The station area is 200 ha and lies between longitudes 54°11'49" to 54°12'56" E and latitudes 31°21'31" to 31°23'02" N. This area with an altitude of 2110-2170 m above sea level is a pattern of highland plains in steppe regions and its general slope is less than 3%. The 15-year average annual rainfall is 133 mm, whose minimum value is 25 mm in 2008 and maximum value is 227 mm in 2007 (Yazd Province Meteorological Administration, 2014).

Field survey and data analysis

This study was conducted on a part of experimental research at the Nir rangeland station. The experiment included the areas in which moderate grazing intensities were applied as heavy and light grazing intensities, respectively 25% higher or lower than the moderate grazing, and without grazing (control) according to rangeland capacity until the end of the grazing season in 2006 and thereafter, the whole area was under enclosure. The vegetation cover was measured within the plots and forage production was measured by clipping and weighing method (Moghaddam, 2014; Mesdaghi, 2015; Arzani and Abedi, 2015). For this purpose, in each experimental unit, five transects were established at equal distances, and on each transect, 10 plots of 2 m^2 were deployed at a distance of 25 m.

In this study, three key species: *Artemisia sieberi* Besser, *Salsola rigida* Pall and *Stipa barbata* var. arabica (Trine & Rupr) as well as companion species including *Scariola orientalis* (Boiss) Sojak and *Launaea acanthodes* (Boiss) Kuntre were considered. The remaining species were not separated due to their insignificant importance and are mentioned as "other species". Annual species were also not separated and they referred to as annuals in this study. Sampling was performed in each experimental unit once in May 2007 (the beginning of grazing rest) and repeated after seven years in May 2014 (Fig. 1).

A

B

Fig. 1. (A) The exclusion area 2007; (B) after seven-year rest period in 2014

Data analysis

The data of both phases studied were statistically analyzed in a completely randomized block design with four experimental treatments (heavy, moderate, light and no grazing intensities) in three replications. Statistical analysis of the data was done through the GLM program of SAS. Also, Duncan test was used to compare the means of experimental treatments.

Results

Effect of grazing rest on vegetation cover

The results of means comparison for vegetation cover (VC) in two periods of time i.e 2007 (coincide with the start of research) and 2014 (coincide with end of research) are presented in Table 1. At the beginning of 2007, the minimum and maximum VC% (*S. rigida*) were recorded for the experimental parts under heavy grazing intensity (1.6%) and control treatment (5.7%), respectively showing significant difference ($p<0.05$) (Fig. 2). On the other hand, the VC (*S. rigida*) in moderate, light, and control treatments was located in the same group. In *S. barbata*, the minimum and maximum VC were recorded for heavy grazing (1%) and moderate grazing intensity (2.1%), showing significant difference ($p<0.05$). On the other hand, the VC% (*S. barbata*) in moderate, light, and control treatments was located in the group. In the treatment of heavy grazing intensity, the VC% (*Launaea acanthodes*) as an undesirable species was 1%, ranked in the first order (Fig. 2). The VC of other species did not differ significantly in different treatments of grazing intensity ($p>0.05$). As well, no significant difference was found for total VC in the treatments of grazing intensity ($p>0.05$). At the beginning of 2014, the minimum and maximum VC (*S. rigida*) were recorded for the treatments of heavy and moderate grazing intensity (3.8% and 6.6%, respectively), showing a significant difference ($p<0.05$). On the other hand, the VC (*S. rigida*) in light and control treatments was located in the group (Table 1).

Effect of grazing rest on forage production

The results of means comparison for forage production (FP) data in two periods of time i.e 2007 (coincide with the start of research) and 2014 (coincide with end of research) are presented in Table 1. At the beginning of 2007, the minimum and maximum FP of *S. rigida* was recorded for the treatments of heavy grazing intensity (41.8 kg/ha) and control treatment (146.2 kg/ha), respectively, showing a significant difference ($p<0.05$). On the other hand, the FP of this species in the treatments of heavy, moderate, and light grazing intensities was located in one statistical group (Fig. 2).

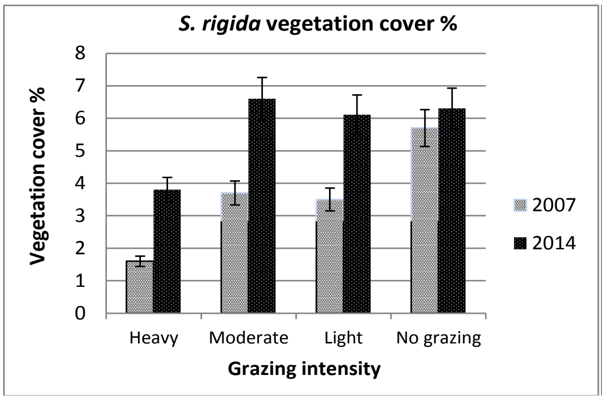
In *S. barbata*, the minimum and maximum FP was recorded for the treatments of heavy (49 kg/ha) and moderate grazing intensity (135 kg/ha), showing a significant difference ($p<0.05$). On the other hand, the FP of this species in the treatments of heavy, light and no (control) grazing intensities was located in one statistical group. In the treatment of heavy grazing intensity, the maximum FP of undesirable species, *L. acanthodes* and *S. orientalis*, was calculated to be 113.7 kg/ha and 13.2 kg/ha, respectively, showing a significant difference ($p<0.05$) (Fig 2). The maximum FP of other species was calculated to be 58.2 kg/ha in the treatment of heavy grazing intensity. The minimum FP of these species was 20.9 kg/ha in the treatment of moderate grazing intensity. On the other hand, the FP of these species in the treatments of moderate, light and no (control) grazing intensities was located in one statistical group. No significant difference was found between the FP of other species and total FP ($p>0.05$).

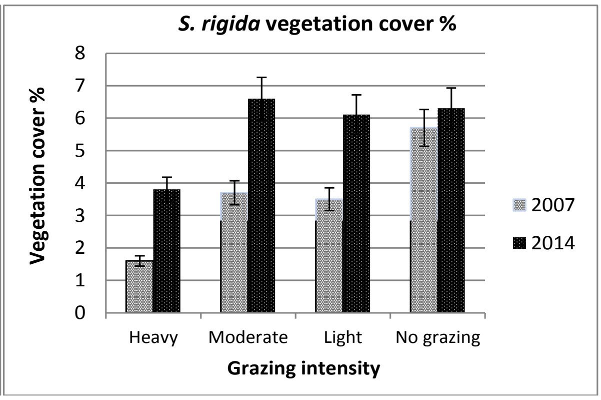
At the beginning of 2014, the minimum and maximum FP of *S. rigida* was recorded for the treatments of moderate grazing intensity (140.4 kg/ha and 244.5 kg/ha), respectively, showing a significant difference ($p<0.05$). On the other hand, the FP of this species in the treatments of moderate, light and no (control) grazing intensities was located in one statistical group. No significant difference was found between the FP of other species and total FP in different treatments of grazing intensities ($p>0.05$) (Table 1).

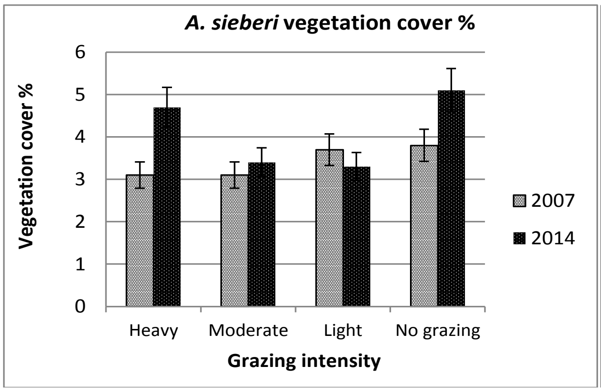
Table 1. The results of means comparison for vegetation cover and forage production in different treatments at two periods of time 2007 (the start of research) and 2014 (the end of research)

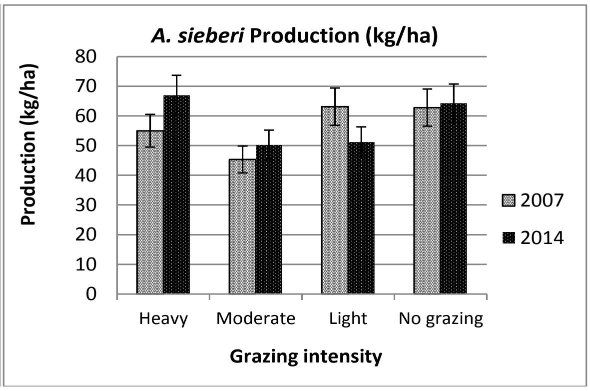
Species name	treatment	Vegetation cover %		Forage production (kg/ha)	
		2007	2014	2007	2014
S. rigida	Heavy	1.6 [b]	3.80 [b]	41.80 [b]	140.4 [b]
	Moderate	3.7 [ab]	6.60 [a]	81.60 [b]	244.5 [a]
	Light	3.5 [ab]	6.11[a]	88.80 [b]	214.1 [a]
	No grazing	5.7 [a]	6.30 [a]	146.2 [a]	244.4 [a]
A. sieberi	Heavy	3.1 [a]	4.7 [a]	55.0 [a]	67.0 [a]
	Moderate	3.1 [a]	3.4 [a]	45.3 [a]	50.2 [a]
	Light	3.7 [a]	3.3 [a]	63.1 [a]	51.2 [a]
	No grazing	3.8 [a]	5.1 [a]	62.8 [a]	64.3 [a]
S. barbata	Heavy	1.0 [b]	0.9 [a]	49.00 [b]	34.1 [a]
	Moderate	2.1 [a]	1.1 [a]	135.0 [a]	38.4 [a]
	Light	1.9 [a]	1.0 [a]	104.3 [ab]	36.1 [a]
	No grazing	1.8 [ab]	1.1 [a]	86.90 [ab]	40.6 [a]
N. mucronata	Heavy	0.1 [a]	0.3 [a]	2.1 [a]	6.1 [a]
	Moderate	0.1 [a]	0.4 [a]	0.9 [a]	7.8 [a]
	Light	0.2 [a]	0.4 [a]	2.3 [a]	10.2 [a]
	No grazing	0.2 [a]	0.5 [a]	1.9 [a]	12.0 [a]
S. orientalis	Heavy	5.4 [a]	1.1[a]	113.7 [a]	22.3 [a]
	Moderate	2.4 [a]	0.7 [a]	36.70 [b]	15.0 [a]
	Light	4.3 [a]	0.8 [a]	77.30 [b]	17.6 [a]
	No grazing	3.2 [a]	0.7 [a]	57.70 [b]	14.6 [a]
L. acanthodes	Heavy	1.0 [a]	0.6 [a]	13.2 [a]	6.2 [a]
	Moderate	0.2 [b]	0.8 [a]	2.30 [b]	8.5 [a]
	Light	0.8 [ab]	0.4 [a]	8.20 [ab]	4.6 [a]
	No grazing	0.4 [ab]	0.5 [a]	4.00 [b]	5.1 [a]
Other perennial	Heavy	2.9 [a]	1.9 [b]	58.2 [a]	34.6 [a]
	Moderate	1.6 [a]	1.0 [a]	20.9 [b]	19.1 [a]
	Light	1.8 [a]	0.9 [a]	37.0 [ab]	19.7[a]
	No grazing	1.9 [a]	0.8 [a]	26.5 [b]	16.5 [a]
Annual	Heavy	1.9 [a]	2.9 [a]	53.5 [a]	31.4 [a]
	Moderate	2.6 [a]	2.8 [a]	80.4 [a]	26.9 [a]
	Light	2.4 [a]	2.7 [a]	64.3 [a]	31.4 [a]
	No grazing	1.9 [a]	2.5 [a]	56.4 [a]	27.8 [a]
Total	Heavy	17.2 [a]	16.1 [a]	386.4 [a]	341.9 [a]
	Moderate	15.9 [a]	17.3 [a]	403.1 [a]	392.9 [a]
	Light	18.6[a]	16.6 [a]	445.2 [a]	400.3 [a]
	No grazing	18.7[a]	17.4 [a]	442.7 [a]	425.3 [a]

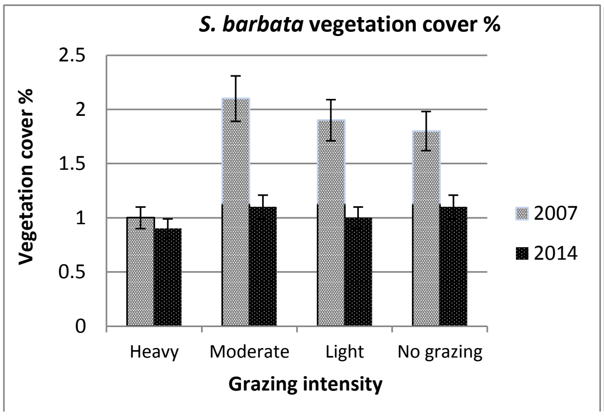
Similar letters in each column for each species has no significant differences based on the Duncan test ($p< 0.05$)

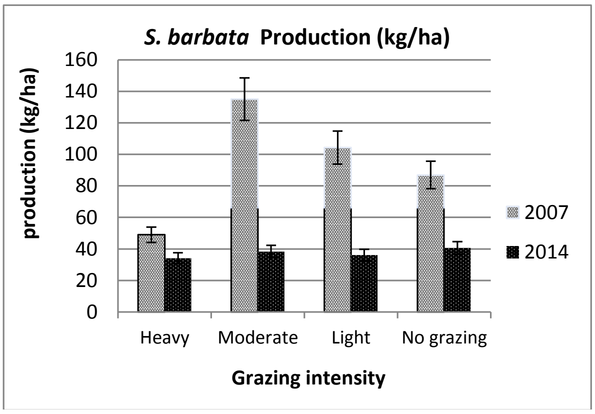

S. rigida vegetation cover %
Vegetation cover %
0
1
2
3
4
5
6
7
8
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014

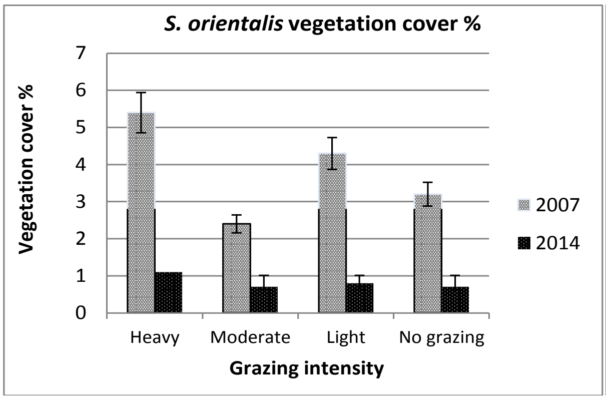

S. rigida vegetation cover %
Vegetation cover %
0
1
2
3
4
5
6
7
8
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014

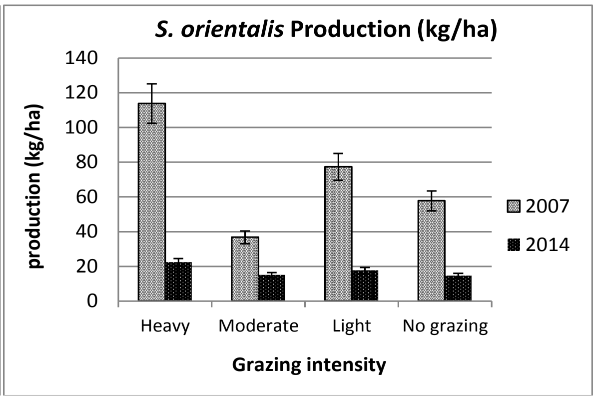

A. sieberi vegetation cover %
Vegetation cover %
0
1
2
3
4
5
6
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014


A. sieberi Production (kg/ha)
Production (kg/ha)
0
10
20
30
40
50
60
70
80
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014


S. barbata vegetation cover %
Vegetation cover %
0
0.5
1
1.5
2
2.5
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014


S. barbata Production (kg/ha)
production (kg/ha)
0
20
40
60
80
100
120
140
160
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014


S. orientalis vegetation cover %
Vegetation cover %
0
1
2
3
4
5
6
7
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014


S. orientalis Production (kg/ha)
production (kg/ha)
0
20
40
60
80
100
120
140
Heavy
Moderate
Light
No grazing
Grazing intensity
2007
2014

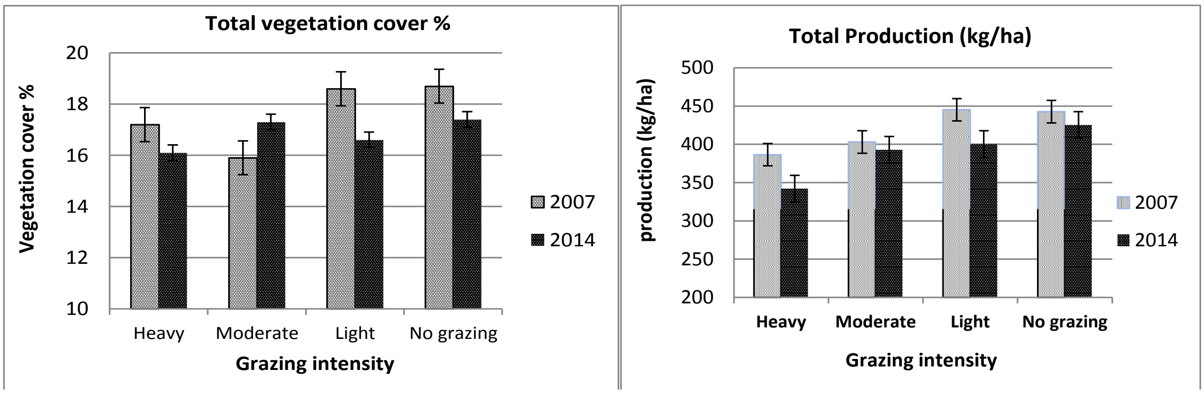


Fig. 2. Effect of grazing intensities on vegetation cover and forage production of *A. sieberi*, *S. rigida*, *S. barbata*, *S. orientalis* and total values of VC% and FP at two periods 2007 and 2014

Discussion

According to the data of vegetation cover (VC) and forage production (FP) in the treatments of grazing intensity at the beginning of 2007, it was evident that the minimum values of VC and FP were recorded for *S. rigida* and *S. barbata* in the treatment of heavy grazing intensity. The continuous grazing of the three-year period (2004-2006) and the previous grazing management practices in the study area have been effective in this phenomenon. The past heavy grazing intensity has led to increase VC and FP of *L. acanthodes* as well as increased FP of *S. orientalis* as undesirable species. No significant changes were recorded for other species under the influence of past grazing ($p>0.05$). Although heavy grazing during the three-year period and earlier had no negative impact on total VC and species composition, the palatable perennial species like *S. rigida* and *S. barbata* were more consumed due to the past heavy grazing while unpalatable species like *L. acanthodes* had more distribution. Studies by Rotich *et al.* (2018) on the effects of grazing management practices on rangeland vegetation showed that the replacement of palatable species by unpalatable ones reduced not only the diversity of plant species but also rangeland productivity.

This phenomenon has also occurred in two-year grazing after the 14-year-old exclusion (1986 – 2000) in the study area (Baghestani Maybodi, 2003). It seems that if this grazing intensity occurred in a longer period, more changes would occur in the vegetation composition. After 17 years of overgrazing pressure in an alpine meadow, the species composition varied distinctly with a decrease in palatable and productive grass species and an increase in unpalatable forbs at overgrazing intensity (Zhou *et al.*, 2006). Some previous researches showed that the replacement of desirable plants by undesirable ones decreased plant diversity and rangeland productivity (Grime, 2001; Callaway *et al.*, 2005).

The results of vegetation data recorded in the beginning of 2014 showed that the lowest VC and FP of *S. rigida* were obtained in the treatment of heavy grazing intensity. No significant difference was found for the VC and FP of *S. rigida* in other treatments ($p>0.05$). In addition, no significant difference was found for the VC and FP of other study species and total species in different treatments ($p>0.05$). Therefore, after seven-year rest period, the negative effect of heavy grazing on *S. barbata* is overcome, which is consistent with results of the study performed by Zarekia *et al.* (2013) while this negative effect remains on *S. rigida* and the resulting degradation is not fully compensated for over a seven-year rest period and will require more time. A high potential for the recovery of grasslands after heavy grazing was also reported by Loydi *et al.* (2012).

Accordingly, *S. rigida* showed a lower grazing resistance as compared with *S. barbata*. The 7-year rest period resulted in decreased VC of *L. acanthodes*, which had been already distributed in the study area during the three-year period of heavy grazing intensity. Heavy continuous grazing in the study area for long time causes large changes on the quantity and quality of vegetation, whose return needs long time with an optimistic vision (Baghestani Maybodi *et al.*, 2006; Abdelsalam *et al.*, 2017). With the persistence of long-term regression trend in such rangelands, it may be slow or even impossible to return to the past vegetation (Ektova *et al.*, 2015; Moghaddam, 2014; Mesdaghi, 2015). Curtin (2002) stated that degraded rangelands do not necessarily improve by the rest alone, and the conservation of grazed lands requires restoration and maintenance of natural processes. In line with this comment, Arzani *et al.* (1999) in studying the quantitative and qualitative trends of vegetation changes influenced by common grazing intensity in rangelands of this area referred to the slow trend of vegetation changes and declared that a longer period is needed to separate the observation of the actual trends from annual changes of vegetation. According to Baghestani Maybodi (1993), a 7-year exclusion period is inadequate to achieve wide and rapid changes in vegetation composition of Nodoushan steppe rangelands, Yazd province in Iran. The slowness of vegetation changes and the need for a long time to achieve considerable results are also reported in the studies on vegetation changes in arid and semiarid areas abroad (Sharp *et al.*, 1990; Yorks *et al.*, 1992; O ‘ Connor and Raux, 1995).

However, in the rangelands whose vegetation characteristics were changed due to the continuous and heavy grazing, the two following solutions could be applied. Studying the background of rangelands and planning to restore the past capabilities in future, which achieving this goal in most cases is costly and time consuming.

The grazing livestock is adapted with the current vegetation characteristics of rangelands; therefore, the forage resources available in these areas and grazing behavior of livestock are valuable features. In this regard, Moghaddam (2014) emphasizes that in some cases, the release of invasive plants is such that the possibility of establishing the climax plants does not appear to be practical or that cannot be justified economically. Thus, the study of livestock grazing behavior in different range sites of arid regions with current vegetation, determining the allowable use of species in the vegetation composition, and estimating the efficiency of range improvement programs are among the things that the awareness of them in the future management of such areas seems necessary.

Conclusion

Based on results, if improvement and reclamation of steppe rangelands are to be considered, the background of grazing management needs to be taken into account. If the area is grazed heavily in the short term with no significant changes in the quantity and quality of vegetation, a 7-10-year rest period could improve the vegetation to the previous state.

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اثر استراحت چرایی میان مدت بر خصوصیات پوشش گیاهی مراتع استپی ایران

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چکیده: اثرات استراحت چرا بر مراتع در اقالیم مختلف متفاوت می‌باشد و آگاهی از این اثرات برای اعمال مدیریت صحیح بر مراتع ضروری می‌باشد. به همین منظور بررسی اثر استراحت چرایی میان مدت بر درصد پوشش گیاهی و تولید علوفه گیاهان مرتعی در ایستگاه تحقیقات مرتع نیر استان یزد به عنوان سایت الگویی مراتع استپی اجرا گردید. در عرصه مورد مطالعه شدت‌های چرایی مختلف تا پایان فصل چرای سال ۱۳۸۵ اعمال گردیده و از آن زمان به بعد تمام سطح عرصه در قرق بوده است. آماربرداری از پوشش گیاهی و تولید علوفه گیاهان در هر یک از قطعات آزمایشی، یکبار در اردیبهشت ماه سال ۱۳۸۶ و باردیگر با گذشت ۷ سال در اردیبهشت ماه سال ۱۳۹۳ تکرار شد. نتایج داده‌های پوشش گیاهی سال ۱۳۸۶ نشان داد که شدت چرای زیاد اعمال شده گذشته، موجب کاهش درصد پوشش گیاهی و تولید علوفه دو گونه مرغوب *Salsola rigida* و *Stipa barbata* و افزایش درصد پوشش گیاهی و تولید علوفه گونه نامرغوب *Launaea acanthodes* و تولید علوفه گونه نامرغوب *Scariola orientalis* گردیده است. نتایج داده‌های پوشش گیاهی سال ۱۳۹۳ نشان داد مقدار درصد پوشش گیاهی و تولید علوفه گونه *Salsola rigida* در قطعات آزمایشی با شدت چرای زیاد، کمترین مقدار را داراست. بطوریکه درصد پوشش تاجی در شدت چرای زیاد حدود ۳ درصد و تولید علوفه در این تیمار حدود ۱۰۰ کیلوگرم کمتر از سایر تیمارها بوده است. در دیگر قطعات آزمایشی تفاوت معنی‌داری بین درصد پوشش گیاهی و تولید علوفه در این گونه دیده نشد ($p>0.05$). میزان درصد پوشش گیاهی و تولید علوفه دیگر گونه‌های گیاهی و کل گیاهان در قطعات آزمایشی مختلف نیز دارای تفاوت معنی‌داری نبود ($p>0.05$). بنابراین با گذشت دوره استراحت میان مدت هر چند اثر منفی چرای زیاد بر گونه *Stipa barbata* مرتفع شده اما همچنان این اثر منفی بر گونه *Salsola rigida* باقی مانده است و تخریب حاصله با گذشت زمان استراحت هفت ساله در عرصه کاملا جبران نشده و به زمان بیشتری نیاز خواهند داشت. بنابراین مقاومت به چرا در گونه *Salsola rigida* کمتر از *Stipa barbata* می‌باشد. با توجه به نتایج اگر مراتع استپی در کوتاه مدت مورد چرای شدید واقع شود با اعمال دوره استراحت کوتاه مدت پوشش گیاهی به حالت قبل بهبود خواهد یافت.

کلمات کلیدی: شدت چرا، درصد پوشش گیاهی، تولید علوفه، *Stipa barbata*، *Salsola rigida*