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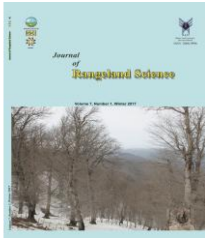

Research and Full Length Article:

The Effects of Deferred Grazing System on Vegetation Parameters in Semi-Arid Rangelands (Case Study: Jashlubar, Semnan, Iran)

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Abstract. Rangeland management plan is one of the major means of management and utilization of rangelands in Iran. The formulation of these plans for the rangeland users should be studied from the ecological and socio-economic points of view. One of the main envisaged activities in almost all the management plans is the grazing system. An experiment was used to study the effects of three deferred grazing systems (15, 30, 45 days delay) and control treatment (Non- grazed) on vegetation parameters in semi-arid rangelands of Jashlubar in Semnan province. The experiment was conducted using a completely randomized block design (RCBD) with three replications over 6 years (2006-2011). In each experimental unit, data from three life forms of vegetation (shrub, forbs and grasses) were collected along a 30 m transect within ten fixed quadrates (0.5 × 0.6 m^2) appropriate to vegetation sizes. In addition, forage productions of two life forms (forbs and grasses) were collected over 5 years. Data were analyzed using SAS software and means comparison was made based on Duncan's method. The results showed the significant effects of deferred grazing systems on the growth of shrubs in terms of canopy cover. However, there were no significant differences between treatments for canopy cover percent of forbs and grasses. The lowest shrub canopy cover was obtained in 45-day delay of grazing. There were also significant effects of deferred grazing systems (15, 30 and 45 days delay) on forage production of both forbs and grasses ($P<0.05$). Result of means comparison showed that the best delay time for the rangeland utilization of this area considering the annual precipitation is the 15-day delay with the highest forage production for forbs and grasses and the highest cover percent for shrubs.

Key words: Rangeland management, Grazing system, Delayed grazing treatment, Vegetation cover, Forage production

Introduction

Rangelands are complex and dynamic ecosystems covering the extended areas of the earth and producing many direct and indirect products and services (Alizadeh *et al.,* 2010). Soil, water, plant, climate and animals are the main components of these ecosystems with complex relations and interactions. A sound knowledge of various components and their capability for utilization in different regions is necessary for social, ecological and economic sustainability of these ecosystems (Vallentine, 2001). Most rangelands are used for grazing, which is defined as the use of land for grazing livestock in order to produce meat, milk, and other animal products (Goldewijk and Battjes, 1997; Asner *et al*., 2004). Rangeland degradation is largely caused by a combination of over-stocking, empirical livestock management, historical-cultural impediments to adopt modern grazing management methods and global climate changes (Harris, 2010). The degraded vegetation provides less protection against the mechanical impacts of grazing animals on soil structure, this feedback produces a vicious cycle between the destabilization of soil structure, soil loss through erosion, and protective vegetation cover, which reinforces the decline in plant production and in turn, reduces the carrying capacity of the land for grazing livestock (Asner *et al.,* 2004; Squires and Karami, 2015).

Skilled grazing managers use their knowledge of plant growth to choose the most appropriate grazing system. They also make year-to-year changes in rangeland-use sequences in order to minimize cumulative effects of grazing and environmental stress (Reece *et al*., 2007). In the 19th century, grazing techniques were virtually non-existent. Rangelands were grazed for long periods with no rest in between. This led to overgrazing which was detrimental to the land, wildlife, and livestock producers. Today, pastoralists have developed the grazing systems to help the forage production improvement for livestock while still being beneficial to the land. So, in general, grazing systems are instruments that can be used by managers to improve the rangeland conditions but they cannot be a successor for management (Fleming *et al*., 2001; Grings *et al*., 2002; Holechek *et al*., 2005; Li *et al*., 2008). Grazing management systems allow the range manager to balance or manage the livestock needs with those of the range ecosystem. Too frequent and heavy grazing during the season is harmful to range plants and soils. Effective grazing management systems must resolve this basic dilemma (Bailey *et al*., 2010). Grazing systems alone will not be sustainable. They must be well managed with proper stocking rates to meet the objectives of grazing operation. Using appropriate stocking rates is very important because no sophisticated grazing system can overcome the consequences of overgrazing when the stocking rate is too high. Most of range managers believe that stocking rate can be ignored if some miraculous specialized grazing systems are applied (Holechek *et al*., 2005). Usually, a moderate stocking rate is required, but occasionally for rangeland management purposes, a brief period of temporary, short-term heavy grazing may be required to realize a specific invasive plant control objective in a rangeland management plan (Bailey, 2008). Deferred grazing system means to delay the grazing to enable plants to regrow and recover from a previous grazing event. It is intended to permit leaf, root, and tiller development, seed production, and seedling establishment (Bailey *et al*., 2010). Arid and semiarid rangelands of Iran suffer from high grazing pressure on one hand and the recurrent and prolonged droughts on the other hand. Arid and semiarid areas account for 85% of national rangeland area and make an important contribution to the country's economy (Badripour, 2006). Azimi *et al.* (2013) mention that despite suffering from heavy grazing and periodic droughts, rangeland still makes an important contribution to the country's economy as well as playing an important role in environmental protection and food security. A long-term policy and strategy for rangeland management is to "establish a comprehensive grazing management, rangeland improvement and development as a part of the principles of sustainable development" (Assareh and Akhlaghi, 2009). Deferred grazing helps establish a dense and productive annual pasture by preventing the overgrazing during establishment. The effects of deferment grazing on plant density will be greater at higher stocking rates. However, autumn deferment may be more appropriate for ranchers at near-optimal stocking rates. In some seasons where pasture growth is very slow, the deferred grazing may be the most beneficial when combined with strip grazing due to the rationing of accumulated pasture (Vallentine, 2001).

With this background, in this study, we aimed to investigate the effects of deferred grazing on vegetation cover and forage production in semiarid rangelands in Semnan province.

Materials and Methods

Study Area

Jashlubar area is located between 53° 7′ 59″ East and 35° 45′ 27″ North in Semnan province, Iran (Fig. 1). The climate is continental with mean annual temperature of 12 °C. The mean elevation is 2600 m above sea level. Mean annual precipitation is 291 mm. Based on the Amberotermic curve, the dry period expands from mid-May till November (Fig. 2). Jashlubar with an area of 2500 ha is a research station for animal and range management. Two third of area equal to 2000 ha is covered with rangelands. In the study area, 28 plant species have been identified as shown in Table 1. The dominant plant species for animal grazing are *Festuca rubra*, *Psathyrostachys fragilis*, and *Bromus tomentellus*. Sheep and goats are domestic animals kept by pastoralists in this area and the number of authorized grazing livestock is 611 animal units (Mozafari, 2009).

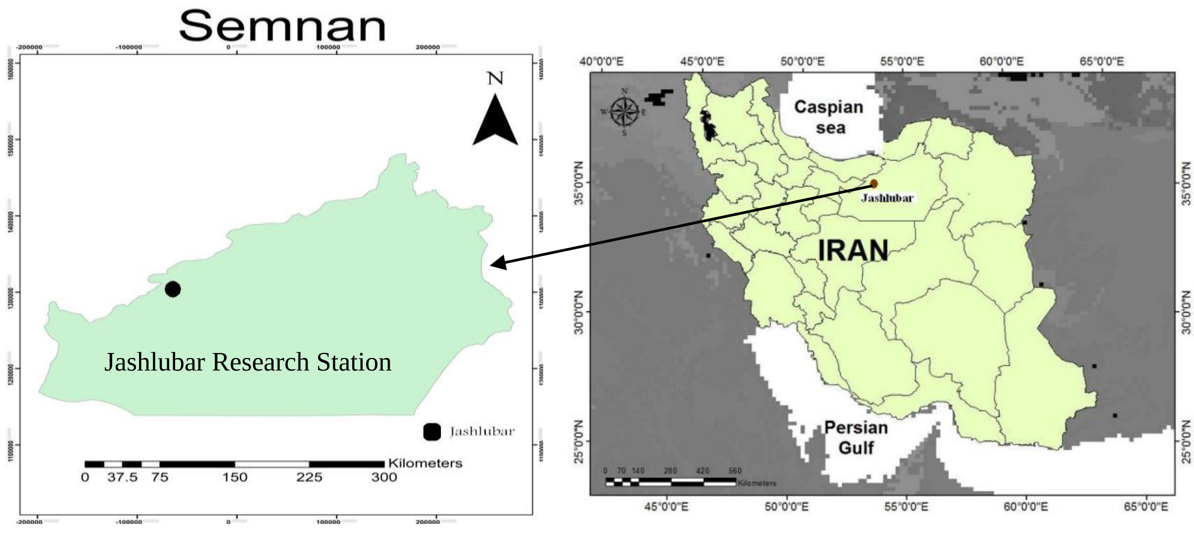

Fig. 1. The Case study site location in Semnan province, Iran

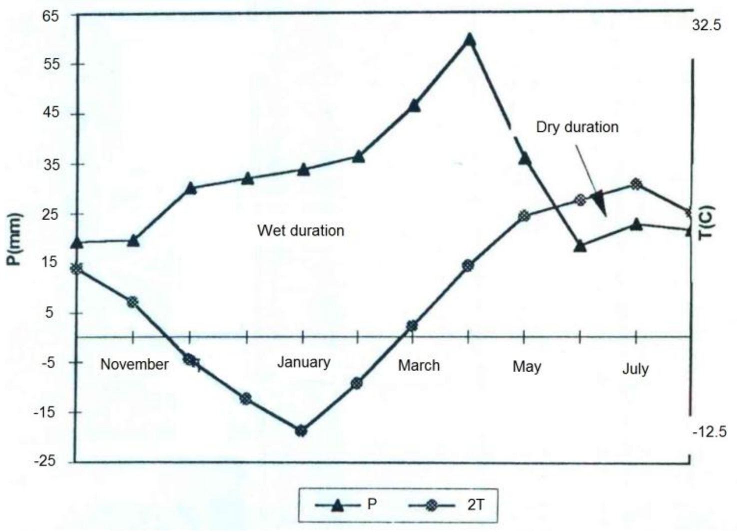

Fig. 2. Amberotermic curve for Jashlubar research station

Table 1. List of plant species in Jashlubar area

Row	Species name	Palatability Class*	Row	Species name	Palatability Class
1	*Agropyron desertorum*	I	15	*Astragalus callistachys*	I
2	*Allium eriophyllum*	III	16	*Astragalus podolobus*	III
3	*Astragalus gossypinus*	III	17	*Achillea wilhelmsii*	III
4	*Bromus tomentellus*	I	18	*Festuca rubra*	I
5	*Cousinia nekarmanica*	III	19	*Onobrychis cornuta*	III
6	*Eryngium bungei*	III	20	*Carex stenophylla*	III
7	*Euphorbia turcomanica*	III	21	*Acanthophyllum sordidum*	III
8	*Noaea mucronata*	III	22	*Acantholimon erinaceum*	III
9	*Onobrychis sintenisii*	I	23	*Polygonum afghanicum*	II
10	*Poa bulbosa*	II	24	*Alyssum bracteatum*	III
11	*Psathyrostachys fragilis*	II	25	*Stipa lessingiana*	II
12	*Scariola orientalis*	II	26	*Eurotia ceratoides*	II
13	*Taraxacum roseum*	II	27	*Stachys inflata*	II
14	*Tragopogon marginatus*	III	28	*Bromus japonicus*	II

* (FRWO. 1982) I: High palatable species II: Moderate palatable species III: Non palatable species

Data collection

In order to study the effects of deferred grazing on vegetation cover, three deferred grazing systems (15, 30, 45 days delay) and control treatment (Non-grazed) were applied using a completely randomized block design (RCBD) with three replications over 6 years (2006-2011) (Table 2).

In each experimental unit, data of shrubs, forbs and grasses were collected along a 30 m transect within 10 fixed quadrates (0.5 × 0.6 m^2) appropriate to vegetation sizes. Also, forage production of forbs and grasses was collected for 5 years. Most of shrub plants in this site were not palatable for livestock and therefore, data of shrub production were not collected. Forage production was measured using the clipping and weighting method in each quadrate. The normality of collected data was verified through Kolmogorov–Smirnov test; then, data were analyzed using SAS software (version 9.2) to test the effect of deferred grazing on vegetation cover and forage production. The means comparison was made using Duncan's Test (P<0.05).

Table 2. Deferred grazing system treatments in this study

N.	Deferred grazing systems
1	15 days delay in grazing from the start of grazing period
2	30 days delay in grazing from the start of grazing period
3	45 days delay in grazing from the start of grazing period
4	Controlled treatment or none grazed

Results

Results of analysis of variance for four deferred grazing systems over six years for the studied traits are presented in Table 3. The results showed the significant effect of deferred grazing systems on the growth of shrubs in terms of canopy cover and forage production in forbs and grasses (P≤0.01). There were also significant differences between years for all the traits except shrub cover percent (Table 3). However, there were no significant differences between the deferred grazing systems for canopy cover percent of forbs and grasses. There were significant interaction effects of deferred grazing systems by year for grass canopy cover and the grass and forb production (Table 3).

The results of means comparison between four grazing systems and years are summarized in Tables 4 and 5, respectively. The result of means comparison of grazing systems by year interaction for forage production is shown in Fig. 3.

Higher and lower shrub canopy covers with the average values of 8.50% and 4.86% were obtained in control and 45-day delay, respectively. Higher forage production with the average values of 192.05 and 421.26 kg/ha was obtained for forbs and grasses in the 15-day delay grazing, respectively. The means comparison between years for all the traits is presented in Table 5. Higher and lower annual rainfall given as 327.2 and 141.8 mm had fallen in 2009 and 2010 (Table 5), respectively indicating the irregular and unpredictable annual precipitation. However, there were strong correlations between annual precipitation and forb cover (r=92) as well as the forb production (r=90). The mean of forage production for grazing by year effects is in Fig. 3. Higher total production (forb and grass) was obtained in 2009 and 2011 for the 15-day delay grazing system and in 2007 and 2009 for the 30-day delay grazing system (Fig 3). High rainfall estimated as 327.2 mm had fallen in 2009 indicating strong relationships between forage production and annual precipitation.

Table 3. Summary of combined ANOVA for grazing treatments over yeas

Sources of variation	df	MS				
		Shrubs cover%	Grasses Cover %	Forbs Cover%	Forbs ≠ Production kg/ha)	Grasses ≠ Production (kg/ha)
Years	5	18.16	75.65**	75.65*	10738*	41542 **
Error1	12	9.24	37.8	6.60	2258.54	1907
Grazing	3	50.04**	2.40	2.40	8542*	25265**
Grazing ×Years	15	5.34	13.31*	13.31	10182**	49130**
Error 2	36	11.00	7.23	5.14	975.35	46906

*,**= significant differences at 5% and 1% probability levels.

≠ Data collected for 5 years and 3 grazing treatments, So, Df of year=4 and Df of grazing=2

Table 4. Means comparison of four treatments for shrubs, forbs and grasses

Grazing treatment	Shrub Cover %	Forb Cover %	Grass Cover %	Forb production (kg/ha)	Grass production (kg/ha)
15 days delay	8.20[a]	17.22[a]	8.50[a]	192.05[a]	421.26[a]
30 days delay	7.68[a]	16.70[a]	7.70[a]	171.26[a]	369.82[b]
45 days delay	4.86[b]	16.35[a]	8.80[a]	144.45[b]	340.15[b]
Control	8.50[a]	16.90[a]	7.80[a]		

Means of column flowed by the same letters are not significantly different based on Duncan method (P<0.05)

Table 5. Means comparison of years for shrubs, forbs and grasses

Years	Precipitation (mm)	Shrub Cover %	Forb Cover %	Grass Cover %	Forb production (kg/ha)	Grass production (kg/ha)
2006	234	5.02^{b}	14.98^{b}	9.76^{a}	-	-
2007	315	7.06^{ab}	16.26^{ab}	8.97^{ab}	183.89^{a}	340.89^{c}
2008	269.2	8.15^{a}	21.34^{a}	7.62^{ab}	159.67^{ab}	409.28^{b}
2009	327.2	8.43^{a}	16.85^{ab}	7.41^{b}	199.12^{a}	375.26^{bc}
2010	141.8	7.34^{ab}	17.13^{ab}	7.01^{b}	113.29^{b}	290.27^{d}
2011	251.2	7.84^{a}	14.13^{b}	8.49^{ab}	190.28^{a}	469.70^{a}

Means of column flowed by the same letters are not significantly different based on Duncan method (P<0.05)

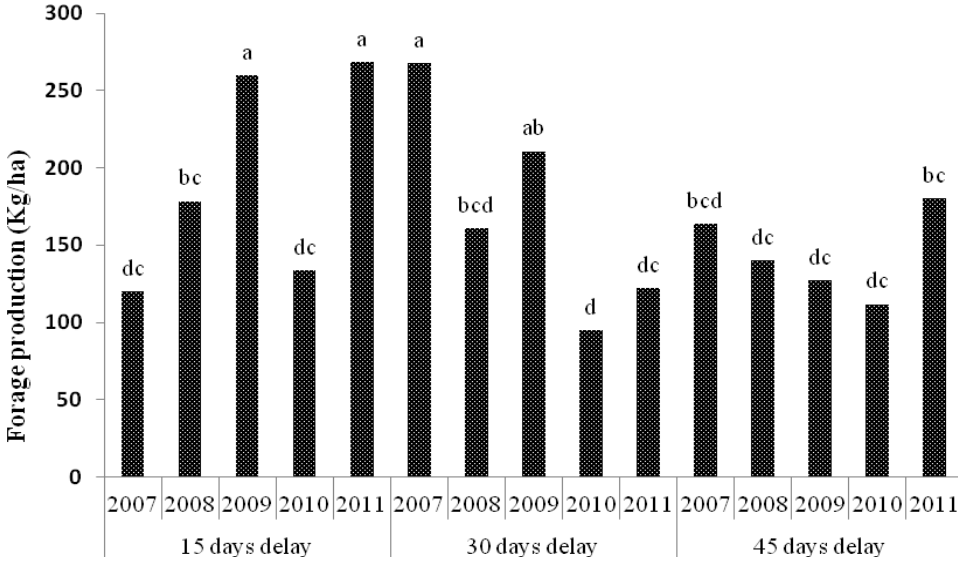

Fig. 3. Comparison of deferred grazing systems and year for forage production
(Means of column with the same letters are not significantly different (P<0.05))

Discussion and Conclusion

Today, the absence of grazing on most natural grasslands is not recommended because the grasslands have evolved with grazing and is strongly adapted to it. Contemporary grazing systems are the management plans that enhance the efficient use of rangelands by livestock (Adams, 1992; Bailey, 2008). Grazing systems can help maintain the rangelands in an ecologically sustainable state and are also useful in repairing the damages created by past inappropriate grazing/ browsing practices by either livestock or wild ungulates. Results of this research showed that there was a significant difference between years and grazing systems for cover percent and forage production in the studied life forms. These results were in agreement with the previous researches (e.g. Fleming *et al.*, 2001; Grings *et al.*, 2002; Holechek *et al.*, 2005; Squires and karami, 2015). In order to implement the deferred grazing systems, delay time considering annual precipitation amount is of great importance in rangeland management. Results for shrub life form indicated that 45-day delay had significantly lower cover percent than the other deferred grazing systems. In some plant species especially shrubs, the preference value declines as growth stages progress (30 or 45-day delays) due to the increment of structural carbohydrates and the reduction of raw protein percent. This leads to the reduction of digestibility and palatability (Karimi *et al.*, 2013). Even though, no significant difference was found between grazing treatments for grasses, the 15-day delay showed the highest cover percent of grass as compared to the other treatments. As for forbs, there was no significant difference between various treatments but the highest canopy cover was found in the 15-day treatments.

Means comparison of forage production indicated that for forbs, the deferred grazing system of 45-day delay was significantly lower than two other treatments but for grasses, the 15-day delay was significantly higher than two other treatments. According to the results, the best delay time for forb and grass production was 15 days with the highest forage production. Results indicated that the interaction of grazing of 15, 30 and 45-day and year delays considering annual precipitation had significant effects on forage production. Grazing systems can be useful when applied effectively in different areas and years. Even with good grazing distribution practices, utilization is rarely uniform. This provides for much of the spatial biodiversity found on well-managed rangelands. Finally, due to differences between rangelands all over the world in terms of climate, seasonal precipitation, geomorphology and topography, all the rangelands cannot be managed in a same way (Bailey *et al*., 2010). Selecting a certain grazing system is based on vegetation type, rangeland physiography, fauna and management goals. Needless to say that each grazing system has also some impacts on rangelands; therefore, the deferred grazing systems were studied in Semnan province. Since the Jashlubar site is a summer rangeland due to the suitable rainfall, the grazing issued permits should be temporary. It is also suggested that grazing licenses should be determined accurately by the cutting-weighing method. Stocking rate should also be based on the rangeland grazing capacity. In case of grazing systems, the best system for this area is the deferred grazing system where the 15-day delay can be considered according to the vegetation composition and annual precipitation. Any plan for rangeland management and restoration should be justifiable scientifically and in order to formulate such a plan, a wide range of information from socio-economy to ecology should be collected and integrated in the plan. This will help develop a plan that integrates both grazing system and rangeland rehabilitation activities.

In conclusion, the best delay time for the rangeland utilization of this area considering annual precipitation is the 15-day delay with the highest forage production for forbs and grasses and the highest cover percent for shrub life form.

Acknowledgement

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بررسی تاثیر سیستم چرای تأخیری بر روی عامل‌های پوشش گیاهی در مراتع نیمه خشک مطالعه موردی (جاشلوبار، سمنان، ایران)

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چکیده. طرح‌های مرتعداری یکی از ابزارهای اصلی مدیریت و بهره‌برداری از مراتع در ایران است که باید در تهیه آن‌ها به ویژگی‌های اکولوژیک منطقه از یک سو و به مسائل اجتماعی بهره‌برداران از سوی دیگر اهمیت داده شود. یکی از برنامه‌هایی که شاید در تمامی طرح‌های مرتعداری پیش‌بینی می‌شود، برنامه سیستم‌های چرایی است. بر این اساس به منظور تاثیر سیستم چرای تأخیری در مراتع نیمه استپی جاشلوبار از توابع استان سمنان سه تیمار چرای تاخیری (۱۵، ۳۰ ، ۴۵ روز) و شاهد (قرق) در قالب طرح بلوک‌های کامل تصادفی در سه تکرار به مدت شش سال (۱۳۸۵-۱۳۹۰) به اجرا در آمد. در هر واحد آزمایشی با استفاده از برقراری پلات‌های ثابت به تعداد ۱۰ عدد (۰/۵ ×۰/۶) متر مربع با اندازه‌های متناسب با پوشش گیاهی، اطلاعات جمع‌آوری و با استفاده از نرم افزار *SAS* مورد تجزیه و تحلیل قرار گرفت، سپس آزمون مقایسه میانگین‌ها به روش دانکن انجام شد. نتایج تجزیه واریانس نشان داد که اثر تیمارهای چرای تاخیری بر درصد پوشش در فرم رویشی بوته‌ای‌ها معنی دار بود. اما تاثیر معنی‌داری بر درصد پوشش گندمیان و پهن برگان نداشت. از لحاظ تولید علوفه اثر تیمارهای مختلف چرایی (۱۵، ۳۰ و ۴۵ روز تاخیر) در فرم‌های رویشی گندمیان و پهن برگان معنی‌دار بود ($P<0.05$). نتایج آزمون مقایسه میانگینِ تیمارها از لحاظ درصد پوشش و تولید علوفه نشان داد که بهترین زمان تاخیر در بهره‌برداری از مراتع مورد مطالعه با توجه به میزان بارندگی، تیمار زمانی ۱۵ روز تأخیر از چرا از لحاظ افزایش میزان تولید علوفه در فرم‌های رویشی پهن برگان و گندمیان و افزایش میزان درصد پوشش برای بوته‌ای‌ها می‌باشد.

کلمات کلیدی: مدیریت مرتع، سیستم چرایی، تیمار تأخیر زمانی ، درصد پوشش، تولید علوفه