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Seasonal changes in production and consumption of range species in Dehno-Kerman Rangelands

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Abstract

It is impossible to planning and managing rangeland and livestock in case of no knowledge of plants production and consumption characteristics. In this research changes of seasonal production and consumption of dominant forage species evaluated during the growing period and grazing season for four years. For each species, five average plants were selected inside and outside the exclosure, and the production was harvested. Collected data were analyzed using SAS software and mean comparisons were done by Duncan's multiple range tests. Results indicated production of these species in 2008 was very fluctuating with the most severe drought. Production in this year was about 43% of production in 2007.In terms of severity of production decline, species showed different reactions to climatic variations. *Stipa barbata* and *Artemisia sieberi* were produced in 2008, 36 and 37.2%, respectively. In other species, the production in 2008 compared to the wet year was between 13 and 41 percent. Results showed that the average production of 8 permanent species was 344.1 kg/ha and the share of grass species was high, and in the middle four years, about 40% of forage pasture was affected by *Stipa barbata, Oryzopsis holciformis, Poa sinaica*. The highest amount of these species was produced in April and May.70-75% of these species was used in March and April. About 40.5% of the forage was produced by *Artemisia sieberi*. A larger share of these species was used in livestock in August and September. Generally, the identification of important rangeland species in different months of the growing season can help to the proper and timely consumption of rangeland forage.

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Introduction

Recognition of vegetative and productive behavior of plants in the growth stage, dynamic production of rangeland, temporal changes in the grazing value of plants, rangeland utilization systems and their effects on the health of the rangeland are important issues in rangeland management and especially in arid rangeland management. Determining the amount of annual forage production in order to calculate the grazing capacity is essential in the management of rangelands.

There are various and diverse species of plants in rangelands. Each species has a certain production in different months during the grazing season and in different years. Forage production is a dynamic variable of a rangeland and it is different during different seasons and different years. The fluctuations in production make it difficult to measure the possibility of production capacity of the permanent and temporary grazing (Moghaddam, 1999). Without understanding the production and consumption characteristics of plants in a rangeland during the grazing period, planning and management of rangeland and livestock is not possible. Climate and management are two important factors in the progress of rangeland development.

Rainfall variability affects the vegetation indices such as coverage, production and rangeland condition. Rashvand *et al.* (2012) in a study on rangeland of Alamut Mountains to assess the sustainability of rangeland forage production pointed out that two species of *Artemisia aucheri* and *Cousinia esfandiari* have sustainable production based on sustainability factors.

Many studies have been conducted in the country about the production and role of rainfall and moisture in plant production (Yang *et al.,* 2008; Zarekia *et al.*2012; Fakhimi *et al.,* 2014). These studies emphasized on the role of rainfall and moisture to increase the forage production. Mirzaali *et al.* (2011) examined the effect of rainfall on the production of four rangeland species using regression analysis from 2003 to 2007 and from 2009 to 2010 in Pashiloq rangeland, Iran.

The results showed that the annual production of various rangeland species will react to the monthly precipitation in a way that the annual production of *Salsola arbusculiformis* had the highest correlation with the rainfall in January and the production of *Artemisia sieberi* had the highest correlation with rainfall in November and January. Also, Smith *et al.* (2005) showed that vegetable production in dry years has decreased about 13.5 percent and in some cases 30 to 40 percent in comparison with normal years. Abdollahi *et al.* (2013) in the Yazd region has examined the production quantities and climate variables using multiple regression techniques and they concluded that amount of rainfall during the period of December to March, December to April and April had the greatest impact on the production of *Artemisia sieberi*, *Iris songarica* and *Stipa barbata*species.

Aliakbarzadeh *et al.* (2017) showed that there is a huge difference between rangeland species in terms of production and consumption in the months of the growing season as well as in the studied years in summer rangelands of Sabalan. So that the total forage production was different during the studied years. The results of this study showed that the highest production was in July, and consumption amount of different species is concentrated in July and August. It is because of the coincidence of vegetative growth and flowering of all species is in July. Grazing animals at any point and different years consume certain amounts of forage that it is different based on conditions and different races. The planning and management of rangeland and livestock is not possible without understanding the production characteristics of the grazing period (Akbarzadeh and Mirhaji, 2007).

Therefore, in this study the production and consumption of key plants in the steppe rangelands were determined and the amount of monthly and annual changes in their production and consumption was examined. Thus, the possibility of revising the management plan of the pasture grazing in the areas with similar vegetation types is provided and finally, it offers useful information about the dynamic production of rangeland and livestock.

Materials and methods

Study area description

The studied steppe rangeland (Dehno rangeland) is located 20 km west away Bardsir, Kerman province between east longitudes 56 °16' to 56 ° 23' and north latitudes 29°55' to 29°64 ' (Fig. 1).

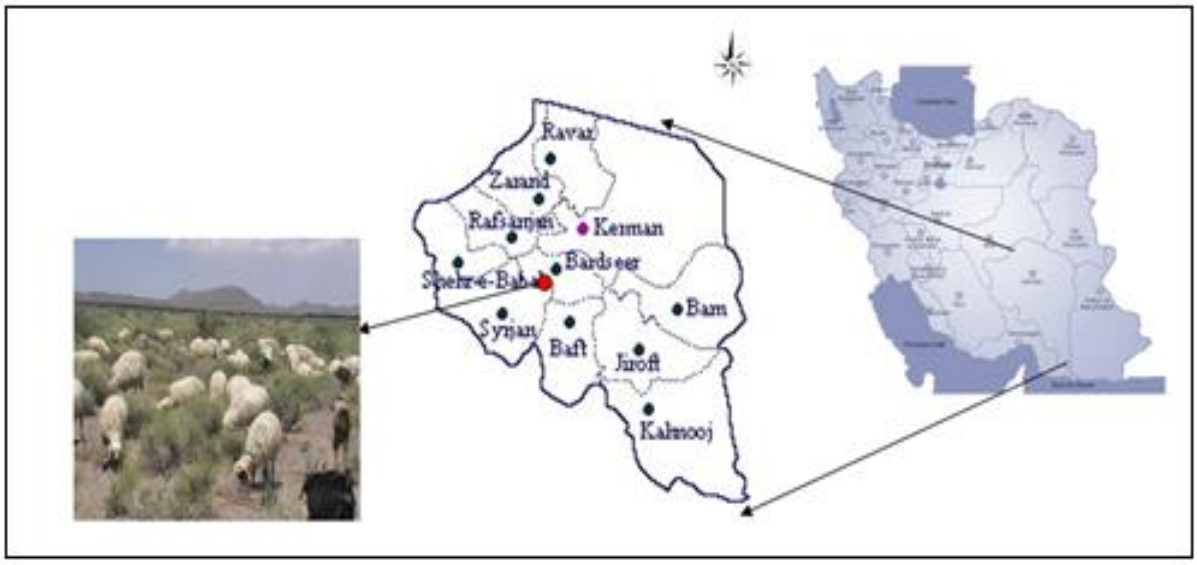

Fig. 1. Location of study area in Iran.

The region has an altitude of 2300 m above sea level. According to the long-term data Dastjerdstation, the average annual rainfall is 162 mm and the average temperature is 13 °C (Table 1). According to the modified Domarten method, the climate of the area has been determined as a dry cold desert. Also, based on the Embrothermic curvein a long period of time, the duration of the wet season and dry season was 5 months and 7 months, respectively.

Seasonal distribution of rainfall is so that 17.8% of rainfall occurs in the spring, 3% in summer, 20.5% in the fall and 58.5% in winter. Based on the long-term statistical data on the distributions of rainfall, the growing season is so that the most rainfall occurs during the winter.

The soil in this area is inceptisol with a sandy loam to loam soil texture. The soil pH ranges between 6.7 to 8.2 and EC is less than 4 mmhos/ds. The exploitation system of rangelands is nomadic.

The dominant vegetation type is *Artemisia sieberi – Zygophyllum eurypterum*. The main species are *Astragalus spachianus, Denderostellera lessertii, Scariola orientalis, Poa sinaica, Cousinia piptocephala, Euphorbia densa, Taenia erumcrinitum, Stipa barbata, Hertia intermedia, Noaea mucronata, Nepeta* sp., *Heteranthelium piliferum, Bromus tectorum, Boissiera squarrosa, Bromus danthoniae, Tragopogon* sp., *Echinops* sp.

Methods

To determine the monthly forage production and consumption of range species in the dehno rangeland, forage production of keys species was measured from the beginning of the growing season every year, for 4 years, inside a one-hectare enclosure and in the outside of the region which was under grazing with one month intervals until the growth dormancy. The amount of consumption was determined with difference between amounts of production in the outside of the enclosed region and the production of the enclosed region.

In the sampling for measuring production and consumption, plants with the average height were used. In each month, at least eight plants with the average height in the enclosed region and eight plants with the average height out of the enclosed region was selected and marked, then in the given time all production of them was measured.

To determine the average height of the plant, in a severe systematic random sampling, the canopy cover and density of the plant was estimated in the enclosed region. Then the average canopy cover was determined by dividing the total canopy cover to the density. After cutting out the plants and drying it in the shade, the dry weight of forage production was measured and by multiplying the production of each plant per density per hectare, the monthly production per hectare is calculated. Summation of the monthly production per hectare during the growing season produces the total production of a species in terms of a kilogram of dry matter per hectare. Finally, the forage (production and consumption) in the statistical design of split plot in a completely randomized design with five replications for three years was analyzed in the SAS software and the average of the studied characteristics was compared using Duncan test.

Results

Production changes in different years

In the present study, the production of species was evaluated from April to September and at the same time consumption by livestock was studied.

The results showed that in most species the maximum production was in June but in some other species the production continued until September. According to the results the maximum amount of forage on rangeland was observed in the first year (2007), and it was about 2.3 times of forage production in the second year (2008). In the fourth year (2010), which the rainfall was less than average rainfall, but more than the rainfall from second year, the production of rangeland was about 80 percent of the first year (2007).

Table 1. Monthly and annual rainfall (mm) and temperature (°c) during the project period (2006-2010).

Month	2007 – 2006		2008 - 2007		2009–2008		2010–2009		Mean (1990-2010)	
	Rain	Temp.	Rain	Temp.	Rain	Temp.	Rain	Temp.	Rain	Temp.
September	0	12.1	0	12.6	0	17.1	0	15.2	2.1	14.5
October	9	11.1	0	9.9	12	9.3	0	10.2	5.4	9.5
November	34.5	4.1	0	5.2	33	4.1	26	4.4	25.6	4.5
December	14	-2	33	-2.1	9	3.7	5	3.8	27.8	1.9
January	90	2.3	0	1.6	9	4.2	0	5.5	36.1	3.4
February	9	6.7	10	8.7	35	9.4	0	11.1	30.9	7.3
March	22	12.1	0	13.5	0	11.1	0	16.3	20.1	11.5
April	4	18.2	0	17.6	0	17.9	0	20.1	6.5	17
May	0	22	0	24.8	0	21	0	23.5	2.1	21.1
June	13	25.3	0	26.1	0	23.2	0	26.1	2	24.3
July	5	22	0	22	6	25.2	0	21	1.6	22.5
August	0	18.6	0	19.3	0	22	0	17.2	1.4	19.5
Annual	200.5	12.7	43	13.3	98	14.1	31	14.5	161.6	13.1

As is clear from the results, *Artemisia sieberi* and *Stipa barbata* species have the greatest amount of production. *Artemisia sieberi* had a high rate of production changes during the studied years. Production of this species in a high production year of 2007 was about 2.2 times of the low production year of 2008.

Similar changes were also observed in the production rate of *Stipa barbata*. So that, production of this species in a high production year of 2007 was about 2.6 times of the low production year of 2008.

Table 2. Comparison of the means of production of species in the studied years using Duncan's test (Kg/ha).

Species	2007	2008	2009	2010
Zygophyllum eurypterum	53.6[a]	21.3[b]	39[b]	30.4[b]
Artemisia sieberi	162[a]	73.7[c]	160.2[a]	139[b]
Oryzopsisholciformis	21.8[a]	4.9[c]	21.3[a]	17.5[b]
Poa sinaica	5[a]	0.8[a]	4.5[a]	3.4[b]
Stipa barbata	189.1[a]	70.8[b]	184.6[a]	159.4[a]
Denderostellera lessertii	22.4[a]	8.8[c]	17[b]	17.2[b]
Euphorbia densa	19.2[a]	7.3[b]	19.5[a]	18.4[a]
Scariola orientalis	16.1[a]	6.2[b]	22.9[a]	20[a]

The means of treatments with same letters were not significantly different.

Therefore, the production of these species was strongly influenced by the amount and distribution of rainfall (Table2).

Production changes in different months

The results also showed that the production in months of the growing season was different. According to measuring in monthly intervals, the total production of rangeland in an average of four years in April was higher than other months and the monthly production rate was gradually decreased with the progress of a growth period in September. In other words, the monthly production rate was decreased from the early growing season (Table 3).

Table 3. Comparison of the means of production of species in the studied month using Duncan's test (Kg/ha).

Species	April	May	June	July	August
Zygophyllum eurypterum	49.5[a]	41.5[b]	17.3[c]	0	0
Artemisia sieberi	90.5[d]	23.3[e]	144.6[c]	151.1[bc]	176.7[b]
Oryzopsis holciformis	14.2[b]	13.1[b]	21.8[a]	0	0
Poa sinaica	3.1[a]	3.9[a]	3.2a	0	0
Stipa barbata	108.2 [c]	201.6[a]	143.1[b]	0	0
Denderostellera lessertii	22.7[a]	5.7[b]	26.2[a]	7.4[b]	27.3[a]
Euphorbia densa	18.3[b]	4[d]	24.5[a]	10.5[c]	28.9[a]

The means of treatments with same letters were not significantly different.

Production changes in different species

On average, production rate in most of the species was decreased. Just as *Artemisia sieberi* in July and September had slightly higher production, which is related to the new mutation (Table 3). On average, around 76.2% of the forage in four years was produced by two species of *Stipa barbata* and *Artemisia sieberi* that 79.6 percent of the total consumed forage was from these two species (Table 6). 20.4% of the produced forage belonged to other six species that they had between 1 to 7% of the total forage production of rangeland (Table 6).

Consumption changes

In four years on average, 67.9% of the total rangeland production was used during the grazing season (Table 5). Based on the results three species of *Stipa barbata*, *Oryzopsis holciformis* and *Poa sinaica* had the highest consumption in this site and more than 99% of the total consumed forage was consumed from these three species.

Three species of *Stipa barbata*, *Oryzopsis holciformis* and *Poa sinaica* had the highest consumption in the rangeland (98.3, 99.5 and 100 percent, respectively).

The lowest consumption rate is 22.8 percent belongs to *Zygophyllum eurypterum* species (Table 5).

But the consumption of forage and its production was different in the studied months. In average of studying years, the share of forage consumption in June and May were high and the lowest amount was in July and April (Table 4).

Table 4. The monthly relative production and consumption of species in different years.

Year	Relative production (%)						Relative consumption (%)					
	April	May	June	July	August	September	April	May	June	July	August	September
2007	35.2	36	11	10.8	1.6	5.3	9.8	32.7	16.6	5.8	14.6	20.6
2008	32	30.9	10.1	9	3.6	14.3	7.6	43.2	10.5	92	14	15.3
2009	27.3	24.5	17.6	21.9	4.4	4.2	11.2	23.4	29.3	9.3	13.2	13.5
2010	32	23.4	12.7	15	8.5	8.4	15.1	27.6	15.4	13	12.7	16.1
average	31.6	28.6	12.8	14	4.5	8	10.9	31.7	17.9	9.3	13.6	16.3

However, this trend was not the same for all species as *Artemisia sieberi* consumption was increased from March to September and the highest consumption occurred in September (Table 5).

The production rate of species was different in the study site. The difference was observed between species and in a species in different years. Production changes became more significant with the extension of canopy cover. The species that had more canopy cover, their share was higher in the rangeland.

Discussion

Table 5. Average production and consumption of species in dehno rangeland.

Species	April			May			June		
	(Kg/ha) Pro.	Cons. (Kg/ha)	Cons. %	(Kg/ha) Pro.	Cons. (Kg/ha)	Cons. %	(Kg/ha) Pro.	Cons. (Kg/ha)	Cons. %
Zygophyllum eurypterum	41.5	3.5	8.5	58.8	10.8	18.5	66.8	13.8	20.7
Artemisiasieberi	89.9	11.28	12.37	113.6	25.6	22.3	167.5	44.2	26.7
Oryzopsis holciformis	14	5.6	38.2	27.2	16.4	61.8	34.9	30.6	84.9
Stipa barbata	107.7	41.4	38.4	309	192	62.4	344.1	266.7	77.5
Poa sinaica	3.1	1.5	48.3	7.1	4.2	59.1	7.2	6.9	95.8
Denderostellera lessertii	22.7	3.7	16.3	28.4	8.7	30.8	31.9	11.5	36.2
Euphorbia densa	18.2	4.2	23	22.3	7.2	32.2	28.4	8.7	30.7
Scariola orientalis	7.6	2.1	27.6	13.83	6.5	46.9	28.9	15.8	54.6
Rangeland total	304.7	73.2	24	580.2	271.4	46.7	709.7	398.2	56.1

Table 5. Continued

Species	July			August			September		
	(Kg/ha) Pro.	Cons. (Kg/ha)	Cons. %	(Kg/ha) Pro.	Cons. (Kg/ha)	Cons. %	(Kg/ha) Pro.	Cons. (Kg/ha)	Cons. %
Zygophyllum eurypterum	66.8	14.5	21.7	66.8	14.5	22.3	66.8	15.2	22.8
Artemisiasieberi	295.4	68	25.2	327.5	112.3	37.8	392.4	184.5	48.7
Oryzopsis holciformis	34.9	33.2	93.2	34.9	34.4	97.9	34.9	34.8	99.5
Stipa barbata	344.1	290.5	84.4	344.1	318.8	92.6	344.1	338.3	98.3
Poa sinaica	7.2	7.2	100	7.2	7.2	100	7.2	7.2	100
Denderostellera lessertii	33.6	13.2	39.4	35.1	19.4	55.4	36.7	24.5	66.8
Euphorbia densa	34.9	11	31.5	38.6	14.4	37.3	39.5	20.3	51.5
Scariola orientalis	38.73	20.4	52.6	45.13	26.1	57.8	45.13	32.3	71.5
Rangeland total	855.6	458	53.5	899.3	547.1	60.8	966.7	657.1	67.9

According to the results, 52.5% of forage was produced by a species that had a greater share of the rangeland compared to other species and about 40 percent of the total forage was produced by grass varieties of *Stipa barbata*, *Oryzopsis holciformis* and *Poa sinaica*. One of the reasons for the frequency of these shrub species in the rangeland can be the type of dominant grazing livestock. The grazing Livestock is mainly sheep and shrubs always are not their priority and based on the grazing history of this rangeland, the species has expanded and been high compared to other growing forms.

Table 6. The monthly relative production and consumption of studied species in different months and the share of each species in the total rangeland production.

Year	Relative production (%)						Relative consumption (%)						Relative production in pasture (%)	Relative consumption in pasture (%)
	April	May	June	July	August	September	April	May	June	July	August	September		
Zygophyllumeurypterum	62.1	25.9	12	0	0	0	23	48.1	19.7	4.8	0	0	6.9	2.3
Artemisiasieberi	22.9	6.1	13.7	32.6	8.2	16.5	6.1	7.7	10.1	12.9	24	39.1	40.6	28.1
Oryzopsis holciformis	40.1	37.8	22.1	0	0	0	16.1	31	40.8	7.5	3.5	1.1	3.6	5.3
Stipabarbata	31.3	58.5	10.2	0	0	0	12.2	44.6	22	7.1	8.3	5.8	35.6	51.3
Poasinaica	43.1	55.5	1.4	0	0	0	20.8	37.5	37.5	4.2	0	0	0.75	1.1
Denderostelleralessertii	61.6	15.8	9.5	4.7	4	4.4	15.1	20.4	11.4	7	25.3	20.8	3.8	3.73
Euphorbiadensa	46.1	10.4	15.4	16.5	9.3	2.3	20.7	14.8	7.4	11.3	16.7	29.1	4	3.1
Scariolaorientalis	16.8	13.8	33.4	21.8	14.2	0	6.5	13.5	28.8	14.3	17.6	19.2	4.1	4.9
Rangeland total	31.5	28.5	13.4	15	4.5	7	11.1	30.2	19.3	9.1	13.6	16.7	100	100

The livestock preferred grass varieties in the region and due to the high grazing pressure in the rangeland, not only the possibility of spreads decreased, but also their share reduced. This finding corresponds well with the report of Akbarzadeh (2005) in the protected region of the Rood-e shoor. Production changes in different years are affected by various environmental factors, especially climatic factors and the most important one is Precipitation.

Rainfall in the first year (2007) was higher than in other years and even higher than the region's long-term average and rainfall in the next three years was below the long-term average. The second year (2008) and the fourth year (2010) were dry years. As the precipitation of these years were only about 26 and 19 percent of long-term annual precipitation in the region. During the second year, the production of the rangeland was about 42.5% of the first year. In the third year (2009), which is the precipitation was less than average, but more than the rainfall of the second year, the rangeland production has been similar to the first year. 8 species studied during four years, among them two species of *Stipa barbata* and *Artemisia sieberi* had the highest production in the studied years.

The second year was the driest year of the period, almost all species produced the lowest forage and forage production of the third year was more than the second year. In general, total rangeland production in the first and third year was higher than the rest of the period. In terms of the intensity decrease of production, species showed different responses to climate change.

Two species of *Stipa barbata* and *Artemisia sieberi* produced 36 and 37.2 percent of the forage in the second and the first year, respectively. In other species, the production of the second year in comparison with the wet years was between 13 and 41 percent, which the difference is caused by rainfall. Rathford (1978) stated that the production of rangelands in the Republic ofZimbabwe and Botswana was less than the East Africa. Sharifi and Akbarzadeh (2013) studied the production changes under the influence of rainfall on rangelands in Arshaq rangeland of Ardebil changes and mentioned the 7 times changes in wet and dry years. Akbarzadeh and Mirhaji (2007) have studied the production rate of Polur rangeland in a 10-year period and concluded that the production rate in wet years was 2.5 times of driest year.

In other research, Akbarzadeh and Mirhaji (2007) have pointed the reduction of density and percentage of canopy cover from 26 to 95 percent in different species in steppe rangelands. All this results confirm the findings of the present research.

The production rate in different months of the growing season was different. So that, the monthly production rate has a decreasing trend of the early growth season and with the progress of the growing season the production rate was decreased compared to the early months. On average in most species the decline in production was dominated and the results were consistent with the findings of Aliakbarzadeh *et al.* (2017).

Prevailing climate in the region and especially seasonal precipitation and temperature plays a key role in this process. In fact, in addition to the moisture provided by seasonal rainfall for plant growth in April, the moisture stored in the soil from winter rainfall leads to the growth and development of the plant. As the results show, most of the plants have the maximum use of the moisture stored in the soil and spring precipitation and the maximum amount of forage produced in the early months of growth. The impact of spring precipitation on the forage production of rangeland species was confirmed by Duncan and Woodmansee (1975) in the rangelands of central California, Zarekia *et al.* (2012), in the rangelands of the Khoshkeh-e Rood, Saveh and their findings fully correspond to the obtained results in the Dehno region.

In the average of four years, 67.9% of the total rangeland production was used during the grazing season. The most commonly used were the three species of *Stipa barbata*, *Oryzopsis holciformis* and *Poa sinaica*. Due to their high consumption by livestock, it is necessary to plan for the development and maintenance of these species in the management of the rangelands of this region. Production and high consumption of grasses in Saraliabad rangelands of Golestan province has been confirmed by Hosseini and Akbarzadeh (2015). Most of the forage produced in the first two months of the year.

But the production of *Artemisia sieberi* species continues until the end of the growing season. It can be assumed that these species are consistent with the humidity regime in the region and they have the maximum use of moisture content of the first two months of the year. Ahmadi *et al.* (2013) also mentioned that the production and consumption of the UrmiaQarabagh rangelands in May during the years 2007-2010 was more than other months. Also, Omar (1990) in investigation of the relationship between seasonal rainfall (October-May) and the vegetation cover of Kuwait's rangelands, founded a significant linear relationship between seasonal rainfall and forage production of herbaceous and grass plants.

On the site of Dehno, the maximum monthly consumption of most species was in May (at the same time as the livestock entered the rangeland) and June. The tendency of livestock to consume green forage and succulent rangeland in the first months of the growing season is far more than that of roughage forage. With the continuation of the vegetative period and the increase of roughage organs, the livestock has a lower tendency to graze and as a result, forage consumption by livestock is also significantly reduced. In most species, the highest amount of crude protein and digestible dry matter is in vegetative growth stage. As the phenological stages progress, the proportion of these substances in the aerial part is reduced and the percentage of fiber material increase and the grazing of the livestock on the plant are reduced.

These results are fully consistent with the results of Karimi *et al.* (2014), Hosseini and Akbarzadeh (2015). In general, due to the decreasing trend of forage production and rainfall in the last months of the grazing season and the prevention of grazing pressure of livestock on the rangeland at this time, it is recommended that livestock be removed from the rangelands earlier than the due date and feed them by hand until the time of departure.

Conclusion

As we know, one of the basic problems of rangelands is lack of proper management of grazing systems, which will eventually lead to the incorrect exploitation of natural forage and overgrazing. For this reason, the identification of important rangeland species in different months of the growing season can help to the proper and timely consumption of rangeland forage, so that the maximum economic use of livestock products without any harm to vegetation cover, soil and the environment is possible.

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