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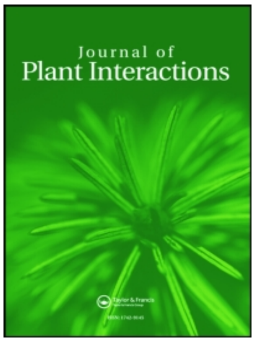

Determining suitable grazing time for *Puccinella distans* Parl. based on its phenology in West Azerbaijan Province of Iran

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Determining suitable grazing time for *Puccinella distans* Parl. based on its phenology in West Azerbaijan Province of Iran

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ABSTRACT
Studying the phenology, which is an important issue of plants, can be used for determining the best time of all kinds of utilizations, and also conservation and stability of plants' growth and breeding will result. Therefore, this study was performed in Tezkharab rangelands, where *Puccinella distans* is an important vegetative element that is consumed by livestock, to determine the suitable grazing time for this plant based on its phenology, for about a 4-year period (2007–2010). For this purpose, plant phenology and changes in its growth characteristics were investigated weekly. Moreover, during this period, all phenological stages were adjusted to the monthly precipitation and temperature. The results indicated that the time of phenological stages had fluctuations which were related to environmental conditions. The best time to start grazing is early May and the best time for collecting the seeds of this species is late July to early August.

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KEYWORDS
Puccinella distans; range readiness; phenology; Urmia Tezkharab site

Introduction

In the semi-arid and arid regions of the Eurasian continent, grazing and water stress are among the most important drivers of ecosystem functions and dynamics (Pennington & Collins 2007; Shao et al. 2013; Chen et al. 2014; Hao et al. 2014), and grazing – the most dominant land-use practice in Eurasian pastoral lands – exerts substantial and extensive influences on plant phenology (Han et al. 2016).

In many regions of the world, pressure on natural resources is steadily increasing due to the rapid growth of population, accordingly overgrazing is often expressed by decreasing vegetation coverage (Pickup & Chewings 1994; Wagenseil & Samimi 2006), Also in Iran, lack of grazing management of rangelands is one of the main problems leading to non-normative and untimely operation of natural forage as well as overgrazing of its capacity. Due to this most of the rangelands have been destroyed and in terms of status moderate rangelands have been classified to poor and very poor rangelands. It is necessary to allow plants to store nutrients for their future growth. Failure to meet this is causing a gradual reduction in the production and breeding of plants and finally leading to their extinction. The absence of generative shoots in plants, ongoing cutting, the decreased height of vegetative shoots and size of their leaves, the decreased leaf plate thickness and the decreased plastid content in cells (Zvereva 2004) may result from intensive and early grazing. In this regard, effects of a disturbance on ecosystem processes may depend on phenology (DeForest et al. 2006; Richardson et al. 2012; Migliavacca et al. 2015), and these effects may also be coupled by the changes in climate and other natural disturbances (Han et al. 2016) and management practices.

One of the major factors that leads to the destruction of rangelands' vegetation and also desirable species is disregard to valid time for entering and existing of livestock. Determination of valid time for grazing is possible when critical periods of plant life (phenology) due to climatic conditions were studied to reach the best time to be introduced for grazing. Plant phenology is the timing of biological processes in relation to climate (Evangelista et al. 2009; Shen et al. 2014). Phenology of plants in an environment that experiences large seasonal extremes will have a profound effect on animals that feed on them (Janecke & Smit 2011). Indirectly, some studies found that phenology altered biogeochemical processes (Bremer et al. 2001), species composition and richness (Socher et al. 2013), forage quality (Crawley 1983; Van Soest 1994; Rossignol et al. 2011), and interspecific competition (Medina-Roldan et al. 2012). Understanding the history of biological process in plants is the appropriate solution to determine the time of utilization of rangeland. Phenology is the study of annual biological cycles in plants and animals and their relationships to climate and other environmental factors (Yu et al. 2015), phenology studies the life-cycle timing of organisms and is a sensitive indicator of the condition and variability of biosphere and atmosphere interactions (Liang et al. 2014).

Phenology is a key component of monitoring terrestrial ecosystem variations in response to global climate change (Liang et al. 2011) and not only affects plants life but also animals and other living organisms could be affected (Artemyev 2013; Bogacheva & Zamshina 2013). Plant phenology tracks the timing of recurring life-cycle events and is considered as one of the most sensitive biological indicators of terrestrial ecosystem responses to global warming (Liu et al. 2014) and temperature is a main driver of many developmental processes in phenology. The rates of chemical reactions are temperature dependent and generally increase with increasing temperature (Walther 2010). Because warmer temperatures are frequently associated with earlier phenological

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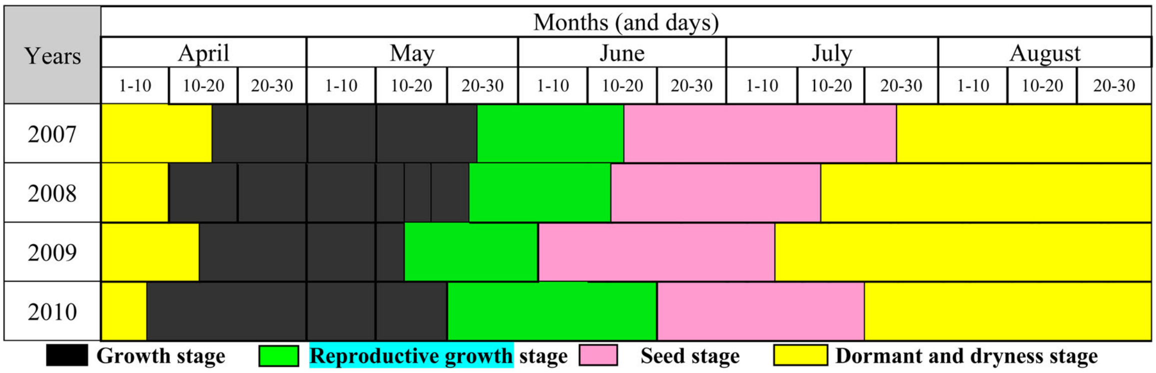

Figure 1. Phenological stages of *P. distans* during years 2007–2010.

events, changes in phenology are common indicators of the effects of climate change on ecological communities (Asch 2015).

Phenological phenomena may include only two stages: the production of leaf on the main stem and the production of seed and clustering or according to Moore et al. (1998) may include five stages: germination, growth, stem elongation, reproduction and seed ripening. There are different phenological stages classification and Radoks et al. (1974) classified it as the following 10 classes: germination, scion growth, tillering, stem elongation, clustering, flowering, seed production, milky seed, seed hardening and seed ripening. Phenology of many plant species has been studied since eighteenth century (Menzel 2000; Roetzer et al. 2000; Defila & Clot 2001; Stöckli & Vidale 2004), for example Wagenseil and Samimi (2006), Derroire et al. (2008), Janecke and Smit (2011), Hafdahl and Craig (2014), Searle et al. (2015), and Sakkir et al. (2015). Schuster and Garcia (1973) tested the phenology of 13 varieties of cool season grasses under dryland and irrigated conditions in the Southern High Plains – Texas. They found that all of the evaluated plants started their autumn growth since September and grew a little during autumn and winter, some species became dry or their growth stopped with the arrival of winter. The same plant species had different life stages (at the beginning and also duration of the phenological stages) when placed in different areas. There are few experimental studies investigating impacts of phenology changes and alterations on communities of interacting species. Hence, it is unclear whether evidence of phenology changes are simply useful indicators of climate change or are evidence that climate change will affect ecosystem functioning (Walther 2010).

Also the soil of rangeland is suitable for livestock entry at a certain time. It is necessary to collect data of plants phenology and rangeland soil to determine the pasture readiness for livestock entry. Timely entry and exit of livestock to pasture lead to better utilization and rangeland conditions improvement. If they graze the plants before their readiness because of disruption of physiological activities there is a decrease of aerial portions of plants and nutrition because of this the plants will become weak and amount of production will be reduced. *P. distans* is a valuable species as a turf grass and forage plant from Gramineae family (Bandani & Abdol Zade 2007); thus, it is important to pay attention to health and sustainable production of this species, because changes in the climate affect the plants phenology directly and finally lead to change of grazing programs in natural fields (Frank & Hofmann 1989); this could be useful to land managers in adjusting the stocking rate and season of grazing to maximize rangeland productivity and profitability (Dunn et al. 2010; Rigge et al. 2013) and achieve conservation objectives (Rigge et al. 2013). Monitoring the phenology of rangelands is important to detect and preclude any deleterious trends caused by land management (Paruelo & Lauenroth 1998; Rigge et al. 2013). The main object of this study is to determine readiness time of rangeland for livestock entry and exit as well as studying revising possibility in rangeland grazing management program, precious species in the West Azerbaijan Province.

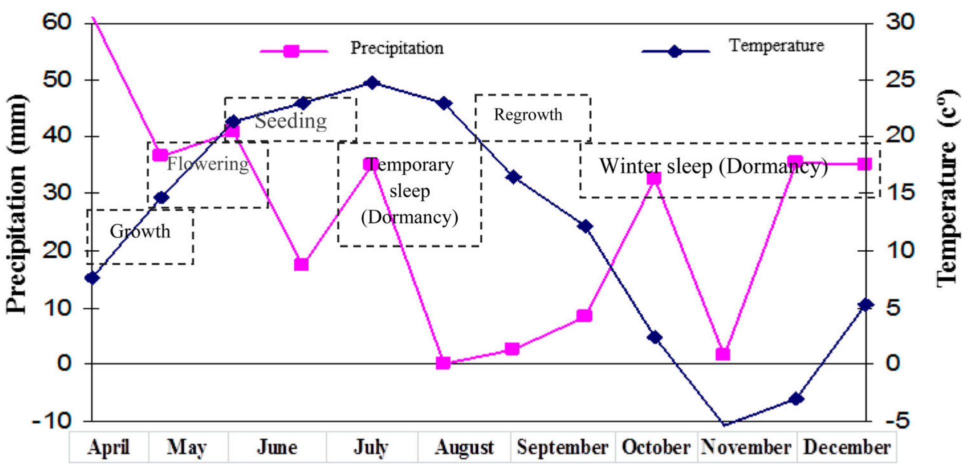

Figure 2. Hyetograph (Embrothermic) curve adjustment (rainfall, temperature) with different phenological stages in *P. distans* (Wet Year 2006–2007).

Table 1. Average of P. *distans* height during phenological stages on the study area based on significant differences of standard deviations of average heights in different year (based on rows).

	Average of plant height (cm)			
Phenological stages	2007	2008	2009	2010
Initiate growth	(32.7 ± 2.1)[a]	(31.7 ± 3.1)[a]	(32.5 ± 3.5)[a]	(35.5 ± 4.2)[a]
Flowering	(36.8 ± 2.8)[b]	(36.4 ± 3.4)[b]	(37.5 ± 4.7)[b]	(41.5 ± 3.7)[a]
Seeding	(42.7 ± 4.7)[b]	(40 ± 3.8)[b]	(41.5 ± 2.1)[b]	(46.5 ± 4.3)[a]
Drying	(42.7 ± 5.2)[b]	(40 ± 4.8)[b]	(41.5 ± 4.9)[b]	(46.9 ± 6.2)[a]

Note. Similar letter showed no significant difference at 5% level.

Materials and methods

Study area

The study area location was the Urmia Tezkharab site situated in 37.30 north latitude and 45.15 east longitude in the Tezkharab village, Urmia, West Azerbaijan of Iran. The soil in the area is salty with heavy to semi-heavy soil texture, the average precipitation being 299 mm, the area is classified as semi-arid climate according to Emberger's classification. Two important factors temperature and precipitation during the specific time were considered in order to evaluate and determine the valid time of grazing and understanding phenological plant planning.

The main types of the study area include *Atriplex verrucifera*, *Halocnemum strobilaceum* and perennial grasses. Also there are several *Aeluropus littoralis*, *Salsola crassa* and *Halocnemum strobilaceum.* The studied site has halophyte species and it encompasses a part of area which is used in winter under operation of field villages, in which cattle are dominant in rangelands. The method of utilization method of rangelands is rural and livestock entry date and exit date are April (Farvardin in Hijri) and mid-November (Aban in Hijri), respectively, each year for about 200 days, the rancher number is 30 households and the number of livestock is 200 cows. The daily grazing time is from 7 a.m. to 19 p.m.

Research methodology

In this study we used frequency and amplitude (Gentry 1974) and also regularity and timing (Newstrom et al. 1994) observation methods (Derroire et al. 2008). To identify rangeland readiness based on *P. distans* species, 10 stands of this species were selected and the stands height were measured every week and four phenology stages (germinate, flowering, seed ripening and complete drying) were recorded since the beginning of April 2007 to the end of October 2010. The phenology stages and total plant height for each stand were recorded and measured at intervals of 15 days in the growth stage and at intervals of 7 days in the natal stage and then recorded in special forms.

Results

The study of phenological stages of *P. distans* species in different years revealed that this species starts its growth in various dates based on weather conditions, especially environment temperature. Phenological stages in this species during four years are shown in Figure 1.

The results of the analysis of the stand height in the studied years along with phenology stages demonstrate that the average maximum plant height varies during different periods of plant growth in various years. In 2007, the maximum plant height was in the drying stage, equal to 42.7 cm. in 2008, the maximum plant height was in the seeding–drying stage, equal to 40 cm. In 2009, the maximum plant height was in the seeding stage, equal to 41.5 cm and in 2010 the maximum plant height was in the drying stage, equal to 46.9 cm. The maximum plant height of this species was recorded in 2010 and its minimum was in 2008. The stands height changes during the mentioned four years are presented in Table 1, in which each phenological stage of a specific year has been compared with other different years (based on rows, not columns) (Figures 2 and 3).

The surface of rangeland soil was moist until early April 2008 because of reduced rainfall in the study area, thus soil moisture decreased since early April. There was moisture in the soil in the past year until 4th May, whereas there was not any moisture after that. Because of decreased precipitation in 2008, rangeland species were not succulent and the duration of plant growth was less than last year. It should be noted that reduced rainfall and weather conditions in this year caused phenology of plants to fall forward for a few days, as the plants were not succulent they led to a decrease in production (Figure 4).

The soil surface was humid because of appropriate rainfall in the study area in April 2009 to early May, but moisture rapidly decreased since early May. Whereas there was moisture in the soil in the past year until early April and then there was no moisture after this. Hence, in 2009, rangeland species

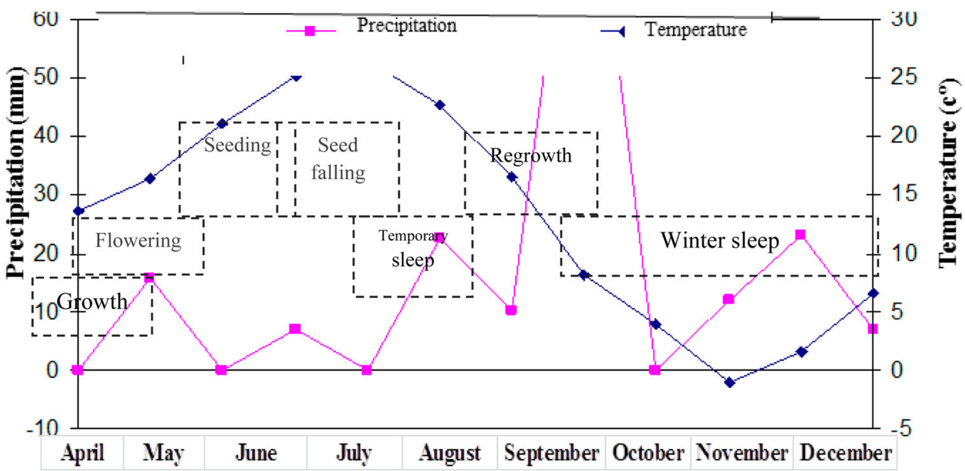

Figure 3. Hyetograph (Embrothermic) curve adjustment (rainfall, temperature) with different phenological stages in *P. distans* (Wet Year 2007–2008).

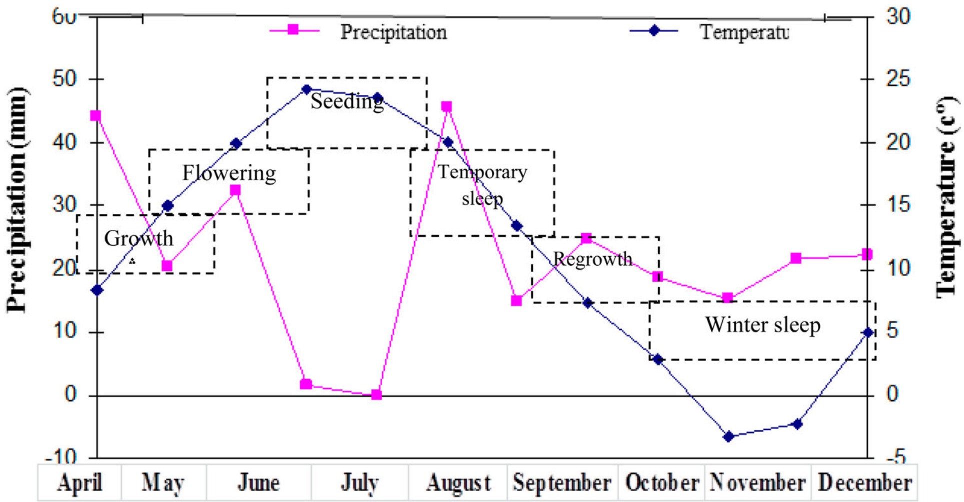

Figure 4. Hyetograph (Embrothermic) curve adjustment (rainfall, temperature) with different phenological stages in *P. distans* (Wet Year 2008–2009).

had more succulence and the plant growth period was more than the past year because of appropriate rainfall. It should be noted that rainfall and climate conditions in this year led to a week delay in plant phenology, and also it increased succulence of the plants, which caused a considerable increase in production (Figure 5).

In 2010, the soil surface was humid because of appropriate rainfall in the study area in April until early June, but moisture rapidly decreased since the first week of June. So rangeland species had more succulence and more growth period because of sufficient precipitation (Table 2).

According to the results, the study area's soil is suitable for livestock arrival at the beginning of the grazing season (early May in all four years, according to the date mentioned in the grazing document) and there is no problem. By studying the phenology of this species and field observations, we can determine the grazing time based on this species readiness.

The embrothermic curve during the studied years demonstrates that the moisture is only high in April, May, December, January, February and March, and the dry period is in June, July, August, September, October and November, but Brandt el al. (2016) mentioned the dry season phenology of dryland plants is defined from October to June. Totally, the moisture season was about 6 months and dry season was 6 months as well.

Discussion

Phenology is a good bio-indicator of temperature, the latter is often used in phenological analyses (Jochner et al. 2011) and according to primary study results about soil moisture and temperature and precipitation change chart, it seems the soil of the study area is suitable for livestock entry at the start of the grazing season (early May) and any damage as a result of pressure from livestock does not occur on the surface of moist soil. The study area is a rural rangeland on which livestock in large villages are yearly fed. On the other hand, the study area is a part of the rural space. So, this area suffers from some problems including overgrazing and hasty grazing.

Phenological studies are important for many applications such as typology in silviculture, afforestation, livestock grazing planning and species selection for park designing. Land management, livestock grazing, invasion of exotic species and prolonged droughts all have the potential to change rangeland's plant community structure and consequently contribute to altered phenological pattern (Tieszen et al. 1997;

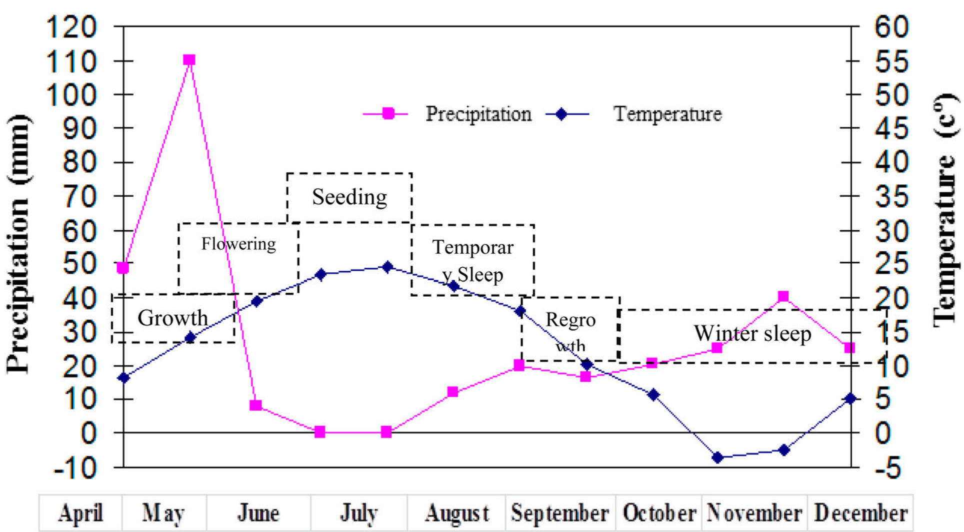

Figure 5. Hyetograph (Embrothermic) curve adjustment (rainfall, temperature) with different phenological stages in *P. distans* (Wet Year 2009–2010).

Table 2. Approximate time of occurrence of different phenological stages of *P. distans* in different years.

Phenological stages	2007	2008	2009	2010
Initiate growth	Mid-April to the third week of May	The first week of April to mid-May	Mid-April to late May	The first week of April to 20th May
Flowering	Late May to the second week of June	The third week of May to the first week of June	The first week of June to the 19th of June	The end of May to the 20th of June
Seeding	The first week of July to the third week of July	Early July to 10th July	26th June to first week of July	Late June to the third week of July
Drying	20th July to 10th August	Late July to 10th August	Early July to late August	Late July to late August

Foody & Dash 2007) and also shifts in species phenology in response to climate change have wide-ranging consequences for ecological systems (Diez et al. 2012). Detecting changes in phenology of plant species has currently received more attention due to current climate change studies (Shahbazi et al. 2012). Plant phenology might be expected to be one of the most responsive and easily observable traits in nature that changes in response to climate (Badeck et al. 2004) and as an indicator of regional climate variations caused by both natural and human factors (Jochner et al. 2011). The timing of many phenological phases is a function of temperature. Therefore, given the well-documented increase in regional and global temperatures, there are good reasons to expect changes in plant phenology (Badeck et al. 2004). According to the results of the present study, *P. distans* growth commences after winter dormancy and coincides with the increase in the air temperature since early April. Growth period will continue until the end of May. Duration of this stage considerably depends on the temperature and the humidity of the air and soil. So that with increasing temperature the growth is faster. The phenology stages of this species in the studied years showed some variations from year to year, which fluctuated (delay or acceleration) in terms of temperature and moisture conditions. Similar to this research, many studies have demonstrated the strong phenotypic responses of plant species to changes in their environment (Arft et al. 1999; Peñuelas & Filella 2001; Peñuelas et al. 2002; Hülber et al. 2006; Domènech et al. 2014). *P. distans* abounds in the semi-steppe rangelands of the West Azarbaijan Province as the main elements because of its high compatibility with drought, salinity and temperatures over 30°C and down to −22°C.

According to Gonsamo et al. (2013) environmental changes can affect tree species and can alter their production and also time of biological stages. Therefore, the effect of climate change on shrubs and herbaceous can be much more intense, that is related to moisture and temperature. Melaas et al. (2013) evaluated plants phenology by using satellite images, and stated that phenology is widely viewed to be an important diagnostic of climate change and is also a first-order control on biosphere–atmosphere interactions.

In the present study, the highest height in different phenological stages of the plants occurred in 2010 (Table 1) due to better temperature and humidity conditions compared to other years.

In 2008, the growth of plants had occurred sooner than other years because of suitable temperature. The average daily temperature in 2008 was approximately 25°C which when compared to the other three years was about 5°C warmer.

Domènech et al. (2014) also mentioned that the temperature had a significant effect on the phenology of all of the snowbed plants in the Pyrenees which they selected to study (*Sedum alpestre, Mucizonoa sedoides, Gnaphalium supinum, Poa alpine*), and on the duration of the growing season. The southern part of China generally has earlier periods of warm temperature and sufficient precipitation in the spring than the northern part. This may trigger the earlier starting date of growing season in croplands in south of China and it usually happens in late January to late February (Bin et al. 2010), but in our case study all phenological changes are due to climate change. Totally, charts of this species' phenological activity in the studied years revealed that in the year 2008 most of phenological stages were performed in a shorter time period than the rest of the studied years due to environment drought and high temperature. So that in this year the plant spends a long time in a state of stagnation since the end of seeding and temporary sleep begin until regrowth (and in the absence of rainfall in autumn until winter sleep). In other years, the plant activity and growth period are longer as well as fall regrowth, and in 2007, as a wet year, the plant phenological stages start a few days later and so later than all the other years. Hence, the duration of rangeland utilization reduces in the drought and increases in wet years. In a prior study, Derroire et al. (2008) also indicate that rainfall has a relationship with plants phenology. Therefore, the results demonstrate that the best time for grazing can be continued from early May to mid-July. Meanwhile, the best time to collect the seeds is in late July to early August.

It is recommended to pay attention to the following recommendations to reach better productivity and conservation of natural forage available in the natural fields.

Given the huge impact of spring rainfall on the growth and production of the plant, especially on salted rangelands, determining the time of arrival and departure of livestock from pasture considering monthly spring rainfall seems necessary.

Also, grazing management and observation of the correct time of entry and exit specially in west Azerbaijan's salty rangeland, which feeds many livestock, should be determined based on saved forage[1] by rancher, hence natural resource administrative offices should forecast facilities to ranchers to prevent hasty grazing. In order to determine the best time for livestock entry or exit, it is essential to study phenology of all species. Therefore, the best time to be determined is based on their growth period, growth and factors that affect plant phenology must be correctly identified.

Note

1. Forage which are stored or silage which are often taken from other parts of the pasture or have been purchased.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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