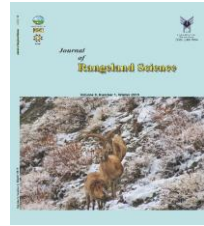


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Research and Short Length Article:

Determining Timely Entry and Exit of Livestock in Rangelands Using *Bromus tomentellus* Phenological Stages (Case Study: Goorab Rangeland of Isfahan)

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Abstract. In the rangelands of Iran, the lack of appropriate grazing management is one of the major problems ultimately leading to untimely and excessive grazing intensity of forage. Accordingly, most of the rangelands show a retrogression trend and poor conditions. In forage species, phenological stage is one of the most important criteria for range management. *Bromus tomentellus* species is an important range species for forage production controlling soil erosion. In order to determine the timely entry and exit of livestock in rangelands based on phenological stages of *B. tomentellus*, this study was conducted in Goorab rangeland, Fereydoun Shahr, Iran during four years (2007-2010). In this research, ten plant bases of *B. tomentellus* were selected and their phenological stages were recorded in a 7-day interval period. At the same time, meteorological data were collected from meteorological station adjacent to the study site. According to the occurrence of biological phenomena in the different years of study (wet conditions in 2007, severe droughts in 2008 and normal years in 2009 and 2010) and also based on plant growth stage in the 4 year study, it was concluded that 30th April and 31th May were suggested as the best time for livestock to enter and exit from the rangeland, respectively.

Keywords: Semi-steppe rangelands, Environmental factors, Grazing management, Fereydoun Shahr

Introduction

One of the major problems in Iran rangelands is the lack of grazing management which ultimately leads to unproductive and untimely exploitation of forage and also grazing more than range capacity. Accordingly, most of the country rangelands have a retrogression trend and are ranked among the rangelands as moderate to poor and very poor condition (Ehsani and Zand Esfahan, 2015). Range plants require an opportunity to store the necessary nutrients for their next growth season. Failure to do so will result in gradual degradation of plant production and regeneration and finally complete destruction.

One of the suitable solutions for determining the time of exploitation of rangelands is the use of phenological stages in plants. Accordingly, the study of the phenology of species is one of the most important ecological issues that should be considered. Temperature, humidity, rainfall and light are the main factors that provide the necessary conditions for growth and development of plant. Some of these factors cause changes in plant growth. Therefore, the relationship between the occurrence date of plant phenological phenomena and climatic variables, especially temperature is important in predicting their emergence dates (Saeedfar and Rasti, 2000). So far, different studies have been carried out on the phenomenology of rangeland plants in Iran and other countries. The presence or absence of vegetation in rangeland ecosystems is influenced by environmental factors such as climate, soil and topography (Kolahi and Atri, 2014); among them, temperature has the greatest impact on plant growth stages (Shim *et al.*, 2017; Zhu *et al.*, 2017).

Bromus tomentellus is perennial herbage belonging to Poaceae family. This species has strong roots and abundant leaves that cover the surface of soil. The presence of this species in the

world is limited to the western regions of the continent of Asia and its distribution in Iran is ranged from 1500 to 3400 m above sea level. It grows in light texture soils. It has a great role in soil conservation and soil erosion. This species is grazed by a variety of livestock (Moghimi, 2005).

In a study conducted by Jafari *et al.* (2010) on phenological stages effects on yield and quality traits in 22 populations of *Agropyron elongatum*, it has been shown that heading and pollination stages were the most appropriate stages for harvesting maximum DM yield coupled with higher quality traits. In a study of several range species in Zagheh rangelands, Lorestan, Khademi *et al.* (2002) showed that the phenological stage is an important criterion to determine the appropriate time of livestock entry in the rangeland.

Since phenological studies of plants play a major role in the range managing (Keneshloo and Ameri, 2012), the phenological stages of *Bromus tomentellus* were investigated in this study in order to determine the appropriate time of livestock grazing from the rangeland of Goorab in 35th km west of Fereydoun Shahr, Isfahan during 4 years (2007-2010).

Materials and Methods

The study area is located in Isfahan province, Fereydoun Shahr, Pishkuh region, Goorab (33° 1' 45" northern latitude and 49° 54' 20" eastern longitude) in 35 km west of Fereydoun Shahr, Iran with average elevation of 2570 m above the sea level. The soil texture of the area is silt loamy and the Soil depth varies from moderate to high. In terms of climatic conditions, the average annual precipitation of this region is 590 mm. The climate is cold in winters along with frost and cool summers; accordingly, this area is categorized as a semi-steppe region based on Gaussian climograph.

Bromus tomentellus, *Poa bulbosa*, *Astragalus ovinus*, *Ferula ovina* and *Prangos ferulacea* are dominant vegetation type in this site and also some perennial annual forbs and grasses are ranked in second place for forage production.

In order to determine the readiness of the rangeland to enter the livestock, phenology data were collected in terms of *Bromus tomentellus*. For these purposes, ten plants were selected and the information related to phenological stages of each plant was recorded in the prepared form every 7 days. The phenological stages included the beginning and end of the growth stage, the beginning and end of the flowering stage (medium), the emergence of flowered stalks and flower spikes on the grasses.

Since the active vegetative growth stage is the most important stage for livestock entry and exit from rangeland (Arzani, 2009); therefore, average active vegetation period of four years was considered (2007-2010). Accordingly, the occurrence of vegetative growth stages was regarded as 30 days of the year (from Early April to late May). In each year, the days having standard temperature were considered as Days Transformed to Standard temperature (DTS) that the active growth stages are likely to occur in.

Results

The Ombrothermic diagram describes the plant ecological status of different stations in terms of supplying water to plants at ambient temperature. These diagrams can accurately illustrate the overall climate of a region if correctly drawn.

Year 2007

Investigation of Ombrothermic diagram in the studied area in 2006-2007 showed that there were high precipitation conditions in October to May. Therefore, 8 months are considered as wet season

and 4 months as dry season. The precipitation variations in October to May were ranged from 52 to 159mm for an individual month (Fig.1a). In 2007, the rainfall and the average temperature were measured 691 mm and 9.6°C, respectively. The utilization time of the region during the drought period is in the second half of spring and summer season (Fig.1a). Growing of the *B. tomentellus* was started in early March 2006-2007 and continued until mid-April. From this date onwards, flowering stems and reproductive organs were appeared on most plant bases. Also, panicles were appeared and completed in all bases in mid-April to late-May. Moreover, seed formations were begun in mid-July to end of the month, seed development was occurred at the same time and finally, the plant goes to dormancy in the first half of August (Fig.1a).

According to Ombrothermic diagram as well as soil moisture, it seems that there was a great potential for livestock entry to the soil of the study area in late May. In the second half of April 2007, many of the plants in the study area were actively grown due to the severe precipitation that occurred in March and the first half of April. By studying the phenological stages of *B. tomentellus*, the grazing time of the livestock from the area should be based on the readiness of this species because the fully vegetative growth time of other palatable species is similar to this species. By studying the phenological stages of this species, it was concluded that in June coinciding with the late grazing season; this species is fully flowered, so it is ready for grazing.

Year 2008

Investigation of Ombrothermic diagram for the rangeland in 2007-2008 showed that there was a high precipitation in October to May. The rainfall of October and May with the average of 24 and 23 mm, respectively was lower than other 6 wet months ranged from 60 to 118mm for an individual month. In 2008, the average

annual rainfall and the average annual temperature were measured as 290.2mm and 10.26°C, respectively (Fig.1b). Growth stage of *B. tomentellus* was started from mid-March 2008 and continued until late May. From this date onwards, flowering stems and reproductive organs were appeared on most bases. Also, flower panicles were appeared and completed in all bases up to early July. Moreover, seed formations were begun in late June until early August. The seed development and falling were occurred together and finally, the plant summer dormancy was in the late July until early October (Fig.1b).

Due to the climate conditions, soil moisture, plant phenology and the growth time of plants in this year, livestock entry should be carried out at the beginning of growth time but its exit should be sooner, so the grazing duration will become shorter.

Year 2009

Investigation of the Ombrothermic diagram in the studied area in 2008-2009 showed that there was a high precipitation in only five months of November, December, February, March, and April ranged from 20 to 121mm. Therefore, 5 months are considered as wet season and 7 months as dry season. The average annual rainfall and the average annual temperature were measured as 439.9 mm and 10.06 ° C, respectively (Fig.1c). Growth of the *B. tomentellus* was started in the mid-March 2009 and continued until mid-May. From this date onwards, flowering stems and reproductive organs were appeared on most bases. Also, panicles were appeared and completed in all bases in early May until early June. Moreover, seed formation was begun from the early Jun until the late of July; their development and falling were occurred at the same time and finally, the plants go to summer dormancy in the late July to late August (Fig.1c).

The climatic condition of 2007 was the wet year with high rainfall and 2008 as dry year (about 440 mm). The length of the dry period was moderate and started from the late May and all biological activities of species (4 growth stages) were low and also, the production was a bit lower than the average one. It is necessary that the livestock should be managed in such cases with full and precise observance of the time of livestock entry and exit in rangeland. This year was in moderate condition.

Year 2010

Investigation of Ombrothermic diagram in the studied area in 2009-2010 showed that there was a high precipitation condition in the months of November, December, February and March. Therefore, 5 months are considered as wet season and 7 months as dry season. The average annual precipitation and the average annual temperature were measured as 510.2mm and 12.4°C, respectively (Fig.1d). Growth of the *B. tomentellus* was started in mid-March 2010 and continued until the first half of May. From this date onwards, flowering stems and reproductive organs appear on the most bases of plant. From the late April, panicles were appeared and completed in all bases in mid-May. Moreover, seed formations were begun from mid-May until the late June. The development and falling were occurred at the same time and finally, the plant dries in the late June (Fig.1d).

In this year, soil drying begins from early May and the average of rainfall was normal. Phenological stages were recorded for *B. tomentellus* species. The time of livestock entry and exit of livestock was set up between mid-May and early September, respectively.

Discussion and Conclusion

In the rangeland studies, setting up the time of livestock entry and exit in rangeland was based on the individual

characteristics of plants such as their phenology, a common context considering the appearance of the soil surface (soil moisture), but it is not the most accurate and best method among the current options because this method does not have similar applications in different habitats with vegetation. In the semi-steppe rangelands such as current studied site, because of high diversity of vegetation (presence of about 80 species of plants in a specific area) and the lack of absolute dominance of one or two plant species, determination of relative time of entering and leaving the livestock is so difficult.

The species *B. tomentellus* can be considered as an index species for determining the time of livestock entry and exit due to the absence of severe changes in its biological phenomena and developing all four growth stages. However, this species has reacted under adverse environmental conditions naturally by reducing the growth rate. In general, it can be stated that due to the behavior of the species in the occurrence

of biological phenomena in different years of the study with wet condition (2007), severe drought (2008) and normal years (2009 and 2010), it was possible to study the behavior of plants with changes in humidity and temperature in different conditions; the best time of livestock entry and exit should be based on the appearance of biological phenomena in the species *Bromus tomentellus*. However, every plant has certain phenological stages and for determining the time of each of them, this period is called the Days of Transformed to Standard Temperature (DTS) index (Hur *et al.*, 2014). According to the results, determination of grazing readiness considers the number of leaves formed on the plant (growth active stage) (Frank *et al.*, 1993). To calculate the four year average of the days when the plant is in growth active stage, a 30-day period was considered as DTS from 1st March to 10th June. The results showed that on average, April 30th and May 31th were the best time to enter and to leave the livestock, respectively.

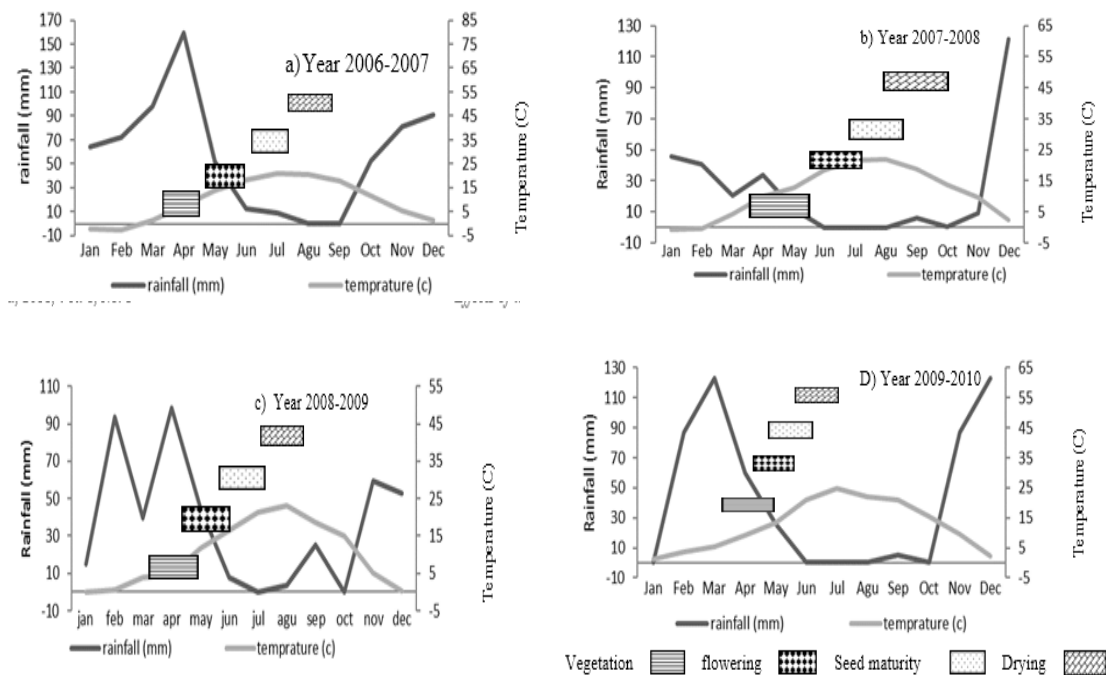


Fig. 1. Adaptation of Ombrothermic diagram to phenological stages of *B. tomentellus* in 2006-2010

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تعیین زمان ورود و خروج دام به مرتع با استفاده از مراحل فنولوژی گونه *Bromus tomentellus* (مطالعه موردی: مرتع گوراب اصفهان)

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چکیده. مطالعه فنولوژی یکی از فاکتورهای مهم و اساسی در اعمال مدیریت جهت بهره‌برداری بهینه از پوشش گیاهی می‌باشد. گونه مرتعی *Bromus tomentellus* از نظر تولید علوفه‌ای و جلوگیری از فرسایش خاک از اهمیت خاصی برخوردار است. در این تحقیق به بررسی زمان مناسب ورود و خروج دام از مرتع در سایت گوراب اصفهان در غرب شهرستان فریدونشهر به مدت ۴ سال (۱۳۸۶-۱۳۸۹) اجرا گردید. در این تحقیق ده پایه انتخاب و اطلاعات مربوط به مراحل فنولوژی برای هر پایه در مقاطع زمانی ۷ روزه در تمام مراحل فنولوژیکی و در فرم ویژه‌ای ثبت گردید. هم‌زمان آمار هواشناسی روزانه از ایستگاه هواشناسی مستقر در محل اجرای طرح برداشت شد. نتایج نشان داد که با توجه به رفتار گونه‌ی مورد مطالعه در بروز پدیده‌های زیستی در سال‌های مختلف مطالعه، که دارای شرایط ترسالی (۱۳۸۶)، خشکسالی شدید (۱۳۸۷) و سال‌های نرمال (۸۸ و ۸۹) بوده و همچنین طبق نتایج حاصل از میانگین ۴ ساله رشد فعال رویشی، بازه تقریباً ۳۰ روزه، بهترین زمان آمادگی مرتع می‌باشد که بدین ترتیب بطور متوسط تاریخ ۱۰ اردیبهشت و ۱۰ خرداد به ترتیب بهترین زمان ورود و خروج دام است.

کلمات کلیدی: *Bromus tomentellus*، عوامل محیطی، مدیریت چرا، فریدونشهر