INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 8, p. 97-103, 2013

RESEARCH PAPER OPEN ACCESS

Comparison on phenology of *Artimisia sieberi* in different steppe regions of Iran

Ali Ehsani, Ehsan Zandi Esfahan*

Rangeland Research Division, Research Institute of Forests and Rangelands, Tehran, Iran

Key words: phenology, *Ar. sieberi,* range readiness, steppe, time of entry into and exit from rangeland.

doi: http://dx.doi.org/10.12692/ijb/3.8.87-103 Article published on August 20, 2013

Abstract

The purpose of the study was to investigate the changes of different phenological stages of *Artimisia sieberi*. It is a shrub species with an appropriate forage value, widely distributed in arid and semi-arid steppes and Irano-Turanian regions as a dominant species in range composition. It grows in a wide range of shallow to moderately deep loamy, sandy and loamy clay soils and tolerates harsh environmental conditions. In this research, different phenological stages of *Artimisia sieberi* were investigated in six sites of different steppe regions. Therefore, data of phenological stages were measured and recorded for 15-day and 7-day periods in vegetative stage and reproductive stage, respectively. Meteorological data including temperature and precipitation were recorded from the nearest synoptic station for each site. Results of comparison of different phenological stages in the study years showed that the vegetative growth of *Ar.sieberi* started from early March to early April, and it continued until July in the presence of moisture. Flowering stage started from early July and continued until late October. Seeding stage gradually started from early October and continued until late January. Winter dormancy started in late January and continued until early March. According to the results, this species had a long phenology which indicates its tolerance and resistance to environmental conditions. Consequently, a complete understanding on phenological stages of *Ar.sieberi* enables us to plan grazing management in order to determine the time of livestock entry into and exit from rangelands, optimal number of livestock for grazing and proper grazing systems.

* **Corresponding Author:** E. Zandi Esfahan ✉ zandiesfahan@gmail.com

Introduction

Rangelands usually have complex ecological systems, which are mainly affected by changes of climate factors specially precipitation and temperature. Changes of climate factors are of utmost importance in phenomena of plant life such as germination, vegetative growth and development, flowering and seeding. Therefore, study of phenology enables us to plan rangeland utilization, prevention of untimely harvesting, understanding the nutritional value of plant species, determination of the time of livestock entry to and exit from rangeland, seed collection, apiculture, removal of invasive species and pests, and determination of extracts.

One of the basic problems of Iran's rangeland is lack of grazing management which leads to the non-practical and untimely utilization of natural forage of the rangelands and overgrazing. Accordingly, much of the rangelands show a regressive trend with a range condition of moderate to poor and very poor. Range readiness and observing the time of livestock entry to and exit from rangelands requires that the plant be given the opportunity to accumulate the necessary nutrients for the next growing. Failure to observe this matter will result in gradual reduction of the production, regeneration, and eventually complete destruction of plant species. One of the best ways to determine the time of rangeland utilization is study of phenology and understanding different biological phenomena of important and key species including germination, vegetative growth and development, seeding, temporary dormancy, autumn growth and winter dormancy.

Various species of the genus *Artemisia* from *Asteraceae* family, with a semiarid shrub form and good forage value have the ability to cope with drought conditions and relative resistance to salinity in arid and semi-arid steppe regions and mainly grows in loam, sandy and loam-clay soils. It is a dominant species in vegetation communities of arid and semi-arid steppes of the country. It has a height of 3 to 50 cm with several branches. *Artemisia* has a wide distribution in Iran as well as in other parts of the world, as it is seen in all vegetative regions of the country.

Artemisia sieberi is one of the most important and dominant species of the steppe in Iran. The root system of this species is important since its ratio is higher compared to the shoots, and the main root is more than one meter deep. The production of this species is strongly influenced by climatic fluctuations and the difference in the amount of annual production is resulted from the amount and distribution of rainfall during the growing season and soil moisture storage in the beginning of the growing season (Ehsani, 2007).

Different phenological stages of rangeland species are completely dependent on annual evapotranspiration and it also depends on the effects of temperature, radiation and precipitation. Temperature, as an indicator of energy, is effective in the rate of molecular motion. Cumulative degree days are often used to predict the phenological stages of plant's life. Temperature below zero degrees centigrade breaks down the cell wall and destroys the meristem tissue in plants (Pearce and Donald, 1978). Temperature below zero degrees has a high impact on reducing the forage yield of rangelands (Smart *et al.*, 2005). Plant species especially forbs are more affected by temperature in the vegetative stage and consequently dry weight decreases strongly under the effect of temperature below zero degrees (Humphreys and Eagles, 1988). The amount of total daily temperatures, required for different stages of the growth period, is called degree – days. Degree-days are calculated from daily mean temperature data above biological thresholds at different stages of growth.Therefore, temperature, as a climatic indicator, plays an essential role in vital activities of plant species especially production and evapotranspiration.

In their studies on phenology, most researchers (Menke and Trlica, 1981; Frank and Hofmann, 1989; Frank, 1996; Bertiller *et al.*, 1991) stated that among climatic factors, temperature had the most influence on plant's growth including the period of growth and phenological stages.

Jafari *et al.* (2003) investigated some ecological characteristics of *Artemisia sieberi* in rangelands of Ardebil. Results showed that, due to the diversity of ecological factors, this species, with a broad tolerance, was able to adapt to local conditions. Also, the highest density was observed in deep soils with a clay texture located in mild eastern slopes.

Sparks *et al.* (2000) studied the relationship between flowering date and temperature using long-term phenological records. Results showed that phenological events had significant relationship with temperature ($P<0.001$). Sekhwela and Yates (2007) studied the phenology of dominant acacia tree species in areas with different rainfall regimes in the Kalahari of Botswana. Results showed that all three species showed comparable seasonal responses regardless of the average annual precipitation in each site. Temperature and day length strongly influenced the phenology of *A. erioloba* and *A. mellofera* while in *A. luederitzii* precipitation was identified as the important factor. Phenological dates are very important in terms of economic. Any change in climatic factors, affected by these dates, may have adverse consequences. Drought is a well-known example of an extreme change. Ansquer *et al* (2009) in a study on characterizing and predicting plant phenology in species-rich grasslands at Toulouse and Pyrenees, France, concluded that the difference in flowering time in plant communities was greater than 40 days resulted from species composition of plant communities compared to their sensitivity to management practices. Mahall *et al.*, (2010) in a quantitative comparison of two extremes in chaparral shrub phenology showed that leaf longevity in *Styrax officinalis* and *Arctostaphylos glauca* were 180 and 849 days in average, respectively. Aging and senescence of leaves in *Styrax officinalis* often occurs in Auguest and September which apparently is not related to drought. In drought years, *Styrax officinalis* was less affected by changes, indicating the high adaptability and robustness of the growth pattern in this species. However, *Arctostaphylos glauca* was influenced by wide phenological changes, indicating the flexibility of this species. This research was aimed to investigate and compare different phenological stages of *Ar. sieberi* as an important range species at six different sites in semi-steppe regions of the country.

Material and methods

Habitat characteristics of the six study sites (reprehensive of different steppe regions of Iran) are briefly presented in Table 1.

Study of phenological stages

In order to identify the phenological stages of *Artemisia sieberi*, phenological data were recorded in 15-day and 7-day intervals at vegetative stage and reproductive stage, respectively during 2007-2009. The data were as follows: start and end of the vegetative stage, start and end of the flowering stage, start and end of the seed maturity, seeding stage, drying and winter dormancy.

Study of climatic parameters

Climatic data including temperature and rainfall were collected from the nearest synoptic stations for each site during the study period. Monthly and annual temperature and precipitation values for the two sites during 2006-2009 are presented in tables 2 and 3.

Results

The results of different phenological stages of *Ar. sieberi* in different years and at different steppe sites are as follows:

a- Results of phenological stages of *Ar. sieberi* in 2007 at most sites showed that vegetative stage started in early March to mid-April and continued to early June and even to mid-October. The mentioned stage varied only at Til Abad site which started from early December and continued to mid-June. Also, in 2007, the flowering stage at Til Abad site differed compared to other sites, and started in June and continued to mid-November. The flowering stage at the sites of Salafchegan, Dehno and Tabas started in early October to mid-November and continued to mid-December. At Soh site, the flowering stage was not observed. The seeding stage started in early November to mid-December and continued to the end of January. At the sites of Soh, Nodoushan, and Til Abad, due to the intense heat and drought in 2007, the growth was stopped and entered into dormancy. At the sites of Salafchegan, Tabas and Dehno, this stage started from December.

Table 1. Characteristics of the study sites.

Site	Province	Location	Altitude (m)	Vegetation type	Average annual rainfall (mm)
Nodoushan	Yazd	N 31° 52' 57" E 53° 32' 03"	2320	*Artemisia sieberi*	130
Soh	Esfahan	N 33° 19' E 51° 22' 18"	1988	*Artemisia sieberi-Stipa arabica*	175
Dehno	Kerman	N 29° 56' 00" E 56° 16' 00"	2300	*Artemisia sieberi – Zygophyllum eurypterum*	150
Til Abad	Golestan	N 36° 53' 38" E 55° 28' 51"	1050	*Artemisia sieberi*	268.9
Tabas	Yazd	N 33° 44' 31" E 56° 51' 38"	725	*Cymbopogon olivieri - Hammada salicornica – Cornulaca monacantha*	84
Salafchegan	Qom	N 34° 31' 08" E 50° 23' 46"	1555	*Stipa arabica-Artemisia sieberi*	282.5

Table 2. Comparison of temperature and precipitation in the study years (Soh Synoptic station, 1980 m a.s.l.).

Year	Factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
2006-2007	Temperature (°c)	13.52	6.74	4.04	0.22	0.38	5.06	11.8	15.65	24.71	26.3	24.9	19.9	12.77
	Precipitation (mm)	6.7	17.8	31.2	11.14	16.7	34.5	24.8	27.3	15	6.2	0	0	191.34
2007-2008	Temperature (°c)	14.87	9.95	2.4	-4.06	2.53	11.89	14.98	3.17	25.3	27.1	24.3	22.04	14.05
	Precipitation (mm)	5.1	1.5	7.5	9.8	0	0	14.5	1.5	0	0	1	3.7	44.6
2008-2009	Temperature (°c)	16.04	6.83	2.54	0.8	5.2	8.79	10.72	18.3	21.32	27.3	26.9	18.52	13.6
	Precipitation (mm)	11.8	28.8	7	14.5	13.5	26	29.6	13.8	10.6	0	0	0	155.6

b- Results of the study on phenology of *Ar. sieberi* in 2008 showed that the growth stage started in early March. The start of this stage at the sites of Soh, Salafchegan and Nodoushan was delayed slightly due to the reduced temperature and started in March. Vegetative growth of this species continued until early October and only at Til Abad site this stage ended in late June. Flowering and bud emergence varied at the study sites. At Til Abad site, due to drought and increased temperature, this stage started in early June. Also, at Nodoushan site, this stage started in mid July. At Tabas and Salafchegan sites, this stage started in mid November and at Dehno site it started in October. This stage ended in early January. At Soh site, like in 2007, the species did not enter into the flowering stage due to the heat and drought. Seeding stage at Tabas and Salafchagan sites started in early December and continued to late January and then entered into dormancy.

c-The results of phenological stages of *Ar. sieberi* in 2009 (Figure 1) shows that vegetative growth stage begins in early March. However, at Salafchegan site this stage started in early April. At Tabas site, this stage took about 8 months which showed the longest vegetative growth stage compared to the other sites. On average, this stage ended in late October. In Til Abal and Nodoushan sites, flowering stage started sooner than the other areas. This stage began in mid-June and ended in mid-November. At Soh site, this stage lasted from August to late September. This stage was so short at Dehno site and lasted about one month. At Tabas and Salafchgan, this stage started in November and ended in mid-December. In Nodoushan site, due to the severe drought of 2008, little budding was observed for *Ar. sieberi* in the second half of June. Poor flowering of *Ar. sieberi* was due to the effects of drought on the changes of phenology in 2008. In 2009, the regional rainfall (124 millimeters) was near to its long-term average (130 mm).

Table 3. Comparison of temperature and precipitation in the study years (Tabas Synoptic station, 711 m a.s.l.).

Year	Factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
2006-2007	Temperature (°c)	27.9	20.8	8.6	6.9	12.2	13.4	21.6	28.3	33.1	36.3	33.5	31	22.8
	Precipitation (mm)	0	9.1	22.2	3.5	21	3.2	12.9	0.4	6.7	0	0	0	79
2007-2008	Temperature (°c)	23	19.3	12.1	1.7	5.4	16.5	23.8	29.2	34.9	34.1	34.1	31.2	22.4
	Precipitation (mm)	0	0	7.5	25.9	22.6	0	3	0	0	0	0	0	59
2008-2009	Temperature (°c)	27.7	16.7	11.8	8.5	12.2	17.6	19	26.9	31.9	7.5	7.5	31.8	23.1
	Precipitation (mm)	0	2.4	10.8	0.9	3.5	11.1	41.3	10.7	0	0	0	0	80.7

At Soh site, seeding stage started in October and ended in November. At Salafchegan and Nodoushan sites, this stage lasted for a month and the seeds matured fast and finally, this species entered into dormancy and drying stage in November. In general, it seems that reduced precipitation in 2008 and no significant rainfall during the winter of 2009 caused the weakness of the majority of stands. At Soh site, the reduction of soil moisture at the beginning and middle of the hot season (summer) caused the slow growth and the stop of reproductive stage.

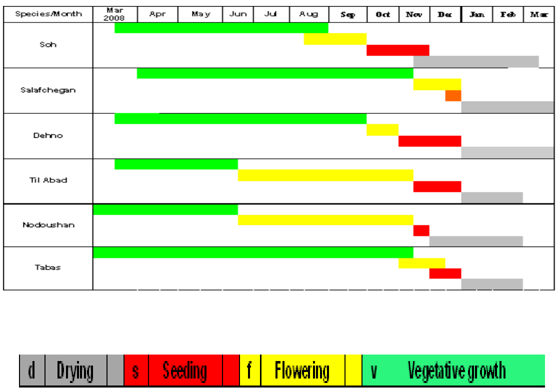

Fig. 1. Phenological stages of *Artemisia sieberi* in 2009.

Discussion and conclusion

Rangeland vegetation consists of various plant species. Each species has different phenological stages. *Ar sieberi* is the most abundant plant species in steppe grasslands of various regions of the country which is present as the dominant species in the composition of rangeland vegetation types.

The results of this study indicated that, based on temperature and soil moisture, the vegetative growth stage of *Ar. sieberi* at different sites started from early March to early April from the lower stems of the previous year. At this time, due to winter rains, the soil moisture is sufficient and the temperature is viable. Low temperature is considered as the main limiting factor for the vegetative growth and increasing the height of this species at the beginning of the growing season. Rainfall in the second decade of May and the increase of temperature have resulted in increase of growth rate and maximum growth. Vegetative growth stage continued until early August with a relatively constant trend. Flowering stage started in early July and continued until late November. Seeding stage gradually started from early October and lasted until the end of January. According to the resluts, the phenology of *Ar. sieberi* is relatively long. This indicates the tolerance and resistance of this species to

the environmental conditions. Vegetative growth of this species is accelerated based upon the increase of temperature, so that in case of rain in early April together with temperature within ten days, it will be equivalent to 50 days of vegetative growth. In contrast, reduced rainfall and humidity lead to the stop of vegetative growth. This result is consistent with the results of Menke and Trlica. 1981.Frank and Hofman. 1989. Frank. 1996. Bertiller *et al.*, 1991. Smart *et al.*, 2005, Bertiller *et al.,* 1991. Frank *et al.*, 1993. Keith T. W, 2001. Thompson, J.N. 1990 which stated that among climatic factors, the temperature had the greatest effect on plant growth during the period of growth and phenological stages.

Ar sieberi has a higher potential for drought tolerance due to its deep roots and the use of soil moisture and for this reason there was little difference in terms of phenological stages in the study years. In other words, *Ar sieberi* showed minimal phenological changes to drought. However, it does not apply in severe droughts. However, this study showed that reduced rainfall in the previous year and a decrease in winter precipitation and a decrease in winter precipitation stands in growing season. At Nodoushan site, due to the severe drought of 2008, *Ar.sieberi* could produce buds in the second half of June. Poor flowering has been due to the effects of drought and the changes in phenology in 2008. Phenological dates are very important economically. Any change in climatic factors which is influenced by these dates may have adverse consequences. Drought is a well-known example of an extreme change.

Consequently, knowledge on phenological stages of *Ar.sieberi* contributes to the sustainable use of rangeland forage through determining the time of entry and exit of livestock so that the range species could pass the phenological stages with no damage from grazing. It is clear that considering the time of entry and exit of livestock leads to the development of vegetation, soil moisture storage and the stability of production. This is very important in arid and semi-arid regions.

Due to the resistance to grazing during the vegetative growth, flowering, and seeding stage as well as proper regeneration and development and relatively high production and resistant to drought, *Ar. siberi* could be recommended as a key and economic species in range management.

Therefore, based on a full understanding of the various phenological stages of *Ar. siberi*, a proper planning can be applied in the management of grazing systems, the time of entry and exit of livestock, the optimal number of livestock for grazing, and the best time of seed collection.

References

Ansquer P, Al Haj Khaled R, Cruz P, Theau JP, Therond O, Duru M. 2009. Characterizing and predicting plant phenology in species-rich grasslands. Grass and Forage Science **64**, 57–70. http://dx.doi.org/10.1111/j.1365-2494.2008.00670.x

Bertiller MB, Beeskow AM, Coronato, F. 1991. Seasonal environmental variation and plant phenology in arid Patagonia (Argentina). Journal of Arid Environments **21**, 1-11.

Ehsani A. 2007. Determination of habitat indicators to estimate the long term production of rangeland in steppe regions of Iran, case study: Markazi province. PhD thesis, Faculty of Natural Resources, University of Tehran, 301 p.

Frank A, Hofmann L. 1989. Relationship among grazing management, growing degree days and morphological development for native grasses on the northern Great Plaints. Journal of Range Management **42(3).**

Frank A, Sedivec K, Hofmann L. 1993. Determining grazing readiness for native and tame pastures. North Dakota State University, Extension Service.

Frank AB. 1996. Evaluating grass development for grazing management. Rangelands **18(3).**

Humphreys MO, Eagles CF. 1988. Assessment of perennial ryegrass (*Lolium perenne* L.) for breeding. I. Freezing tolerance. Euphytica **38**, 75-84. http://dx.doi.org/10.1007/BF00024813

Jafari M, Ali Akbarzadeh E, Arzani H, Malekpour B. 2003. Investigation on some ecological characteristics of *Artemisia sieberi* in rangelands of Ardebil. Journal of Environmental Sciences **32**, 10 p.

Keith TW. 2001. A method to incorporate phenology into land cover change analysis. Journal of Range Management **54**, A1-A7.

Mahall BE, Thwing LK, Tyler CM. 2010. A quantitative comparison of two extremes in chaparral shrub phenology. Flora **205**, 513–526. http://dx.doi.org/10.1016/j.flora.2009.12.011

Menke JW, Trlica MJ. 1981. Carbohydrate reserves, phenology and growth cycles of nine Colorado range species. Journal of Range Management **34(3),** 262-277.

Pearce RS, McDonald I. 1978. The independent assessment of frost hardiness of excised laminae, excised roots and trimmed tillers of tall fescue (*Festuca arundinacea*). Journal of Applied Ecology **15**, 885-895.

Sekhwela MBM, Yates DJ. 2007. A phenological study of dominant acacia tree species in areas with different rainfall regimes in the Kalahari of Botswana. Journal of Arid Environments **70**, 1–17. http://dx.doi.org/10.1016/j.jaridenv.2006.12.006

Smart SM, Bunce RGH, Marrs R, LeDuc M, Firbank LG, Maskell LC, Scott WA, Thompson K, Walker KJ. 2005. Large-scale changes in the abundance of common higher plant species across Britain between 1978, 1990 and 1998 as a consequence of human activity. Tests of hypothesized changes in trait representation. Biological Conservation **124**, 355–371. http://dx.doi.org/10.1016/j.biocon.2004.12.013

Sparks TH, Jeffree EP, Jeffree CE, 2000. An examination of the relationship between flowering times and temperature at the national scale using long-term phenological records from the UK. International Journal of Biometeorology **44**, 82–87.

Thompson JN. 1990. Coevolution and the evolutionary genetics of interactions among plants and insects and pathogens. p 249-271 in: Pests, Pathogens, and Plant Communities, J.J. Burdon and S.R. Leather, eds. Oxford, Blackwell.