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The role of *Holocnemum strobilaceum* phenology on grazing management and sustainable utilization of rangeland forage

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ABSTRACT: In this study, the phenological role of *Holocnemum strobilaceum* was examined as a key species at three habitats during 2007-2010. Results indicated that the occurrence of phenological phenomena of *H. strobilaceum* was more affected by temperature and precipitation indices of the growing season. Accordingly, phenological stages in wet and dry years varied in different vegetative regions. Consequently, the role of the phenology of *H. strobilaceum* is crucial in grazing management as well as determination of grazing season. Applying proper grazing management in rangelands based on key species is very important in improvement of ecological indicators, sustainability of rangeland ecosystems, conservation and restoration of basic resources and sustainable and economic development. Consequently, a complete understanding on phenological stages of *Holocnemum strobilaceum* 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.

Key words: climate, grazing management, *Holocnemum strobilaceum*, phenology, sustainable utilization of rangeland forage

INTRODUCTION

Rangelands have complex ecological systems mainly affected by the changes of climate factors specially precipitation and temperature. These factors are very influential and important in temporal changes of the phenological stages of plant species. One of the basic problems of Iran's rangeland is the lack of grazing management leading to the non-practical and untimely utilization of natural forage of the rangelands and overgrazing. Observing the grazing season is among the basic components of range management principles. Key species is a range forage species that its utilization is an indicator for the utilization of companion species in the region. Since this species is considered important, it should be taken into account in management planning (Walker and Heitschmidt, 1986). Grazing management is regulated based on the key species. When the key species are properly utilized, it could be said that the entire range is properly utilized.

Over the life of a plant, there are critical phenomena including seed germination, vegetative growth, flowering, fruit and seed dispersal. Ackerman *et al.* (1980) studied the phenology of some shrub species including *Atriplex confertifolia, Atriplex caneceens, Artemisia tridentate*, *Artemisia spinescens*, and *Ephedra necadensis* in Nevada. Results showed that the onset of spring growth in these species was correlated with the amount of rain and snow in winter. They also stated that low humidity and temperature led to the delay in growth and the phenology of each species was defined by a certain temperature and humidity. Knowledge of phenological stages of the species which constitute the composition of a vegetative community has an important role in determining the grazing time and livestock grazing management in order to achieve the goal of forage production and also to management desirable and undesirable factors (Gibbens, 1991). Study on phenology of plant species and plant growth stages is considered as the basis of safe and proper management of resources to determine the range readiness (Ahas and Aasa, 2006). Temperature, humidity, rainfall and light are among the factors that somehow provide the necessary and appropriate conditions for growth and development. Variety of these factors causes to growth changes in plant species. Therefore, correlation between phenological phenomena and climate variables, especially temperature, could be most effective in prediction of the appearance dates. Brando *et al.* (2006) stated that temperature and photoperiod were among the factors regulating phenology. Results of the research conducted by Fraser (2006) showed that the study species started to grow when minimum temperature was above zero. Such findings allow range managers to determine range readiness by collecting daily temperature form synoptic stations. *Holocnemum strobilaceum* is one of the resistant and dominant species in most saline regions of Iran. It is a perennial and shrub species with a height of 25 to 50 cm, an obligatory halophyte with succulent stems, distributed in many salty and humid lowlands.

It is an important conservation and forage species that its preservation and development in very salty environments will result in fixation and sustainability of large areas of winter rangelands (Asadi, 2001). Therefore, the aim of the present study was to investigate the phenological stages of this species in different climatic conditions. Phenology study of range key species is important to regulate and to apply proper range management including determining the best time of livestock entry into and exit from rangelands. In this study, the role of *Holocnemum strobilaceum* phenology was investigated as a key species in order to regulate and apply proper management for sustainable utilization of rangeland forage.

MATERIAL AND METHODS

The present study was performed in three habitats (vegetative regions) of Golestan, Hormozgan and Qom provinces, having different geographical locations and different climates. Habitat characteristics of the study sites are presented in Table 1.

Table 1: Characteristics of the study sites.

Site	Province	Location	Altitude (m)	Climate	Average annual rainfall (mm)
Incheboroon	Golestan	N 37º 7' E 54º 29'	-4	Dry Temperate	238
West Lake Qom	Qom	N 50º 53' E 35º 15'	820	Dry	166
Zaminsang	Hormozgan	N 27º 22' 45" E 56º 50' 3"	40	Dry	160

Ten relatively uniform species of *H. strobilaceum* were selected. Phenological data including vegetative growth, flowering, seed maturity and drying stage were recorded during four years in 15-day and 7-day intervals at vegetative stage and reproductive stage, respectively.

RESULTS

Results of five phenological stages of *H. strobilaceum* in the study sites are presented in Fig. (1-4). Results of the investigation on phenological stages showed that at Incheboroon site, due to the humidity and temperature, vegetative stage started in March and continued until early October. Flowering stage usually occurred in October, November and December. At this site, seeding stage lasted until December and the species would go to winter dormancy stage by March of the next year. At West Lake Qom site, depending on the temperature and humidity conditions, vegetative stage started in early April and ended in late August and early September. After this stage, flowering started from early September and ended in late October. Seeding stage eventually continued until the end of October and seed maturity stage was completed from late November to mid-December, and it started the winter dormancy stage from mid-December. At Zaminsang site, vegetative growth stage started from early March and continued until late September. Flowering stage started from mid-September and lasted to mid-October and then seeding stage would be completed by late December. Seed maturity started from early December and continued to early January (the beginning of winter dormancy and drying stage).

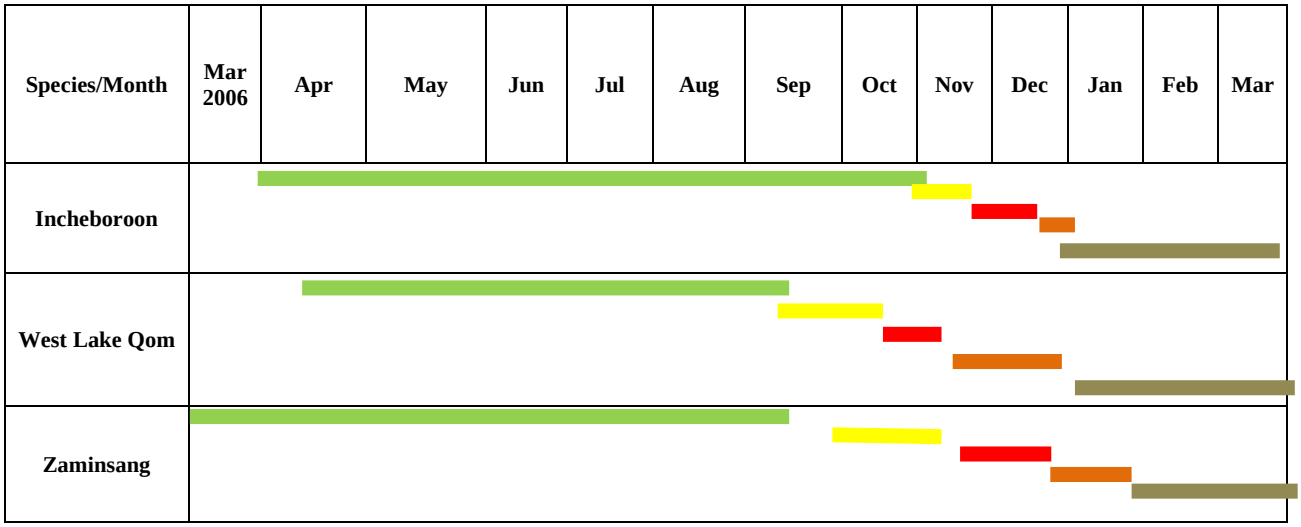

Fig. 1. Phenological stages of *Halocnemum strobilaceum* in 2007.

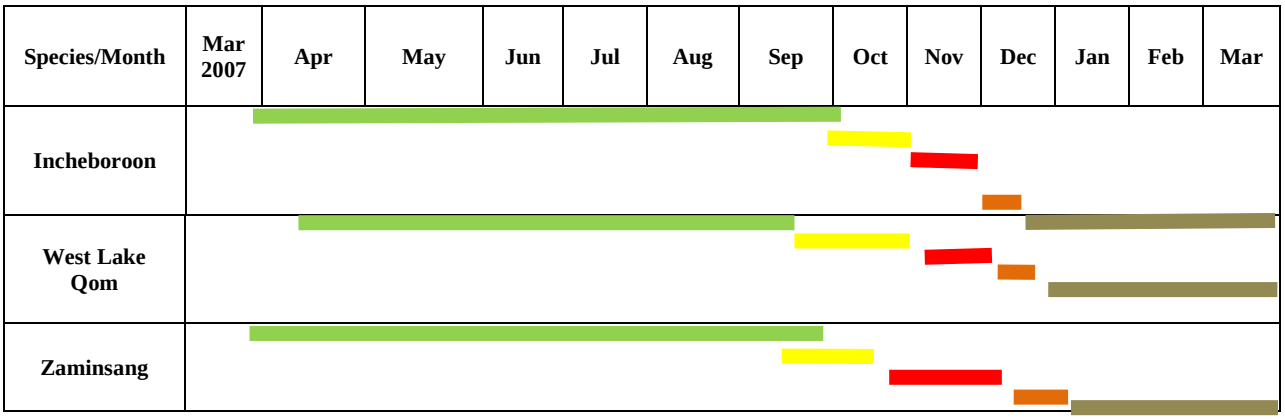

Fig. 2. Phenological stages of *Halocnemum strobilaceum* in 2008.

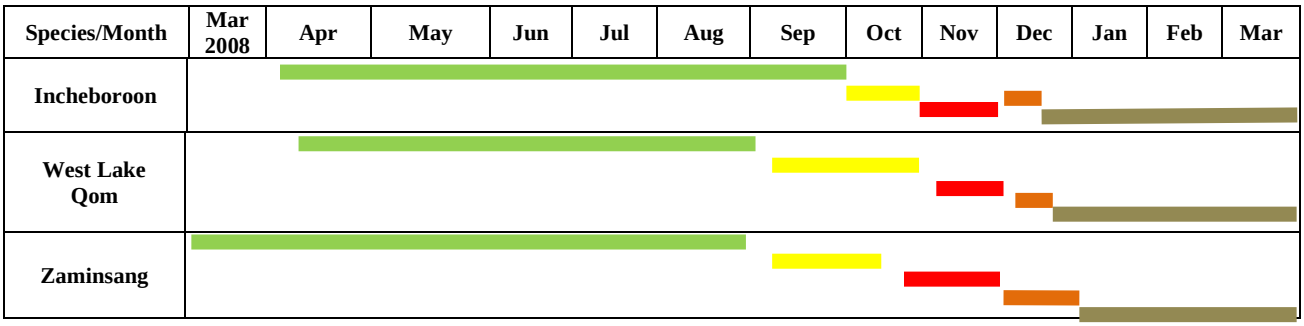

Fig. 3. Phenological stages of *Halocnemum strobilaceum* in 2009.

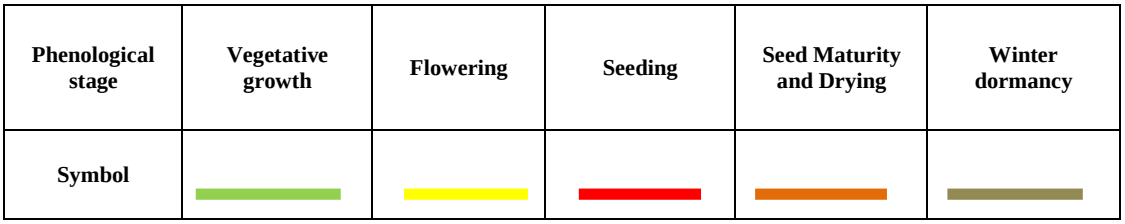

Fig. 4. Phenological stages of *Halocnemum strobilaceum* in 2010.

DISCUSSION

Key species is a range forage species that its utilization is an indicator for the utilization of companion species in the region. Since this species is considered important, it should be taken into account in management planning (Walker and Heitschmidt, 1986). Grazing management is regulated based on the key species. When the key species are properly utilized, it could be said that the entire range is properly utilized. The results of the study showed that phenological stages of *Halocnemum strobilaceum* were different at different climatic conditions during the years of the study. Depending on the year and region with proper temperature and favorable soil moisture, vegetative growth of this species at Inchehboroon site started in mid-March and lasted until early October and then flowering and seeding stages occurred. Drying stage started from early November and continued for two months. Due to high rainfall in 2007 and 2010 compared to 2008 and 2009, vegetative growth of this species started earlier and also vegetative growth period was longer in the years 2007 and 2010. It may be due to higher rainfall during these two years and that more moisture was available to the species for a longer period. Average rainfall in March 2007 and 2010 was more than other years. Also, average annual temperature in 2010 was more than other years, indicating the availability of moisture and temperature for plant growth. Our results are consistent with the findings of Ackerman *et al.* (1980), stating that the start of spring growth was correlated with the amount of rain and snow in winter. In addition, low humidity and temperature led to the delay in growth, and the phenology of each species was defined by a certain temperature and humidity.

As a result, based on phenological data of *H. strobilaceum*, companion species at Inchehboroon site including *Frankenia hirsuta, Aeluropus lagopoides, Aeluropus littoralis*, annual grasses and annual forbs could be used in grazing management.

At Zaminsang site, compared to Incheboroon and West Lake Qom, vegetative growth of *H. strobilaceum* started earlier and this could be due to the high temperature in February in this region. Vegetative growth of this species started from early March until the first week of September and then flowering stage was from the first week of September to the third week of October. Seeding stage started from the last week of October. Drying stage started in January and continued for two months. Many researchers (Crimmins, *et al.* 2010; Gibbens, 1991; Jentsch, *et al.* 2009) have stated that temperature is the most important regulator in plant phenology. Rainfall of Zaminsang site was low and growth of the species was most affected by moisture and sea atmospheric conditions. Studies of several researchers indicate the relationship between the date of the emergence of each phenological stage with moisture and thermal factors as well as photoperiod condition. Fitter *et al.* (1995) showed that flowering stage was significantly dependent on the temperature. Temperature is considered as one of the most important factors affecting the phenology of plant species. As a result, based on the phenological data of *H. strobilaceum*, companion species at Zaminsang site including *Salsola baryosma, Bienertia cycloptera, Suaeda fruticosa, Anabasis setifera, Atriplex leucocladax, Aeluropus littoralis, Desmostachya bipinata, Alhagi graecorum* could be used in grazing management.

At West Lake Qom site, due to the small fluctuations in temperature and rainfall during the study, little change was observed at the beginning and end of the phenological stages. Vegetative growth started from early April to early September and lasted about 6 months. Flowering stage started from late September and continued until late October. Seeding stage started from early November and continued until early December. Seed maturity lasted for one month until early January. Therefore, there is a logical relationship between vegetative and reproductive stages and temperature, and temperature fluctuation in different years causes changes in occurrence of phenological phenomena. Also, since the altitude of West Lake Qom site was higher than other sites, as a result, vegetative growth at this site started later than the other two sites. Crimmins *et al.* (2010) also stated that altitude affected the occurrence of phenological events and with increasing altitude, vegetative growth was delayed due to the reduced temperature and late melting snow at high altitudes. Plant phenology in middle and high latitudes is regulated by temperature and photoperiod, while it is regulated by seasonal rainfall at low altitudes and semi-arid areas. As a result, based on the phenological data of *H. strobilaceum*, companion species at West Lake Qom site including *Seidlitzia rosmarinous, Alhaji commelorum* could be used in grazing management.

According to the results of the study, phenological stages of *H. strobilaceum* differed in the sites of different vegetative regions during the years of the study. Vegetative stage started earlier in wet years, while in dry years it started later. There is also difference in terms of the duration of vegetative and reproductive stages. The growth of this species is dependent on environmental factors including moisture, temperature and altitude. Consequently, grazing management and sustainable utilization of range forage as well as determination of grazing season could be possible on the basis of phenological data of *H. strobilaceum*?. In addition, utilization of key species is an indicator for the utilization of the companion species. Applying proper grazing management in rangelands based on key species is very important in improvement of ecological indicators, sustainability of rangeland ecosystems, conservation and restoration of basic resources and sustainable and economic development. This could be used by the rangeland planners, managers, and beneficiaries.

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