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Phenology of *Stipa krylovii* Roshev. and *Stipa tianschanica* var. *klemenzii* Roshev., Species Dominating the Vegetation Communities of Hustai National Park

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ABSTRACT

Hustai National Park (HNP), which is one of the important parts of the Mongolian Special Protection Areas network, was founded in 1992 with the purpose of reintroducing the Takhi horse (*Equus ferus przewalskii*). HNP vegetation phenology research was first done in 1999 and since 2003 has been conducted each year between 24th of April and 24th of September, every 10 days. The purpose of this study is to identify, with the help of dominant species, the response of vegetation growing period to climate changes and to clarify features of species' phenology changes. As a result of the research we identified and recorded general trends of dominant vegetation phenology stages and how these changes respond to environmental factors (air temperature and precipitation). Comparison of the phenology stages of the two grasses dominant in the mountain steppe and steppe communities, *Stipa tianschanica* var*. klemenzii* Roshev. and *Stipa krylovii* Roshev. identified that the May and June precipitation amount had a significant effect on the beginning of the species' spring growing period ($p<0.027$). The results show that the vegetation growing period of the species has been increasing in the mountain steppe communities.

Keywords: phenology, growing period changes, Kryllov's feather grass, Klement's feather grass

INTRODUCTION

Research on the growing season regime and phenology studies help to identify relationships between species and their natural environment (Donnelly, 2006). Along with detecting the regularity of each year's seasonal changes, phenology studies also evaluate the normality of particular vegetation development by clarifying the extrinsic factors that influence it (Schwarts, 2003). Vegetation development stages generally happen in the same order each year and with the same regularity, but phenological stages occur in relatively different time periods depending on each species' geographical location, the local climate condition and the individual age structure in the population

(Beideman, 1960). Phenology data is used to detect the impact of climate changes in vegetation, but there are few long term studies. The beginning of vegetation growth, flowering and fruiting periods are sensitive to the air temperature and moisture levels, and climate changes is likely to impact the phenology trends of community-level reproduction (Donnelly, 2006). Conducting research beginning from initial growth in spring until withering in autumn, making measurements once every 10 days is an easy way to identify particular vegetation's annual phenology dynamics.

The purpose of our research was (1) to determine the phenology period of dominant species in each community of Hustai National Park (HNP), and (2) to analyse weather data from each observation period to identify the influence of particular environmental conditions on vegetation phenology.

The two species of feather grass (*Stipa*) which we chose for our research are both thick bushy, perennial species which are dominant in a particular community. Krylov's feather grass (*S.krylovii* Roshev.) occurs in all Mongolian vegetation-geographical regions except for the Transaltai Gobi region and Alashaa Gobi region. Globally, it occurs in Russia, Kazakhstan, Kirgizstan, Uzbekistan and China. It grows in dry and stony steppe and mountain steppe. Klement's feather grass (*Stipa tianschanica* var. *klemenzii* Roshev.), which is one of three tianschanica feather grass (*Stipa tianschanica*) variations, occurs in all vegetation-geographical regions of Mongolia except for Khuvsgul, Khentii, Khovd and the Mongolian Altai. Globally, it occurs in the northern areas of China, in Russia along the Mongolian border, in Kazakhstan, Kyrgyzstan and Uzbekistan. It is adapted to dry environments (xerophytic), and grows in dry mountain steppe, pure steppe and Gobi desert habitats (Grubov, 1982; Urgamal et al., 2014; eFloras.org, 2015).

FEATURES OF RESEARCH SITE

Hustai NP was founded in 1992 for the purpose of reintroducing the Takhi (*Equus ferus przewalskii*), which is rare and critically endangered species globally and regionally. HNP is a part of the National Special Protection Areas (NSPA). HNP is located in the semi-cold sub-zone of the semi-dry and temperate climate zone (Tsegmid, 1969). As the area contains mountains, hills, and wide and narrow valleys between the mountains and plains, the range of micro-climates means there are many different characters, such as steppe, mountain steppe and forest steppe vegetations. Ninety-five percent of total area is considered suitable for grazing (Bolormaa, 2004). In the recent years the forest steppe of HNP has dried considerably and changed its landscape appearance (Bayarsaikhan et al., 2009; Enkhsaikhan, 2009; Tuvshintogtokh, 2013) which indicates the need to observe and study the future vegetation trends in the area (Figure 1).

From the climate diagram developed by Walter's method using multiyear reports from Hustai hydrological observers (Munkhbat, 2014), the general trend in HNP shows suitable conditions for vegetation growing during summer, with a drying trend in September. However, rainfall is delayed for longer periods in some years which leads to semi-drought conditions. Annual precipitation is an average 228 mm, out of which 70% (156±30 mm) falls in the warm season (in June, July and August) (Munkhbat, 2014). Excessive hot weather in the middle of July of some years leads to an interruption of vegetation growth and subsequent early withering (Sergelen, 2007). The trend of temperature variations increase and cooling trend in April or at the beginning of vegetation growing period is being observed since 1995. However, according to the recent 10 year average, the there is a trend of increasing growing period, which is vegetation growing period after May, with an increase of days with regular temperature above +5 ^{0}C.

MATERIALS AND METHODS

Vegetation monitoring in HNP has been conducted each year since 2003, from the 24th of April until the 24th of September, on the 4th, 14th, and 24th of each month. On each occasion, species composition, cover, plant height, phenology stages were recorded. In this paper we have focused on records of two chosen species. Phenology stages of dominant species were recorded in consistence with bio-morphological characteristics. Our research principle is based on Beideman's (1960) method. We measured basic stages such as beginning to grow, seedhead formation, flowering, withering and total growing period stages. When the same stage was detected in not less than 75 percent of the same species in a research plot at the particular time period we considered it as the beginning of particular phenology stage.

Our research focused on four plots, consisting of: couch grass – Adams' wormwood – Kryllov's feather grass community (plot 1) and forb – grass community (plot 3) where Kryllov's feather grass dominates; small grass – caragana – bindweed – Klement's feather grass community (plot 2) and small grass – needle grass – bindweed - Klement's feather grass community (plot 4) where Klement's feather grass dominates (Figure 1). Statistical analysis of multiple factor regression (Multiple GLM) was performed using "R" to identify the effect of air temperature and precipitation on the spring regrowth, budding, flowering, withering and total growing period of each species.

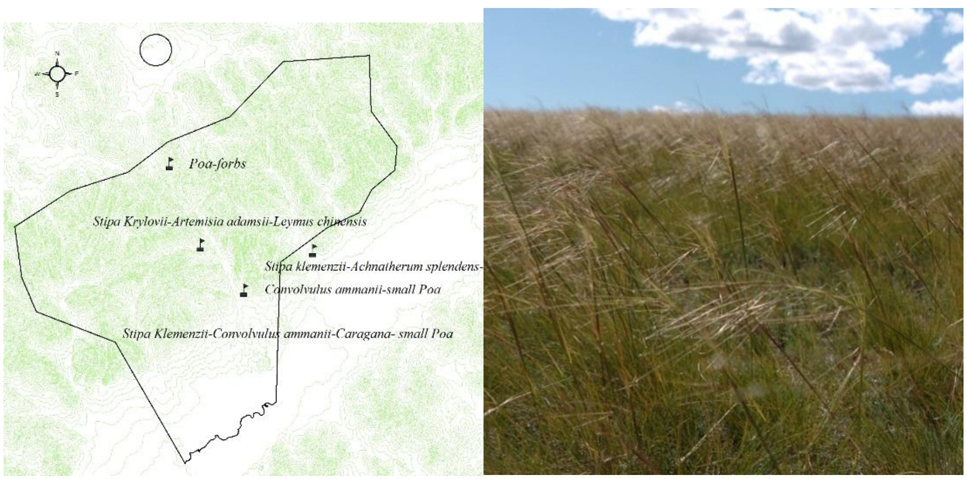

Figure 1. Research area and view of Kryllov's feather grass.

RESULTS AND COMMENTS

The assessment of the relation between the beginning of spring regrowth day, beginning of budding, beginning of flowering, total plant growth period at each plot and total monthly precipitation and temperature indicators showed that beginning of spring regrowing period of Kryllov's feather grass at the first plot (Figure 2) is dependent on May and June precipitation ($P<0.02685$). Beginning of budding ($P<0.0207$) and beginning of flowering ($P<0.01$) was dependent on July and August air temperature. Total plant growth period had positive correlation with precipitation ($r=0.78$). When entered into multi-factor linear regression pattern is showed greater dependence on average September air temperature ($P<0.04$). According to Mann-Kendall test extention of plant growing period has been detected only in Kryllov's feather grass from the first plot ($P<0.0282$). However at the third plot, regrowing period depended on May and June precipitation ($P<0.01$) and beginning of budding period of Kryllov's feather grass depended on June precipitation

(P<0.02). Except from the first plot, no changes were detected in flowering and total growing period. The reason for this may be the location of those two plots in different environmental context. The third plot situates in meadow-like steppe, while the first plot situates in the mountain steppe.

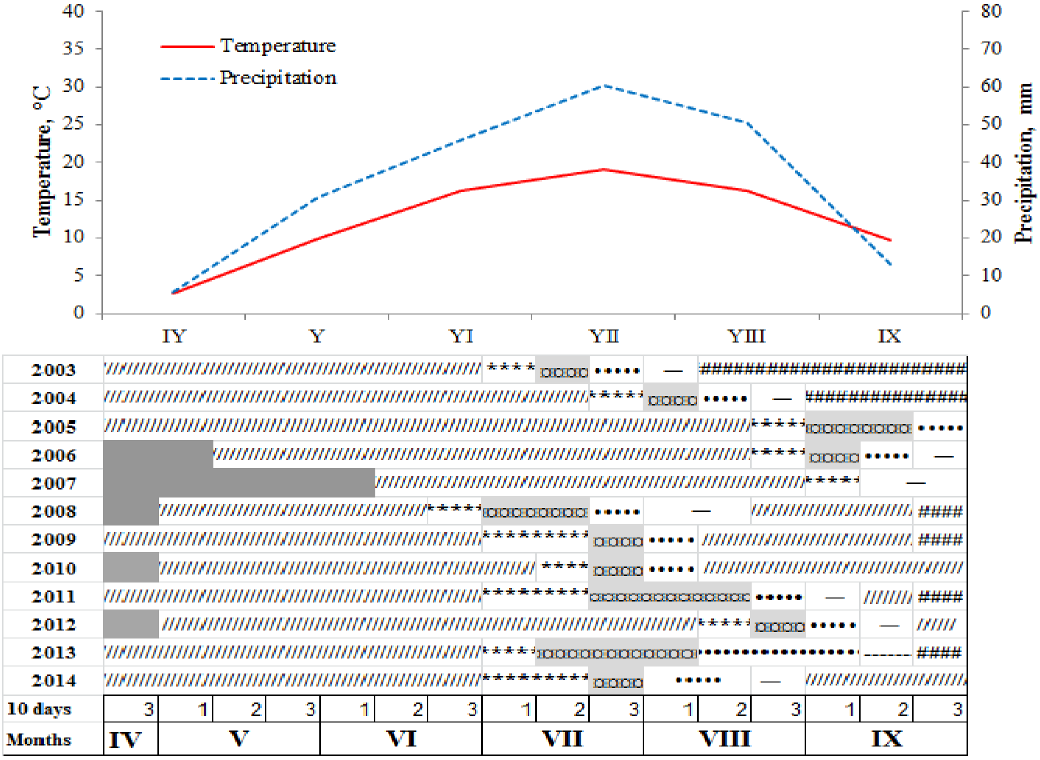

Figure 2. Climate diagram of Hustai National Park (1999-2014) and phenology of *Stipa krylovii* at the 1st plot (2003-2014).

Plot: [grey box] eriod without vegetation, /////////- growing, ****- seadhead formation, ¤¤¤- flowering, •••••- seed formation, ------- seed dispersal, ###- withering

In the second mountain steppe plot, beginning of growing period of Klement's feather grass depended on May and June precipitation (P<0.02), while seedhead formation (P<0.007) and beginning of flowering (P<0.04) period depended on July and August temperature. If the level of statistical significance is set at 90%, then the beginning of flowering was dependent on average summer air temperature (P<0.0821) and total summer precipitation (P<0.0693). But total plant growth period changes related to September air temperature. According to our choice pattern, total growing period was dependent on September precipitation (P<0.04) and total summer precipitation (P<0.01). This last result is consistent with research that has shown that plant withering or autumn growing period showed more variance than the beginning of the growing period in spring (Sparks and Menzel, 2002; Cleland et al., 2007). The fourth plot located in the pure steppe was quite specific compared to other plots. This plot is exposed to intensive livestock grazing as it is situated outside of protected area. Since the research has been conducted here since 2007 due to insufficient data array there may be many statistically inconclusive indicators.

CONCLUSIONS

Temporal changes of plant phenology stages are becoming more evident in the recent years, and were revealed in this work carried out at HNP. Our study showed the influence of precipitation and temperature changes over the total plant growing period for the past 10 years. The preliminary conclusion is that the changes detected in the feather grass species' phenology in the mountain steppe is more influenced by the autumn growing period rather than beginning of growth in spring.

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