A Study on the Plants for Phenology of the Mt. Palgongsan Provincial Park

Byung Do Kim¹, Sung Tae Yu¹, Hyun tak Shin², Myung hoon Yi³, Jung won Yoon³, Gi song Kim³ and Jung won Sung³*

¹Daegu Arboretum, Daegu, 711-832, Korea
²Korea National Arboretum, Pocheon, 487-821, Korea
³Department of Landscape Architecture, Yeungnam University, Gyeongsan, 712-749, Korea

Abstract: The study performed monitoring on seasonal changes of a total of 13 plants including 10 woody plants and 3 herbaceous plants vulnerable to the climate change around the Mt. Palgongsan Provincial Park from April 10 to November 30, 2010. The plants were divided with 5 features including leaf unfolding, flowering, falling blossom, fall foliage and fallen leaves. The meteorological data were measured from early January, 2010 to late December, 2011 and the maximum and minimum monthly average temperatures were 25.3°C and −4.7°C and the maximum and minimum monthly average relative humidity was 96% and 28.3%, respectively. The study analyzed indicator species which may be compared as a result of monitoring indicator plants. The flowering period delayed from 2 to 10 days. In contrast, the flowers fell 3 to 25 days earlier. The leaf unfolded earlier than the previous year except some trees. No clear pattern changes were observed in the leaf foliage, time of leaf falling and growth duration compared to the previous year. It is required to perform long-term climate monitoring, observe phenology of plants and compare and analysis depending on vegetation, soils and slopes for each individual entity.

Keywords: Climate Change, Flowering, Aestivation, Mt. Palgongsan

Introduction

Changing the biotic seasonal phenomena is the clearest reaction to the recent climate change (Post and Strenseth, 1999; Hughes, 2000; Penuelas and Felella, 2001; Walther et al., 2002; Menzel, 2003; Gordo and sanz, 2005; Menzel et al., 2006; Doi and Katano, 2008). Despite some contradict results, the results of the phenomena observed for a long time indicate outstanding evidence that times were moved forward in various biological phenomena (Parmesan and Yohe 2003; Root et al., 2003). These consistent patterns may be observed from the fact that the growth and dates of flowering became faster from the aspect of the plant phenology (Menzel and Fabian, 1999; Fitter and Fitter, 2002; Penuelas et al., 2002). Generally, these reactions are the most outstanding in the spring (Walter et al., 2002). Song (2008) analyzed the correlation between the annual average temperature and the flowering dates of Prunus serrulata var. spontanea (Maxim.) E.H.Wilson blossoms from 1922 to 2008 for major cities in Korea and reported that the flowering dates moved forward to about 3 days when the annual average temperature increased by 1°C and this was due to the climate change and the temperature increase due to the heat island phenomena in the cities shortened the flowering dates. Recently, studies are continuously performed to protect and manage protected species in the forest through long-term monitoring of climate changes on the regional basis in Korea (Shin et al., 2011; Sung and Shin, 2011; Yu et al., 2011; Kim, et al., 2011; Shin and Sung, 2011; Kim et al., 2012). The investigation site, Mt. Palgongsan Provincial Park, is located 20 km on the northeast direction from the center of Daegu City and affected by the continental climate. Also, the park has a high value of preservation for nature preservation, primeval forest, wild animals and plants but the endangered species including Aconitum austrokoreense Koidz. and Iris odaesanesis Y. N Lee are affected by climate change (Kim, 2009).

The purpose of the study is to perform monitoring for bioclimatology in the Mt. Palgongsan Provincial Park, analyze the results, establish biogeographic long-term and management system, predict and manage changes in growing environment for plants and provide fundamental data to preserve plants vulnerable to the climate change in the mountain.

*To whom correspondence should be addressed.
Tel: +82-53-810-3807
E-mail: onsulove2036@hanmail.net
Material and Method

Install Micrometeorologic Equipment
The trends in temperature changes were observed for spots where the plants vulnerable to climate change by installing micrometeorologic equipment. The equipment was installed in Baekandong (N35°57'14.21" E128°41'37.07") and measured climate data from early January, 2000 to late December, 2011. Among Hobo sensors in the micrometerologic equipment, the temperature and the humidity were observed by TMB-M006 in the simplified instrument screen (RS3) and the U23 series, temperature and humidity sensor, was used as auxiliary equipment.

Monitoring Indicator Plants
The GPS (GPS60CS) was used to mark coordinates on each indicator plant, granted distinct number tags and recorded times of flowering, flower falling, leaf unfolding and fall foliages and changing growth period (Figure 1). More than 3 entities were observed for the identical species to reduce errors in the nearby same species with the investigation and the data were measured considering the averages. The investigation was performed once a week from April 10, 2010 to November 30, 2011 and every 2 weeks in July and August due to not showing changes of the phenology (Korea National Arboretum, 2010).

The plants under biometeorologic investigation were selected in accordance with the investigation manual of the Korea Forest Service (2010) focusing on rare plants, local plants in the site out of special plants and common plants evenly distributed nationwide. A total of 13 entities including 10 wood species of wild Prunus sargentii Rehder, Rhododendron mucronulatum var. latifolium Nakai, Lindera obtusiloba Blume and Acer pseudosieboldianum (Pax) Kom and 3 herbs like Eranthis stellata Maxim. and Hemerocallis fulva (L.) L. were under investigation (Table 1).

![Site](image)

**Fig. 1. Study area of Mt. Paalgongsan**

**Table 1. Survey plant List of Mt. Paalgongsan**

<table>
<thead>
<tr>
<th>No.</th>
<th>Korean Name</th>
<th>Scientific Name</th>
<th>GPS Coordinate</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>산벚나무</td>
<td>Prunus sargentii Rehder</td>
<td>36°01'38.90&quot; N</td>
<td>128°37'44.78&quot; S</td>
</tr>
<tr>
<td>2</td>
<td>진달래</td>
<td>Rhododendron mucronulatum var. latifolium Nakai</td>
<td>36°01'40.61&quot; N</td>
<td>128°37'46.75&quot; S</td>
</tr>
<tr>
<td>3</td>
<td>생강나무</td>
<td>Lindera obtusiloba Blume</td>
<td>36°01'39.29&quot; N</td>
<td>128°37'44.01&quot; S</td>
</tr>
<tr>
<td>4</td>
<td>당단풍나무</td>
<td>Acer pseudosieboldianum (Pax) Kom.</td>
<td>36°01'41.01&quot; N</td>
<td>128°37'50.21&quot; S</td>
</tr>
<tr>
<td>5</td>
<td>총참나무</td>
<td>Quercus serrata Thunb. ex Murray</td>
<td>36°01'40.77&quot; N</td>
<td>128°37'51.48&quot; S</td>
</tr>
<tr>
<td>6</td>
<td>신갈나무</td>
<td>Quercus mongolica Fisch. ex Ledeb.</td>
<td>36°01'40.81&quot; N</td>
<td>128°37'51.70&quot; S</td>
</tr>
<tr>
<td>7</td>
<td>물박달나무</td>
<td>Betula davurica Pall.</td>
<td>36°01'39.56&quot; N</td>
<td>128°08'53.29&quot; S</td>
</tr>
<tr>
<td>8</td>
<td>청록</td>
<td>Rhododendron schlippenbachii Maxim.</td>
<td>36°01'40.33&quot; N</td>
<td>128°08'57.31&quot; S</td>
</tr>
<tr>
<td>9</td>
<td>소나무</td>
<td>Pinus densiflora Siebold &amp; Zucc.</td>
<td>36°01'39.08&quot; N</td>
<td>128°08'44.23&quot; S</td>
</tr>
<tr>
<td>10</td>
<td>일본일갈나무</td>
<td>Larix kaempferi (Lamb.) Carriere</td>
<td>36°01'41.05&quot; N</td>
<td>128°08'47.52&quot; S</td>
</tr>
<tr>
<td>11</td>
<td>너도바람꽃</td>
<td>Eranthis stellata Maxim.</td>
<td>36°01'41.92&quot; N</td>
<td>128°07'50.54&quot; S</td>
</tr>
<tr>
<td>12</td>
<td>원추리</td>
<td>Hemerocallis fulva (L.) L.</td>
<td>36°01'41.16&quot; N</td>
<td>128°08'50.65&quot; S</td>
</tr>
<tr>
<td>13</td>
<td>나도개감채</td>
<td>Lloydia triflora (Ledeb.) Baker</td>
<td>36°01'41.92&quot; N</td>
<td>128°07'50.54&quot; S</td>
</tr>
</tbody>
</table>
1). The periods of starting flowering were measured when the inflorescences of male flowers were completely open for at least 3 spots or pollen flew by slightly shaking for needleleaf trees and blossomed flowers were observed from at least 3 spots for deciduous broadleaf tress. Here, the blossomed flower means flower leaves completely opened. The falling blossom period was observed by percentage for blossomed flower and considered the fallen period when 90-100% of the flower was fallen. The leaf unfolding was considered as unfolded herb with more than 3 spots looking like leaves and the fall foliage was considered with more than 3 foliage spots on the total leaves. The leaf starts falling when fallen leaves were observed from more than 3 spots. All the data were recorded as percentage. For herbs, the plant started blossoming when the flower bud was ruptured and the flower blossomed and the blossom was considered when the flower leaves were completely open. The falling period is when 90-100% of the flower was withered or dead. The growth started when the buds were observed above the soil surface and the unfolding started when leaves completely open was observed for the leaf unfolding period. The fallen blossom was considered and observed when 90-100% of leaves were withered or dead.

Result and Consideration

Climatic Overview
Monthly average temperature, monthly average relative humidity, daily highest and lowest temperatures and daily highest and lowest relative humidity were observed from early January 2010 to late December 2011 based on the micrometeorologic data of Baekandong (N35°57'14.21" E128°41'37.07""). The highest daily average temperature was 27.6°C on July 28, 2011 and the lowest was 10.2°C on January 16, 2011. The highest and lowest monthly average temperatures were 25.3°C in August 2010 and −4.7°C in January 2011, respectively (Figure 2). In addition, it was found out that the average temperature between January and March of 2011 was 0.02°C higher than that of 2010 and the number of days below 0°C was 49 in 2010 and 47 in 2011. The highest and lowest monthly average relative humidity were 87% in August 2010 and 55% in January 2011, respectively (Figure 3). The highest and lowest daily average relative humidity was 96% on October 22, 2011 and 28.3% in September 10, 2010.

Monitoring Indicator Plants
The physiologic cycle of the indicator plan consists of 5 stages including blossoming, fallen blossom, leaf unfolding, fall foliage and fallen leaves and the times of starting physiologic changes of each indicator plant were recorded. The starting points for each physiologic features were categorized for 2010 and 2011 and the cycle trends in climate change were analyzed (Table 2). The Acer pseudosieboldianum (Pax) Kom, Quercus mongolica Fisch. ex Ledeb, Rhododendron schlippenbachii Maxim. and Hemerocallis fulva (L.) L. did not show the blossom and Quercus serrata Thunb. ex Murray, Betula davurica Pall, Larix kaempferi (Lamb.) Carriere and Lloydia triflora (Lede.) Baker failed comparing because they did not blossom in 2011. The flowering period delayed from 2 to 10 days for tree species under comparison. It was observed that the blossoms started falling 3 to 25 days earlier. It was found out that the leaves unfolded 4 to 33 days earlier than 2010 except Lindera obtusiloba Blume, Quercus serrata Thunb. ex Murray, Rhododendron schlippenbachii Maxim and Lloydia triflora (Lede.) Baker out of total indicator tree species. Fall foliages were observed 2 to 10 days earlier for Prunus sargentii Rehder, Lindera obtusiloba Blume, Quercus mongolica Fisch. ex Ledeb, Larix kaempferi (Lamb.) Carriere and Eranthis stellata Maxim. and 2 to 18 days for other species. Prunus sargentii Rehder, Quercus mongolica Fisch. ex Ledeb, Betula davurica Pall, Rhododendron schlippenbachii Maxim and Larix kaempferi (Lamb.) Carriere showed fallen leaves 4 to 18 days later than before but other tree species showed 1 to 13 days earlier. No constant pattern changes were observed for the growth period.
Blossom

Plants except *Prunus sargentii* Rehder, *Rhododendron mucronulatum* var. *latifolium* Nakai, *Lindera obtusiloba* Blume, *Pinus densiflora* Siebold & Zucc. and *Eranthis stellata* Maxim. failed comparing blossom period as a result of analyzing blossom periods. *Eranthis stellata* Maxim. observed 11 days earlier than before and other species showed 2 to 10 days later than that of 2010 (Figure 4). The blossom period depended on sunshine duration, temperature, humidity, precipitation and light intensity and was particularly sensitive to climate element, temperature (Vegis A, 1964). It was considered due to physiologic stress by abnormal climate in the spring which affected the blossom in 2011 and the blossom in 2011 started later than 2010. Therefore, comparison studies through long-term climate monitoring are required.

Fallen Blossom

The fallen blossom analysis results were opposite to those of the flowering period. *Eranthis stellata* Maxim.. showed flowering and fallen blossom simultaneously in 2011 and it was observed that the growth period increased than the previous year because the flowering was observed early but the fallen was observed late in 2011. Other tree species showed later to 3 to 25 days compared to 2010 (Figure 5). This is due to the fact that the temperatures of March and April which affect the falling period continued longer than 2010 and the timing delayed. Management plans and promotion are required to preserve plant species in the Mt. Palgongsan for *Lloydia triflora* (Ledeb.) Baker which has been lost in 2011 due to hikers and wildlife animals.

Leaf Unfolding

There was no clear pattern difference in that *Lindera obtusiloba* Blume, *Quercus serrata* Thunb. ex Murray, *Quercus mongolica* Fisch. ex Ledeb and *Rhododendron schlippenbachii* Maxim. were 2 days later and other plants were 4 to 33 days later than before (Figure 6). It is known that there are various environmental factors like soil, temperature and humidity which affect the leaf unfolding.
In addition, it is reported that the temperatures in the winter and spring are the most sensitive factor in seasonal changes of spring plants and the spring plants are affected by temperature after the hibernation (Lechowicz, 1995; Chmielewski and Rotzer, 2001). However, comparison and analysis are required through long-term monitoring depending on physiologic features, altitude above sea level, soils and slope directions because the monitoring period is short to mention the phenology.

Fall Foliage

Fallen Leaves
Like the foliage period, no clear pattern differences were observed for the fallen leaves. *Prunus sargentii* Rehder, *Lindera obtusiloba* Blume, *Quercus serrata* Thunb. ex Murray, *Quercus mongolica* Fisch. ex Ledeb, *Betula davurica* Pall, *Rhododendron schlippenbachii* Maxim and *Hemerocallis fulva* (L.) L. were observed 2 to 18 days earlier than before, meaning that the trees were well-adapted to the surrounding environment and had fallen leaves.
Conclusion

The purpose of the study is to predict and manage changes in the growth environment of plants by monitoring for phenologic researches in the Mt. Palgongsan Provincial Park and analyzing the data. The study analyzed indicator species which may be compared as a result of monitoring indicator plants. The flowering period delayed from 2 to 10 days. It is judged that the flowering date is highly related to the temperature and humidity between February and March and largely affected by the daily average temperature and the daily average relative humidity before flowering because the flowering is done between March and April. In addition, the phenology of plants under current climate change shows that the flowering of Rhododendron mucronatum var. latifolium Nakai and Rhododendron schlippenbachii Maxim, flowering in the spring, delayed but the phenology for other plants showed 3 to 25 days earlier than before. The leaves unfolded earlier than the previous year except some trees. It is difficult to investigate accurate tendency in fall foliage and fallen leaves due to a short period of investigation and shows that the period was earlier or later than the previous year. The growth period shows no constant pattern changes and the periods of Prunus sargentii Rehder, Quercus mongolica Fisch. ex Ledeb, Larix kaempferi (Lamb.) Carriere and Eranthis stellata Maxim. extended to 3 to 23 days. Opposed to the prediction that the growth period was extended due to earlier flowering and later foliages by increasing the temperature in the spring, no changes were observed and future long-term climate monitoring, observing plant phenology, comparing and analyzing vegetation, soils and slopes for each entity are required.

Acknowledgment

The study was performed thank to the research fund for preserving and adapting forest plants vulnerable to the climate change in 2012.

References


Kim, K.E. 2009, Distribution of Vegetation and Conservation of the Palgongsan Provincial Park, Ma. D. in Korea


Menzel, A. 2003, Plant phenological anomalies in Germany and their relation to air temperature and NAO, Climate Change, 57(3), 243-263.


Song, H.K., 2008, Responses of Ecosystem to Climate Change in Korea: Abnormal Growth of The Korea Pine (Pinus densiflora) and Flowering Date of Cherry (in Korea)


Received: 29. Oct. 2012
Accepted: 29. Nov. 2012