



# The Relationship between Flowering Dates of several Woody Plants and Air Temperature

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**Abstract:** To look into relationship between some xylophyte species blooming time and temperature, this study was researched blooming time of year 2010 and 2011 and investigated the correlation between blooming time and temperature. The species with low blooming time, year day index and warmth index bloomed early. Warmth index was calculated in two ways, TN and TL. The result of correlation between blooming time and temperature showed that the species that bloom in spring had positive correlation between blooming time and temperature while purple bloom maple had no correlation between the two. More climate data and monitoring data are necessary for comparative analysis on correlation between blooming time and temperature.

**Keywords:** Blooming time, Climate change, Temperature, Purple bloom maple, Korean azalea, Pine, Korean rosebay, Vulnerable plants

## Introduction

The Republic of Korea is a peninsula located in the middle latitude region of the Northern hemisphere and is influenced by the continental climate and the maritime climate, leading to four distinct seasons and a typical temperate climate. Plants of the temperate regions of the Northern hemisphere unfold during spring and undergo leaf abscission during the winter, displaying an annual plant life cycle. The study of such periodic plant life cycle events is referred to as a phenology.

A single plant life cycle is distinctly divided into the stages of germination, leaf unfolding, flowering, flower shedding and leaf abscission (Lieth *et al.*, 1974), and the beginning and the end and the duration of each stage vary with surrounding environmental factors.

Flower in especially is the most important response so plants to seasonal changes, and it has been known that it changes in accordance with the photo period and temperature changes (Grainer, 1939; Nuttonson, 1948).

It has been reported that, in terms of the factors which influence the flowering period during spring, the temperature is more significant than the distribution of photo period or the amount of rainfall and sunshine (Brown, 1953), and it can be seen that, as an important environmental factor which influences the developmental

stages of plants, increased temperature during the early stages of plant development is important in determining the time of flowering.

In such way, among methods which display relationship between flowering period and temperature changes, the use of the time-temperature concept or the day of year brought advancements in explaining the relationship between physiological phenomena and climate conditions and in establishing bio climatic principles (Huberman, 1941; Nuttonson, 1948; Lindsey and Newman, 1956; Yim, 1983).

Therefore, the purpose of this study was to confirm if the flowering period of the same xylophyte species of different regions is the same for each year and to investigate the correlation between flowering period and temperature.

## Materials and Method

### Study site conditions

Juwangsan Mountain has an altitude of 720.6 m over sea level and is located in the Taebaek Mountain Range, which is included in the central part of Korea. It stretches over the regions of Cheongsong-gun and Yeongdeok-gun of the Gyeongsangbuk-do region and was designated as a national park on March 30<sup>th</sup> of 1976, with surface are of 107.425 km<sup>2</sup>. In terms of the flora of the region, it is included in the central subregion (Lee and Lim, 1978), and in terms of its plant formation, it is included in the southern cool temperate zone (Yeddo Hornbeam (*Carpinus tschonoskii* MAX.) community) (Yim and Kira, 1975). The study site included the land surrounding the hiking path from

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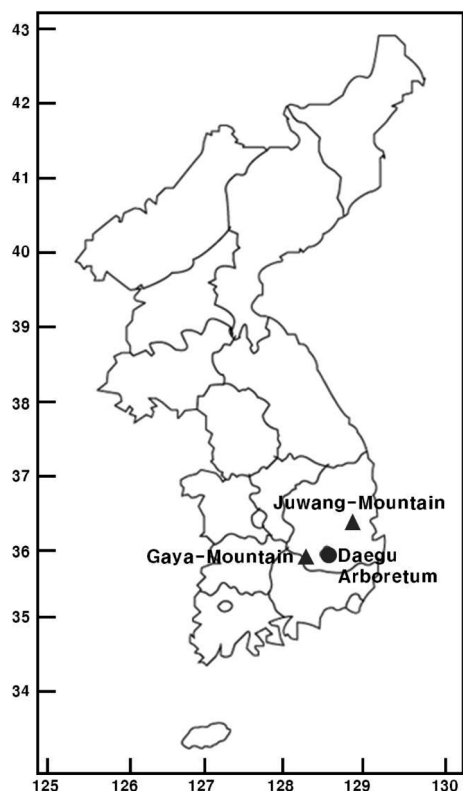


Fig. 1. Map showing the study area.

Baekryeonam (280 m) and Juwangsang Mountain peak (720 m). Gayasan Mountain was designated as a national park on October 13<sup>th</sup> of 1972 and stretches over Hapcheon-gun and Geochang-gun of the Gyeongsangnam-do region and Seongju-gun and Goryeong-gun of Gyeongsangnam-do region.

It is also one of the most representative high altitude mountains of the Sobaek Mountain Range, which is located to the southern in land of the Korean peninsula. Furthermore, with Sangwangbong (1,430 m) as the main peak, Duribong (1,134 m) is located to the west, Chilbulbong (1,433 m) and Dongseongbong (1,227 m) to the east, and peaks such as Danjibong (1,028 m), Namsanjeilbong (1,010 m) and Maehwasan Mountain (954 m) to the south. Gayasan Mountain is located in the southern temperate zone in terms of climate region, southern sub region in terms of floristics (Lee and Lim, 1978) and cool temperate zone in terms of vegetation regions (Yim, 1977). The area surrounding the hiking trail stretching from the parking lot in Baegundong (562 m) to Chilbulbong (1,433 m) and to Sangwangbong (1,430 m) was selected as the study site.

The Daegu Arboretum is located at 284, Daegok-dong, Dalseo-gu, Daegu and includes a surface area of approximately 247,596 m<sup>2</sup>. The mountain region located to the right of the site includes 3 peaks and is difficult to approach as a result of steep slopes. Connection to Apsan Mountain (659 m) and Daedeoksan Mountain (598 m) to the east creates a

gentle slope. The overall geography of the region includes mountainous terrain surrounding the east, west and the south of the site and residential area to the north, forming a U-shaped cliff region.

### Study on plants and season

**Measuring temperature:** The automatic weather system installed by the Korea National Parks Authority was used as the temperature document of the Gayasan Mountain and Juwangsang Mountain region, and the data by the Daegu Arboretum was gathered by taking measurements every hour at 0.1°C increment with an equipment installed by this study (Model name: STL-STH). From the documents, daily maximum temperature, daily mean temperature, year day index (YDI; Yim, 1983) of daily minimum temperature of over 0°C and Nuttonson's index (Tn, Lieth *et al.*, 1974; Yim and Cho, 1977) of temperature exceeding 5°C, and Lindsey & Newman's Index (TI, Lindsey and Newman, 1956), which proposes a method of calculating warmth using the relationship between daily minimum temperature and meteorological threshold value, were calculated.

$$YDI = \sum_{n_r} (t > 0^\circ\text{C})$$

t: daily mean temperature

n: number of days over 0°C

$$Tn = \sum_n (t - 5)(t > 5^\circ\text{C})$$

t: daily mean temperature

n: number of days over 5°C

$$TI = 24(w - t) + \frac{24(h - w)}{2} \quad (t \leq w)$$

$$= \frac{12(h - t)^2}{h - w} \quad (t > w)$$

h: daily maximum temperature (°F)

w: daily minimum temperature (°F)

t: meteorological threshold value

Of the calculated YDI, the daily maximum temperature YDI was noted as Ymax, the daily mean temperature YDI as Ym and the daily minimum temperature YDI as Ymin, and the daily maximum temperature Tn of the calculated Tn was noted as Tmax, the daily mean temperature Tn as Tm, and the daily minimum temperature Tn as Tmin.

**Study subject selection and study of plant phenology:** 5 species of the pine (*Pinus densiflora* S.etZ.), Manshurian full moon maple (*Acer pseudo sieboldianum* (Pax) Kom.), ginger plant (*Lindera obtusiloba* BL.), Korean rosebay (*Rhododendron mucronulatum* Turcz. var. *mucronulatum*) and the Korean azalea (*Rhododendron yedoense* ar.

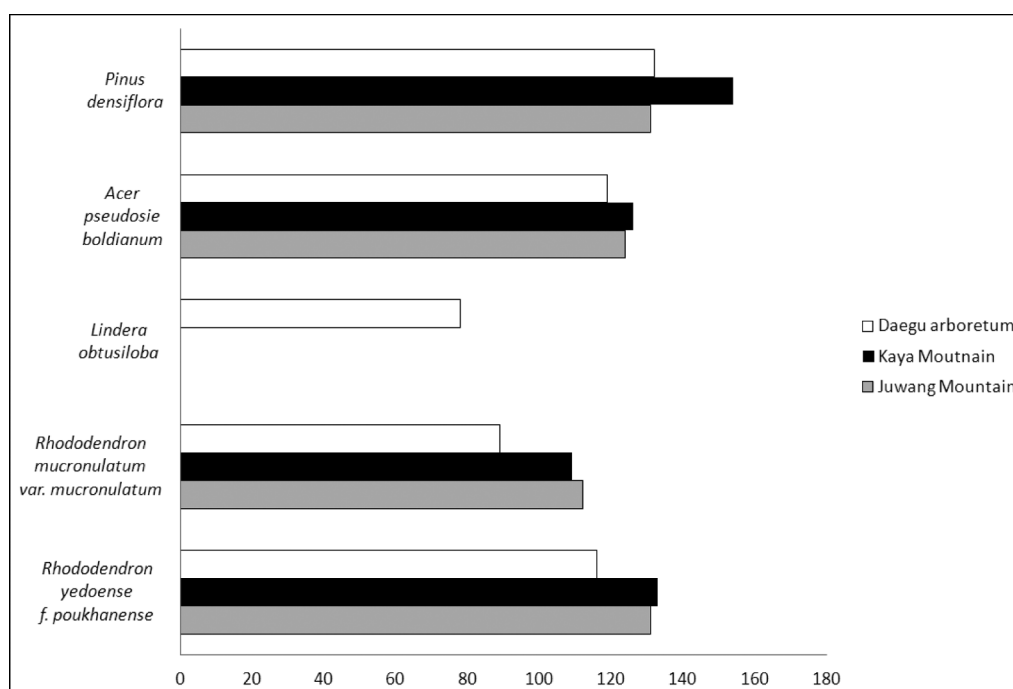


Fig. 2. The year day of 5 species at each site in 2010.

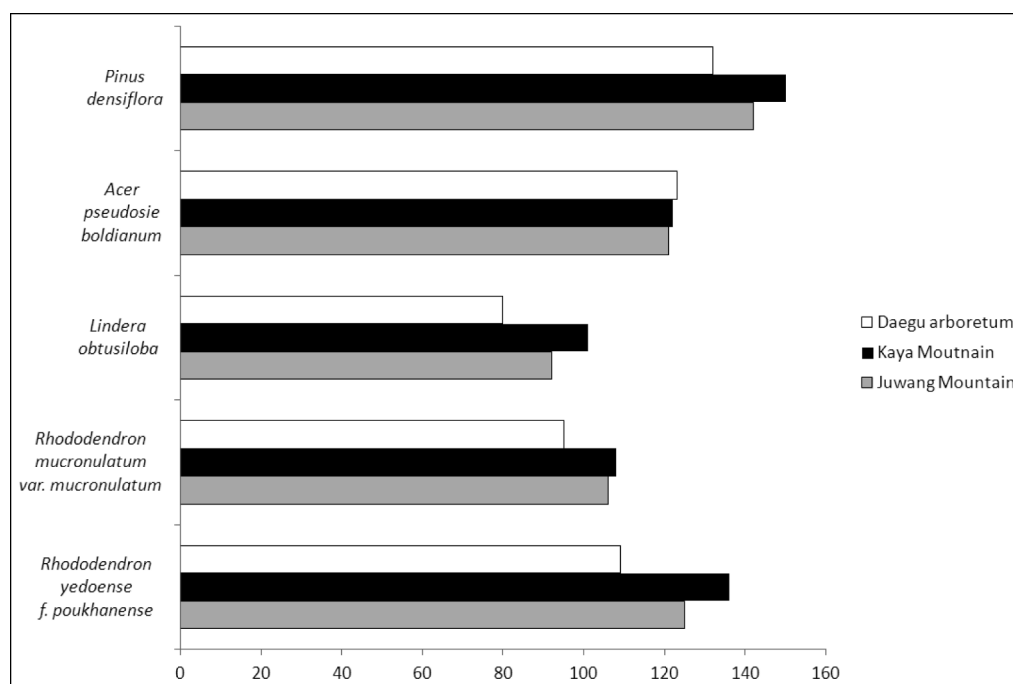


Fig. 3. The year day of 5 species at each site in 2011.

*poukhanense* (Lev.) Nakai) were selected as the study subjects, based on their distinct seasonal traits and the fact that they are plant species living in the study site recorded in the Manual of Preservation of Mountain Plant Species Vulnerable to Climate Changes (Korea Forest Service Korea National Arboretum, 2009). Furthermore, in order to assess the quantitatively accurate flowering period, healthy branches of individual study subject trees were selected and

marked before examining the flowering period (plant phenology index) of the branches. The study was conducted once a week, between March 3<sup>rd</sup> of 2010 and year 2011, and the beginning of the flowering period was set as the time in which flowering was first observed in at least 3 locations, even if not full bloom.

**Statistical analysis:** The 5 same species of the Daegu

Arboretum, Gayasan Mountain and Juwangsang Mountain were selected using data of plants studied in order to examine their flowering period in 2010 and 2011. The year day (YD) and year day index (YDI), alongside the Nuttonson's index (Tn) and the Lindsey & Newman's index (Tl) of the first flowering day were compared. Furthermore, correlation between flowering period and YDI and between Tn and Tl of 4 species excluding the ginger plant (*Lindera obtusiloba* BL.), which had in sufficient data, were analyzed in order to exam in which temperature analysis has significant correlation with the flowering period.

## Results and Discussion

### Changes in the yearly and regional flowering period of study subject species

The YDI until the first day of flowering, Tn and Tl of species studied from January 1<sup>st</sup> of 2010 and 2011 were calculated (Table 1).

Based on the data collected, calculation of the YDI of first day of flowering for individual plant species in years 2010 and 2011 both showed that the ginger plant (*Lindera obtusiloba* BL.), which has low YDI and Tn values, under went flowering first, and the pine (*Pinus densiflora* S.etZ.) flowered the latest, between mid-May and early-June. However, in the 2010 data, ginger plant (*Lindera obtusiloba* BL.) of Gayasan Mountain and Juwangsang Mountain was already undergoing flowering when the study was starting and therefore, such data were excluded from the study.

Species which underwent flowering earlier in 2010 than in 2011 in the Daegu Arboretum included the Manshurian full moon maple (*Acer pseudo sieboldianum* (Pax) Kom.), ginger plant (*Lindera obtusiloba* BL.) and the Korean rose bay (*Rhododendron mucronulatum* Turcz. var. *mucronulatum*), which were 4days, 2days and 6days earlier, respectively. In Gayasan Mountain, with the exception of the ginger plant (*Lindera obtusiloba* BL.) data which were included in the 2010 data, all species began flowering earlier in 2011. In Juwangsang Mountain, only the pine (*Pinus densiflora*

**Table 1.** YDI, Tn, Tl value at each site

Year	Species	Site	Anthesis		Year day index			Nuttonson's index(Tn)			Lindsey & Newman's Index
			Date	Year day	Average	Max	Min	Average	Max	Min	
2010	<i>Pinus densiflora</i>	Daegu arboretum	5. 12	132	730.6	1378.1	303.1	339.6	816.2	90.9	8148.9
		Mt. Kaya	6. 3	154	894.7	1438.6	531.0	448.1	859.2	225.6	12581.6
		Mt. Juwang	5. 11	131	489.3	973.6	162.8	200.9	537.1	39.3	6541.3
	<i>Acer pseudosieboldianum</i>	Daegu arboretum	4. 29	119	514.2	1061.6	189.9	188.2	564.7	38.5	4604.1
		Mt. Kaya	5. 6	126	484.8	907.9	228.2	178.3	468.5	62.7	6063.9
		Mt. Juwang	5. 4	124	374.6	809.7	100.6	121.2	408.3	12.1	4699.7
	<i>Lindera obtusiloba</i>	Daegu arboretum	3. 19	78	165.1	469.2	59.2	37.7	177.3	7.6	764.0
		Mt. Kaya	-	-	-	-	-	-	-	-	-
		Mt. Juwang	-	-	-	-	-	-	-	-	-
	<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	Daegu arboretum	3. 30	89	234.2	603.1	76.3	56.5	256.2	11.7	1332.2
		Mt. Kaya	4. 19	109	304.8	636.0	118.7	80.3	301.6	19.1	3532.2
		Mt. Juwang	4. 22	112	265.8	630.4	69.1	120.9	389.0	8.1	3559.2
	<i>Rhododendron yedoense</i> f. <i>poukhanense</i>	Daegu arboretum	4. 26	116	485.2	1019.9	175.7	174.2	538.0	35.6	4294.4
		Mt. Kaya	5. 13	133	592.2	1050.1	302.0	250.7	575.7	101.5	7784.9
		Mt. Juwang	5. 11	131	489.3	973.6	162.8	200.9	537.1	39.3	6541.3
2011	<i>Pinus densiflora</i>	Daegu arboretum	5. 12	132	758.3	1564.7	253.5	385.7	1031.5	86.8	9924.9
		Mt. Kaya	5. 30	150	877.5	1713.4	386.7	474.0	1120.0	152.1	12371.9
		Mt. Juwang	5. 22	142	725.2	1469.7	267.9	370.4	933.4	96.4	9318.1
	<i>Acer pseudosieboldianum</i>	Daegu arboretum	5. 3	123	602.5	1339.4	162.5	274.9	856.2	40.8	7249.3
		Mt. Kaya	5. 2	122	444.1	1092.4	127.1	180.5	639.0	24.4	5281.3
		Mt. Juwang	5. 1	121	399.4	993.7	94.9	149.6	562.4	22.1	4139.4
	<i>Lindera obtusiloba</i>	Daegu arboretum	3. 22	80	151.6	541.5	26.2	28.5	263.3	0.5	1097.0
		Mt. Kaya	4. 11	101	219.3	722.8	39.9	60.7	374.4	3.5	2347.9
		Mt. Juwang	4. 2	92	124.3	523.4	6.5	17.3	237.1	0.0	967.1
	<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	Daegu arboretum	4. 5	95	245.2	749.0	31.7	57.6	400.8	0.5	2023.4
		Mt. Kaya	4. 18	108	297.0	862.5	61.1	103.5	479.1	6.8	3437.7
		Mt. Juwang	4. 16	106	249.7	755.2	29.8	75.0	398.9	3.0	2327.4
	<i>Rhododendron yedoense</i> f. <i>poukhanense</i>	Daegu arboretum	4. 19	109	416.3	1051.0	80.5	158.7	632.8	12.0	4528.4
		Mt. Kaya	5. 16	136	631.9	1102.9	328.5	275.3	613.5	113.0	5897.4
		Mt. Juwang	5. 5	125	456.3	1076.1	125.7	186.5	624.8	34.3	5000.7

S.etZ.) began flowering earlier 2010, at 11 days earlier.

On the other hand, the flowering period by research area was observed to be generally later in Gayasan Mountain, and this is because, while the study site is located to the south, it experiences a relatively low temperature as a result of high altitude.

### Correlation analysis of study subject species and YDI (year day index), Tn (Nuttonson's index) and T1 (Lindsey & Newman's index)

Analysis of correlation between flowering period and YDI, Tn and T1 of same tree species showed that, there was no statistically significant correlation between Ymax (daily maximum temperature YDI) and flowering period and, between Tmax (daily maximum temperature Tn) and flowering period in all the species. In other words, variables which were calculated based on the daily maximum temperature did not affect changes in the flowering period.

Correlation analysis between Ymin (daily minimum temperature YDI) and flowering period and, between Ymin (daily minimum temperature YDI) and flowering period displayed statistically significant correlation in the pine

(*Pinus densiflora* S.etZ.) (coefficient of correlation 0.872,  $P=0.023$ ) and the Korean azalea (*Rhododendron yedoense* var. *poukhanense* (Lev.) Nakai (coefficient of correlation 0.822,  $P=0.045$ ), but not in other plant species. It is assessed that there is a need to examine which changes occur in future correlation analysis based on the accumulation of future annual temperature. In the case of YDI (year day index), daily minimum temperature and daily mean temperature were found to influence plants more than daily maximum temperature, and this will enable future comparative studies for the determination of which factors affect plants and temperature in different regions.

Results of the correlation analysis between Tmin (daily minimum temperature Tn) and flowering period and between Tm (daily mean temperature Tn) and flowering period displayed strong correlation in the pine (*Pinus densiflora* S.etZ.) (coefficient of correlation 0.911,  $P=0.012$ ). Korean azalea (*Rhododendron yedoense* var. *poukhanense* (Lev.) Nakai) (coefficient of correlation 0.820,  $P=0.045$ ) and the Korean azalea (*Rhododendron yedoense* var. *poukhanense* (Lev.) Nakai) (coefficient of correlation 0.884,  $P=0.020$ ). Korean rose bay (*Rhododendron*

**Table 2.** Correlation between Ymax and Anthesis for 4 species

Species	Anthesis		Ymax		Pearson's Correlation	P-value
	Mean	SD	Mean	SD		
<i>Pinus densiflora</i>	5.10(140.17)	10.088	1423	249.3	0.516	0.295
<i>Acer pseudosieboldianum</i>	4.28(117.5)	14.068	1034.1	181.8	-0.118	0.823
<i>Rhododendron yedoense</i> for. <i>poukhanense</i>	5.5(125)	10.564	1045.6	45	0.160	0.763
<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	4.13(103.17)	9.065	706	100	0.204	0.698

**Table 3.** Correlation between Ymin and Anthesis for 4 species

Species	Anthesis		Ymin		Pearson's Correlation	P-value
	Mean	SD	Mean	SD		
<i>Pinus densiflora</i>	5.10(140.17)	10.088	317.5	127.3	0.872*	0.023
<i>Acer pseudosieboldianum</i>	4.28(117.5)	14.068	150.5	52.7	-0.276	0.597
<i>Rhododendron yedoense</i> for. <i>poukhanense</i>	5.5(125)	10.564	195.9	98.6	0.795	0.059
<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	4.13(103.17)	9.065	64.5	32.8	0.230	0.661

**Table 4.** Correlation between Ym and Anthesis for 4 species

Species	Anthesis		Ym		Pearson's Correlation	P-value
	Mean	SD	Mean	SD		
<i>Pinus densiflora</i>	5.10(140.17)	10.088	745.9	145.7	0.774	0.071
<i>Acer pseudosieboldianum</i>	4.28(117.5)	14.068	469.9	83	-0.238	0.650
<i>Rhododendron yedoense</i> for. <i>poukhanense</i>	5.5(125)	10.564	511.9	82.8	0.822*	0.045
<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	4.13(103.17)	9.065	266.1	28.9	0.724	0.104

**Table 5.** Correlation between Tmax and Anthesis for 4 species

Species	Anthesis		Tmax		Pearson's Correlation	P-value
	Mean	SD	Mean	SD		
<i>Pinus densiflora</i>	5.10(140.17)	10.088	882.9	202.7	0.450	0.371
<i>Acer pseudosieboldianum</i>	4.28(117.5)	14.068	583.2	156.3	0.009	0.987
<i>Rhododendron yedoense</i> f. <i>poukhanense</i>	5.5(125)	10.564	587	43	-0.172	0.745
<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	4.13(103.17)	9.065	370.9	79.6	0.482	0.333

**Table 6.** Correlation between Tmin and Anthesis for 4 species

Species	Anthesis		Tmin		Pearson's Correlation	P-value
	Mean	SD	Mean	SD		
<i>Pinus densiflora</i>	5.10(140.17)	10.088	115.2	64.9	0.911*	0.012
<i>Acer pseudosieboldianum</i>	4.28(117.5)	14.068	33.4	17.9	-0.059	0.912
<i>Rhododendron yedoense</i> f. <i>poukhanense</i>	5.5(125)	10.564	56	41	0.820*	0.045
<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	4.13(103.17)	9.065	8.2	6.6	0.182	0.731

**Table 7.** Correlation between Tm and Anthesis for 4 species

Species	Anthesis		Tm		Pearson's Correlation	P-value
	Mean	SD	Mean	SD		
<i>Pinus densiflora</i>	5.10(140.17)	10.088	369.8	96.6	0.774	0.071
<i>Acer pseudosieboldianum</i>	4.28(117.5)	14.068	182.1	51.8	-0.058	0.913
<i>Rhododendron yedoense</i> for. <i>poukhanense</i>	5.5(125)	10.564	207.7	45.7	0.884*	0.020
<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	4.13(103.17)	9.065	82.3	25.6	0.844*	0.035

**Table 8.** Correlation between Tl and Anthesis for 4 species

Species	Anthesis		Tl		Pearson's Correlation	P-value
	Mean	SD	Mean	SD		
<i>Pinus densiflora</i>	5.10(140.17)	10.088	9814.5	2364.1	0.882*	0.020
<i>Acer pseudosieboldianum</i>	4.28(117.5)	14.068	5339.6	1145.9	0.360	0.484
<i>Rhododendron yedoense</i> for. <i>poukhanense</i>	5.5(125)	10.564	5674.5	1336.2	0.789*	0.048
<i>Rhododendron mucronulatum</i> var. <i>mucronulatum</i>	4.13(103.17)	9.065	2702	942.6	0.933**	0.007

*mucronulatum* Turcz. var. *mucronulatum*) (coefficient of correlation=0.844, P=0.035). While this signifies that Tmin and Tm may become variables more influential in explaining the changes of the flowering period on individual plant species, since not a high level of data was used for the analysis, there is a need for continuous monitoring of flowering period and temperature in order to more accurately examine the relationship.

Results of the correlation analysis between Tl and flowering period displayed correlation in the pine (*Pinus densiflora* S.etZ.) (0.882, P=0.02), Korean azalea (*Rhododendron yedoense* var. *poukhanense* (Lev.) Nakai) (0.789, P=0.048) and the Korean rosebay (*Rhododendron mucronulatum* Turcz. var. *mucronulatum*) (0.933, P=0.007). This signifies that it may be the most appropriate variable to explain the temperature variable calculated by Lindsey and Newman (1956), based on the relationship between daily minimum temperature and meteorological threshold value. It is assessed that further data collected through continuous monitoring may lead to better results.

The results of this study shows that Tn (Nuttonson's index) and Tl (Lindsey & Newman's Index) are more closely related to flowering period than YDI (year day index). Therefore, there must be continuous studies on the correlation between the variables and other plants and on whether there are regional differences in temperature index and flowering duration.

Furthermore, the study also observed that, while plants which undergo flowering during the spring season generally

show positive correlation with temperature, the Manchurian full moon maple (*Acer pseudo sieboldianum* (Pax) Kom.) shows no correlation. Continuous research is needed to explain such finding. This study assesses that statistical data gathered through continuous studies, based on future data, must be computed and that there is a need for mutual correlation studies based on the examination of flowering period and flowering duration of various plant species.

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## References

- Brown, D. S. (1953) Climate in relation to deciduous fruit production in California. VI. The apparent efficiencies of different temperatures for the development of apricot fruit. Proceedings of the American Society for Horticultural Science. 62:173-183. (in English)
- Grainger, J. (1939) Studies upon the time of flowering of plants, anatomical, floristic and phenological aspects of the problem. Annals of Applied Biology. 26:685-702. (in English)
- Huberman, M. A. (1941) Why Phenology? Journal of Forestry. 39:1007-1013. (in English)
- Korea National Arboretum. (2009) Manual of Conservation Project of Threatened Plants for Climate Change. 11-45. (in English)
- Lee, W. T., Y. J. Yim (1978) Studies on the distribution of

- Vascular plants in the Korean Peninsula. Korean journal of plant taxonomy 8(Appendix):1-33.
- Lieth, H. (1974) Phenology and seasonality modeling. Springer-Verlag, Berlin, Heidelberg, New York. 444p. (in English)
- Lindsey, A. A. and J. E. Newman. (1956) Use of official weather data in springtime temperature analysis of an Indiana phenological record. 37:812-823. (in English)
- Nuttson, M. Y. (1948) Some preliminary observations of phenological data as a tool in the study of photoperiodic and thermal requirements of various plant material, "Vernalization and Photoperiodism", *Chronica Botanica*, Waltham. Mass: 129-143. (in English)
- Yim, Y. J. and T. Kira. (1975) Distribution of forest vegetation and climate in the Korean Peninsula I. Distribution of forest vegetation in relation to thermal climate. *Jap. J. Ecology* 27:267-278. (in English)
- Yim, Y. J. (1977) Distribution of forest vegetation and climate in Korean Peninsula IV Zonal distribution of forest vegetation in relation to thermal climate. *Jap. J. Ecol.* 27:269-278. (in English)
- Yim, Y. J., M. Y. Cho. (1977) On the Flowering Dates of the Woody Plant Species in the Hongneung Arboretum, Seoul. *Journal of ecology and field biology.* 1:17-23.
- Yim, Y. J., M. K. Rim and J. K. Shim. (1983) The Thermal Climate and Phenology in Korea. *Korean Journal of Botany.* 26(2):101-117.
- Yim, Y. J. (1987) The Effects of Thermal Climate on the Flowering Dates of Plants in South Korea. *The Korean journal of apiculture.* 2(1):9-28.

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