

Research article

Phenology and Morphometric Parameters of *Spiraea cantoniensis* Lour. as Indicators of Climate Change in Urban Ecosystems



Mirjana Ocokoljić¹, Jelena Čukanović^{2*}, Nevenka Galečić¹, Ivana Sentić², Radenka Kolarov², Sara Đorđević², Djurdja Petrov¹



¹University of Belgrade - Faculty of Forestry, Kneza Visaslava 1, Belgrade 11000, Serbia

²University of Novi Sad - Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia

*Corresponding author: jelena.cukanovic@polj.uns.ac.rs

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ABSTRACT

The identification of phenological patterns and morphological changes in *Spiraea cantoniensis* Lour. in urban ecosystems is essential for the optimal selection of taxa. Given that changes in vegetation dynamics are strongly associated with variability in climatic patterns, this study employed the extended BBCH scale, accumulated heat sums, and circular statistical methods to analyse phenological patterns, together with morphometric analyses of inflorescences, flowers, and fruits. The results indicate that extreme climatic events influenced the flowering and fruiting phenophases, with the accumulated heat sums emerging as a more significant predictor than the day of the year. In this research, the year factor affected the occurrence of secondary and tertiary flowering at the end of May and at the end of July 2024. It is noteworthy that in urban landscape phenology, *Spiraea cantoniensis* exerts a dominant influence at the beginning of April, while from mid-April *Spiraea × vanhouttei* (Briot) Carrière assumes dominance within the same composition. For the first time, this study defines the diameters of inflorescences, the number of flowers per inflorescence, the occurrence of flowers with six petals (38%), the diameters of individual fruits, the number of fruits per infructescence, and the number of seeds per fruit. Our study confirms that the phenological and morphological changes of *Spiraea cantoniensis* are influenced by the year factor, i.e. climatic conditions, and highlights the need for continued research in the coming years. Monitoring and documenting the phenological and morphological characteristics of *Spiraea cantoniensis* are essential for assessing the impacts of climate change on its ecological functioning and the potential risks to the sustainable development of urban ecosystems, as well as for evaluating its potential as an indicator of climate change.

Key words:

Reeve's *spiraea*, shrubs, functional traits, environmental stress, green areas

Citation:

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INTRODUCTION

Climate change, particularly changes in air temperature and precipitation, affects shifts in the phenological patterns and morphometric characteristics of woody plants (Caparros-Santiago et al., 2021; Ocokoljić et al., 2023a; Čukanović et al., 2025). Although plant responses to climate change represent a global phenomenon, the most evident changes in recent decades have been observed in the boreal and temperate regions of the Northern Hemisphere (Gao et al., 2020; Huang et al., 2020; WMO, 2024). Woody species are the most prevalent plants in

natural, semi-natural and urban ecosystems ([Mitrović et al., 2024](#)), and they have the capacity to regulate climatic variables, stabilise soil, and ensure carbon absorption and storage ([Galečić et al., 2026](#)). Numerous studies have been conducted to mitigate urban microclimatic conditions, in which trees and shrubs represent essential components of landscape design and require particular attention in order to create functional, sustainable and aesthetically valuable urban ecosystems ([Dessi, 2010](#); [Toma & Zaharia, 2014a](#)). However, studies addressing the responses of urban ornamental shrubs remain limited, although it is well established that climatic variables influence plant development and that the selection of ornamental species is crucial for achieving the full capacity of ecosystem services ([Fitchett et al., 2015](#); [Petrov and Ocokoljić, 2023](#)). From an ornamental perspective, shrub species are characterised by diverse traits, including growth patterns and structural textures that reduce transpiration, leaf characteristics, flower and fruit morphology, and their phenological patterns, which contribute to landscape diversity and enhance the aesthetic quality of urban ecosystems ([Read and Bavougian, 2014](#); [Götmark et al., 2016](#); [Francini et al., 2022](#); [Galečić et al., 2025](#)). In this context, the study analyses *Spiraea cantoniensis* Lour. (*S. cantoniensis*) as an introduced shrub species under the complex influence of climatic factors, with the aim of establishing a rational basis for its selection and more efficient application in the phyto-optimisation of urban ecosystems. Given the above, and considering the global deficit of phenological and morphological studies on *S. cantoniensis*, the principal objective is, for the first time through long-term research, to determine the morphological and phenological responses of Reeve's spiraea in urban parks as elements of green infrastructure. Furthermore, the purpose of the study is to optimise cultivation conditions in urban ecosystems under a moderately continental climate with hot summers, no pronounced dry season, and minimum precipitation during the winter half of the year, by predicting the sustainability of morphometric traits and phenological patterns as potential indicators of climate change.

MATERIAL AND METHODS

On the Balkan Peninsula, *Spiraea cantoniensis* Lour., native to southeastern China, has been recorded in the municipality of Savski Venac, Belgrade, Serbia ([Flora of China Editorial Committee, 2017](#)). As an introduced and naturalised species, it is distributed across both hemispheres, including Brazil, Bulgaria, Guatemala, Japan, Korea, Nepal, New Zealand, Pakistan, Portugal, the United States of America, Spain and Trinidad and Tobago ([POWO, 2026](#)). The analysed Reeve's spiraea forms part of a cascade-designed composition in the urban park "Lep izgled", situated in front of the Skyline mixed-use residential and commercial complex within the Sava amphitheatre, approximately 710 m from the right bank of the River Sava ([Figure 1](#)). The specimen is georeferenced at 44°47'54.94"N and 20°27'00.54"E, at an altitude of 81 m above sea level, on gently inclined terrain (4.2° slope) with western (W) exposure and anthropogenised Haplic Fluvisol soil ([Škorić et al., 1985](#)).



Figure 1. Study area: (a) location of the "Lep izgled" park and the position of Reeve's spiraea in Belgrade; (b) habitus of *Spiraea cantoniensis* Lour. at phenophase 65 BBCH, against the background of *Cedrus deodara* (Roxb. ex D. Don) G. Don and the Skyline Tower within the urban ecosystem

During field investigations, 30 inflorescences (at full flowering stage) and 30 infructescences (at full maturity) were collected from the southern part of the crown. In autumn 2024, radical and untimely pruning was recorded *in situ*.

Consequently, only a comparative analysis of the morphometric characteristics of flowers and inflorescences was performed for 2023 and 2024, as climatically contrasting years, while 2025 was excluded because any differences could not have been attributed solely to climatic variables due to the inability to eliminate the effect of pruning. For the same reason, the morphometric analysis of fruits was conducted only for fruits matured in 2023. On fresh material, the number of flowers per inflorescence, the number of petals, the number of fruits per infructescence, and the number of seeds per fruit were determined. The material was subsequently herbarised and measured using the UTHSCSA Image Tool software to determine inflorescence diameter, individual flower diameter, and individual fruit diameter. Seed germination was assessed according to [Varsamis et al. \(2025\)](#) in early spring, using the method of moist stratification on filter paper, kept in darkness for 60 days. The seeds were stored prior to the experiment under controlled laboratory conditions at $20\pm 2^{\circ}\text{C}$, with a relative air humidity of 40–50%, and under light–dark cycles. ([Varsamis et al., 2025](#)).

Phenological data were obtained through daily *in situ* monitoring during the period 2023–2025. Observations were conducted using the extended BBCH scale ([Meier, 1997](#)) for the following stages: beginning of flowering – 61 (more than 10% of flowers had opened), full flowering – 65 (more than 50% of flowers had opened), end of flowering – 69 (more than 80% of flowers had faded), repeated flowering – 61/2 and 61/3 (the initial flowering phase recurred), and fruit ripening – 89 (fruits were fully mature). Recorded dates were converted into days of the year (DOY), with DOY 1 corresponding to 1 January. Growing degree days (GDD) were calculated following the method of [Lalić et al. \(2021\)](#), separately for each research year, based on hourly and daily climatological data obtained from the [Republic Hydrometeorological Service of Serbia \(RHMZ\)](#) from the Main Meteorological Station (MMS) Surčin (φ 44°47'54.44"N; λ 20°27'53.35"E). Percentile and tercile statistical methods were applied to air temperature and precipitation data, where the n-th percentile represents the value below which n percent of the data, previously arranged in ascending order, fall ([RHMZ](#)).

The study employed descriptive statistics, the analysis of variance (ANOVA), Tukey's HSD, least squares (LS) means, and Spearman rank tests. Circular statistical analysis ([Morellato et al., 2010](#)) was also applied to determine seasonality, with the Rayleigh test used to assess its significance. Seasonality was examined by comparing elements of flowering phenophases for the period 2023–2025 for *S. cantoniensis* and *Spiraea* $\times$ *vanhouttei* (Briot) Carrière. Circular statistical analysis and the non-parametric Watson–Williams test were used for data processing, implemented in the software packages XLSTAT 2022, PAST 4.11, and BioEstat 5.3. Google Earth Pro and the authors' photographs were also utilised in the study.

RESULTS AND DISCUSSION

Variability of Morphological Traits in Reeve's *Spiraea*

A comparative analysis of morphometric parameters revealed mean values of inflorescence diameter (3.915 cm), number of flowers per inflorescence (22.35), individual flower diameter (1.115 cm), and number of petals (5.4). Our observations are consistent with the [Flora of China Editorial Committee \(2003\)](#), which reports that the flowers are hermaphroditic, with individual flowers approximately 1 cm in diameter, but they differ from the [Flora of China Editorial Committee \(2017\)](#), which cites diameters of 5–7 mm. Furthermore, whereas both literature sources indicate that flowers have five petals, this study found that 38% of flowers had six petals and 62% had five petals over the course of the research years. According to the authors' knowledge, these are the first recorded measurements of inflorescence diameters and the number of flowers per inflorescence, which warranted detailed statistical analyses of the investigated parameters.

Low variability between research years is indicated by the small standard deviation values for three parameters (0.423, 0.169, and 0.503), except for the number of flowers per inflorescence, which showed a standard deviation of 5.284. Nevertheless, statistical significance between years was confirmed by ANOVA ($F = 5.175$, $p = 0.035$). Based on the ANOVA results presented in [Table 1](#), the Tukey HSD test results are shown, highlighting variations in the measured parameters depending on the year of study.

Table 1. Comparison of categories using Tukey's HSD test (95% CI) for inflorescence and flower parameters recorded in 2023 and 2024 at "Lep izgled" Park, Belgrade ($p < 0.05$)

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant	Lower bound (95%)	Upper bound (95%)	Lower bound (95%)	Upper bound (95%)
Inflorescence diameter (cm)									
2 vs 1*	0.390	2.275	2.101	0.035	Yes	0.030	0.750		
Number of flowers per inflorescence									

2 vs 1*	9.500	10.121	2.101	0.0001	Yes	7.528	11.472	
Individual flower diameter (cm)								
1 vs 2*	0.250	4.913	2.101	0.000	Yes	0.143	0.357	
Number of petals per flower								
2 vs 1*	0.200	0.885	2.101	0.388	No	-0.275	0.675	
Legend: *1 (2023) and 2 (2024) represent the sampling years								

Different patterns of homogeneous groups between the sampling years were revealed by the Tukey test for inflorescence diameter, number of flowers per inflorescence, and individual flower diameter; nevertheless, the between-year differences were statistically significant (95% confidence interval). For the number of petals per flower, the difference between years was not statistically significant. To further assess the effect of the sampling year and the differences identified in the previous tests, the LS means (least squares means) test was applied. LS means estimate average values under the assumption of balanced data and indicate the significance of the responses of the analysed parameters (Figure 2).

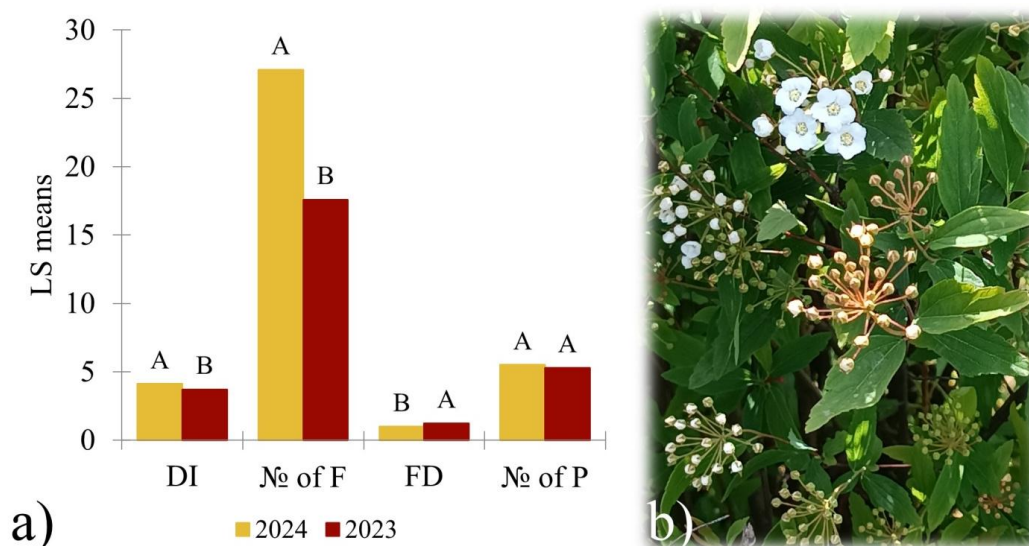


Figure 2. Visual presentation of LS means: a) by research years: DI – inflorescence diameter (cm), No of F – number of flowers per inflorescence, FD – diameter of an individual flower (cm), and No of P – number of petals per flower; and b) first open flowers of Reeve's spiraea (60 BBCH) in Belgrade

According to the LS means results, statistically significant differences between the study years were confirmed for three parameters; however, no significant differences were observed for the number of petals in the analysed genotype. The observed variability patterns may serve as a starting point for developing strategies aligned with climate change projections, given the evident differences associated with the year factor, as the years differed in climatic conditions (Table 2).

Table 2. Climatic variables, according to data from the Surčin Meteorological Monitoring Station (MMS Surčin), for the reference period (1991–2020), 2024, and the 2023–2025 period during which the research was conducted in “Lep izgled” Park in Belgrade

Mean air temperatures (°C)													
Months	1	2	3	4	5	6	7	8	9	10	11	12	$\bar{x}$
Period/Year													
1991/2020	1.0	3.0	7.5	12.9	17.6	21.4	23.3	23.2	18.0	12.8	7.4	2.2	12.5
2023/2025	4.0	5.5	10.4	13.4	17.1	23.4	25.3	25.0	20.9	14.6	7.6	4.3	14.3
2024	2.9	10.1	11.6	15.7	18.6	24.7	26.8	27.4	19.9	14.4	5.7	3.2	15.1
Mean maximum air temperatures (°C)													
1991/2020	4.5	7.4	12.9	18.4	23.2	26.9	29.0	29.3	24.1	18.5	11.9	5.5	17.6

2023/2025	7.9	10.6	16.1	18.8	22.4	28.7	31.4	31.4	27.1	20.2	12.1	7.7	19.5
2024	7.1	15.5	17.2	21.6	23.7	29.9	32.2	33.6	25.9	20.3	10.4	5.9	20.3
Mean minimum air temperatures (°C)													
1991/2020	-2.3	-1.0	2.6	7.1	11.8	15.4	16.8	16.9	12.6	7.9	3.6	-0.9	7.5
2023/2025	0.6	1.2	5.1	7.8	11.8	16.9	18.8	18.0	15.1	9.5	3.6	1.3	9.1
2024	-0.8	5.2	6.3	9.3	13.6	18.4	20.1	19.8	14.1	9.3	1.4	0.7	9.8
Mean monthly and annual relative air humidity (%)													
1991/2020	85.0	78.0	68.8	64.9	66.2	66.4	63.1	62.5	68.8	74.6	79.9	85.3	72.0
2023/2025	81.4	67.1	64.1	63.8	67.6	59.7	56.0	53.3	60.0	67.0	78.8	83.0	66.8
2024	78.2	62.8	62.6	55.7	64.8	59.2	52.3	45.4	60.0	68.3	78.3	86.3	64.5
Total and mean precipitation amounts (mm)													
1991/2020	42.4	34.0	41.7	47.4	68.1	80.1	58.2	54.0	56.0	50.7	45.5	48.3	626.4
2023/2025	41.7	22.6	40.6	44.5	85.2	62.5	59.9	28.5	56.8	44.7	67.0	36.8	590.8
2024	37.1	4.8	27.7	23.3	99.8	92.5	69.4	6.5	86.8	44.0	45.6	63.2	600.7

Comparative analysis also highlights the mean values of individual fruit diameter (2.4 mm), number of fruits per infructescence (20.20), and number of seeds per fruit (3.6). The relevance of these values is reflected in the results of the descriptive statistics (Table 3), while the significance of this research is supported only by general statements in previous studies by [Gilman \(1999\)](#): “Fruit shape: unknown; Fruit length: less than 1.27 cm; fruits inconspicuous and not showy,” and [PlantFinder \(2026\)](#): “The fruit is a poly-follicle, with 3–5 plurisemined carpodia.”

Table 3. Descriptive statistics for the morphometric characteristics of fruits: individual fruit diameter (FD), number of fruits per infructescence (№ of FR), and number of seeds per fruit (№ of S) of Reeve’s spiraea in Belgrade

Parameters	FD	№ of FR	№ of S
Min	2.000	15.000	1.000
Max	3.000	25.000	5.000
Sum	24.000	202.000	36.000
Mean	2.400	20.200	3.600
Std. error	0.163	0.998	0.542
Variance	0.240	8.960	2.640
Stand. dev	0.490	2.993	1.625
Median	2.000	20.000	4.500
Variation coefficient	0.204	0.148	0.451
Geom. mean	2.352	19.973	3.073

Phenology in an urban environment

The absolute differences between the earliest and latest DOY values within the phenological patterns were 13 days (BBCH 61), 16 (BBCH 65), 25 (BBCH 69), and 34 (BBCH 89) ([Figure 3a](#)). All key phenological stages occurred earliest in 2024, the globally warmest year ([RHMZ](#)), and latest in 2023. These were observed after the accumulation of heat sums ([Figure 3b](#)) as follows: 61 BBCH from 325.1°C (2023) to 417.4°C (2024), 65 BBCH from 366.9°C (2023) to 463.1°C (2024), 69 BBCH from 553.1°C (2025) to 650.3°C (2024), and 89 BBCH from 2820.1°C (2024) to 3393.5°C (2023). The results indicate that changes in the DOY of these phenophases do not influence heat accumulation, suggesting that flowering and fruiting take place within defined ranges of accumulated heat sums ([Figure 3b](#)). This is further supported by Spearman’s rank correlation coefficient (ρ) values for all investigated phenological elements, which were not statistically significant. The results indicate that in the study years, extreme climatic events influenced that for flowering and fruiting phenophases, the determining factor was not the day of the year (DOY) but the accumulated heat sums (GDD).

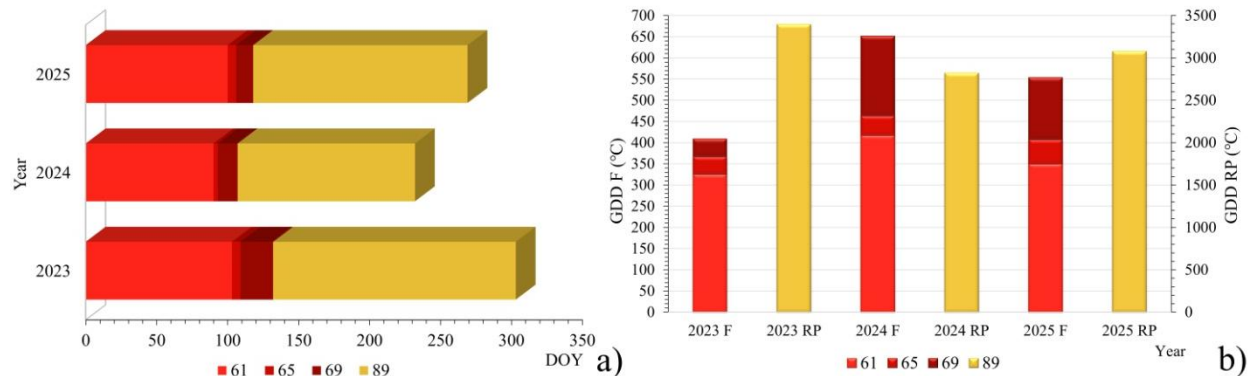


Figure 3. Phenological patterns of flowering and fruit ripening of Reeve's spiraea in Belgrade: a) DOY (day of the year, based on own research) and b) GDD (accumulated heat sums, based on data from MMS Surčin) for 61 BBCH (beginning of flowering), 65 BBCH (full flowering), 69 BBCH (end of flowering), and 89 BBCH (fully ripe fruits)

The flowering patterns in our study align with the observations from [iNaturalist \(2026\)](#) for the Northern Hemisphere, occurring between March and June ([Figure 3](#)). To the authors' knowledge, this is the first study examining the phenological patterns of Reeve's spiraea across consecutive years. Other sources report that Reeve's spiraea flowers in April–May ([Flora of China Editorial Committee, 2017](#); [POWO, 2026](#)) or simply “spring flowering with pleasant fragrance” ([Gilman, 1999](#)). Additionally, in 2024 in Belgrade, secondary and tertiary flowering was recorded at the 61 BBCH stage (61/2: DOY 152, GDD 1172.3°C; 61/3: DOY 206, GDD 2270.1°C). The [Flora of China Editorial Committee \(2017\)](#) and [iNaturalist \(2026\)](#) report these only as a second flowering from July to August or from August to November, without specifying the exact BBCH phase. The year factor in this study influenced the timing of secondary and tertiary flowering, beginning at the end of May and the end of July 2024, which can be explained by extreme climatic events ([Figure 4](#)). By early autumn 2024, air temperatures were significantly above the upper tercile ([Figures 4a, b, c, d](#)), while precipitation was below the lower tercile ([Figures 4b, d](#)), near normal ([Figure 4a](#)), or above the upper tercile ([Figure 4c](#)), leading to the earliest occurrence of all phenological elements. In contrast, the latest occurrences were in 2023, when by early autumn air temperatures were above the upper tercile ([Figure 4a](#)), above normal ([Figure 4d](#)), or below the lower tercile ([Figures 4b, c](#)), while precipitation ranged from normal ([Figure 4a](#)) to near the upper tercile ([Figures 4c, d](#)) or above the upper tercile ([Figure 4b](#)).

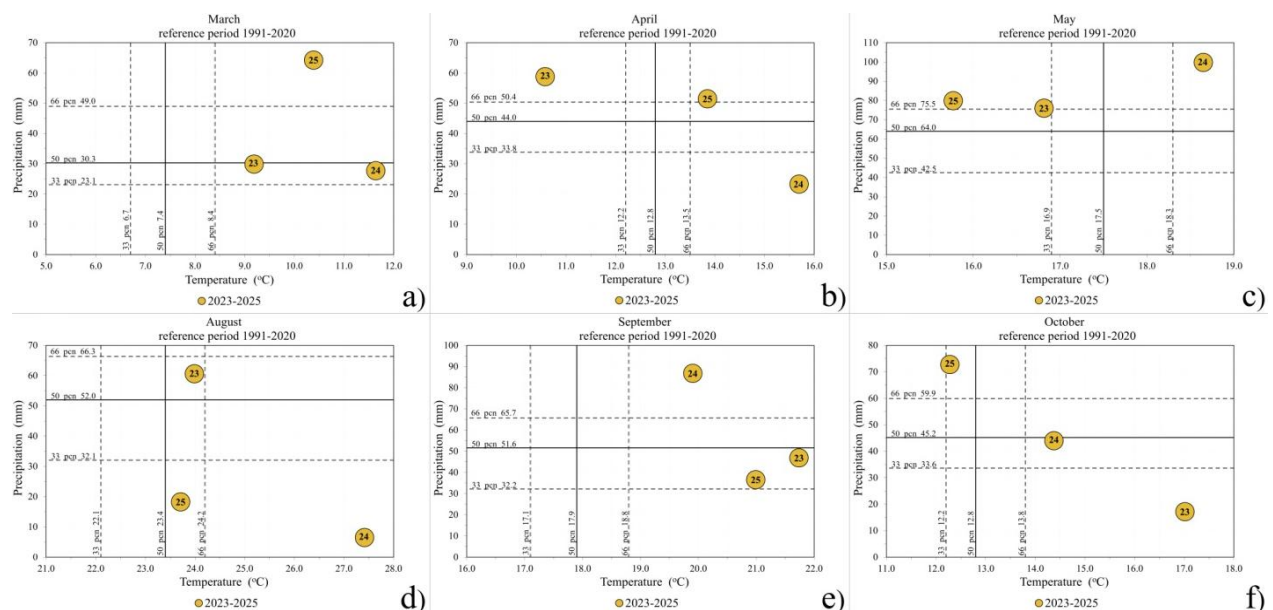


Figure 4. Mean monthly air temperatures and precipitation totals for 2023, 2024, and 2025 for the months of: a) March, b) April, c) May, d) August, e) September, and f) October, with corresponding terciles for the reference period (1991–2020), based on data from MMS Surčin in relation to the reference period (1991–2020)

Reeve's spiraea is most ornamental during the flowering phenophase, but it is also suitable for nature-based solutions that are important for ecosystem services negatively affected by accelerated urbanization (Ocokoljić et al., 2023b). Notably, climatic and anthropogenic pressures lead to the displacement of birds and other organisms, which in the food chain help control harmful insects or assist in pollination (Čukanović et al., 2024; Đurašinović et al., 2025). During the study, the presence of *Protaetia aeruginosa* L. and *Pyrrhocoris apterus* L. was recorded on the inflorescences (Figure 5a). In Poland, *P. aeruginosa* is a protected species included on the Red List of Threatened Species (VU – Vulnerable), indicating a high risk of becoming endangered in the wild. It typically occurs in open, sunny habitats within deciduous forests with mature trees, as well as in old shrub vegetation along rivers, roadsides, and in parks (Byk and Cieślak, 2011). It is listed in the same category in Bosnia and Herzegovina, while in Europe it appears on the IUCN list under NT – Near Threatened, meaning it is not currently endangered but could become so soon (Lelo and Kašić-Lelo, 2009). In this context, our record is significant because the species was observed in an urban park near a river and roads. The presence of *P. apterus* may be concerning, as it feeds on plant sap (Gavranović, 1974). However, during all three research years, the fruits were successfully formed (Figure 5b) and reached full maturity (89 BBCH), a stage that was either not recorded or not reached according to iNaturalist (2026). This observation is associated with temperature and precipitation conditions. The earliest fruit ripening occurred under values significantly above the upper terciles for both parameters (Figure 4e), whereas the latest ripening was recorded under conditions of temperatures well above the upper tercile and precipitation well below the lower tercile (Figure 4f). Nevertheless, the seed germination analysis in this study revealed low viability (8%), indicating that vegetative propagation methods are recommended for multiplication.



Figure 5. Reeve's spiraea: a) at full flowering with recorded visitors (*Protaetia aeruginosa* and *Pyrrhocoris apterus*) on the inflorescences, and b) fruits in the ripening stage in Belgrade, Serbia

Although changes in climatic variables, particularly air temperature and precipitation, were evident. Reeve's spiraea exhibited clear seasonality across all three flowering stages, as confirmed by the Rayleigh test results (Table 4). High vector (r) values close to 1 indicate a concentration of flowering onset around 100° , full flowering around 112° , and end of flowering around 120° . All p -values were below the significance threshold (0.05), indicating a significant directional pattern in the flowering of Reeve's spiraea towards the early to mid-spring period.

Table 4. Circular statistical analysis and Rayleigh test results for the flowering phenology of *S. cantoniensis* (2023–2025) in “Lep izgled” Park, Belgrade

Parameter	61BBCH DOY	65BBCH DOY	69BBCH DOY
Vector r	0.994	0.9991	0.9871
Rayleigh R	3.976	3.9659	3.9483
Rayleigh Z	3.9521	3.932	3.8972
u	2.865	2.865	2.865
p value	0.04	0.04	0.04
Mean date	Early April	Middle April	Late April/Early May
Mean angle	100.008	112.248	120.746

The year of observation influenced all elements of the flowering phenophase, driven by air temperature and precipitation, as confirmed by high *r* values ranging from 0.9871 to 0.9991 (Table 4). It was observed that *S. cantoniensis* has a dominant influence in early April, as the individual was positioned among 10 *S. × vanhouttei* individuals, while from mid-April, the dynamics were also contributed to by the full flowering phenophase of *S. × vanhouttei*. The comparative circular statistical analysis (Table 5) showed *r* values close to 1 and *p*-values below the significance level (0.05) for both species and all flowering phenological elements, together with a significantly low variance of the mean angle, indicating pronounced seasonality in flowering patterns in both species. However, the higher standard error of the mean angle suggests that, in these two *Spiraea* species, flowering phenology follows cyclical life-history events that are primarily driven by changes in climatic variables.

Table 5. Phenological flowering pattern elements of *S. cantoniensis* (1) and *S. × vanhouttei* (2) during 2023–2025 in Belgrade, based on circular statistical analysis

Species	(1)	(2)	(1)	(2)	(1)	(2)
Parameter	61BBCH DOY	65BBCH DOY	65BBCH DOY	69BBCH DOY	69BBCH DOY	69BBCH DOY
Mean angle	100.008	108.741	112.248	122.233	120.746	131.487
Vector r	0.994	0.9294	0.9991	0.9611	0.9871	0.9602
Variance of the mean angle	0.0296	0.0371	0.0292	0.0778	0.069	0.0796
Standard error of mean angle	9.8586	11.0332	9.7909	15.9766	15.0544	16.165

All flowering phases exhibited statistically significant differences between the analysed *Spiraea* taxa service tree species throughout the study years (Table 6), confirming that flowering was closely timed and synchronous.

Table 6. Comparisons of mean phenophase angles between *S. cantoniensis* and *S. × vanhouttei* (Watson–Williams test), together with circular correlation analyses, during 2023–2025 in “Lep izgled” Park, Belgrade

Parameter	61BBCH DOY	65BBCH DOY	69BBCH DOY
F	1.7489	0.818	2.6557
p value	0.0003	0.0000	0.0000
Circular correlations			
Raa (coefficient of correlation)	0.9958	0.9982	0.9799
p value	< 0.01	< 0.01	0.02

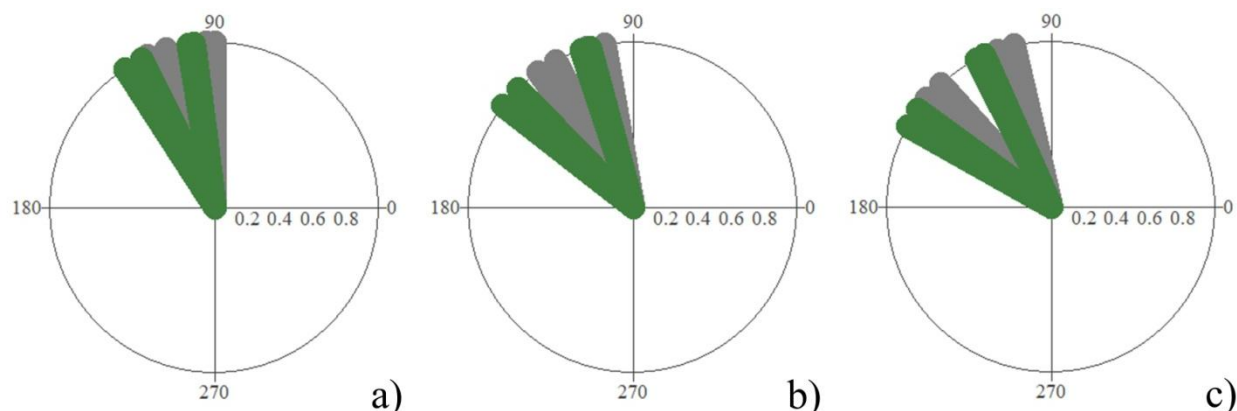


Figure 6. Flowering seasonality of *S. cantoniensis* and *S. × vanhouttei* in the period 2023–2025, according to the Watson–Williams test: (a) onset of flowering (61 BBCH), (b) full flowering (65 BBCH), and (c) end of flowering (69 BBCH) (* In Figures a, b and c, the flowering phenophases of *S. cantoniensis* are indicated in grey, and those of *S. × vanhouttei* in green)

Circular correlations were applied to evaluate the relationship between two independent variables, namely the elements of the flowering patterns of *S. cantoniensis* and *S. × vanhouttei*. The strength of their association was quantified using the Raa notation for the correlation coefficient (Table 6). The high positive Raa values and corresponding p-values indicate a strong correlation between the elements of the flowering phenological patterns, i.e. their seasonality, which was also confirmed by the Watson–Williams test (Table 6, Figure 6). The established sequence of flowering phenological elements varies from year to year, depending on the requirement for the accumulation of heat sums (GDD) for each species. It is also evident that the urban environment accelerates phenological phases (Buican Stanciu et al., 2021). In contrast to *S. cantoniensis*, studies on *S. × vanhouttei* have been conducted over two consecutive years in Romania (Buican Stanciu et al., 2021), where flowering was recorded between DOY 137 and 189, which is 23 days later for the onset and 38 days later for the end of flowering compared with the present study. The analysis of phenological phases in service trees provides valuable information that can contribute to improved management and maintenance of urban ecosystems (Toma and Zaharia, 2014b). In addition to climatic factors, which play a key role in flowering phenology, attention should also be given to anthropogenic influences, such as pruning, as these may affect the progression of flowering phases in ornamental shrubs of the Rosaceae family (Selvavinayagam and Rameshkumar, 2022; Farrokhpour et al., 2025). This is particularly relevant given the extensive datasets that can be collected worldwide through the application of the BBCH phenological coding system.

CONCLUSION

Changes in climatic variables, particularly in urban ecosystems due to the urban heat island effect, accelerate the onset and progression of phenological patterns from year to year. Owing to the phenological differences observed in *S. cantoniensis* between successive climatic years, its phenology may therefore be considered an indicator of climate change. The sequence of phenological pattern elements varies across calendar years, indicating the requirement for a certain accumulation of heat sums.

Studies of the morphological parameters and phenology of *S. cantoniensis* in urban ecosystems are essential for developing strategies to maintain ecosystem services and their aesthetic value. The present research confirmed that emphasising the aesthetic qualities of *S. cantoniensis* as a deciduous shrub is not valid without long-term investigation. Identifying key moments in phenological patterns, as well as morphological characteristics, may enhance the ecological and visual quality of both service tree taxa, enabling them to contribute effectively to the functioning of urban ecosystems and provide benefits to human populations.

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Authors' ORCID iDs: Mirjana Ocokoljić  (<https://orcid.org/0000-0002-9171-2833>); Jelena Čukanović  (<https://orcid.org/0000-0003-3327-5484>); Nevenka Galečić  (<https://orcid.org/0000-0003-2771-4583>); Ivana Sentić  (<https://orcid.org/0009-0007-2999-5661>); Radenka Kolarov  (<https://orcid.org/0000-0003-1976-7618>); Sara Đorđević  (<https://orcid.org/0000-0002-4096-8433>); Djurdja Petrov  (<https://orcid.org/0000-0001-5207-2741>);

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