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Short Communication: The flowering process of *Prunus cerasoides* in Bali Botanic Gardens, Indonesia

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Abstract. *Oktavia GAE, Iryadi R, Warseno T, Purnobasuki H. 2023. Short Communication: The flowering process of* Prunus cerasoides *in Bali Botanic Gardens, Indonesia. Biodiversitas 24: 1186-1191. Prunus cerasoides* Buch.-Ham. Ex D.Don is a native plant of the Indian-Indochinese floristic zone and one of the Eka Karya Bali Botanical Gardens' collection plants (EKBBG). Weather factors have an impact on the length of blossoming. Moreover, the microclimate variations study is a fascinating subject. A plant's adaptation is influenced by changes in the environment regularly. This research goal was to figure out how *P. cerasoides* flowers in EKBBG and how that relates to environmental parameters. The flowering time of four *P. cerasoides* trees from the EKBBG collection was observed. The weather from satellite data of the EKBBG Registration Unit provided environmental data in the form of air temperature, humidity, air pressure, and rainfall. The IBM SPSS Statistics 23 software was used to analyze the data. The results revealed that *P. cerasoides* in EKBBG flower twice a year, with the development stage of flower buds, blooming, and then the fall phase of the floral ornaments. Due to the blossoms falling, the fruit did not mature. Moreover, the number of blooms that develop is unaffected by temperature or UV index.

Keywords: Climate adaptation, conservation, ecotourism, mountain species

INTRODUCTION

The Eka Karya Bali Botanic Gardens (EKBBG) is one of Indonesia's ex-situ plant conservation institutions. The EKBBG is a mountainous region with elevations ranging from 1,200 to 1,909 meters above sea level (masl). From 2011-2016, the annual rainfall in the Bukit Tapak area, including EKBBG, was 2,964.80 mm/year (Iryadi et al. 2017). Meanwhile, the average relative humidity for the year is 89%.

Prunus is an important woody plant genus and is mostly cultivated as an ornamental and food crop. *Prunus cerasoides* Buch.-Ham. Ex D.Don is a flowering plant belonging to the Indian-Indochinese floristic zone (POWO, 2021). This plant species is a mountainous plant that can adapt to various climates and is found in EKBBG (Normasiwi 2015). With white to pink blossoms, *P. cerasoides*, also known as the Himalayan cherry, possessed ornamental potential. However, the *P. cerasoides* flower can only be found in altitudes higher than 1,000 masl (Siregar and Darma 2003). *Prunus* has also been identified as a fruit-producing genus (Normasiwi and Surya 2016). Furthermore, the content of secondary metabolites produced by *P. cerasoides* has been demonstrated to have therapeutic compounds (Joseph et al. 2018; Kim et al. 2022). The antimicrobial activity of *P. cerasoides* has also been observed (Arora and Mahajan 2018, 2019).

The appeal of *P. cerasoides* can be found in its flowers, and many people wait for it to blossom. One of the ex-situ collections that has successfully thrived and flowered in EKBBG is *P. cerasoides*. It serves as a tourist attraction and public education on the characteristics of *P. cerasoides* in Indonesia. *P. cerasoides* blooms twice a year in EKBBG. Previous research shows that the species blossomed between February-April and July-October (Siregar and Darma 2003). It began by falling off all the leaves and followed by the growth of the flower bud (Kurniawan et al. 2021). *P. cerasoides* blossom simultaneously and last for about 7-10 days from the first flower buds open to the flowers' fall. Weather factors impact the length of blossoming (Agus et al. 2016).

Weather conditions are now commonly documented to be highly connected with global climate change (Sisco 2021). At the same time, climate change is a fascinating research subject. Periodic changes in environmental conditions will affect a plant to adaptation, such as changes in leaf morphology related to photosynthesis, root development, and reproductive organ development (Gray and Brady 2016; Rindyastuti and Hapsari 2017). In the EKBBG collection of *P. cerasoides*, the current conditions may imply a shift in the number of blooming and flowering times. The observations result of *P. cerasoides* flowering and the recording of microclimate data are expected changes affecting the flowering process of *P. cerasoides* in EKBBG. In other botanical gardens, namely Cibodas Botanic Gardens (CBG), a significant shifting of *P. cerasoides* flowering period is reported due to the difference in rainfall. The high rainfall causes the flower to fall (Kurniawan et al. 2021), while the optimum temperature will produce the most flowers (Kurniawan et al. 2021). From 2001 to 2015, *P. cerasoides* bloomed when the average temperature was between 23-24°C. While in 2020, when the temperature was 24-25°C, *P. cerasoides* made the adaptation to this climate change by producing a lower number of flowers and fruit products on longer flowering periods (Kurniawan et al. 2021).

Flower development is an interesting period to study because of its importance. Angiosperms' evolutionary success in becoming the best-adapted plant groupings on the planet is due to their reproductive structure, notably flowers (Prunet et al. 2020). *P. cerasoides* flowering research was previously conducted in KREKB, but only biological observations of its flowering were made (Siregar and Darma 2003). Therefore, this research aimed to learn more about the flowering process of *P. cerasoides* in KREKB and how it relates to environmental conditions.

MATERIALS AND METHODS

Study area

This research was carried out from 20 July 2017 to 29 March 2019 at Eka Karya Bali Botanic Gardens (EKBBG). The garden is located in Candikuning Village, Baturiti Sub-district, Tabanan District, Bali, Indonesia (Figure 1). This location has a high rainfall of 155 wet days per year, with 2,964.8 mm per year and an average temperature of 11.5-25° C (Iryadi et al. 2017; Sutomo et al. 2018). The research area's geography is mountainous, at an elevation of 1,200 m asl.

Flowering observation of *Prunus cerasoides*

The flowering time on four *P. cerasoides* trees from the EKBBG collection was observed. Flowering data was collected using the EKBBG Registration unit's flowering form. The flower in each phase was documented with a digital camera and illustrated with pencil on paper.

Data collection and data analysis

Air temperature, humidity, air pressure, and rainfall data were acquired from the EKBBG Registration Unit's weather satellite. The IBM SPSS Statistics 23 software was used to analyze the data. Furthermore, the Spearman rho correlation test was used to assess the relationship between environmental conditions and flowering.

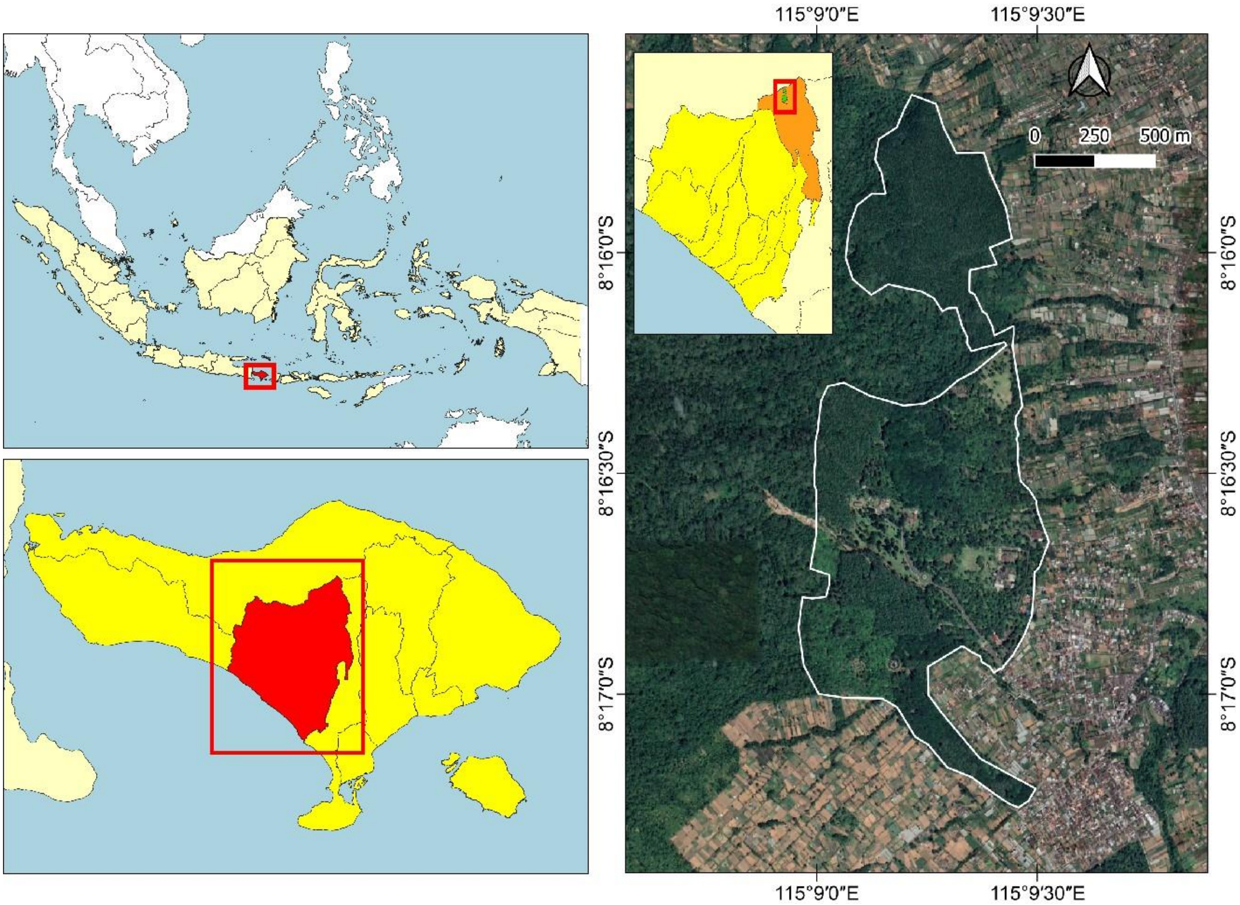

Figure 1. Study area in Eka Karya Bali Botanic Gardens, Candikuning Village, Baturiti Sub-district, Tabanan District, Bali, Indonesia

RESULTS AND DISCUSSION

Flowering process of *Prunus cerasoides*

The flowering period of *P. cerasoides* in EKBBG is twice a year. This finding is consistent with observations of *P. cerasoides* flowering in the Cibodas Botanic Gardens, which revealed that flowering occurs twice a year (Normasiwi 2015; Kurniawan et al. 2021). The first flowering phase in this study occurred in January-March, while the second was in July-August. The bud, blooming, and fall phases of the flower ornaments (perianthium) may all be seen in *P. cerasoides*' flowering processes (Figure 2).

More observations were made to evaluate the perianthium retention time on *P. cerasoides* in KREKB. Several ovules were identified, and their development was monitored morphologically. Flower buds needed 5-6 days to blossom before they could be harvested fully. The perianth would also endure 2-3 days before falling on the eighth day, as seen in Figure 3. The flower's petal, a component of the perianthium, attracted the pollinator, resulting in pollination (Idžojtić 2019). The fall of the perianthium was frequently caused by a signal from the fruit's early stages of development (Woltering 2003).

Bees and flies visited *P. cerasoides* flowers in this study, as illustrated in Figure 4. Pollination of *P. cerasoides* flowers was observed to occur in India with the help of butterflies (Bhuyan et al. 2014). Interactions between the same plant and different pollination agents are caused by differences in growth habitats (Kuswantoro 2017).

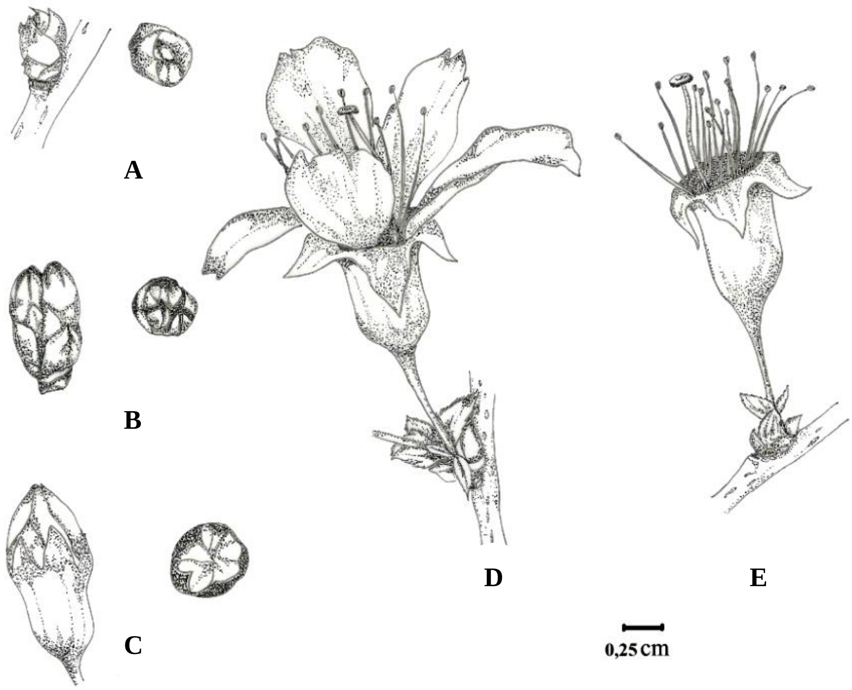

Figure 2. Flowering process of *Prunus cerasoides*: A-C. Bud phase; D. Blooming phase; E. Perianth fall phase

Figure 3. Time and flower development of *Prunus cerasoides*: 0 days (flower bud was still closed); 2 days (green sepal was open: pinkish-white petals visible); 3-4 days (petals open); 5-6 days (fully blooming: petals fully open); 8 days (petals fall)

Figure 4. *Prunus cerasoides* flower pollination by (A) bees and (B) flies

This study suspended *P. cerasoides* flower development until the perianthium fell phase. Subsequently, the flower stems would dry out, and all the flower parts would fall to the ground. Therefore, the visible flowering process did not progress to fruition. However, In 1998-2000, development to the juvenile fruit stage was documented in the same *P. cerasoides* tree (Siregar and Darma 2003). This phenomenon also occurred in Cibodas Botanical Gardens' *P. cerasoides* collection, where early fruit growth occurred only twice in the last 20 years, in 2010 and 2015 (Kurniawan et al. 2021). Therefore, the failure of the early fruit development process may be caused by fruit development failure. Therefore, there should be a mechanism for controlling fruit sets through related genes that repress programmed cell death (PCD) genes (Sarma et al. 2020). This controlling PCDs involves glucose metabolism (Borghi and Fernie 2017; Sarma et al. 2020).

The falling flowers or floral organs in this study may be affected by senescence or aging in flowers. That is a complicated process regulated by various factors, including internal factors controlling blooming time genes and external factors such as pollination, pathogen presence, or environmental factors (Ascough et al. 2005). Gibberellins hormone, applied to flowers, can be used in further studies to preserve fruit growth. The gibberellins have been shown to trigger the production of parthenocarpic fruit, in which the ovaries were mature without pollination (Bobrov and Romanov 2019; Agustí and Primo-Millo 2020). Moreover, because it is more profitable to produce seedless fruit, this treatment is frequently performed on cultivated plants (Setiawan et al. 2016; Sarma et al. 2020).

Correlation between the flowering of *Prunus cerasoides* with environmental factors

During the 20 months of observation in 2017-2019, the flowering phase occurred four times: July-August 2017, January-March 2018, July-August 2018, and February-March 2019. The result demonstrates that *P. cerasoides* had two flowering phases every year. Figure 5 shows each season's flowering time length of the *P. cerasoides* trees.

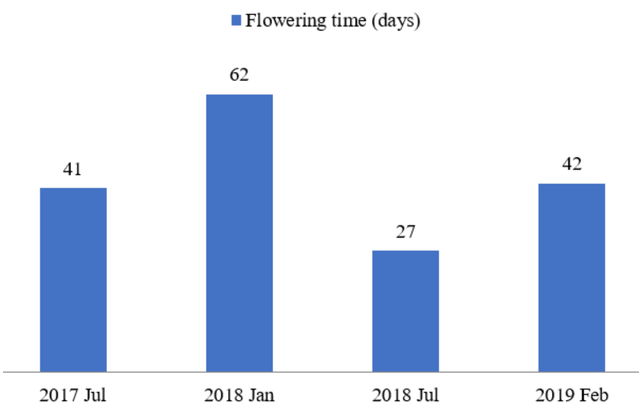

Figure 5. Time length of *Prunus cerasoides* flower presence

Table 1. Average of environmental factor variables

Time of flowering	Temp (°C)	RH (%)	Air pressure (millibar)	Rainfall (mm/day)
1 (2017 July - August)	16.2	89.1	1009.1	0.45
2 (2018 January - March)	18.4	90.5	1005.3	0.03
3 (2018 July - August)	16.9	86.9	1010.1	0.04
4 (2019 February - March)	18.7	94.2	1006.7	0.64

Internal and extrinsic variables influence flower development. The activity of genes encoding the flowering period, reproductive organ identity, and meristem determination during flower formation are all important internal variables in the commencement of flower morphogenesis (Liu et al. 2009; Wagner 2009; Pelayo et al. 2021). Other factors alter the action method of the genes encoding floral morphogenesis, such as plant age and phytohormones, particularly gibberellins (Teotia and Tang 2015). Temperature (Ding et al. 2020), CO_2 levels (Gray and Brady 2016), photoperiod (Teotia and Tang 2015), quality and amount of light, vernalization (prolonged cold stress), and availability of nutrients and water are all elements that influence floral morphogenesis (Levy and Dean 1998). Table 1 shows the environmental parameters observed during the flowering of *P. cerasoides*. The data showed that *P. cerasoides* bloomed when the temperature was 16.2-18.7°C, and it differed from *P. cerasoides* in CBG which bloomed at 23-25°C temperature. It revealed that the blooming of this species could occur over a particular temperature range. A study in *Malus domestica* showed that flowering needs an intermediate temperature of 18-21°C, which can be inhibited by lower and higher temperatures (Heide et al. 2020).

The temperature's influence on plant development is significant (Hatfield and Prueger 2015). In this study, *P. cerasoides* flower development phase was used to conduct a correlation test between temperature and ultraviolet (UV) index. Due to data limitations in other observation periods, the correlation test in this study was conducted on the flowering data of the final two observation periods (the third and fourth periods). The temperature and UV index had a strong relationship. The correlation between the two factors was positive; the higher the temperature, the higher the UV index, and the lower the temperature, the lower the UV index.

The scores of the bud, bloom, and fall phases were found to have a very weak relationship (correlation coefficient <0.250) with environmental parameters of temperature and UV index. On the contrary, both environmental variables have a negative relationship. The fewer blooms in each phase, the higher the temperature and UV index, and vice versa, but with a weak correlation. The number of blooms that formed was unaffected by temperature or the UV index. The timing of early flower development is affected by air temperature, with greater temperatures leading some *Prunus* spp. to bloom later. As a result, they bloomed a few days early than their forecasted schedule (Primack et al. 2009; Woznicki et al. 2019). In several plant species, UV-B radiation has been shown to alter flower size, anther number, pollen output, germination, and pollen tube growth (Gan et al. 2013). Environmental influences affect the genes that govern morphogenesis (Teotia and Tang 2015). Environmental and hormonal factors send signals to genes that govern morphogenesis, resulting in various plant responses (Wils and Kaufmann 2017). At the same time, a previous study mentioned that the *P. cerasoides* flowering and fruiting might be more influenced by biological phenomena than relative humidity, temperature, and rainfall. That finding could be good information to explore and study other factors influencing flowering (Kurniawan et al. 2021). Future research should focus on the various environmental conditions that influence *P. cerasoides* flowering. Furthermore, a variety of temperature, photoperiodic, and relative humidity treatments can be used to investigate the effect of environmental variables on flowering variables. Moreover, experimental greenhouses were used to study the quality of *P. cerasoides (*cherry*)* and microclimate factors (Bing et al. 2019).

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