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Phenology of *Campomanesia adamantium* (Cambess.) O. Berg in Brazilian Cerrado

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Abstract- *Campomanesia adamantium* is a fruit tree native to Cerrado and important for human consumption as food, herbal medicine and even in the beverage industry. The aim of this study was to evaluate the vegetative and reproductive phenology of *C. adamantium* plants in the region of Ipameri-GO, the synchronization of phenophases and the correlation with climatic data. Rainfall, relative humidity, average, maximum and minimum temperature, as well as sprouting, flowering and fruiting data of *C. adamantium* plants were collected between September and December of 2016 and 2017. Graphs were plotted for climatological data and phenological phases. Phenophase synchrony analysis and correlation of these phases with the climate of the region were performed. Sprouting and flowering began before the first rains of the rainy season and the peak of these phenophases occurred in October. Fruiting began in October and peak was observed in November. Sprouting is highly synchronous from the second ten days of October and flowering reveals high synchronicity between the second half of October and the first half of November. Fruiting is considered highly synchronous from the second half of November. Not all plants reach reproductive stages. Sprouting and fruiting are related to the occurrence of rainfall and increase of air RH. Flowering has no correlation with rainfall, air RH and temperature.

Index terms: flowering, fructification, gabiroba, phenophases, rainfall, relative humidity, savannah, sprouting, temperature.

Fenologia de *Campomanesia adamantium* (Cambess.) O. Berg no Cerrado Brasileiro

Resumo- *Campomanesia adamantium* é uma espécie frutífera nativa do Cerrado, importante pelo uso na alimentação humana, como fitoterápico e até mesmo na indústria de bebidas. O objetivo deste estudo foi avaliar a fenologia vegetativa e reprodutiva de plantas de *C. adamantium* na região de Ipameri-GO, a sincronia das fenofases e a correlação com dados climáticos. Foram coletados dados de precipitação, umidade relativa do ar, temperatura, bem como dados de brotação, floração e frutificação de plantas de *C. adamantium,* entre setembro e dezembro de 2016 e 2017. Foram elaborados gráficos para os dados climatológicos e fases fenológicas, foi realizada análise de sincronia para as fenofases e análise de correlação destas fases e o clima da região. A brotação e o florescimento iniciaram-se antes das primeiras chuvas, e o pico destas fenofases ocorreu em outubro. A frutificação teve início em outubro, e o pico, em novembro. A brotação é altamente sincrônica a partir da segunda dezena de outubro, e o florescimento revela alta sincronia entre a segunda quinzena de outubro e a primeira de novembro. Para frutificação, a sincronia é considerada alta a partir da segunda quinzena de novembro. Nem todas as plantas atingem estágios reprodutivos. A brotação e a frutificação estão relacionadas às chuvas e ao aumento da UR do ar. O florescimento não tem relação com precipitação, UR do ar e temperatura do ambiente.

Termos para indexação: brotação, fenofases, florescimento, frutificação, gabiroba, precipitação, savana, temperatura, umidade relativa do ar.

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Introduction

Campomanesia adamantium, known as gabiroba, belongs to the Myrtaceae family and presents natural distribution in several regions of the Brazilian Cerrado (LANDRUM, 1986). Fresh fruits are widely consumed by populations of regions where fruit occurs, being also used to make sweets, jellies and ice creams. Fruits distinguished by the characteristic flavor and because they are sources of mineral elements and energy (VALLILO et al., 2006). Leaves and fruits are used in phytotherapeutic medicine for urinary tract, flu symptoms treatment and recomposition of intestinal flora (LORENZI et al., 2006). In addition, leaves have high concentrations of phenolic compounds, which are related to antioxidant activity (COUTINHO et al., 2008).

The current use of this species is limited to the extractive activity of places of its occurrence (ARAÚJO and SOUZA, 2018), and the development of tools for management and conservation depends on knowledge about plant phenology (FREITAS and OLIVEIRA, 2002). The phenology study helps to understand the vegetative and reproductive patterns of plants, evaluating the occurrence of phases over time (MORELLATO, 1995). The phenological phases of plant species have causes of occurrence related to biotic and abiotic forces (BRITO NETO et al., 2018).

In tropical areas, there is marked seasonality in rainfall, which determines plant phenology, interfering with growth and reproduction (MORELLATO et al., 1989). The need for water is indisputable for the good development of plants. In this way, the presence of this abiotic factor can determine the occurrence of vegetative and / or reproductive phases.

Other factors such as photoperiod and temperature also determine the phases of plant development (MORELLATO et al., 2000; MARQUES et al., 2004). According to Medeiros et al. (2005), air temperature promotes direct and significant effects on physiological processes in plants, making knowledge of these interferences fundamental for agricultural planning and analysis of crop adaptation to different regions. In addition, air relative humidity, parameter intrinsically linked to rainfall and temperature, may also contribute to the occurrence of phenological events.

Thus, the aim of this study was to evaluate the vegetative and reproductive phenology of *Campomanesia adamantium* plants in the region of Ipameri-GO, the synchronization of phenophases and the correlation with climatic data.

Material and methods

Study area characterization - The experimental area is located in the municipality of Ipameri, Goiás, Brazil, whose geographic coordinates are 17°43’34’’ S and 48°09’23’’ W. The altitude is 820 m a.s.l. and the climate of the region is classified as Cwa - Wet Mesothermal, with average annual rainfall of 1,490 mm and average annual temperature of 25°C. The area corresponds to a collection of Cerrado Native Plants maintained by the State University of Goiás, Ipameri campus. It covers more than 10 native Cerrado shrub and tree species, totaling approximately 1,600 plants. There are over 1,000 plants of *Campomanesia adamantium* species, whose original materials were collected from five municipalities in the state of Goiás: Anápolis, Gameleira, Cidade de Goiás, Ipameri and Silvânia. Plants had, in 2016, the occasion of the beginning of experiments, 13 years from the transplantation of seedlings, spaced 1.0 m between plants and 1.5 m between rows and the height of plants ranged from 0.4 to 1.8 m.

Data acquisition - Climatic data were obtained at the Meteorological Station of Ipameri, National Institute of Meteorology (INMET), located at coordinates 17°71’66’’ S and 48°16’66’’W and 772 m a.s.l. Rainfall (mm), maximum, minimum and average temperature (°C) and air relative humidity (air RH in %) data were collected between September and December of 2016 and 2017.

For data collection of phenological events, 360 plants were selected in the year 2016 (Year I) and 180 in the year 2017 (Year II). The number of plants was reduced due to the homogeneity of occurrence of events among plants in Year I. These plants were identified according to the order of appearance in the experimental area. Phenological phases were evaluated every three days from September 1 to December 31 of each year.

The following phenological events were observed *i.* budding: from the appearance of small leaves in branches until they reach the size and coloration characteristic of the species; *ii*. flowering: plant with flower buds or anthesis; *iii.* fruiting: when it was possible to visualize fruits with at least 3 mm in diameter after the fertilization of flowers until seed dispersal (BRITO NETO et al., 2018).

For sprouting and flowering, methodology described by Ribeiro and Castro (1986) was used, in which scores are assigned for events according to class intervals, 0 being the absence of the phenomenon; 1 when approximately 4% of the plant presents the phenomenon; 2 to 15%; 3 to 30%; 4 to 50%; 5 to 70%; 6 to 85%; 7 to 96% and 8 when 100% of the plant presents the phenomenon. These percentages were visually estimated based on the period of maximum activity of phenophases, previously observed in the year 2015. For fruiting, the amount of fruits produced per plant was recorded. The average sprouting and flowering scores and the number of fruits per plant at each period were calculated.

Data analysis and presentation - Graphs for climatological data were plotted during the months of September and December, as well as graphs with sprouting flowering and fruiting phases in the same period for Years I and II.

Phenophase synchrony analysis was performed, and the synchrony index evaluates the presence or absence of the phenological phase in the individual. This index has quantitative character at population level and indicates the percentage of individuals that is manifesting each phenological phase. Asynchronous (when less than 20% of individuals were in the phenophase), low synchrony (when 20 to 60% of individuals were in the phenophase) and high synchrony (when more than 60% of individuals were in the phenophase) were considered (MORELLATO et al., 1990; BRITO NETO et al., 2018).

Data were tested for normality by the Shapiro-Wilk test at 5% significance. As data did not present normal distribution, that is, data presented non-parametric nature, the Spearman's simple correlation test (r_s) was used to verify the relationship between climatic data and sprouting, flowering and fruiting phases. For correlation analysis, rainfall data used were the sum of the last three days, since phenology evaluation was performed every three days. To obtain average temperature and air relative humidity data, the average of the last three days was used. The analysis of r_s was performed according to recommendation of Brito Neto et al. (2018): if $| r_s | <0.20$, then the correlation is negligible; $0.20 <| r_s | <0.40$, the correlation is weak; if $0.40 <| r_s | <0.60$, the correlation is moderate; if $0.60 <| r_s | <0.80$, there is strong correlation; and if $| rs | > 0.80$, the correlation among variables is very strong.

For correlation results above 50%, i.e., moderate, strong or very strong correlation, graphs were plotted to illustrate the relationship among data.

Results and discussion

Year I – 2016 - The climatological data of the first year of experiment showed the onset of rains, with volume of 11 mm, on September 20 (Figure 1). From this date on, new rainfall was only observed on October 3. There is a reduction in maximum and minimum temperatures shortly after rainfall.

Air RH is calculated by the ratio between the water vapor content in the current condition and the water vapor content in the saturation condition for a given temperature. Thus, air RH is related to rainfall and temperature; thus, an increase in air RH was observed from the first rains (Figure 2). This is clearer when the occurrence of rainfall is higher, as in the period between the month of November and the first half of December. In this period, high air RH and reduction of the average temperatures could be observed.

The first *Campomanesia adamantium* leaves were observed on September 18 (Figure 3), shortly before the first rainfall of the season, but an increase in air RH was already observed (Figures 1 and 2). Sprouting increased significantly and peaked in the month of October. For *Eugenia dysenterica*, another species native to the Brazilian Cerrado, the peak of emission of new leaves was observed in September and October (SOUZA et al., 2008). From the beginning of November, there was a small increase in the emission of new leaves until November 29, when there was no further emission of new shoots.

Flowers were observed from September 18 to November 17, a transition period between dry and rainy seasons (Figure 3), which according to Rossato and Franco (2008), are well-defined seasons in this region. These data agree with those obtained by Luz and Krupek (2014), who studied the phenology of *Campomanesia xanthocarpa* and observed that flowering occurs from September to November. Studies with Myrtaceae have shown that this is a trend in the genus: predominant flowering in the transition between dry and rainy seasons (LUGHADHA and PROENÇA, 1996; SILVA and PINHEIRO, 2007; NUCCI and ALVES-JÚNIOR, 2017).

Flowering occurring at this time may be related to the increase of photoperiod, average temperature and air RH, characteristics of this transition period. The main benefits of flowering under these conditions are increased light availability, nutrient availability, and activity of pollinators (MORELLATO et al., 1989; MORELLATO and LEITÃO-FILHO, 1992).

Fruits were already observed on October 8, but the peak of the fruiting phase was in November (Figure 3). After 20 days of the appearance of the first flowers, it was possible to identify fruits in *Campomanesia adamantium* plants. Nucci and Alves-Júnior (2017) also reported peak fruiting in November for *C. adamantium* in the state of Mato Grosso do Sul.

Year II – 2017 - In the second year of experiment, the first rain of the rainy season occurred late when compared to 2016, 5 mm on the last day of September (Figure 4). The next three days, already in the month of October, were marked by rainfalls that summed up 50 mm, followed by a period without rainfall. Rainfall resumption and the regularization of the rainy season only occurred on October 28. The month of October, practically without rain, was marked by high maximum and minimum temperatures in comparison with the other months.

It was possible to observe increase in air RH and reduction in average temperature after the first rains that occur in late September and early October and also from November to the end of the study period (Figure 5). October was marked by low air RH and high average temperatures.

As in Year I, the first sprouts and flowers occurred before the beginning of the occurrence of rains, but in a period in which increase in air RH and reduction in average temperature were observed on September 26 in Year II (Figure 6). Shoot emission increased until the first half of November, when there was stabilization for this phenophase, indicating that there were no new shoots and leaves emitted from this moment. In a study with *Campomanesia adamantium*, the first sprouts also occurred in period coinciding with the first rains (NUCCI and ALVES-JÚNIOR, 2017).

Flowering increased from September with peak in October and from November 17, there were no more flowers in the evaluated plants, confirming what occurred in the first year of the study and literature data, which showed that the beginning of flowering of Myrtaceae plants coincides with the beginning of the transition to the wet season (FIDALGO and KLEINERT, 2009). Nucci and Alves-Junior (2017) found flowering peak in September for the same species, but in the municipality of Ponta Porã, MS, Brazil.

The average number of fruits per plant recorded at the end of flowering in the second year was 60. In the previous year, this value was 108. This difference should be related to the long dry period and high temperatures in the month of October of Year II (Figure 5), intense flowering moment (Figure 6). October had a total of 74 mm of rainfall, and between days 3 and 27, there was no rainfall. The average temperature in the month of October was 26.1°C and in 15 days of the month, the temperature was higher than 27°C.

The smaller amount of fruits produced can be explained by the ideal conditions required for the fertilization process. During anthesis, pollen grains reach the stigma and adhere to its surface, absorb the stigmatic fluid, swell and "germinate" to form the pollen tubes, which in turn develop inside the stylet towards the ovary (MARCOS-FILHO, 2015). The development of the pollen tube depends, among other factors, on temperature and humidity. The ideal temperature varies between 21 and 27°C (DUMAS and MOGENSEN, 1993; MARCOS-FILHO, 2015). In addition, cellular tugor assists in the germination and development of the pollen tube (MARCOS-FILHO, 2015) to enable the ovule fertilization. Thus, conditions of average high temperature and low air RH in the month of October may have affected fruit fertilization and consequent formation.

Phenophases synchrony - High sprouting synchrony was observed from the second ten days of October for both years studied (Figure 7). The sprouting activity index reached maximum synchrony (100% with n = 360) from October 28 in the first year and from November 9 in the second year (n = 180). Thus, as the species is deciduous (NUCCI and ALVES-JÚNIOR, 2017), that is, it loses all or part of its leaves in the dry season, it could be concluded that there is emission of new leaves from September and from October / November the sprouting synchrony is maximal.

Flowering was considered to be highly synchronous from the third ten days of October to the first ten days of November in both years. The production of flowers in excess in a short period of time guarantees continuous availability of pollen grain for floral visitors (LORENZON et al., 2003), which in the case of *Campomanesia adamantium*, despite being visited by several insects, pollination is mainly performed by bees (ALMEIDA et al., 2000; ARAÚJO and SOUZA, 2018), especially *Apis mellifera*, an exotic species that guarantees gene flow from pollen transfer among *C. adamantium* plants (NUCCI and ALVES-JÚNIOR, 2017).

On the other hand, fruiting showed high synchrony from November 17 on Year I and a little earlier on November 13 on Year II. Fruiting did not reach maximum activity index, that is, did not reach 100% of individuals in the phenophase in both years studied. This can be explained by the fact that this index also did not reach the maximum flowering value. Thus, although all plants studied in Year I (n = 360) and Year II (n = 180) emitted shoots, not all reached reproductive phases. Further studies related to factors that interfere in the floral induction of this species are required. In this work, it was possible to observe that factors related to climate such as rainfall, temperature and air RH do not explain flowering in *Campomanesia adamantium*.

Correlation between phenophases and climatic factors - Spearman's correlation revealed, in Year I, moderate positive correlation for sprouting and fruiting with rainfall and weak negative correlation with average temperature (Table 2). Strong positive correlation of sprouting and fruiting with air RH was observed. The emission of shoots followed the occurrence of rainfall and increase in air RH (Figure 8).

There was no significant correlation between plant flowering and rainfall, average temperature and air RH data in Year I (Table 1). Flowering in the dry season is characteristic of most species of the Brazilian Cerrado (OLIVEIRA, 1998; DONADIO et al., 2004; SOUZA et al., 2008). In this biome, flowering in the spring is independent of the local pluviometric regime, and floral induction depends on other factors (SOUZA et al., 2008).

In Year II, strong positive correlation of sprouting and fruiting with rainfall and air RH data was observed (Table 2). The relationship between the occurrence of rains and the appearance of shoots in the second year (strong correlation) compared to the first year was more striking.

This can be explained by the high volume accumulated between the last day of September and the first days of October of Year II, which was probably sufficient to allow the emergence of shoots during the dry period of October (Figure 9).

The fruiting trend in Year II was similar to that of Year I, occurrence of the phenophase associated with the occurrence of rainfall and increase in air RH. As *Campomanesia adamantium* is a species with seeds susceptible to dehydration (DRESCH et al., 2014), fruit dispersion during wet periods and with high temperatures consists of an evolutionary strategy of these plants, allowing early germination (BARBEDO et al., 2013; MARCOS -FILHO, 2015) ensuring propagation. This represents an advantage in competition with orthodox species in which dehydration is a defense for germination in less favorable environments (BARBEDO and MARCOS-FILHO, 1998).

As in Year I, there was no correlation between flowering data and climatic data collected from Year II (Table 1). Studies with *Eugenia desynterica* also did not find significant correlation of flowering with climatic conditions in four populations of the species (SOUZA et al., 2008).

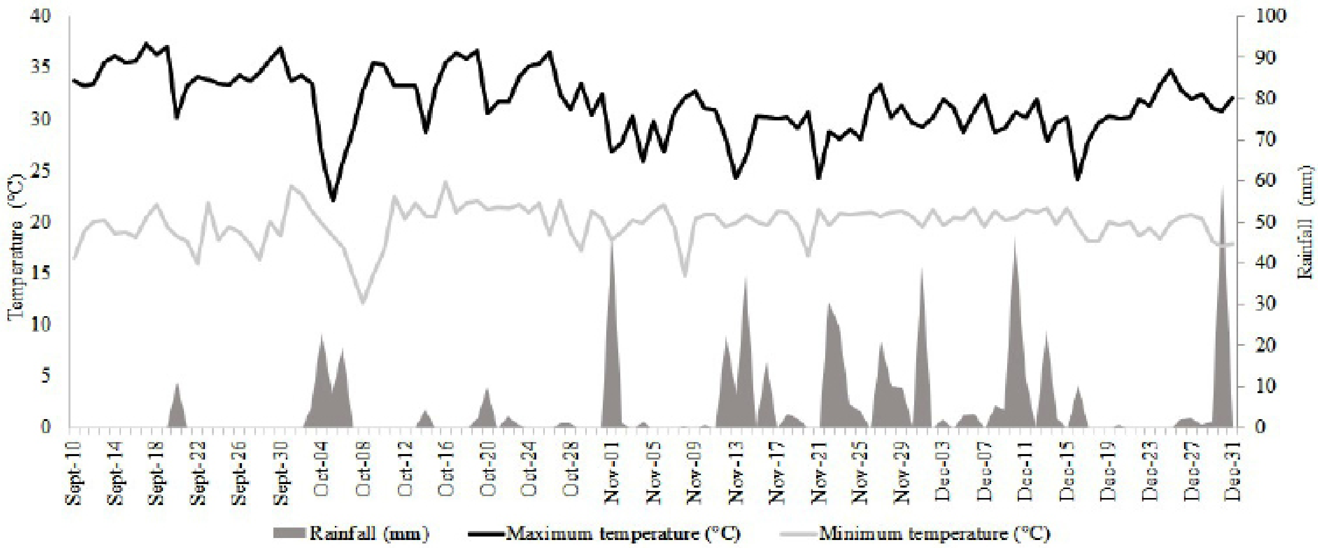

Figure 1. Maximum and minimum temperature (°C) and rainfall (mm) between September and December 2016 in Ipameri-GO.**Source:** INMET, 2018.

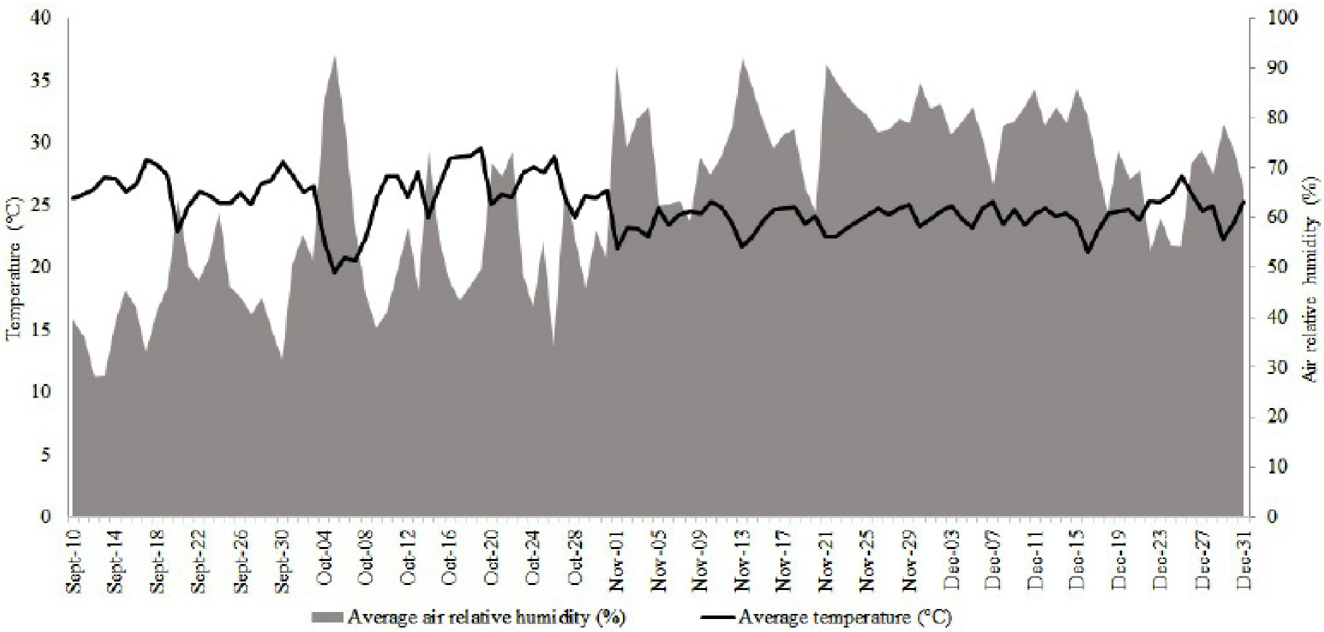

Figure 2. Average temperature (°C) and air relative humidity (%) between September and December 2016 in Ipameri-GO.**Source:** INMET, 2018.

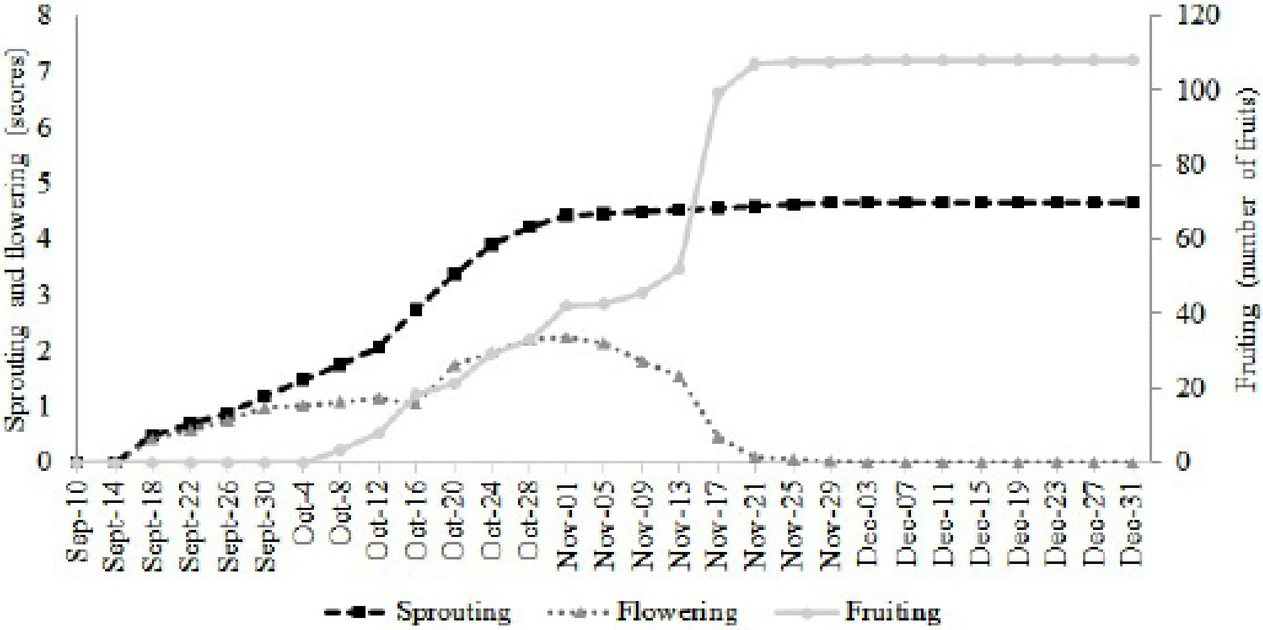

Figure 3. Phenogram for sprouting, flowering (scores according to Ribeiro and Castro, 1986) and fruiting (number of fruits per plant) of *Campomanesia adamantium* between September and December 2016 in Ipameri-GO.

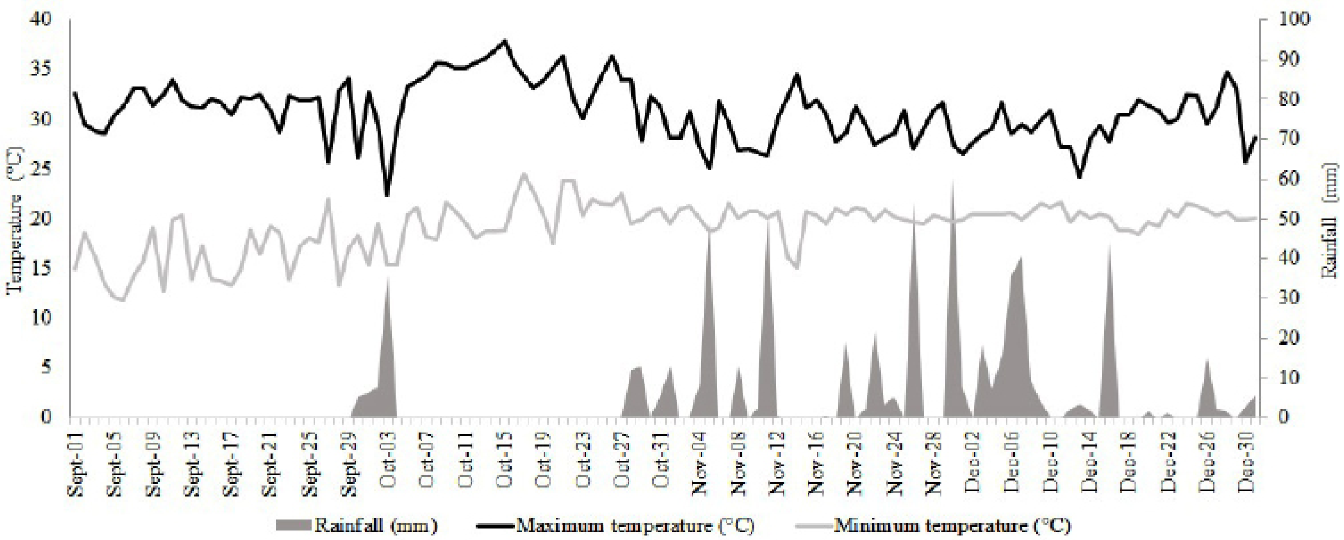

Figure 4. Maximum and minimum temperature (°C) and rainfall (mm) between September and December 2017 in Ipameri-GO. **Source:** INMET, 2018.

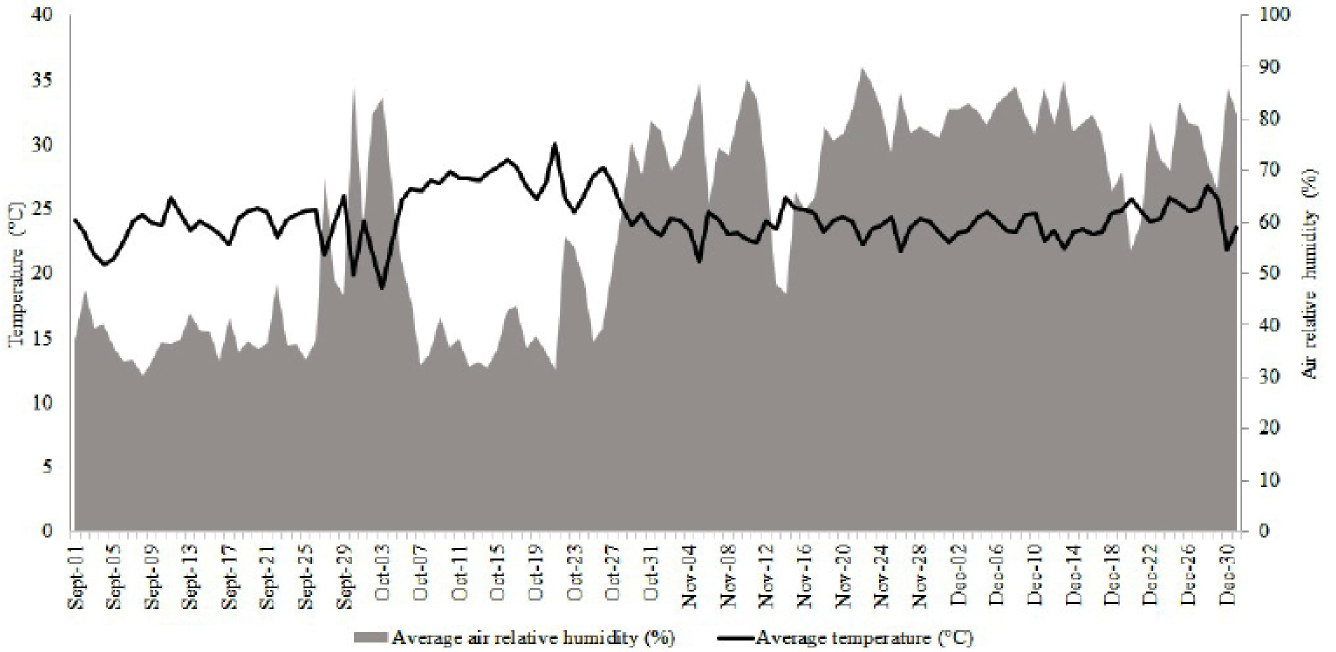

Figure 5. Average temperature (°C) and air relative humidity (%) between September and December 2017 in Ipameri-GO.**Source:** INMET, 2018.

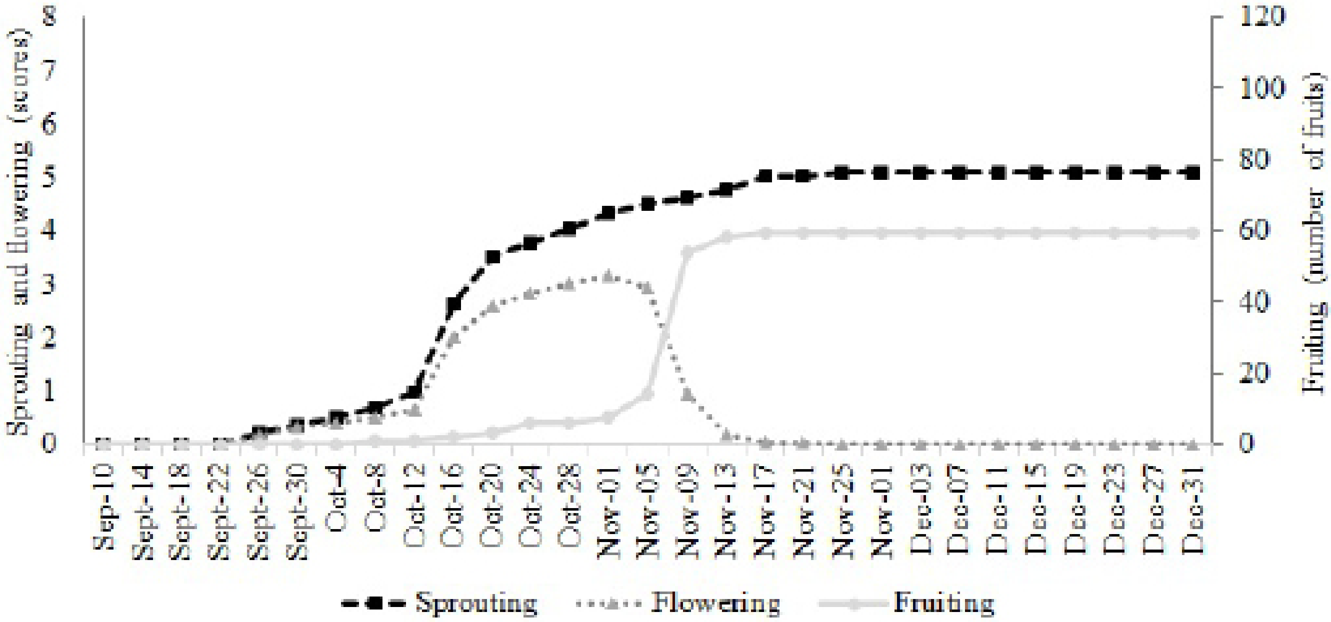

Figure 6. Phenogram for sprouting, flowering (scores according to Ribeiro and Castro, 1986) and fruiting (number of fruits per plant) of *Campomanesia adamantium* between September and December 2017 in Ipameri-GO.

	Year I - 2016			Year II - 2017		
Date	**SP**	**FL**	**FR**	**SP**	**FL**	**FR**
Sept 10	0	0	0	0	0	0
Sept 14	0	0	0	0	0	0
Sept 18	24	20	0	0	0	0
Sept 22	35	25	0	0	0	0
Sept 26	39	31	0	17	13	0
Sept 30	45	35	0	19	16	0
Oct 4	51	38	0	21	17	0
Oct 8	57	43	3	27	22	2
Oct 12	64	44	7	46	32	2
Oct 16	89	42	16	99	91	3
Oct 20	99	75	18	99	93	4
Oct 24	99	73	22	99	93	5
Oct 28	100	75	27	99	93	5
Nov 1	100	69	32	99	87	8
Nov 5	100	67	34	99	78	13
Nov 9	100	60	37	100	32	49
Nov 13	100	51	41	100	7	61
Nov 17	100	18	65	100	4	62
Nov 21	100	4	74	100	4	62
Nov 25	100	2	74	100	0	63
Nov 29	100	2	74	100	0	63
Dec 3	100	0	75	100	0	63
Dec 7	100	0	75	100	0	63
Dec 11	100	0	75	100	0	63
Dec 15	100	0	75	100	0	63
Dec 19	100	0	75	100	0	63
Dec 23	100	0	75	100	0	63
Dec 27	100	0	75	100	0	63

Asynchronous | Low Synchrony | High Synchrony

Figure 7. Synchrony index (%) for sprouting (SP), flowering (FL) and fruiting (FR) phenophases of *Campomanesia adamantium* in years 2016 and 2017 in Ipameri-GO.

Table 1. Spearman correlation index (r_s) for sprouting (SP), flowering (FL) and fruiting (FR) phenophases of *Campomanesia adamantium* in years 2016 and 2017 in Ipameri-GO.

	Year I - 2016			Year II - 2017		
	SP	**FL**	**FR**	**SP**	**FL**	**FR**
	....	....	.... r_s	....	....	....
Rainfall	0,55	ns	0,53	0,65	ns	0,64
Average temperature	-0,41	ns	-0,39	ns	ns	ns
Air relative humidity	0,65	ns	0,62	0,65	ns	0,61

ns: Not significant

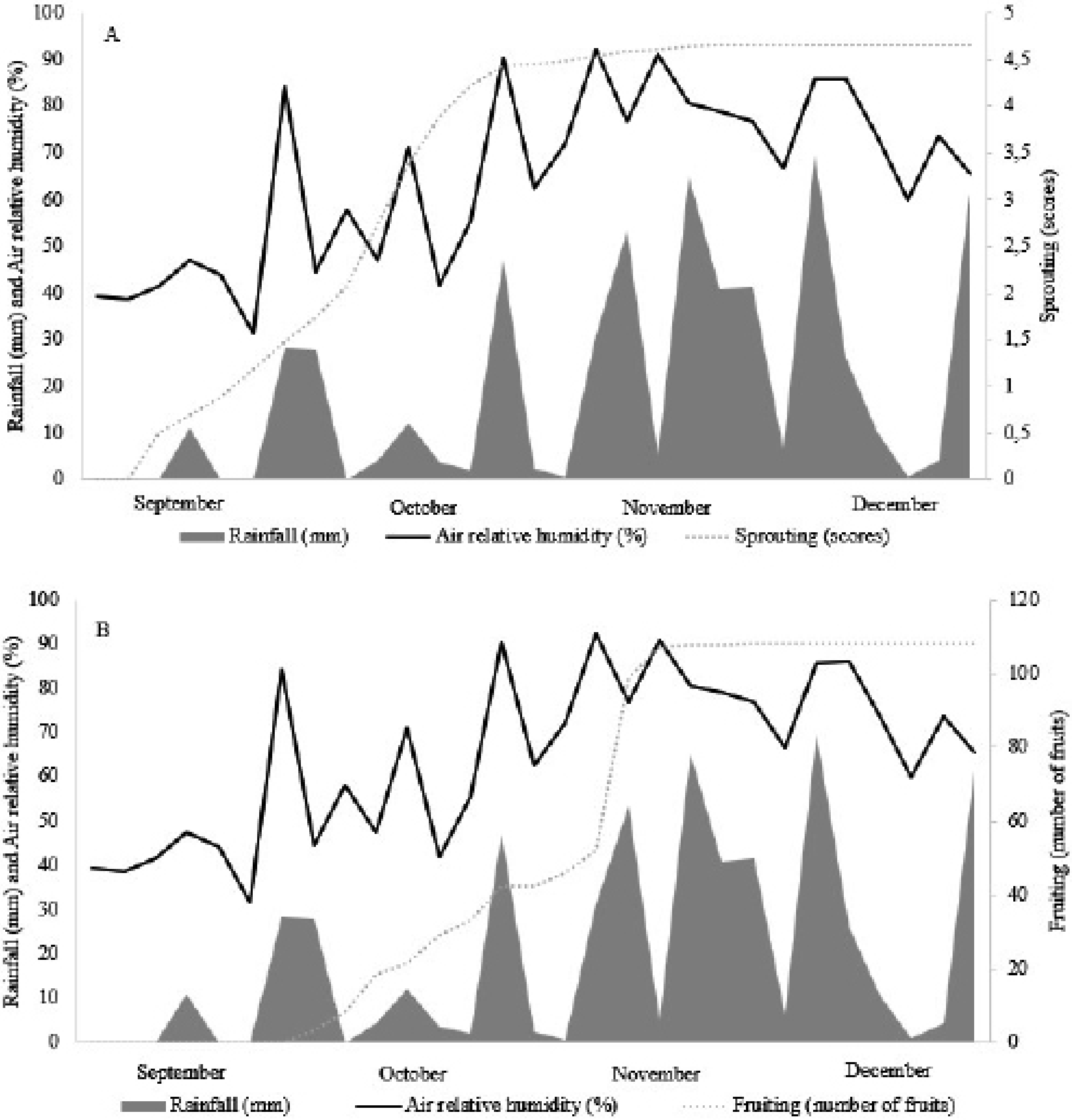

Figure 8. Rainfall (mm) and air relative humidity (%) in Ipameri-GO year 2016 (Year I); of sprouting (scores according to Ribeiro and Castro, 1986) - A and fruiting phenophases (number of fruits) - B of *Campomanesia adamantium*.

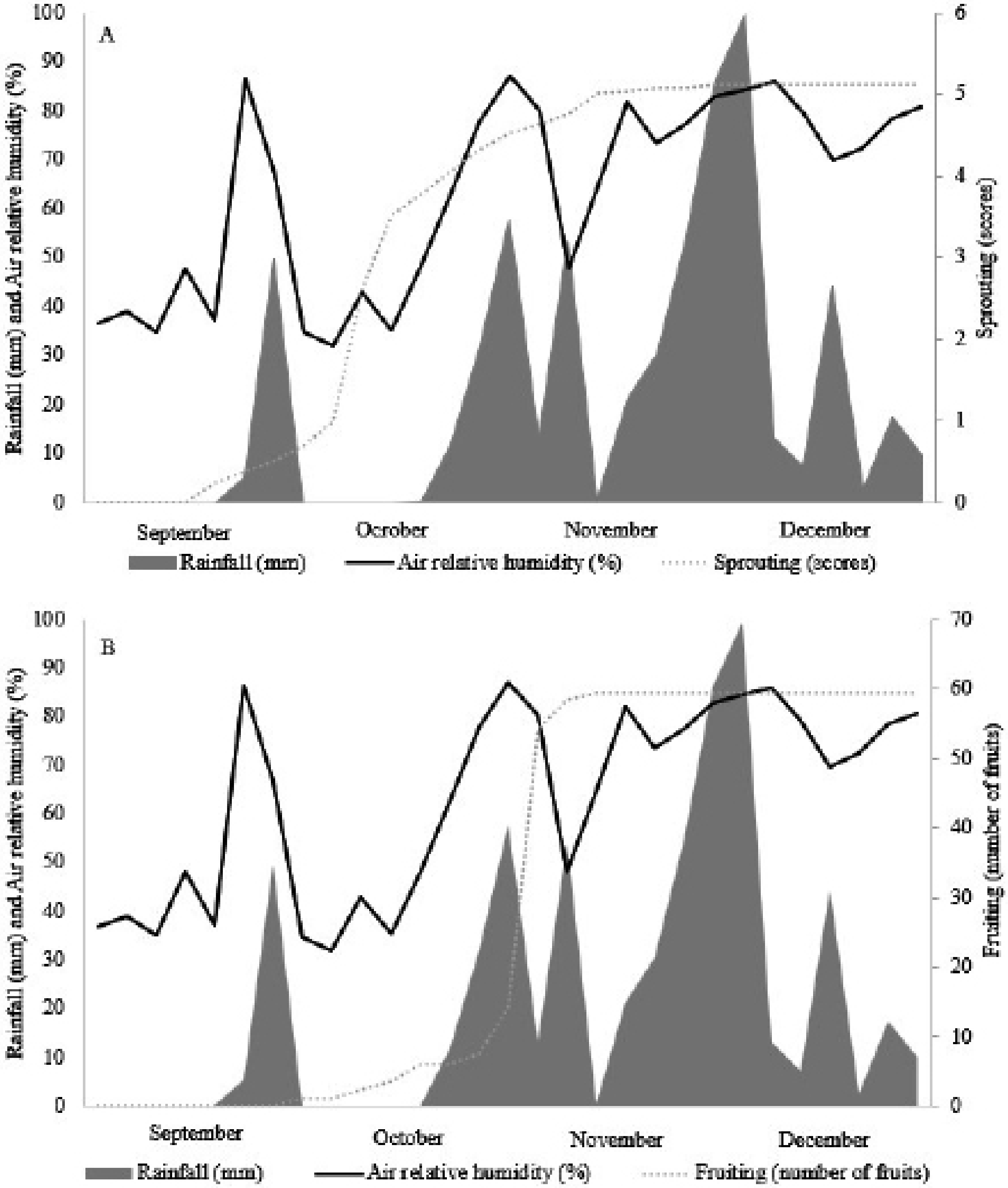

Figure 9. Rainfall (mm) and air relative humidity (%) in Ipameri-GO year 2017 (Year II); of sprouting (scores according to Ribeiro and Castro, 1986) - A and fruiting phenophases (number of fruits) - B of *Campomanesia adamantium*.

Conclusions

Sprouting and flowering begin before the first rains of the rainy season; however, the peak of these phenophases occurs in October. Fruiting started in October and peak occurred in November.

Sprouting is highly synchronous from the second ten days of October and flowering reveals high synchronicity between the second half of October and the first half of November. For fruiting, synchrony is considered high from the second half of November. Not all plants reach reproductive stages.

Sprouting and fruiting are related to the occurrence of rainfall and increase in air RH. Flowering has no relation with rainfall, air RH and temperature.

Acknowledgments

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References

ALMEIDA, M. J. O. F.; NAVES, R. V.; XIMENES, P. A. Influência das abelhas (*Apis melífera*) na polinização da Gabiroba (*Campomanesia* spp.). **Pesquisa Agropecuária Tropical**, Goiânia, v.30, n.2, p.25-28, 2000.

ARAÚJO, E. F. L.; SOUZA, E. R. B. Fenologia e reprodução de *Campomanesia adamantium* (Cambess.) O. Berg (Myrtaceae). **Scientific Electronic Archives**, Sinop, v.11, n.2, p.166-175, 2018.

BARBEDO, C. J.; MARCOS-FILHO, J. Tolerância à dessecação em sementes. **Acta Botânica Brasileira**, Porto Alegre, v.12, n.2, p.45-164. 1998.

BARBEDO, C. J.; CENTENO, D. C.; RIBEIRO, R. C. L. F. Do recalcitrante seeds really exist? **Hoehnea,** São Paulo, v. 40, n. 4, p. 583-593, 2013.

BRITO NETO, R. L.; ARAÚJO, E. I. P.; MACIEL, C. M. S.; PAULA, A.; TAGLIAFERRE, C. Fenologia de *Astronium graveolens* Jacq. em floresta estacional decidual em Vitória da Conquista, Bahia. **Ciência Florestal**, Santa Maria, v.28, n.1, p.641-650, 2018.

COUTINHO I. D.; COELHO R. G.; KATAOKA V. M. F.; HONDA N. K.; SILVA J. R. M.; VILEGAS W.; CARDOSO C. A. L. Determination of phenolic compounds and evaluation of antioxidant capacity of *Campomanesia adamantium* leaves. **Eclética Química,** Araraquara, v.33, n. 4, p. 53-60, 2008.

DONADIO, L. C.; MÔRO, F. V.; SERVIDONE, A. A. **Frutas Brasileiras**. 2 ed. Jaboticabal: FUNEP, 2004. 248p.

DRESCH, D. M.; SCALON, S. P. Q.; MASETTO, T. E.; MUSSURY, R. M. Storage of *Campomanesia adamantium* (Cambess.) O. Berg seeds: influence of water content and environmental temperature. **American Journal of Plant Science**, v.5, n.17, p.2555-2565, 2014.

DUMAS, C.; MOGENSEN, H. L. Gametes and fertilization: maize as a model system for experimental embryogenesis in flowering plants. **The Plant Cell**, Rockville, v. 5, n. 3, p. 1337-1348, 1993.

FIDALGO, A. O.; KLEINERT, A. M. P. Reproductive biology of six Brazilian Myrtaceae: Is there a syndrome associated with buzzpollination? **New Zealand Journal of Botany**, Wellington, v.47, n.4, p.355-365. 2009.

FREITAS, C. V.; OLIVEIRA, P. E. Biologia reprodutiva de *Copaifera langsdorffii* Desf. (Leguminosae, Caesalpinioideae). **Revista Brasileira de Botânica,** São Paulo, v.25, n.3, p.311-321, 2002.

INMET- Instituto Nacional de Meteorologia. BDMEP - Banco de Dados Meteorólogicos para Ensino e Pesquisa. Disponível em: http://www.inmet.gov.br/portal/index.php?r=bdmep/bdmep. Acesso em:1 junho 2018.

LANDRUM, L. R. ***Campomanesia, Pimenta, Blepharocalyx, Legrandia, Acca, Myrrhinium,* and *Luma* (Myrtaceae)**. New York: The New York Botanical Garden, 1986. 178p. (Flora Neotropica. Monograph, 45).

LORENZI, H.; BACHER, L.; LACERDA, M.; SARTORI, S. **Frutas brasileiras e exóticas cultivadas** (de consumo in natura). São Paulo: Plantarum, 2006. 640p.

LORENZON, M. C. A.; MATRANGOLO, C. A. R.; SCHOEREDER, J. H. Flora visitada pelas abelhas eussociais (Hymenoptera, Apidae) na Serra da Capivara, em Caatinga do sul do Piauí. **Neotropical Entomology**, Londrina, v.32, n.1, p.27-36, 2003.

LUGHADHA, E. N.; PROENÇA, C. A survey of the reproductive biology of the Myrtoideae (Myrtaceae). **Annais of the Missouri Botanical Garden**, Saint Louis, v.83, n.4, p.480-503. 1996.

LUZ, I. J.; KRUPEK, R. A. Fenologia reprodutiva, biometria do fruto e semente de *Campomanesia xanthocarpa* O. Berg. (Myrtaceae). **Estudos de Biologia,** Curitiba, v.36, n.86, p.115-124, 2014.

MARCOS-FILHO, J. **Fisiologia de sementes de plantas cultivadas**. 2 ed. Londrina: Abrates, 2015. 660p.

MARQUES, M. C. M.; ROPER, J. J.; SALVALAGGIO, A. P. B. Phenological patterns among plant life forms in a Subtropical Forest in Southern Brazil. **Plant Ecology,** Dordrecht, v.173, n.2, p.203-213. 2004.

MEDEIROS, S. de. S.; CECÍLIO, R. A.; MELO JUNIOR, J. C. F. de.; SILVA JUNIOR, J. L. C. Estimativa e espacialização das temperaturas do ar mínimas, médias e máximas na Região Nordeste do Brasil. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Campina Grande, v.9 n.2, p.247-255, 2005.

MORELLATO, L. P. C.; LEITÃO-FILHO, H. F.; RODRIGUES, R. R.; JOLY, C. A. Estratégias fenológicas de espécies arbóreas em floresta de altitude na Serra do Japi. **Revista Brasileira de Biologia**, Jundiaí, v.50, n.1, p.163-173, 1990.

MORELLATO, L. P. C.; RODRIGUEZ, R. R.; LEITÃO-FILHO, H. F. & JOLY, C. A. Estudo comparativo da fenologia de espécies arbóreas de floresta de altitude e floresta mesófila semidecídua na Serra do Japi, Jundiaí, São Paulo. **Revista Brasileira de Botânica**, São Paulo, v.12, p.85-98. 1989.

MORELLATO, L. P. C.; LEITÃO-FILHO, H. F. Padrões de frutificação e dispersão na Serra do Japi. In: MORELLATO, L. P. C. (Org.) **História Natural da Serra do Japi**: ecologia e preservação de uma área florestal no sudeste do Brasil. Campinas: UNICAMP/FAPESP, 1992. p.112-140.

MORELLATO, L. P. C. As estações do ano na floresta. In: LEITÃO FILHO, H. F.; MORELLATO, L. P. C. (Org.). **Ecologia e preservação de uma floresta tropical urbana:** Reserva de Santa Genebra. Campinas: UNICAMP, 1995. p.187-192.

MORELLATO, L. P. C.; TALORA, D. C.; TAKAHASI, A.; BENCKE, C. C.; ROMERA, E. C.; ZIPPARRO, V. B. Phenology of Atlantic Rain Forest trees: a comparative study. **Biotropica**, Washington, v.32, n.4b, p.811-823, 2000.

NUCCI, M.; ALVES-JUNIOR, V. V. Biologia floral e sistema reprodutivo de *Campomanesia adamantium* (Cambess.) O. Berg - Myrtaceae em área de cerrado no sul do Mato Grosso do Sul, Brasil. **Interciencia**, Caracas, v.42, n.2, p.127-131, 2017.

OLIVEIRA, P. O. Fenologia e biologia reprodutiva das espécies de cerrado. In: SANO, S. M.; ALMEIDA, S. P. (Ed.). **Cerrado:** ambiente e flora. Planaltina: Embrapa-CPAC, 1998. p.169-192.

RIBEIRO, J.F.; CASTRO, L.H.R. Método quantitativo para avaliar características fenológicas em árvores. **Revista Brasileira de Botânica,** São Paulo, v. 9, n.1, p.7-11, jul. 1986.

SILVA, A. L. G.; PINHEIO, M. C. B. Biologia floral e da polinização de quatro espécies de *Eugenia* L. (Myrtaceae). **Acta botânica brasileira**, v.21, n.1, p.235-247, 2007.

SOUZA, E. R. B.; NAVES, R. V.; BORGES, J. D.; VERA, R.; FERNANDES, E. P.; SILVA, L. B.; TRINDADE, M. G. Fenologia de cagaiteira (*Eugenia dysenterica* DC.) no estado de Goiás. **Revista Brasileira de Fruticultura**, Jaboticabal, v.30, n.4, p.1009-1014, 2008.

VALLILO, M.I., LAMARDO L.C.A., GABERLOTTI, M.L., OLIVEIRA, E., MORENO, P.R.H. Chemical composition of *Campomanesia adamantium* (Cambessédes) O. Berg' fruits. **Ciência e Tecnologia de Alimentos**, Campinas, v.26, n.4, p.805-810. 2006.