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Articles

Phenology of *Alibertia edulis* (Rich.) A. Rich in two vegetation types of Cerrado Matogrossense

Fenologia de *Alibertia edulis* (Rich.) A. Rich em duas fitofisionomias do Cerrado Matogrossense

Reinaldo de Souza Bilio[I]
Maria de Fatima Barbosa Coelho[I]
Elisângela Clarete Camili[I]
Flávia Richelli Pirani[II]
Simone dos Santos da Silva[III]

[I]Federal University of Mato Grosso, Cuiabá, MT, Brazil
[II]Independent Researcher, Barra do Garças, MT, Brazil
[III]Independent Researcher, Cuiabá, MT, Brazil

ABSTRACT

Phenology is a useful tool in the planning of multiple studies, ranging from the reproductive biology, fruit and seed collection, and diaspore dispersal. Through observations of phenological events, reproductive patterns can be easily characterized, which are relevant information for assessing the success of a species in a given environment. The phenology of *Alibertia edulis* was observed in two phytophysiognomies of the Cerrado Mato-Grossense: Cerradão and Cerrado sensu stricto, between February 2015 and January 2017, using the Fournier index. The phenophases of leaf fall, budding, flowering and fruiting were correlated with the environmental variables: maximum and minimum temperatures, relative humidity and precipitation. Leaf fall did not exceed 8% in the two evaluated locations. *A. edulis* showed vegetative growth in the rainy season between December 2015 and January 2016 and between September 2016 and November 2016. Flower buds occurred in December 2015 and November 2016 in both areas. Flower opening occurred in December 2015, and November and December 2016. In August and September 2015, the highest rates of ripe fruit occurred in both areas, with values not exceeding 12%. In 2016 there was no fruit maturation. *A. edulis* is an evergreen species with budding influenced by rain. Its reproductive phenophases are influenced by precipitation, except for fruit maturation that occurs in dry and hot months. Individuals from the Cerradão area have considerable reproductive performance indices when compared to individuals from the Cerrado strict sense.

Keywords: Phenological cycle; Phenophases; Marmelada-bola

RESUMO

A fenologia é útil no planejamento de múltiplos estudos, que envolvem desde a biologia reprodutiva, coleta de frutos e sementes, até a dispersão de diásporos. Através das observações dos eventos fenológicos é possível facilmente caracterizar os padrões reprodutivos, que são informações relevantes para a avaliação do sucesso de uma espécie em um determinado ambiente. A fenologia de *Alibertia edulis* foi observada em duas fitofisionomias do Cerrado Mato-Grossense: Cerradão e Cerrado sentido restrito, entre fevereiro de 2015 e janeiro de 2017, utilizando o índice Fournier. Correlacionaram-se as fenofases de queda de folhas, brotação, floração e frutificação, com as variáveis ambientais: temperaturas máxima e mínima, umidade relativa do ar e precipitação. A queda de folhas não ultrapassou 8% nos dois locais avaliados. *A. edulis* apresentou crescimento vegetativo no período chuvoso entre os meses de dezembro de 2015 e janeiro de 2016 e entre setembro de 2016 e novembro de 2016. Os botões florais ocorreram em dezembro de 2015 e novembro de 2016, nas duas áreas. A abertura das flores ocorreu em dezembro de 2015, e novembro e dezembro de 2016. Nos meses de agosto e setembro de 2015, ocorreram os maiores índices de frutos maduros nas duas áreas, com valores não ultrapassando 12%. Em 2016, não houve maturação dos frutos. *A. edulis* é uma espécie perenifólia com a brotação influenciada pela chuva. Suas fenofases reprodutivas são influenciadas pela precipitação, exceto a maturação dos frutos que ocorre nos meses secos e quentes. Os indivíduos da área de Cerradão apresentaram consideráveis índices de desempenho reprodutivo quando comparados aos indivíduos do Cerrado sentido restrito.

Palavras-chave: Ciclo fenológico; Fenofases; Marmelada-bola

1 INTRODUCTION

Phenology is an important tool in planning multiple studies, ranging from the reproductive biology, fruit and seed collection to diaspore dispersal. Along with knowledge of these events, reproductive patterns can be easily characterized, which is relevant information for assessing the success of the species in a given environment (Souza; Camacho; Melo; Rocha; Silva, 2014; Rocha; Silva; Dantas; Vieira, 2015).

By carrying out phenological studies, it is possible to predict the period of reproduction, deciduousness and vegetative growth cycle, parameters that can be used for species management (Morellato; Alberton; Alvarado; Borges; Buisson; Camargo; Cancian; Carstensen; Escobar; Leite; Mendoza; Rocha; Soares; Silva; Staggemeier; Streher; Vargas; Peres, 2016). Phenology is based on observing the phenophases of species, such as bud emergence, leaf development, flowering, fruiting, leaf discoloration and senescence. These processes make it possible to estimate the plant reproduction periods, growth cycles, the relationship with the climate and the best time to harvest seeds (Fournier, 1974; Freire; Azevedo; Cunha; Silva; Resende, 2013).

The Rubiaceae family is the fourth largest family of angiosperms distributed in the Cerrado and is considered the seventh richest family in terms of genera and species (Barbosa; Zappi; Taylor; Cabral; Jardim; Pereira; Calió; Pessoa; Salas; Souza; Di Maio; Macias; Anunciação; Germano Filho; Oliveira; Bruniera, 2013). The genus Alibertia has a large number of species with high economic value and pharmaceutical importance, since some species of this genus have antitumor, cytotoxic and antioxidant activities (Mendonça; Silva; Seixas; Santos, 2013). *A. edulis*, popularly known as “marmelo do cerrado” or “marmelada-bola”, is a plant widely distributed in Brazil. Its pharmacological effects have been widely studied, mainly in the use of its leaves, through teas, as a hypoglycemic, antihypertensive, diuretic and anti-tumor potential (Rieder, 2013; Marques; Hamerski; Garcez; Tieppo; Vasconcelos; Torres-Santos; Garcez, 2013).

Due to the medicinal potential of the species, its natural population is continually exploited through extractivism, most of which is predatory. Thus, increasing the number of studies that help understand the reproduction and regeneration process of native species such as *A. edulis* is becoming increasingly necessary, as is data on their phenological behavior (Pires; Rosa; Cabral; Silva; Nogueira; Ferreira, 2016).

The low availability of research on the phenological aspects of the vast majority of native species endorses the need for more studies on this subject, especially in specific bioclimatic regions (Freire; Azevedo; Cunha; Silva; Resende, 2013). Thus, analyzing the floral biology of Cerrado tree species as a source of information on the uniqueness of each species and on the dynamics that govern the organisms that make up the biome, makes it possible to understand how Cerrado plants are adapting to local changes and how these changes affect their reproductive success (Santos; Añez, 2018). In addition, the research aimed at characterizing the different stages of plant development is fundamental to understand how plant populations behave in response to climatic and soil conditions. These studies act as indicators of plant responses to local environmental conditions (Fournier, 1974).

In the view of this, the aim of this study was to evaluate the phenology of *A. edulis* in two Cerrado areas with different phytophysiognomies, relating phenological events to environmental factors in order to generate subsidies for the sustainable management and conservation of its natural population in its natural areas of occurrence.

2 MATERIALS AND METHODS

2.1 Study area

This study was carried out on a private property located 15 km from Cuiabá (15°43' South and 56°04' West), accessible via the MT-040 highway, which connects the capital to the municipality of Santo Antônio do Leverger.

According to the Köppen classification, the climate in the region is of the Aw type, with an average monthly temperature varying between 22ºC and 28ºC, and an average annual rainfall of 1320 mm. The area's altitude varies between 165 and 189 m above sea level, and it covers an area of 54,522 km^2. It is also worth noting that the area has been protected from fire for twenty years (Dalmolin; Lobo; Vourlitis; Silva; Dalmagro; Antunes Junior; Ortíz, 2015).

This study was carried out in two different areas in terms of vegetation and soil. The first area (Area 1) has typical Cerradão vegetation, with species that occur not only in the Cerrado in the strict sense but also in the forest. The trees in this area have continuous canopies and an average height of 8 to 15 meters, which creates favorable light conditions for shrubs and herbaceous plants. On the other hand, the second area (Area 2) has Cerrado vegetation with strict sense together with smaller, sloping, crooked trees with irregular, twisted branches. The trees in this area are more widely spaced and the undergrowth is less dense.

2.2 Sampled individuals and phenology

Fifty individuals of *A. edulis* were randomly selected, 25 of which were located in the Cerradão and 25 in the Cerrado strict sense. The individuals sampled had good canopy visibility and were of reproductive age, on average from the third year of age. Phenophase observations were made every two weeks from February 2015 to January 2017.

The percentage of occurrence of the vegetative and the reproductive phenophases were recorded: i) sprouting (the period in which leaf buds appear until new leaves expand); ii) leaf fall; iii) flowering (divided into the period with bud production and open flowers); iv) fruiting (divided into the period with immature fruit and ripe fruit).

The phenophases observed were related to the following meteorological data from the area: accumulated monthly rainfall, average monthly relative humidity and average monthly maximum and minimum temperatures. The relative humidity and temperature data were collected by a station located on the property where the studies were carried out, while the rainfall data was obtained from INMET (National Institute of Meteorology).

2.3 Data analysis

Data from the two areas were analyzed separately, using Fournier's intensity percentage indices (Fournier, 1974). The values were obtained *in situ*, through observation using a five-category semi-quantitative interval scale. These categories ranged from 0 to 4, with 25% intervals between each of them. This scale allowed estimating the percentage of phenophase intensity in each individual: (0) the phenological event does not occur; (1) 1% to 25% event; (2) 26% to 50% event; (3) 51% to 75% event and (4) 76% to 100% event.

The activity index, also known as percentage of individuals, is a simplified method that detects the presence or absence of phenophase in an individual. However, it does not take into account the intensity of the phenological event. This index indicates the percentage of individuals in the population that are manifesting the phenophase in question.

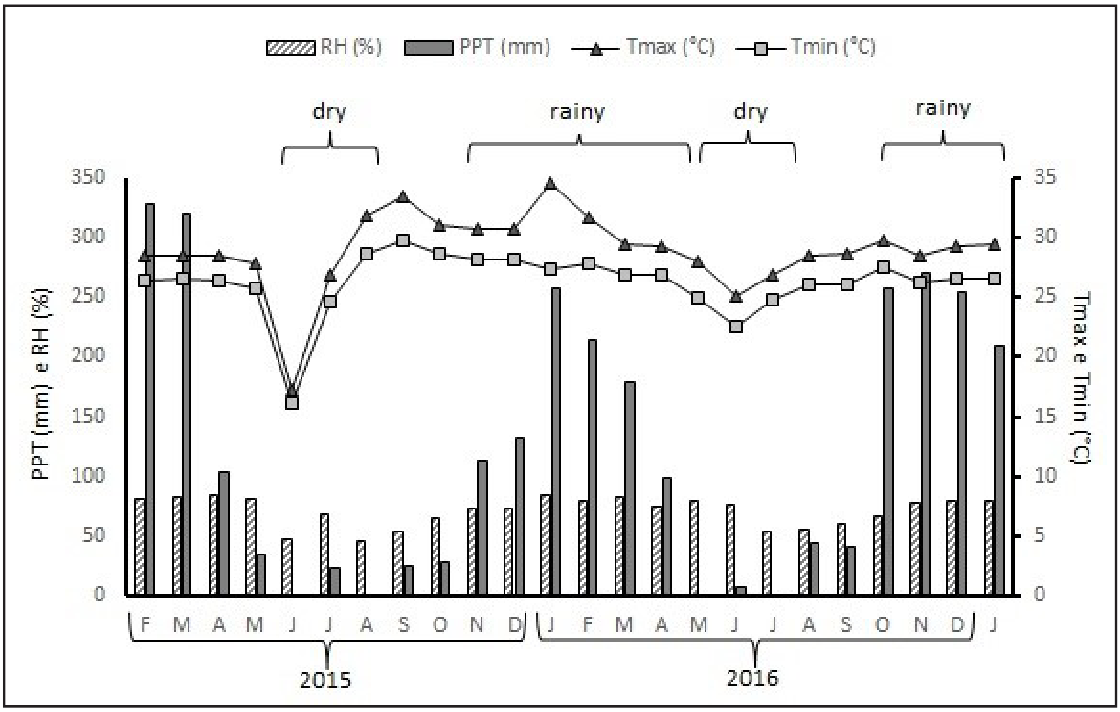
Spearman's correlation coefficient (rs) was used to examine the relationship between phenophases and climate variables. The calculations were carried out using the number of species observed monthly in each phenophase and the climatic variables (Zar, 1998).

3 RESULTS AND DISCUSSIONS

3.1 Local climatic characterization

During the period during which this study was carried out, climatic seasonality was observed (Figure 1), covering two rainy periods, two dry periods, two rainy-dry transition periods and two dry-rainy transition periods.

Figure 1 – Monthly averages of maximum (Tmax) and minimum (Tmin) temperatures, monthly average of relative humidity (RH) and accumulated monthly precipitation (PPT) between the months of February 2015 and January 2017



Source: Authors (2022)

In 2015, the rainy season began in November and lasted until April 2016, where the highest levels of precipitation were concentrated (reaching up to 250 mm). In the months of May, June and July 2016, precipitation was low (reaching a maximum of 10 mm), characterizing the dry period, increasing in the months of August and September 2016, and in October 2016 a new period of rain, marking the beginning of the new wet period. In the months of August 2015 and July 2016 there was no precipitation and the month that rained the most during the twenty-four (24) months of observation was February 2015, with a total accumulated precipitation of 328 mm. The dry periods in 2015 and 2016 lasted just three months.

The minimum monthly temperatures in the dry period varied between 16.1ºC and 29.1ºC and the maximum between 17.2ºC and 33.5ºC. During the rainy season, minimum monthly temperatures varied between 26.3ºC and 28.2ºC and maximum temperatures between 28.5ºC and 34.5ºC. The monthly average relative humidity in the dry months reached 45% and, during the rainy season, it varied between 67% and 85%.

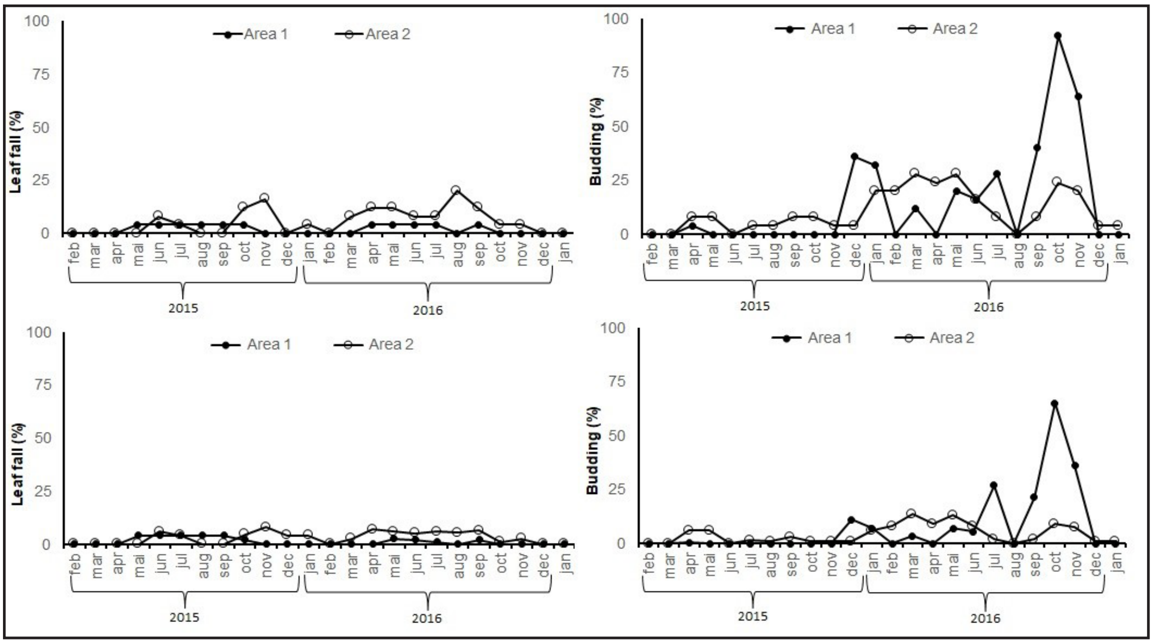
3.2 Vegetative phenophases

The percentage of *A. edulis* individuals that had leaf fall throughout the entire evaluation period was below 25%, with a slight increase in individuals between October and November 2015, and between August and September 2016, in Area 2 (Figure 2).

Leaf fall remained low throughout the observed period, not exceeding 8% in the two areas evaluated. This same behavior was also observed by Coelho, Consolaro and Oliveira (2020) in individuals of *Palicourea crocea* (SW.) Roem. & Schult. (Rubiaceae), when the foliage remained persistent for most of the year, with a slight increase in leaf loss between the months of June and October, the period of greatest water deficit.

Similar results were observed by Almeida, Silva, Menino and Silva (2018) in individuals of *Hancornia speciosa* G. in a Cerrado remnant located in the region of Montes Claros, GO state, where 30% of the individuals were manifesting the leaf fall phenophase in the month of September, coinciding with the end of the dry period and the beginning of the rainy.

Figure 2 – Activity index (A) and (B), and intensity (C) and (D) of leaf fall and sprouting of 50 individuals of *Alibertia edulis* Rich., in two areas of Cerrado Matogrossense



Source: Authors (2022)

Unlike the results found in this work, Pereira, Boaventura, Cornelissen, Nunes and Castro (2022) recorded intense leaf fall in a study that evaluated the variation in the phenological events of four species (*Banisteriopsis campestris* (A.Juss.) Little, *Byrsonima verbascifolia* (L.) DC, *Heteropterys umbellata* A.Juss. and *Peixotoa tomentosa* A.Juss.) subjected to a seasonal environment. The authors explained that the phenological patterns of the species studied are directly linked to climatic variables, and that different abiotic factors can affect different phenophases.

In area 1, leaf fall correlated negatively with the variables RH (rs= -0.53) and precipitation (rs= -0.85) (Table 1). Although *A. edulis* showed a slight increase in leaf fall in November 2015, a month with a considerably high precipitation rate, this result indicates that lower precipitation rates and relative humidity led to greater leaf fall.

In area 2, the leaf fall correlation index was not significant with any of the climatic variables.

Table 1 - Spearman correlation coefficients (rs) between total monthly precipitation, minimum and maximum temperatures and relative air humidity and the percentage of individuals of *Alibertia edulis* Rich., in the leaf fall (Lf) and budding (B) phenophases

	Area 1			Area 2		
Var. ambiental	**Phenophase**	**r_s**	**p**	**Phenophase**	**r_s**	**p**
RH (%)	Lf	-0,53	0,0067*	Q	-0,33	0,11
	B	0,06	0,77	Br	0,23	0,27
Máxmum T (°C)	Lf	-0,31	0,13	Q	-0,18	0,37
	B	-0,02	0,91	Br	0,19	0,36
Mínimum T (°C)	Lf	-0,28	0,17	Q	-0,25	0,23
	B	-0,12	0,56	Br	0,11	0,60
Precipitation (mm)	Lf	-0,85	0,0001*	Q	-0,34	0,09
	B	0,11	0,60	Br	-0,01	0,94

Source: Authors (2022)

In where: *Significative correlation at the significance level of 5% probability.

In area 1, in the periods between December 2015 and January 2016, and September and November 2016, there was a greater number of individuals in the budding stage with 36% and 92%, respectively. However, the sprouting intensity did not exceed 11% and 65%, respectively. These leaf growth peaks occurred precisely at the beginning of the rainy season, in the two years of evaluation.

The difference in the production of new leaves between the two years of evaluation can be explained by the delay in the beginning of the rainy season in 2015. In 2016, the rains began at the end of August and reached an accumulated amount of 257 mm (Figure 1).

Regarding vegetative growth, this was remarkable in area 1 in the months of December 2015 and from September to November 2016. In area 2, vegetative growth of *A. edulis* was recorded from January to May 2016 and, from October to November 2016.

It can be observed that, in both study areas, there was a stimulus to the vegetative growth of the species during the rainy months. This behavior is similar to surveys carried out by Ferreira, Fina, Rêgo, Rui and Kusano (2017), in a remnant of Cerrado restricted sense in Aquidauana, Mato Grosso do Sul state, who observed that individuals of *Qualea parviflora* Mart. showed the beginning of leaf sprouting predominantly at the beginning of the rainy season. The authors point out that in regions with a seasonal climate, as occurs in the Cerrado biome, leaf sprouting occurring in the period before the first rains may suggest a strategy to avoid the emission of new leaves during periods of water scarcity.

Valentini, Almeida, Coelho and Rodríguez-Ortíz (2013) observed in individuals of *Siparuna guianensis* Aubl. that the rains also stimulated the sprouting of the species and, consequently, an increase in the number of young leaves during the transition between the rainy and dry periods, in the municipality of Cuiabá, MT state.

The intensity index of the budding phenophase was close to zero (Figure 2) in both areas, in the dry season of 2015, when the relative humidity levels recorded were around 45%. The sprouting phenophase correlation index was not significant for any of the meteorological variables in both study areas (Table 1).

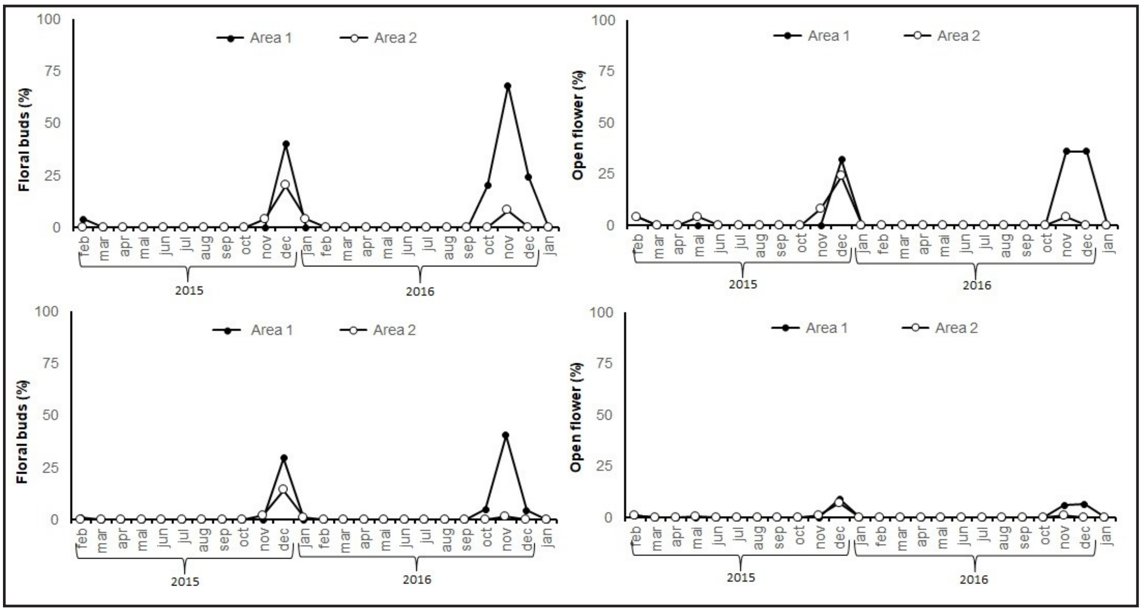
3.3 Reproductive phenophases

The observation of the first flower buds began in December 2015 in area 1, with 40% of the individuals. In November of the same year in area 2, the first flower buds appeared, and, in the following month, flower buds could be observed in 20% of the individuals (Figure 3).

In November 2016, the percentage of individuals with flower buds increased to 68% in area 1 and decreased to 8% in Area 2. The rainy period in the two years of evaluation contributed to the appearance of the first flower buds in individuals of the species. The peaks of activity and intensity of the event occurred in December 2015 and November 2016 in the two study areas, periods with precipitation rates of 132 and 270 mm, respectively. The intensity index of floral buds was higher in 2016, with

40% of the phenophase occurring in November, precisely the month that recorded the highest rainfall of the entire evaluation period, approximately 270 mm.

Figure 3 – Activity index (A) and (B) and intensity (C) and (D) of flowering (flower bud and open flowers) of 50 individuals of *Alibertia edulis* Rich. in two areas of Cerrado Matogrossense



Source: Authors (2022)

Almeida, Silva, Oliveira, Alves and Menino (2021), when carrying out a reproductive phenological assessment of *Qualea grandiflora* Mart., stated that there was variation in flowering (flower buds and anthesis) between the years of study. In the first year, the event lasted just four months, in the second year, the event lasted longer. Differences in Fournier indices from one year to the next were also verified.

These results are close to what was found with the flowering of *A. edulis*, which showed a higher frequency of individuals with floral buds in 2016. The observation of floral buds on *A. edulis* plants occurred during the rainy season, in both years of study.

Therefore, it can be inferred that most tropical species do not, in fact, present annual flowering patterns. Many species record the occurrence of flowers every year, but there is interannual variation in the quantity of flowers produced, culminating in years in which production may be reduced. The emission of flower buds during the rainy season was also observed in *Byrsonima basiloba* A.Juss. in the Cerrado of Goiás state, in the two years of research (Silva; Balestra; Soares; Menino, 2016).

Almeida, Silva, Oliveira, Alves and Menino (2021) reported in their studies with *Qualea grandiflora* Mart., that the highest concentration of floral buds occurred in November, associated with the increase in water availability due to precipitation. The authors stated that the intensity of the event correlated positively with precipitation.

The presence of *A. edulis* flower buds in Area 1 was significantly positive with precipitation (rs = 0.55) (Table 2). This demonstrates the dependence of the species on hydration for the emergence of floral buds.

Table 2 – Spearman correlation coefficients (rs) between total monthly precipitation, minimum and maximum temperatures and relative air humidity and the percentage of individuals of *Alibertia edulis* Rich in phenophases

Environmental variables	Area 1			Area 2		
	Phenophase	r_s	**p**	**Phenophase**	r_s	**p**
RH (%)	Fb	0,06	0,77	Bf	0,12	0,55
	Of	0,14	0,49	Fa	0,14	0,50
	If	0,39	0,05	Fi	0,28	0,17
	Mf	-0,46	0,02*	Fm	-0,27	0,19
Máximum T (°C)	Fb	0,05	0,80	Bf	0,31	0,13
	Of	-0,01	0,92	Fa	-0,01	0,93
	If	-0,37	0,07	Fi	-012	0,56
	Mf	0,50	0,01*	Fm	0,78	0,0001*
Mínimum T (°C)	Fb	0,13	0,53	Bf	0,27	0,19
	Of	0,05	0,81	Fa	0,10	0,62
	If	-0,30	0,15	Fi	0,02	0,91
	Mf	0,57	0,003*	Fm	0,78	0,0001*
Precip. (mm)	Fb	0,55	0,005*	Bf	0,33	0,10
	Of	0,47	0,01*	Fa	0,30	0,15
	If	-0,03	0,87	Fi	-0,03	0,88
	Mf	-0,38	0,06	Fm	-0,12	0,55

Source: Authors (2022)

In where: floral buds (Fb); open flowers (Of); immature fruits (If); mature fruits (Mf); *Significative correlation at the significance level of 5% probability.

Anthesis occurred between November and December 2015 in Areas 2 and 1, respectively. The peak of the activity index occurred in December of the same year in both areas. In 2016, 36% of individuals presented the event in area 1 and, in area 2, the event practically did not occur this year.

The significant record of the intensity index occurred in December 2015 with only 9% and 7% of the phenophase of the open flowers among individuals, in areas 1 and 2, respectively. In 2016, only 6% of flower openings occurred among individuals in area 1 in the months of November and December (Figure 3).

The occurrence of anthesis at the beginning and during the rainy season was notable in the two areas evaluated. Santos and Ferreira (2012) working with *Q. grandiflora* Mart. in Cerrado in the strict sense of Tocantins, they found a strong correlation between flowering and precipitation, and suggested that flower production is strongly associated with this environmental variable.

In the observations of Soares, Reis, Sá, Silva and Santos (2014) the greater production of buds and flowers of *Xylopia aromatica* (Lam.) Mart. in the second half of October 2010. The authors found that the flowering of the species, despite having started at the end of the dry season, occurred more intensely in the wet season, as demonstrated by the results of this work. Silva, Almeida, Oliveira, Menino and Alves (2020) confirmed a highly positive correlation between precipitation and the bud production of *Qualea multiflora* Mart. in a remnant of Cerrado in Goiás. When evaluating the phenology of *Annona crassiflora* Mart. in the municipality of Goiânia, Melo, Seleguini, Leite, Souza and Naves (2015) recorded a greater number of individuals flowering during the rainy season, more precisely in the months of November and December in both evaluation periods.

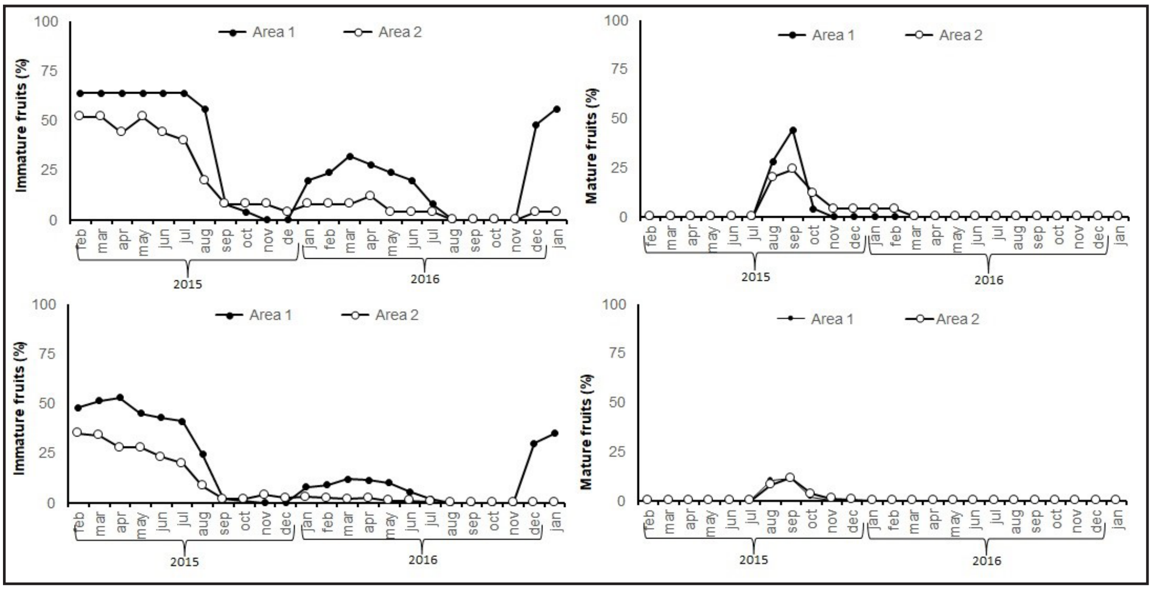
Corroborating the previous information, Silva (2018) concluded that the anthesis of *Hymenaea stigonocarpa* Mart. ex Hayne., a species from Cerrado sensu stricto, occurred at the beginning of the rainy season, more precisely in October, and remained until February. Their study concluded that the floral anthesis event demonstrated a positive correlation with precipitation and average and minimum temperatures. Cobra, Nascimento, Antoniazzi, Krause and Silva (2015) found in their studies on the reproductive biology of *Cordiera macrophylla* (K.Schum.) Kuntze in the municipality of Tangará da Serra-MT, that unlike *A. edulis*, the flowering of the species, belonging to the Rubiaceae family, was limited three months of the year, during the dry season and the beginning of the rainy season.

Like the floral buds, the open flower phenophase in area 1 was positively correlated with precipitation (rs = 0.47), indicating a strong dependence of this phenological event on the wet season. The tendency for flowering at the beginning of the rainy season for Cerrado tree species appears to be quite common in tropical regions with a seasonal climate, which is what Soares, Silva, Sá, Reys, Dourado and Santos (2013) also concluded in their study with *Annona Coriacea* Mart. in a Cerrado sensu stricto in the municipality of Rio Verde, Goiás state. The flowering events evaluated in area 2 did not show a significant correlation with any of the climatic variables (Table 2).

The fruiting of *A. edulis* showed an annual and slightly synchronized pattern. The observation of immature fruits occurred between the months of February and August 2015, in the two areas evaluated. During this period, 64% of individuals in area 1 presented the event and, in May 2015, 52% of individuals in area 2 had immature fruits on the tops (Figure 4).

The beginning of fruiting, coinciding with the rainy season and continuing until the end of the rainy season and the beginning of the dry season, and with high relative humidity, was observed during the two years of evaluation. Nunes, Reis, Guilherme, Pinto and Silva (2018), evaluating the reproductive phenology of *Syagrus oleracea* (Mart.) Becc. in a remaining population of the species located in the municipality of Jataí, GO state, they found that green infructescences occurred practically throughout the evaluation period, with the highest frequency of green fruits being observed during the rainy season and the lowest frequency in the months when temperature and relative humidity were lower.

Figure 4 – Activity index (A) and (B) and intensity (C) and (D) of fruiting (green fruits and ripe fruits) of 50 individuals of *Alibertia edulis* Rich. in two areas of Cerrado Matogrossense



Source: Authors (2022)

In 2016, fruiting in area 1 began in January, reaching 32% of individuals in March. In area 2, the event did not occur with the same intensity, reaching the highest level of activity in April, with only 12% of individuals with immature fruits. In December 2016, a new fruiting cycle occurred in area 1, with 56% of *A. edulis* individuals bearing fruits in January.

Faria, Coelho, Albuquerque and Azevedo (2015) observed that the species *Brosimum gaudichaudii* Trécul. also showed fruiting at the beginning of the rainy season, in a study carried out in the restricted cerrado in the Mata Cavalos region, a community located in the municipality of Nossa Senhora do Livramento, MT state, between November 2006 and May 2008.

The observation of immature fruits lasted for a period of approximately six months, between January and August 2015 and between January and June 2016. This period can be called the fruit maturation or development phase. Ferreira, Fina, Rêgo, Rui and Kusano (2017) observed a long period of maturation and growth of *Qualea parviflora* Mart. and, a gradual drop in the intensity of this phenophase, even before the occurrence of ripe fruits, a fact that can be justified by the fruit abortion.

The intensity index of immature fruits in individuals of *A. edulis*, in this study, presented significant values between the months of February and August 2015, recording more precisely in the months of February and April, 35 and 53% of the phenophase, in areas 2 and 1, respectively. In 2016, the immature fruit intensity index in Area 1 began in January, reaching 12% in March. In December of the same year, there was an increase in the intensity index of immature fruits, reaching 35% of the phenophase in January 2017. In Area 2, the event intensity index values were below 2% in 2016.

These results demonstrate two important facts, the decrease in both activity and intensity rates from one year to the next, and the low fruit production, even with a significant number of individuals presenting the event. It is worth mentioning that no correlation was obtained between immature fruits and any of the variables analyzed in area 1.

The peak activity of ripe fruits occurred in September 2015, in 44% and 24% of individuals in areas 1 and 2, respectively. However, before beginning the ripening process, the fruits were heavily preyed upon by insects, making collection and use of the material unfeasible in most cases. The insect larvae completed their development cycle inside the fruits, compromising the seeds. Therefore, the ripening of the fruits that developed in 2016 in the two areas studied was not observed, as the majority of the fruits did not complete the process. In the months of August and September 2015, the highest levels of ripe fruit intensity occurred in the two areas analyzed, however, it did not exceed 12% (Figure 4).

The correlation was significantly negative ($p < 0.05$) with relative humidity (r_s = -0.47), and positive with maximum (r_s = 0.50) and minimum (r_s = 0.57) temperatures in area 1, corroborating field observations, where the peak of fruit ripening occurred in September, a highly dry and hot period. In area 2, the correlation index for ripe fruits was significantly positive ($p < 0.05$) for the variables, maximum (r_s = 0.78) and minimum (r_s= 0.78) temperatures (Table 2).

Regarding phenological behavior, it was observed that individuals located in Area 1 showed higher levels of activity and intensity, especially during the reproduction phases. This occurred due to variations in phytophysiognomy and, consequently, in the floristic composition of the Cerrado, which affected the occurrence of phenological events in this Biome.

4 CONCLUSIONS

A. edulis presents an evergreen behavior with vegetative growth notably concentrated in the rainy season. The species' leaf loss is strongly related to relative humidity and precipitation in the 'Cerradão' area.

The incidence of floral buds, flowers, as well as fruiting in *A. edulis* occurs intensely during the rainy season, but fruit maturation occurs punctually in months considered highly dry and hot, that is, it has a strong relationship with relative humidity and temperature.

Individuals from the Cerradão area present considerable rates of reproductive performance in flowering and fruiting when compared to individuals from the restricted Cerrado.

For management and conservation purposes of the species, the collection of fruits and seeds must be carried out in the months of August and September, that is, in the driest and hottest period of the year.

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Authorship Contribution

1 Reinaldo de Souza Bilio

Forestry Engineer, Doctor in Tropical Agriculture, Professor

https://orcid.org/0000-0001-6777-9600 • reinaldobilio@hotmail.com

Contribution: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing

2 Maria de Fatima Barbosa Coelho

Agronomist, Doctor in Phytotechnics, Professor

https://orcid.org/0000-0003-1393-2504 • coelhomfstrela@gmail.com

Contribution: Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing

3 Elisângela Clarete Camili

Agronomist, Doctor in Agronomy, Professor
https://orcid.org/0000-0002-4642-2511 • eccamili@hotmail.com
Contribution: Formal analysis; Methodology; Resources; Writing – original draft; Writing – review & editing

4 Flávia Richelli Pirani

Biologist, Doctor in Forestry Sciences, Independent Researcher
https://orcid.org/0000-0001-5695-7977 • flaviarichelli@yahoo.com.br
Contribution: Data curation; Formal analysis; Writing – review & editing

5 Simone dos Santos Silva

Geographer, Doctor in Geography, Professor, Independent Researcher
https://orcid.org/0000-0002-1416-3172 • simonebotanica.23@gmail.com
Contribution: Data curation; Investigation; Methodology

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