Floresta Ambient., Rio de Janeiro, 2023; 30(3): e20220043
https://doi.org/10.1590/2179-8087-FLORAM-2022-0043
ISSN 2179-8087 (online)

Floresta e Ambiente

ORIGINAL ARTICLE – Conservation of Nature

Physical Characteristics and Productive Performance of Pequiá Fruit Under the Influence of Natural Vegetation

Bruna Maria Roldão Lopes[1]
Rayleen Whaiti Lopes da Silva[3]
Clarissa Fernandes[1]
Oriales Rocha Pereira[1]
Joaquim Manoel da Silva[1,2]

[1]Universidade do Estado de Mato Grosso (UNEMAT), Faculdade de Ciências Agrárias, Biológicas e Sociais, Nova Xavantina, MT, Brasil.
[2]Universidade do Estado de Mato Grosso (UNEMAT), Programa de Pós-Graduação em Ecologia e Conservação, Nova Xavantina, MT, Brasil.
[3]Universidade do Estado de Mato Grosso (UNEMAT), Rede Pró-Centro-Oeste, Programa de Pós-Graduação em Biotecnologia e Biodiversidade, Nova Xavantina, MT, Brasil.

Abstract

This study aimed to investigate the physical characteristics of pequiá fruits in the Cerrado areas of Nova Xavantina-MT, and to determine the influence of native vegetation on fruit biometry and productivity. The research question was whether proximity to fragments of native vegetation increases the productivity of pequiá fruit. In 2017 and 2018, 40 ripe fruits that had fallen to the ground were collected from three locations, two of which were close to native vegetation and one of which was close to crops and pastures. The highest values were observed in fruits collected in 2018, when there was more rainfall, and in fruits from the locations close to native vegetation, indicating that the presence of native vegetation can provide ecosystem services that promote the productivity of pequiá fruits. These findings have important implications for the conservation and management of Cerrado ecosystems.

Keywords: *Caryocar villosum*, *Cerrado, pollination, rainfall.*

1. INTRODUCTION AND OBJECTIVES

The Cerrado biome has been suffering from high destruction and fragmentation of its natural habitats, and even presenting high richness and biodiversity, it is the most threatened tropical savanna on the planet (Scariot et al., 2005). There are several causes that threaten this biome: uncontrolled fire to 'clear pastures' during the period of drought, deforestation, uncontrolled use of environmental contaminants, erosion, leaching and soil loss through the use of inappropriate techniques (Alho, 2005).

According to Klein (2002), about 35% of the areas belonging to the Cerrado have already been converted into crops or pastures due to the strong agricultural expansion; another aggravating factor is plant extraction in the Cerrado, which can evolve into predatory exploitation that aims only at increasing profits, and ends up impairing the maintenance of natural resources in forest areas (Bispo et al., 2021).

Pequi trees represent an example of this reality, it is a potential extractive and promising species that can be used to restore degraded areas (Camargo et al., 2014). Grzebieluckas et al. (2010) studied opportunity cost in municipalities of the state of Mato Grosso and found that the gains obtained with the exploitation of pequi from the Cerrado are greater than the gains of agricultural crops such as soybeans (*Glycine max* L.) and rice (*Oryza sativa* L.), meaning that pequi generates a higher return for rural producers than the agricultural crop of the municipality. Pequiá is another extractive species with high commercial demand mainly in the state of Pará, Brazil (Conceição et al., 2017).

Caryocar villosum (Aubl.) Pers is a species popularly known as pequiá or pequi, belonging to the family Caryocaraceae, with a natural occurrence in the north and northeast of Brazil (Prance & Silva, 2006). Its pollination is carried out mainly by bats, which are considered the most important pollinators - for this species, thanks to the frequency of visits to flowers and for promoting crossings over long distances (Martins & Gribel, 2007).

Pollination is considered an ecosystem service that provides many benefits to humanity, one of which is the role in the production of grown or wild plants (BPBES, 2019). Services provided by ecosystems are divided into four essential categories: support services (biodiversity maintenance, maintenance of the life cycle and soil formation); provision (food, water, wood, genetic, medicinal and ornamental resources); regulation (pollination, biological control, disaster prevention and regulation of climate, air and water); and cultural (recreation, tourism and aesthetic, spiritual and educational values) (Parron et al., 2015).

Areas of vegetation in forests provide ecosystem regulating services, with emphasis on the supply and availability of water and the regulation of microclimates (Dantas et al., 2017). Climate variables can alter phenological processes of plants in savanna formations in the Cerrado (Silva et al., 2019), such as *Caryocar brasiliense* Cambess., which has its fruit set influenced by changes in average monthly rainfall, thus playing an important role in production of this fruit (Françoso et al., 2014).

The world population is totally dependent on the activities that ecosystem services provide (BPBES, 2019). In order for plant production of potential agricultural species to occur, the action of pollinators is required, and ecosystem services promote biological regulation and pest control in crops (Venzon et al., 2018).

In this context, the present study aimed to physically characterize pequiá tree fruit from areas in the Cerrado domain, in the eastern region of the state of Mato Grosso, and to determine the influence of natural vegetation as a provider of ecosystem pollination services on the biometry and productivity of pequiá fruit.

2. MATERIALS AND METHODS

The experiment was conducted across three properties within the municipality of Nova Xavantina, Mato Grosso state, each presenting unique environmental attributes. Property 1 (14°41”22,40”S and 52°21’16,52”W) was proximal to a fragment of Cerrado vegetation, adjacent to the Bacaba Municipal Park, representing a significant natural ecological context. Property 2 (14°38’21,85”S and 52°21’45,59”W) was situated near a legally designated permanent preservation area (PPA), characterized by a controlled interaction with endemic flora. Conversely, Property 3 (14°36’41,85”S and 52°20’22,60”W) was positioned nine kilometers from the urban center, in a predominantly anthropogenic landscape, limited in natural vegetation and bordered by agricultural crops and pastures. These distinct localities served as the basis for the study, providing diverse settings to investigate the physical characteristics and productive performance of pequiá fruit under varied influences of natural and human-modified vegetation.Monthly climate data on rainfall and temperature were obtained from the National Meteorological Institute (INMET, 2019) for the municipality of Nova Xavantina during the years 2017 and 2018 (Figure 1).

Fruit samples were collected at the beginning of the rainy season, in November of both 2017 and 2018. A total of 40 *C. villosum* fruits were collected from random trees in each of the three properties analyzed. Only healthy, undamaged, and ripe fruits that had fallen to the ground were selected for analysis.

Fruit were taken to the laboratory of the State University of Mato Grosso (UNEMAT), Nova Xavantina campus, to evaluate the following parameters: fruit weight (FW, in grams), shell weight (SW, in grams) and pyrene weight per fruit (PWF, in grams), using a digital scale; equatorial diameter of the fruit (EDF, in millimeters), longitudinal diameter of the fruit (LDF, in millimeters), equatorial diameter of the pyrene (EDP, in millimeters), longitudinal diameter of the pyrene (LDP, in millimeters), and shell thickness (ST, in millimeters), with a digital caliper. Fruit of *C. villosum* containing more than one pyrene were averaged to obtain the values of equatorial diameter of the pyrene (EDP) and longitudinal diameter of the pyrene (LDP).

Subsequently, pyrenes of *C. villosum* were separated into batches of 10 units to evaluate: pyrene weight with pulp (PWP, in grams), pyrene weight without pulp (PWWP, in grams), pulp weight (PW, in grams) and pulp yield (PY, in grams). Each batch of pequiá pyrenes was cooked separately for 40 minutes to facilitate the removal of the pulp. To find the pulp yield, the value of pyrene weight with pulp (PWP) was subtracted from the value of pyrene weight without pulp (PWWP). These values were obtained using a digital scale.

Biometric variables were tested by analysis of variance (property factor), where the means of the significant variables were compared by Tukey’s test at 1% significance. Between the years of study, the biometric variables were compared by Student’s *t*-test at 1% significance. Pearson linear correlation test (r) was applied and the level of significance (p) between variables was checked using the *t*-test. Pearson correlation (r) can be useful to determine the linear association between variables, this model assumes that the increase or decrease of one variable can generate the same impact on another variable (Filho et al., 2014). The Excel version 2010 software was used to construct the graph of rainfall and air temperature; descriptive statistical analyses and Pearson linear correlation test (r) were run in the statistical software PAST version 2.17 (Hammer et al., 2001).

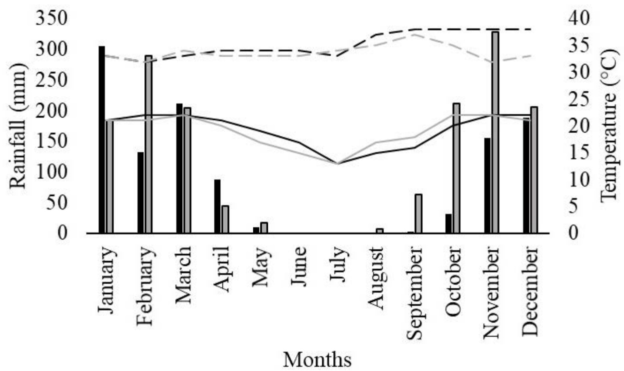

Figure 1. Monthly climatic variatioqns of rainfall and air temperature in the municipality of Nova Xavantina, state of Mato Grosso, Brazil. Rainfall in millimeters (mm) characterized by bars, ■ 2017, ■ 2018; maximum average temperature and minimum average temperature in degrees Celsius (°C) characterized by lines, -- 2017, -- 2018 and — 2017, —, 2018 respectively. Source: National Institute of Meteorology (INMET).

3. RESULTS AND DISCUSSION

The biometric parameters analyzed showed a significant correlation between the data; most variables are significant (p <0.01) by the *t*-test, with a high correlation between fruit weight (FW), equatorial diameter of the fruit (EDF), shell weight (SW) and pyrene weight per fruit (PWF) for properties 1 and 2 in 2017 and 2018 (Tables 1 and 2). Moreira et al. (2016) found a high correlation between weight, diameter and length of pupunha fruit (*Bactris gasipaes* Kunth), emphasizing that these correlations may be related to the genetic characteristics of the plant. Equatorial diameter of the fruit (EDF) was also highly correlated with shell weight (SW) and pyrene weight per fruit (PWF). The variability between biometric variables can be influenced by environmental factors, such as the availability of water considered essential for the production of species with fleshy fruit (Ferreira et al., 2016; Leandro et al., 2018).

For property 3, fruit weight (FW) was positively correlated with shell weight (SW), pyrene weight per fruit (PWF) and equatorial diameter of the fruit (EDF) in 2017 (Table 3), obtaining a strong interaction with [r] values greater than 0.8. In 2018, the test showed a correlation with a high level of significance for fruit weight (FW) in relation to shell weight (SW) and pyrene weight per fruit (PWF), showing a strong interaction between the variables, with [r] values of 0.956 and 0.816, respectively. Positive correlations between fruit size and weight were reported by Souza et al. (2019) in gabiroba fruit (*Campomanesia adamantium* (Cambess.) O.Berg) and murici fruit (*Byrsonima verbascifolia* (L.)Rich) and umbu fruit (*Spondias tuberosa* Arruda) (Costa et al., 2015). Another very relevant variable is the relationship between the equatorial diameter of the pyrene (EDP) and the longitudinal diameter of the pyrene (LDP), which showed a high correlation with [r] of 0.846, demonstrating that both are linearly proportional.

Biometric variables analyzed for *C. villosum* fruit showed normal or approximately normal distribution, according to the descriptive statistical analysis (Table 4). Based on the coefficient of variation values, the largest variations were found for the equatorial diameter of the fruit (EDF) and pyrene weight per fruit (PWF), and smallest variations for the equatorial diameter of the pyrene (EDP) and longitudinal diameter of the pyrene (LDP).

The mean values were higher for most biometric parameters in 2018, except for equatorial diameter of the pyrene (EDP) and pulp weight (PW). The test showed a significant difference (p <0.01) between 2017 and 2018 for fruit weight (FW), longitudinal diameter of the fruit (LDF), shell weight (SW), pyrene weight with pulp (PWP) and pyrene weight without pulp (PWWP). The highest fruit production was observed in 2018 with the highest levels of rainfall; in 2017, there was a lower level of rainfall and consequently less fruit production. Zardo & Henriques (2011) verified the same influence from rainfall, analyzing fruit production of *Caryocar brasiliense* in consecutive years.

For the study sites, mean values of properties 1 and 2 did not differ statistically, but had a significant effect when compared to property 3. This occurred for the parameters fruit weight (FW), shell thickness (ST), equatorial diameter of the pyrene (EDP), longitudinal diameter of the pyrene (LDP), pyrene weight with pulp (PWP), pyrene weight without pulp (PWWP), pulp weight (PW) and pulp yield (PY). The *C. villossum* orchard in property 3 is located in a degraded area and distant from native vegetation, and it is assumed that the farther the orchard is from fragments of natural habitat, the lesser the number and diversity of pollinators and ecosystem services they perform (Flores et al. 2012; Hipólito et al., 2018).

Property 1 differed statistically from properties 2 and 3 for the longitudinal diameter of the fruit (LDF); there was also a significant difference between properties 2 and 3 for the same parameter. As for shell weight (SW) and pyrene weight per fruit (PWF), properties 1 and 3 showed statistical difference from property 2. The equatorial diameter of the fruit (EDF) showed no significant difference between properties.

Properties 1 and 2 are located next to a fragment of natural vegetation, forming a landscape around the orchards of *C. villosum*, which can provide the maintenance and survival of pollinator populations (BPBES, 2019). Gaglianone et al. (2010) reported the importance of secondary vegetation around the area of cultivation of sweet passion fruit (*Passiflora alata* Curtis), and the maintenance of this vegetation can result in shelter and food for pollinators, and consequently assist in natural pollination.

Table 1. Correlation coefficients of biometric variables of pequiá fruit (*Caryocar villosum* (Aubl.) Pers) on property 1 for the years 2017 and 2018, in the municipality of Nova Xavantina, in the state of Mato Grosso, Brazil.

	FW	EDF	LDF	ST	SW	PWF	EDP
				2017			
EDF	0.747 **						
LDF	0.571 **	0.272					
ST	0.222	0.158	0.669 **				
SW	0.748 **	0.802 **	0.661 **	0.565 **			
PWF	0.835 **	0.872 **	0.336	0.031	0.698 **		
EDP	0.591 **	0.447 **	0.643 **	0.467 **	0.553 **	0.547 **	
LDP	0.546 **	0.447 **	0.599 **	0.433 **	0.504 **	0.529 **	0.955 **
				2018			
EDF	0.836 **						
LDF	0.565 **	0.213					
ST	0.399 **	0.093	0.767 **				
SW	0.943 **	0.763 **	0.621 **	0.590 **			
PWF	0.778 **	0.695 **	0.281	-0.091	0.525 **		
EDP	0.147	-0.059	0.606 **	0.436 **	0.116	0.162	
LDP	0.038	-0.216	0.634 **	0.436 **	0.006	0.090	0.912 **

** Significant at 1% probability by *t*-test. FW: fruit weight; EDF: equatorial diameter of the fruit; LDF: longitudinal diameter of the fruit; ST: shell thickness; SW: shell weight; PWF: pyrene weight per fruit; EDP: equatorial diameter of the pyrene; LDP: longitudinal diameter of the pyrene.

Table 2. Correlation coefficients of biometric variables of pequiá fruit (*Caryocar villosum* (Aubl.) Pers) on property 2 for the years 2017 and 2018, in the municipality of Nova Xavantina, in the state of Mato Grosso, Brazil.

	FW	EDF	LDF	ST	SW	PWF	EDP
				2017			
EDF	0.906 **						
LDF	0.504 **	0.371					
ST	0.236	0.095	0.273				
SW	0.936 **	0.876 **	0.570 **	0.366			
PWF	0.791 **	0.797 **	0.270	-0.216	0.627 **		
EDP	0.350	0.181	0.275	-0.017	0.197	0.521 **	
LDP	0.103	-0.105	0.099	-0.104	-0.071	0.279	0.831 **
				2018			
EDF	0.861 **						
LDF	0.111	-0.081					
ST	0.094	0.016	0.559 **				
SW	0.832 **	0.748 **	0.358	0.458 **			
PWF	0.877 **	0.732 **	-0.183	-0.271	0.488 **		
EDP	0.320	0.148	0.412 **	0.309	0.305	0.259	
LDP	0.229	-0.063	0.285	-0.081	0.036	0.355	0.629 **

** Significant at 1% probability by *t*-test. FW: fruit weight; EDF: equatorial diameter of the fruit; LDF: longitudinal diameter of the fruit; ST: shell thickness; SW: shell weight; PWF: pyrene weight per fruit; EDP: equatorial diameter of the pyrene; LDP: longitudinal diameter of the pyrene.

Table 3. Correlation coefficients of biometric variables of pequiá fruit (*Caryocar villosum* (Aubl.) Pers) on property 3 for the years 2017 and 2018, in the municipality of Nova Xavantina, in the state of Mato Grosso, Brazil.

	FW	EDF	LDF	ST	SW	PWF	EDP
				2017			
EDF	0.831 **						
LDF	0.787 **	0.425 **					
ST	0.039	-0.318	0.417 **				
SW	0.984 **	0.790 **	0.810 **	0.173			
PWF	0.931 **	0.831 **	0.659 **	-0.240	0.852 **		
EDP	0.603 **	0.507 **	0.666 **	-0.032	0.551 **	0.649 **	
LDP	0.501 **	0.319	0.445 **	0.009	0.442 **	0.572 **	0.383
				2018			
EDF	-0.083						
LDF	0.694 **	-0.067					
ST	0.523 **	-0.122	0.497 **				
SW	0.956 **	-0.078	0.717 **	0.695 **			
PWF	0.816 **	-0.085	0.426 **	0.061	0.642 **		
EDP	0.195	-0.140	0.230	-0.147	0.061	0.377	
LDP	0.341	-0.206	0.304	-0.019	0.211	0.494 **	0.846 **

** Significant at 1% probability by *t*-test. FW: fruit weight; EDF: equatorial diameter of the fruit; LDF: longitudinal diameter of the fruit; ST: shell thickness; SW: shell weight; PWF: pyrene weight per fruit; EDP: equatorial diameter of the pyrene; LDP: longitudinal diameter of the pyrene.

Table 4. Descriptive statistical analysis of biometric variables of pequiá fruit (*Caryocar villosum* (Aubl.) Pers) from three properties (1: located near the Bacaba Municipal Park; 2: close to a permanent preservation area; 3: far from vegetation patches) for the years 2017 and 2018, in the municipality of Nova Xavantina, in the state of Mato Grosso, Brazil.

	Fruit weight					Equatorial diameter of the fruit				
	2017	2018	1	2	3	2017	2018	1	2	3
N	200	200	80	80	80	200	200	80	80	80
Mean	330.14 a	371.96 b	393.83 a	372.98 a	269.31 b	95.33 a	137.41 a	100.77 a	99.46 a	190.16 a
SD	129.91	143.81	135.44	131.19	117.54	16.55	566.41	14.75	18.56	896.13
CV (%)	39.35	38.66	34.39	35.17	43.64	17.36	412.22	14.64	18.66	471.26
	Longitudinal diameter of the fruit					**Shell thickness**				
	2017	2018	1	2	3	2017	2018	1	2	3
N	200	200	80	80	80	200	200	80	80	80
Mean	75.55 a	79.97 b	78.97 a	80.83 ba	70.49 bb	12.49 a	12.78 a	10.80 a	12.50 a	13.55 b
SD	8.56	13.98	8.72	9.43	9.20	3.53	3.95	3.21	3.15	3.52
CV (%)	11.33	17.48	11.04	11.67	13.05	28.30	30.89	29.76	25.16	25.94
	Shell weight					**Pyrene weight per fruit**				
	2017	2018	1	2	3	2017	2018	1	2	3
N	200	200	80	80	80	200	200	80	80	80
Mean	217.34 a	253.97 b	231.86 a	248.31 b	199.48 a	110.75 a	118.36 a	153.70 a	126.05 b	70.77 a
SD	83.24	104.76	86.89	81.91	85.57	52.76	56.10	52.26	58.63	39.04
CV (%)	38.30	41.25	37.48	32.99	42.90	47.64	47.40	34.00	46.52	55.16
	Equatorial diameter of the pyrene					**Longitudinal diameter of the pyrene**				
	2017	2018	1	2	3	2017	2018	1	2	3
N	200	200	80	80	80	200	200	80	80	80
Mean	41.39 a	41.13 a	44.03 a	43.55 a	35.78 b	57.15 a	57.99 a	62.28 a	61.73 a	48.75 b
SD	5.73	6.11	5.02	4.53	5.06	8.27	9.26	7.61	6.14	7.22
CV (%)	13.84	14.86	11.40	10.41	14.16	14.47	15.97	12.22	9.95	14.80
	Pyrene weight with pulp					**Pyrene weight without pulp**				
	2017	2018	1	2	3	2017	2018	1	2	3
N	25	25	10	10	10	25	25	10	10	10
Mean	602.00 a	655.12 b	783.66 a	744.10 a	357.28 b	246.77 a	275.95 b	304.93 a	296.20 a	179.90 b
SD	177.06	210.66	147.90	112.24	49.91	63.15	62.82	55.27	42.02	23.80
CV (%)	29.41	32.16	18.87	15.08	13.97	25.59	22.77	18.12	14.19	13.23

Table 4. Continued...

	Pulp weight					Pulp yield				
	2017	2018	1	2	3	2017	2018	1	2	3
N	25	25	10	10	10	25	25	10	10	10
Mean	318.88 a	318.49 a	408.76 a	380.17 a	162.39 b	292.37 a	336.62 a	375.20 a	359.58 a	222.07 b
SD	96.27	128.74	76.89	72.35	29.50	78.51	86.86	75.50	43.94	70.64
CV (%)	30.19	40.42	18.81	19.03	18.17	26.85	25.80	20.12	12.22	31.81

Significant at 1% probability by *t*-test. N: number of fruits; SD: standard deviation; CV: coefficient of variation.

According to Junqueira & Augusto (2017), the yellow passion fruit (*Passiflora edulis* f. *flavicarpa* Deneger), when going through the natural pollination process, may present fruits with more seeds, greater nutritional value, better shape, flavor and durability. In this way, pollination services can promote greater production, better quality and add greater economic value to fruit.

Conceição et al. (2017) report the economic importance of *C. villosum* for generating work and income for several families in Santarém, state of Pará, and it may also be more profitable than agricultural crops, such as soybeans and rice (Grzebieluckas et al., 2010).

The data obtained in this study highlight the relevance of the presence of natural vegetation close to pequiá orchards in the provision of ecosystem services, such as pollination that contributes to greater productivity, size and weight of fruit in *C. villosum* orchards.

4. CONCLUSIONS

Rainfall possibly influenced fruit production between the study years, since pequiá fruit presented greater weight and biometric values in 2018, when there was greater rainfall.

Pequiá fruit evaluated in properties 1 and 2 - located close to fragments of native vegetation -, were larger, heavier and with higher pulp yield per batch. Pequiá fruit evaluated in property 3 were smaller biometrically and had low production, possibly due to the low provision of ecosystem services, since property 3 is surrounded by temporary pastures and crops and distant from fragments of natural vegetation.

Therefore, it is important to highlight that the production of *C. villosum* is greatly influenced by the proximity to fragments of native vegetation, which bring pollinators closer to the pequiá orchards, providing greater production and economic return to local producers, who complement the income with the commercialization of pequiá fruit.

SUBMISSION STATUS

Received: 21 Jul. 2023

Accepted: 13 Aug. 2023

Associate editor: Fernando Gomes

CORRESPONDENCE TO

Joaquim Manoel da Silva

Rua Prof. Dr. Renato Figueiro Varella, s/n, CEP 78690-000, Nova Xavantina, MT, Brasil

e-mail: joaquimmanoel@unemat.br

AUTHORS' CONTRIBUTIONS

Bruna Maria Roldão Lopes: Conceptualization (Equal), Data curation (Equal), formal analysis (Equal), Methodology (Equal), Visualization (Equal), Writing – original draft (Equal).

Rayleen Whaiti Lopes da Silva: Data curation (Equal), Methodology (Equal), Visualization (Equal), Writing – review & editing (Equal).

Clarissa Fernandes: Conceptualization (Equal), Supervision (Equal), Validation (Equal), Writing – original draft (Equal), Writing – review & editing (Equal).

Oriales Rocha Pereira: Conceptualization (Equal), Investigation (Equal), Methodology (Equal)

Visualization (Equal), Writing – original draft (Equal), Writing – review & editing (Equal). Joaquim Manoel da Silva: Conceptualization (Lead), Investigation (Equal), Project administration (Lead), Supervision (Lead), Writing – original draft (Equal), Writing – review & editing (Lead).

REFERENCES

Alho CJR. Desafios para a conservação do Cerrado, em face das atuais tendências de uso e ocupação. In: Scariot, A.; Sousa-Silva, C. J.; Feltili, M. J. (In). Cerrado: Ecologia, Biodiversidade e Conservação. Brasília: Ministério do Meio Ambiente, 2005.

Bispo TW, Guéneau S, Braga CL, Lima CC. Cadeias produtivas dos frutos nativos do Cerrado: estudos de caso sobre o agroextrativismo no Vale do Rio Urucuia em Minas Gerais e no sul Maranhense. Informe GEPEC 2021; 25(1):133-152. https://doi.org/ 10.48075/igepec.v25i0.26388

BPBES - Plataforma Brasileira de Biodiversidade e Serviços Ecossistêmicos. Relatório Temático sobre Polinização, Polinizadores e Produção de Alimentos no Brasil. 1ª edição 2019.

Camargo MP, Estevam A, Feroldi M, Cremonez PA. A cultura do pequi (*Caryocar brasiliese* Camb.) na recuperação de áreas degradadas e como alternativa para produção de biodiesel no Brasil. Journal of Agronomic Sciences 2014; 3(1): 180-192.

Conceição SP, Gama JRV, Monteiro RN, Ferreira RJS, Sousa PS. Cadeia produtiva do piquiá no município de Santarém, Estado do

Pará, Brasil. Revista Nativa 2017; 5(1): 31-36. https://doi.org/10.31413/nativa.v5i1.4165

Costa FR, Rêgo ER, Rêgo MM, Eder DG, Silva SM, Schunemann APP. Análise biométrica de frutos de umbuzeiro no semiárido brasileiro. Bioscience Journal 2015; 31(3): 682-690.

Dantas MS, Almeida NV, Medeiros IS, Silva MD. Diagnóstico da vegetação remanescente de Mata Atlântica e ecossistemas associados em espaços urbanos. Journal of Environmental Analysis and Progress 2017; 2(1): 87-97. https://doi.org/ 10.24221/JEAP.2.1.2017.1128.87-97

Ferreira AFN, Krause S, Oliveira EA, Silva MLS, Krause W. Qualidade do fruto e produtividade de cultivares de maracujá em diferentes épocas de colheitas. Enciclopédia Biosfera 2016; 13(1): 1107-1116. https://doi.org/ 10.18677/Enciclopedia_Biosfera_2016_094.

Filho DBF, Rocha EC, Júnior JAS, Paranhos R, Neves JAB, Silva MB. Desvendando os Mistérios do Coeficiente de Correlação de Pearson: O retorno. Leviathan (São Paulo) 2014; 1(1): 66-95. https://doi.org/10.11606/issn.2237-4485.lev.2014.132346

Flores LMA, Filho AJSP, Westerkamp C, Freitas BM. A importância dos hábitats naturais no entorno de plantações de cajueiro anão precoce (*Anacardium occidentale* L.) para o sucesso reprodutivo. Iheringia **Série Botânica** 2012; 67(2): 189–197.

Françoso R, Guaraldo AC, Prada M, Paiva AO, Mota EH, Pinto JRR. Fenologia e produção de frutos de *Caryocar brasiliense* Cambess. e *Enterolobium gummiferum* (Mart.) J.F.Macbr. em diferentes regimes de queima. Revista Árvore 2014; 38(4): 579-590. https://doi.org/10.1590/S0100-67622014000400001

Gaglianone MC, Rocha HHS, Benevides CR, Junqueira CN, Augusto SC. Importância de Centridini (Apidae) na polinização na polinização de plantas de interesse agrícola: o maracujá-doce (*Passiflora alata* Curtis) como estudo de caso na região Sudeste do Brasil. Oecologia Australis 2010; 14(1): 152-164. https://doi.org/10.4257/oeco.2010.1401.08

Grzebieluckas C, Bornia AC, Campos LMS, Selig PM. Evaluation of the opportunity cost for the conservation of the Cerrado in the production of pequi: a study in Mato Grosso. Custos e Agronegócio 2010; 6(1): 104-120.

Hammer O, Harper DAT, Ryan PD. Paleontological Statistics Software Package for Education and Data Analysis (**PAST**). Palaeontologia Electronica 2001; 4(1).

Hipólito J, Boscolo D, Viana BF. Landscape and crop management strategies to conserve pollination services and increase yields in tropical coffee farms. Agriculture, Ecosystems & Environment 2018; 256(1): 218–225. https://doi.org/10.1016/j.agee.2017.09.038

INMET - Instituto Nacional de Meteorologia. Banco de Dados Meteorológicos para Ensino e Pesquisa, 2019.

Junqueira CN, Augusto SC. Bigger and sweeter passion fruits: effect of pollinator enhancementon fruit production and quality. Apidologie 2017; 48(1): 131-140. https://doi.org/10.1007/s13592-016-0458-2

Klein AL. Eugen Warming e o cerrado brasileiro: um século depois. São Paulo: Editora UNESP, 2002.

Leandro CTB, Fonseca Junior EM, Otani FS, Felsemburgh CA. Caracterização biométrica e composição química do fruto de *Caryocar villosum* (Aubl.) Pers. nativo da Amazônia. Revista Ibero-Americana de Ciências Ambientais 2018; 9(6): 295-306. http://doi.org/10.6008/CBPC2179-6858.2018.006.0028

Martins RL, Gribel R. Polinização de *Caryocar Villosum* (Aubl.) Pers. (Caryocaraceae) uma árvore emergente da Amazônia central. Revista Brasileira de Botânica 2007; 30(1): 35-43. http://doi.org/10.1590/S0100-84042007000100005

Moreira WKO, Oliveira SS, Reis JS, Paraense LRC, Guimarães TA, Silva RTL. Análise de correlação em frutos de pupunha (*Bactris gasipaes* Kunth). Global Science and Technology 2016; 9(3): 106-115.

Arco-Verde MF, Amaro GC. Metodologia para análise da viabilidade financeira e valoração de serviços ambientais em sistemas agroflorestais. In: PARRON, L. M.; GARCIA, J. R.; OLIVEIRA, E. B.; BROWN, G. G.; PRADO, R. B. Serviços ambientais em sistemas agrícolas e florestais do bioma Mata Atlântica. Brasília, DF: Embrapa, 2015.

Prance GT, Silva MF. Flora da Reserva Ducke, Amazonas, Brasil: Caryocaraceae. Rodriguésia 2006; 57(2): 155-157. http://doi.org/10.1590/2175-7860200657202

Scariot A, Sousa-Silva CJ, Feltili MJ. (Orgs.). Cerrado: Ecologia, Biodiversidade e Conservação. Brasília: Ministério do Meio Ambiente, 2005.

Silva PO, Almeida SES, Oliveira TCS, Menino GCO, Alves RDFB. Influência climática e sazonalidade da fenologia reprodutiva de *Qualea parviflora* Mart. (Vochysiaceae) em cerradão. Iheringia **Série Botânica** 2019; 74(1): 1-7. https://doi.org/10.21826/2446-82312019v74e2019013

Souza JLC, Silva LB, Reges NPR, Mota EES, Leonídio RL. Caracterização física e química de gabiroba e murici. Revista de Ciências Agrárias 2019; 42(3): 792-800. https://doi.org/10.19084/rca.17521

Venzon M, Togni PHB, Amaral DSSL; Rezende MQ, Batista MC, Chiguachi JAM, Martins E F, Perez AL. Mobilização de mecanismos de regulação natural de pragas via plantas com múltiplos serviços ecossistêmicos. Innovations Agronomiques 2018; 64(1): 83-95.

Zardo RN, Henrriques RP. Growth and fruit production of the tree *Caryocar brasiliense* in the Cerrado of central Brazil. Agroforestry Systems 2011; 82(1): 15-23. https://doi.org/10.1007/s10457-011-9380-9