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Phenology of Species in the Cerrado of Mato Grosso State, Brazil – *Brosimum gaudichaudii* Trécul (Moraceae)

Rozilaine Aparecida Pelegrini Gomes de Faria,
Maria de Fatima Barbosa Coelho,
Maria Cristina de Figueiredo e Albuquerque
and Rodrigo Aleixo Brito de Azevedo
Universidade Federal de Mato Grosso,
Brasil

1. Introduction

The roots of the *Brosimum gaudichaudii* Trécul., a plant of the Moreaceae family, frequent in the cerrado region and Northeast of Brazil, which is popularly known as "mamica de cadela", "mamacadela" and "algodão" (cotton), are employed by popular medicine against vitiligo and skin deseases (Agra et al., 2008). Its fruit, of a yellow-orange color, is chewed as chewing gum, due to the latex it contains and due to its flavor, while the powder obtained of roots is used as a fragrance (Hoehne, 1946).

Usually plants used for fighting vitiligo (leucomelanodermia), contain furocoumarins. Furocoumarins are of a broad spectrum of application in the treatment of leucomelanodermias, with photosensitizing activity upon the skin (Alchorne, 2001). Many studies have been carried out about this type of activity of the furocoumarins (Jimbow, 1998).

The growth of most species of the Cerrado is related to seasonality, with frequent renewal of the leaves and flowering in the dry season. The study of phenology not only contributes to our understanding of the dynamics of the community, but also about the interaction with abiotic factors such as precipitation, photoperiod, radiation, soil quality or biotic factors such as presence / absence of predators, which are inextricably linked with the phenological pattern of species (Pedroni et al., 2002).

Seasonality of fruiting is due to the seasonality of flowering. The great concentration of fruit in synchronized phenophase attracting disperser favoring seed dispersal in space, while asynchrony favors the dispersion over time (Pina-Rodrigues & Piratelli, 1993).

The next occurrence of fruiting individuals may be related to their habit of scattering, however, each plant stage seems to be linked to the strategy of the plant to establish and perpetuate in the middle (Pina-Rodrigues & Piratelli, 1993). Early or late flowering can be a strategy linked to the present pollinators and seed dispersal by animals or mode anemocoric fruiting is linked to either the wet season, both in the dry season (Oliveira 1998).

In general in the Cerrado, the pattern of seed dispersal of species is constant, occurring in the dry season, ensuring the germination of seeds at the beginning of the rainy season (Bulhão & Figueiredo, 2002). Flowering in this dry season occurs after the fall of leaf pattern generally observed in the deciduous species typical of the Cerrado region (Sarmiento & Monasterio, 1983).

Thus, to know the phenology of a species is of fundamental importance for the programming of gathering fruits and seeds in order for an integrated management programs for reforestation and restoration of degraded areas. Whereas there may be variations between phenophases as the region where the species is included, the objective of this study was to evaluate the phenology of *B. gaudichaudii* and relate the phenology with environmental factors such as rainfall and temperature.

2. Material and methods

2.1 Study area

The study was conducted from 2006 to 2008, in an area of 2264m² with Cerrado in the community of Mata Cavalos, coordinates 15°50'34,9"S and 56°24'03,0"W and 10 km away from the town of Nossa Senhora do Livramento, Mato Grosso, Brazil.

The climate is tropical and warm sub-humid and average annual temperature of 24ºC, the peak of 42ºC and less than 0ºC (Arruda et al., 2008). The study area lies in different levels of conservation due to human influence. The monthly data of precipitation and average temperature were obtained from records of agrometeorological Padre Ricardo Remetter in the Experimental Farm of Universidade Federal de Mato Grosso, located in Santo Antonio do Leverger, distant 33 km from Cuiaba city.

2.2 Phenological data

The phenological data were collected in a sample of 50 plants that were randomly selected, identified and numbered. As Fournier and Charpantier (1975), the number of 10 individuals per species is sufficient to monitor the phenological stages. However, some authors used the number of individuals ranging from 2 to 41 (Mantovani et al., 2003). The observations occurred every 20 days by registering the presence of phenophase flowering, fruiting, and proportion of budding leaves in the canopy.

The intensity of the events was estimated for each individual according to the criteria of Fournier (1974), (0) absence of the phenological event; (1) presence of an event in a range of 25%, (2) presence of event in a range of 26 to 50% (3) presence of event ranging from 51 to 75% and (4) presence of event ranging from 76 to 100%.

The botanical material was identified by taxonomist of Central Herbarium of the Universidade Federal de Mato Grosso, Dr Rosilene Rodrigues, and is deposited under the number 37693.

2.3 Data analysis

We used two methods of data analysis: a) percentage of intensity of phenophase where individuals were analyzed in a semi-quantitative scale ranging from 0 to 4, by calculating the percentage of each plant stage (Fournier, 1974), b) activity index indicating the proportion of individuals who express specific phenology. Through these indices can estimate the synchrony of phenophase (Bencke & Morellato, 2002). To check synchrony (Z) between individuals of the sample was applied to the formula:

$$Z = \frac{\sum X_i}{N} \tag{1}$$

and

$$X_i = \sum_{i=1}^{n} e_j (N-1) f_i \tag{2}$$

where,

Xi = individual i synchrony with their conspecifics;
N = total number of individuals in the sample
e_j = number of records in which individuals are in the same phenophase j, i ≠ j;
f_i = the number of reports in which individual i is on phenophase considered.

This index ranges from zero (no synchrony), when there is no synchrony between individuals in the population, a (perfect synchrony), the event of all individuals of the species would have occurred in the same period during the year.

3. Results and discussion

During the 18 months of observations, the period of increased rainfall that characterizes the rainy season, occurred between October to May. It was found that in the month of September was one of the lowest rainfall in the region in October and the highest average monthly temperature, 28.1 ° C (Figure 1).

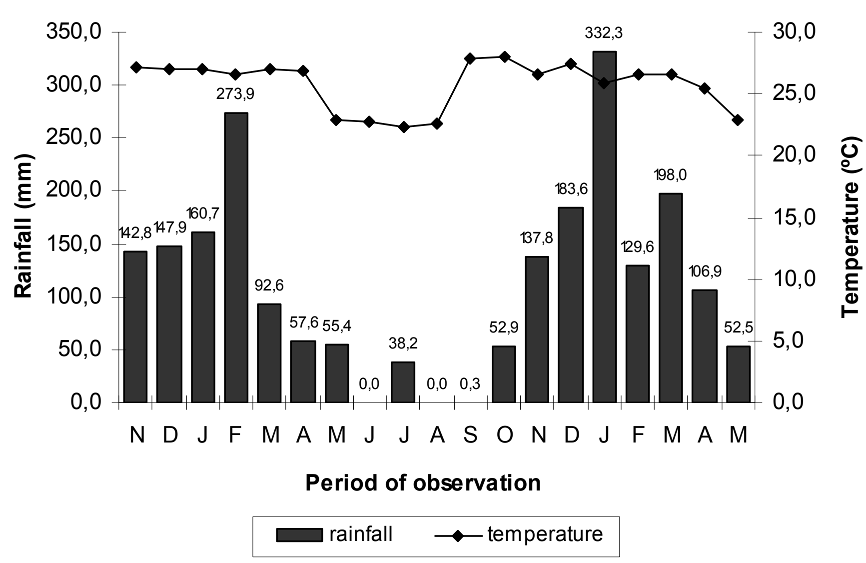

Fig. 1. Meteorological characterization of the study area: precipitation and monthly mean temperatures for the years 2006-2008.

The presence of phenophases is very characteristic among individuals. The sprouting may be present in both apical buds as the whole length of stem and branches. The reproductive phenology, apparently did not affect the leaf fall, since individuals with the presence of leaves in the canopy showed shoots and inflorescences.

In the dry season, abiotic factors such as photoperiod, thermoperiod and irradiance vary with seasonality in spite of their lower amplitudes. The length of day and the maximum and minimum temperatures also tend to increase this time of year (Bulhão & Figueiredo, 2002).

In the period that coincided with the rainy season, from November 2006 to May 2007, a greater number of individuals at the stage of leaf (100% of subjects), but with intensity around 50%. The temperature rise in the period between September and October brought the issue of leaves and shoots, and number of individuals in the phenology of leaf increased by intensifying the phenological pattern, with synchrony index equal to 0.96, indicating high synchrony within the population (Figure 2).

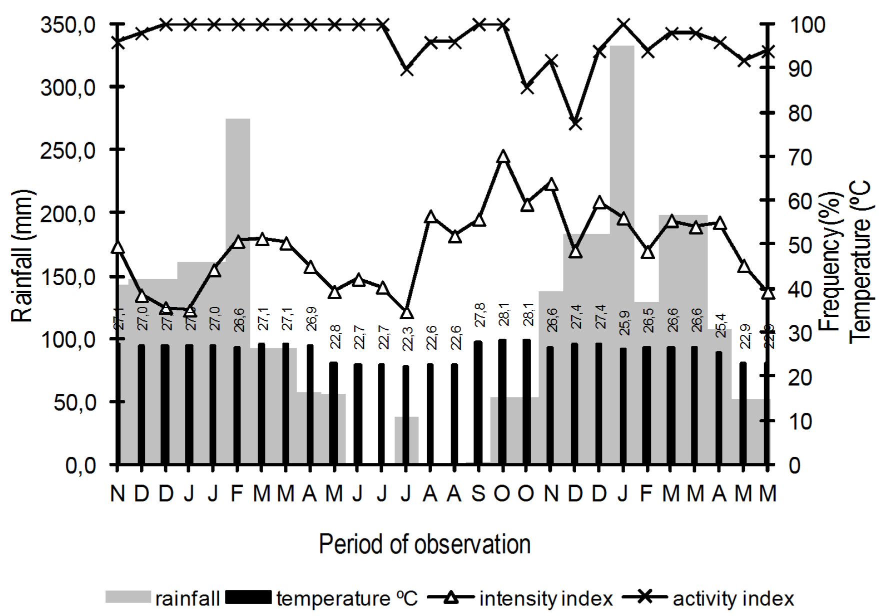

Fig. 2. Activity index and intensity of leaf phenophase of *B. gaudichaudii* in the region of Nossa Senhora do Livramento, Mato Grosso, Brasil in 2006-2008.

Nunes et al. (2005) found that the falling leaves of *G. ulmifolia* happened in the months of dry and cold season, and observed that this occurs for species that are embedded in environments marked seasonality, which concentrate the rain in a restricted period of the year. However, for species in the study of leaf fall occurred in July, the month when we registered the lowest average temperature, 22.3°C (Figure 1), indicating that the low temperature effect was more striking in this event. In *Heteropterys aphrodisiaca* (Coelho & Spiller, 2008), and *Lafoensia pacari* (Santos et al., 2009) the drought period was more relevant to leaf fall.

For the reproductive phase, the index of synchrony was equal to 0.69 and can be classified as average. Flowering occurs between June and December 2007, however, the peak intensity occurred in August with 52% of phenology among individuals while a larger number of plants (92%) developed stage in September 2007 (Figure 3).

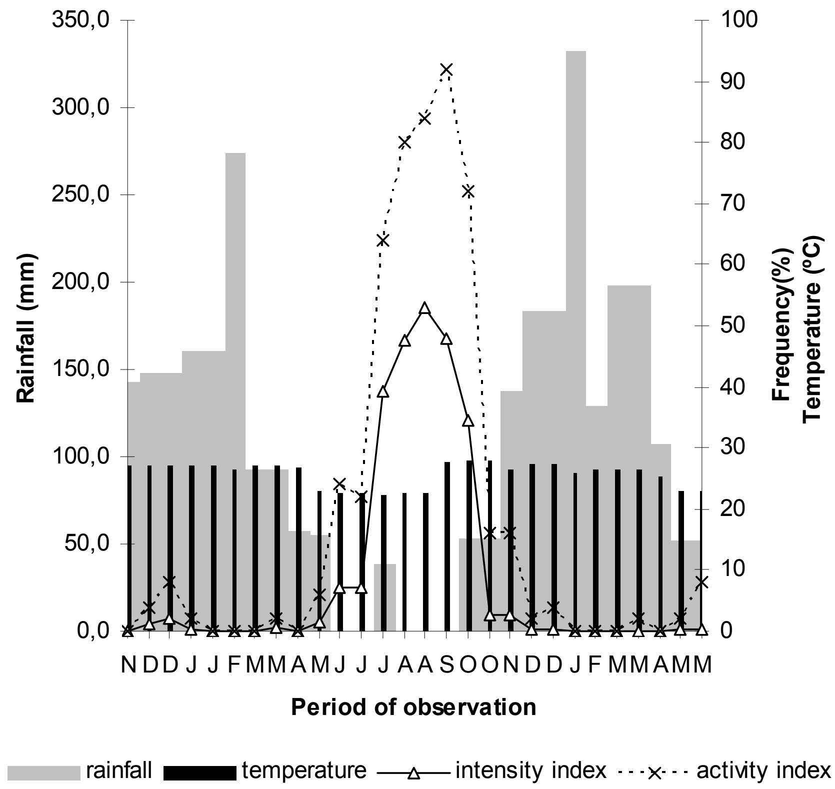

Fig. 3. Activity index and intensity of flowering phenophase of *B. gaudichaudii* in the region of Nossa Senhora do Livramento, Mato Grosso, Brasil in 2006-2008.

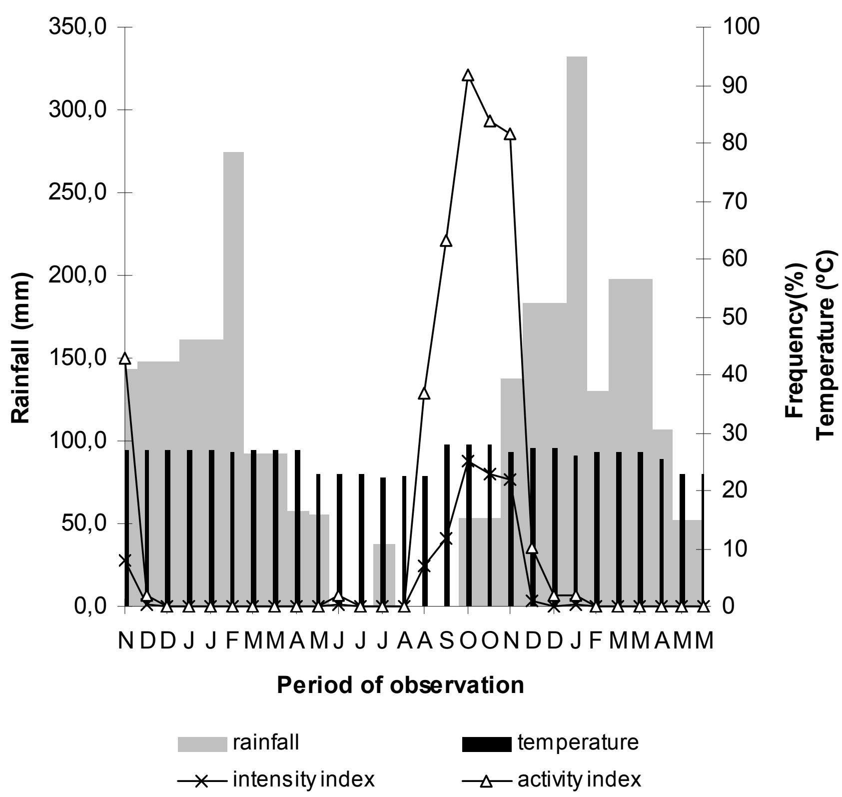

Fig. 4. Activity index and intensity of fruiting phenophase of *B. gaudichaudii* in Nossa Senhora do Livramento, Mato Grosso, Brasil in 2006-2008.

For Bulhão and Figueiredo (2002), flowering in the dry season and / or early rainy season is an indication that the bloom, as well as issuance of sprouts probably depend on rainfall, a factor relative to other environmental factors that do not rains. Emission was observed in flowers and fruits to *B. gaudichaudii* during periods of absence of rain, suggesting a relative independence of the rainy season, as observed by Almeida et al. (1998). But Nunes et al. (2005) suggested that for *Guazuma ulmifolia*, the flowering phenology tended to occur early in the warm season, indicating that these events happen at specific times of year.

The highest average temperature for the year 2007, the area surveyed, was recorded between the months of September (27.8ºC) and October (28.1ºC), the month when the highest indexes of coincident activity for both clones sprouting (95%) and flowering (92%) of subjects analyzed. One may suggest that these events would be more interconnected with thermoperiod than with the onset of the rainy season.

However, fruiting phenophase in synchrony was greater among individuals in the event population index calculated as ($Z = 0.72$). This phenophase occurred between August and December 2007, coinciding for the month of October 2007 a number of higher frequency in individuals with fruits (91%), however with low intensity resulting in a lower production of fruits (25%) (Figure 4).

Factors such as photoperiod and intensity of solar radiation also could influence the duration and intensity of phenological patterns evaluated. Mantovani and Martins (1988) observed that species that thrive in the rainy season are related to higher temperatures and longer photoperiods. The existence of xylopodium for support the period where there is lack of rain, the renewal of foliage and flowering in the dry season are indications that phenophases of woody species of Cerrado are not limited by the reduction of soil water as suggested Lenza and Klink (2006). As the photoperiod and leaf abscission could induce flowering in the dry season.

Seasonality of fruiting species of the Cerrado would be related to the dispersal agent. Thus wind dispersed species produce fruits during the dry season (June to August) while the zoochorous tend to produce throughout the year would be conditioned or to biotic factors as the most appropriate time for the establishment of the plant (Pina-Rodrigues & Piratelli, 1993). Ressel et al. (2004) observed that the dispersal of fruits of *B. gaudichaudii* is zoochorous and peak fruiting occurs at the beginning of the rainy season, as observed in this study area (Figure 4).

The seed germination during the rainy season favors the establishment of seedlings. Species of the Cerrado as *Copaifera langsdorfii*, even dispersal of fruit occurs in the dry season, seedling growth begins in the next rainy season (Felfilli et al., 1999). In *B. gaudichaudii,* the fruiting period is classified as short-lived and occurs during the rainy season. The classification of short period for fruiting period less than five months in a study of phenology of species in gallery forest was used by Antunes and Ribeiro (1999).

4. Conclusions

Phenology of the studied population of *Brosimum gaudichaudii* are asynchronous. The temperature factor is more relevant to the beginning of the reproductive phenology of the rainfall factor. The most appropriate period for collecting the fruits of *Brosimum gaudichaudii* in Mato Grosso State is from October to December.

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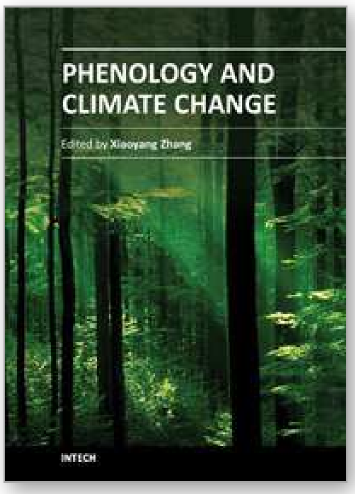

Phenology and Climate Change

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Phenology, a study of animal and plant life cycle, is one of the most obvious and direct phenomena on our planet. The timing of phenological events provides vital information for climate change investigation, natural resource management, carbon sequence analysis, and crop and forest growth monitoring. This book summarizes recent progresses in the understanding of seasonal variation in animals and plants and its correlations to climate variables. With the contributions of phenological scientists worldwide, this book is subdivided into sixteen chapters and sorted in four parts: animal life cycle, plant seasonality, phenology in fruit plants, and remote sensing phenology. The chapters of this book offer a broad overview of phenology observations and climate impacts. Hopefully this book will stimulate further developments in relation to phenology monitoring, modeling and predicting.