Phenology of Arborial Species for recovering degraded areas in the municipality of Machado, MG

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Abstract

It is known that one of the characteristics of semideciduous forests is the evident double seasonality of a climate with well-defined seasons: one of intense summer rains, and the other a dry one. The climate defines flowering and reproduction strategies for the plants. This work aimed to collect behavioral data of ten individuals, from six different species (*Euterpe edulis* Mart., *Vernonanthura divaricate* (Spreng.) H.Rob., *Manihot pilosa* Pohl, *Anadenanthera peregrine* Speg., *Piptadenia gonoacantha* JFMacbr and *Miconia chartacea* Triana) and one from *Platycyamus regnellii* Benth plant. Their behaviors were observed over a period spanning both seasons; the seasonality of phenophase reproductive phases of the individuals in question was tested. In order to achieve our goal, monthly observations of the phenophase stages experienced by each individual were carried out, then they were correlated to climatic variables. The data was processed by circular statistical analysis in order to verify the reproductive seasonality; furthermore, correlation test was conducted to determine the climatic index of greater evidence. The results presented a relation for precipitation/temperature and the reproductive phase of the species. Non-seasonality for the diaspores production may be a reflection of the climatic abnormality experienced in the period. The dry season is the best time to collect the investigated species.

Keywords: Atlantic forest. Reproductive biology. Phenophases. Forest seeds. Circular statistics.

Introduction

Livestock and coffee cultivation stimulated deforestation in Minas Gerais, causing a decrease in native vegetation cover (DEAN, 1996). Machado's coffee cycles and economic processes is highlighted mainly by the agricultural aptitude mentioned by Moura et al. (2007).

There are several methods based on different plant acquisition strategies for recovering those areas. The ecological restoration of an environment has the current objective of reducing the costs of recovering (GANDOLFI; MARTINS; RODRIGUES, 2006). The natural regeneration of vegetation is the most economical procedure to recover degraded areas and consists of reducing the degenerative pressure on the environment, favoring ecological succession. According to Botelho and Davide (2002), the conduction of natural regeneration by requiring less labor and inputs can significantly reduce the cost of forest implantation.

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One of the restoration strategies is the use of surrounding forest diaspores in the recovering area, for its acquisition costs are minimal and allow the vegetation process to accelerate (WUNDERLEE, 1997).

Rainforests exhibit a wide variety of phenological patterns (MORELLATO et al., 2000). Therefore, knowing the proper time of collecting diaspores means optimizing the workforce, what can represent a reduction in the costs of recomposition of degraded areas. These studies are of great importance for understanding the dynamics of forest ecosystems as well as being a good tool for understanding the factors that influence the reproduction and survival of plant species (MORELLATO et al., 2010); they may contribute providing information about resources distribution within the communities (TALORA; MORELLATO, 2000; PINTO et al., 2005).

Phenological cycles of tropical plants are complex, with irregular patterns (BENCKE; MORELLATO, 2002), especially in tropical environments where seasonality in precipitation is pronounced (RIVERA; BORCHERT, 2001). Marques, Roper and Salvalaggio (2004) point out that, in addition to climatic seasonality, the plants are likely to go through local environmental variations that also imply phenological patterns. Thus, the search for general patterns presents obstacles for the great variety of species with biological behavior and different evolutionary histories (WILLIAMS-LINERA; MEAVE, 2002).

In addition to providing bases for propagating material gathering when discussing the recomposition of degraded areas (TALORA; MORELLATO 2000; PINTO et al., 2005), studies on reproductive phenology of tree species in forest areas are necessary to provide parameters conservation and rational exploitation.

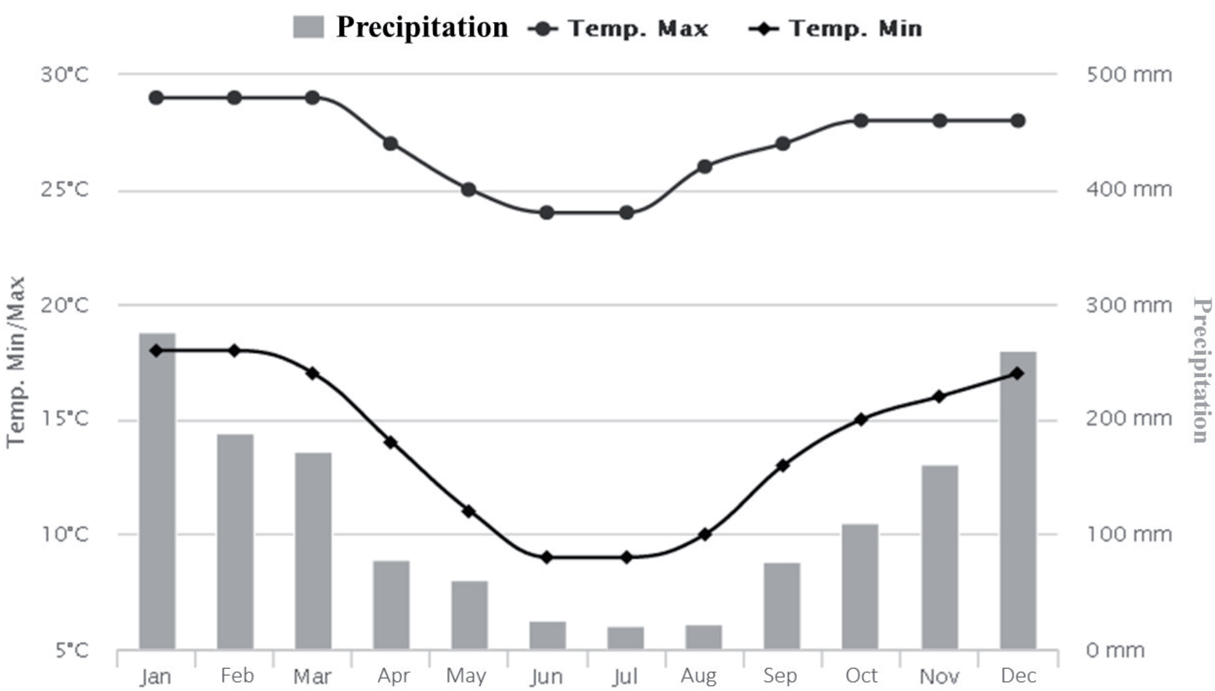
Due to the irregularity of the phenological patterns, the present study was carried out with the objective of analyzing seasonality in the production of flowers, fruits, leaf fall and sprouting in addition to correlating them with monthly rainfall rates during the study period, allowing determination (fruits and seeds) for the studied species, providing a basis for the elaboration of recovery plans for degraded areas.

Material and methods

The studies were conducted in a remnant forest located at the campus of Federal Institute of Education, Science and Technology of South of Minas Gerais, Machado, MG (FIGURE 2). According to campus staff, the fragment has an area of about 7 ha currently, and it has been in the process of natural recovery for more than fifty years.

The region is part of the Semideciduous Seasonal Forest domain within the Atlantic Forest biome (IBGE, 2004). It presents itself ranging from strongly undulating to hilly relief (altitude between 835 m and 1,310 m). The geology presents itself homogeneously being inserted in the Varginha Complex that is constituted mainly by gneisses. Three classes of soils can be found there: Dystrophic Red Latosol, Dystrophic Red-Yellow Argisol and Eutrophic Red Argisol, according to RADAMBRASIL (URURAHY et al., 1983). The annual average temperature is 21.2 ºC; maximum monthly average of 27 ºC and minimum monthly average of 14.2 ºC; the annual average rainfall is 1,824 mm, with dry and cold winters and hot and rainy summers (FIGURE 1) (MOURA et al., 2007).

Figure 1. Climogram of the municipality of Machado. Values represent monthly averages of climatological normal.



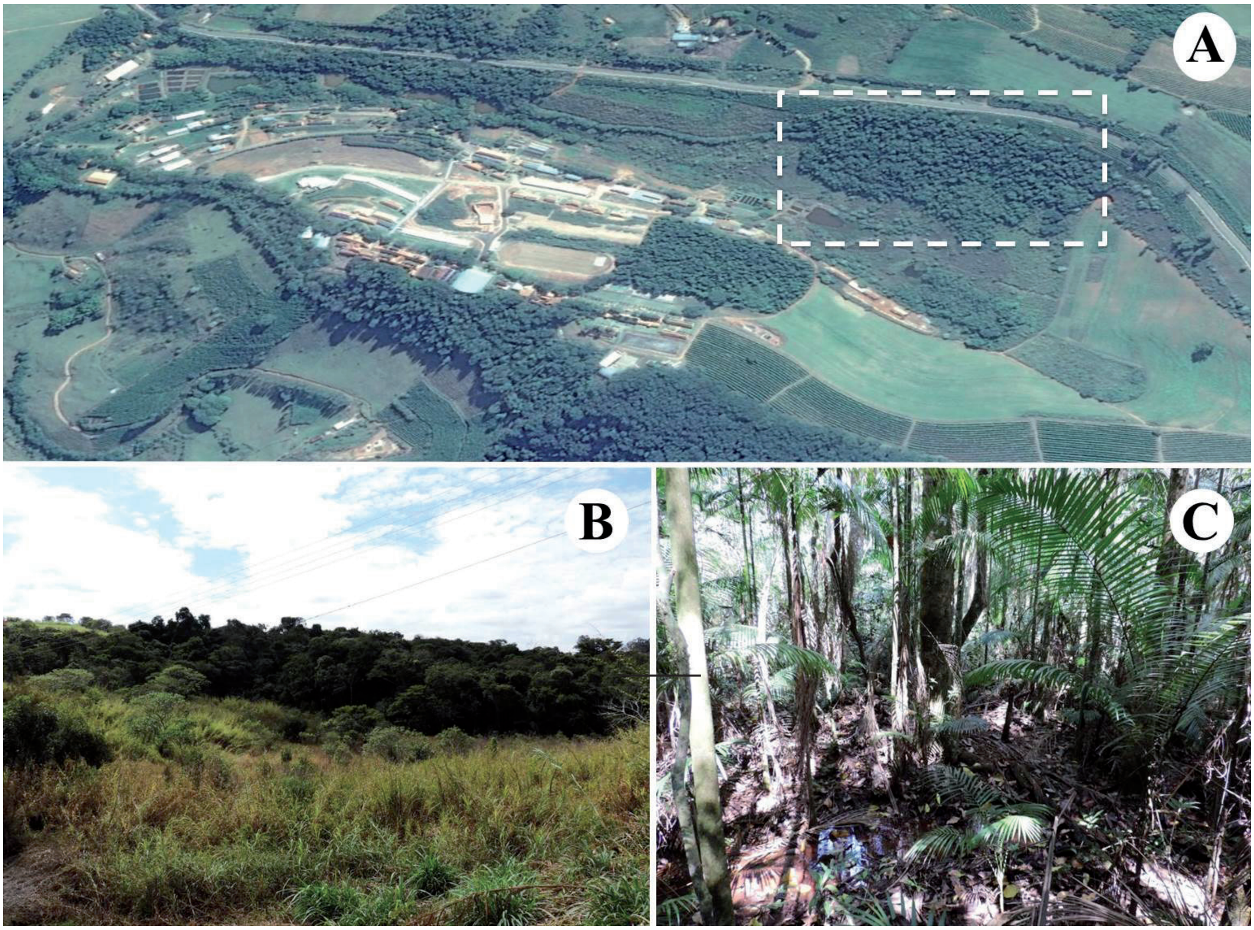
Source: Adapted from Climatempo (2017).

The remnant forest under discussion is the source of work on several ecological fronts. Some of these studies, such as that of Rezende (2015) and Marinho (2015), with phytosociological and floristic focus served as the basis for the choice of species and the number of specimens used to test the seasonality in the production of propagules. Hence, the value of importance of the species alongside a minimum common number of 10 plants of each species were the parameters which defined our choice.

Having this knowledge, we selected seven pioneer species as data source (TABLE 1). Six of these species were followed by 10 adult plants and 1 plant of *Platycyamus regnellii* Benth. (Pau-pereira), totaling 61 plants. The exception presented is due to the absence of other adult plants in the study area and to the appreciation and local importance given to the species.

The botanical families were recognized according to the Angiosperm Phylogeny Group IV system (APG, 2016). Sá et al. (2012) classified the dispersion syndrome of the species studied according to their study.

Figure 2. Different perspectives of the outcrop where the study was carried out. (A) Panoramic image of Machado campus, highlighting the forest where the work was developed. (B) View of the fragment at the edges of the access trail. (C) Photo inside the forest.



Source: Prepared by the authors (2017).

Table 1. Average circumference at chest height (CAP), mean height (Height) and dispersion syndrome (SD) of the species selected for the present study, in a fragment of the Semideciduous Seasonal Forest in Machado, Minas Gerais (acronyms in Portuguese).

FAMILY / Species	Regional popular name	CAP (cm)*	Height (m)
ARECACEAE			
Euterpe edulis Mart.	palmito-jussara	50,5	7,0
ASTERACEAE			
Vernonanthura divaricata (Spreng.) H. Rob.	pau-fumo	98,1	10,0
EUPHORBIACEAE			
Manihot pilosa Pohl	mandioca-brava	20,6	4,0
LEGUMINOSAE			
Anadenanthera peregrina (L.) Speg.	angico-vermelho	95,1	10,9
Piptadenia gonoacantha (Mart.) J.F.Macbr.	pau-jacaré	96,6	9,6
Platycyamus regnellii Benth.	pau-pereira	223,0	15,0

FAMILY / Species	Regional popular name	CAP (cm)*	Height (m)
MELASTOMATACEAE			
Miconia chartacea Triana	quaresmão	74,6	8,7

* in centimeters.
Source: Prepared by the authors (2017).

Phenological observations were performed monthly with the help of binoculars, from September 2013 to August 2015. According to Campos (2007), the presence or absence of the phenophases was recorded: i) flowering (flower buds or flowers in anthesis), ii) fruiting (immature or mature fruits), iii) leaf fall, iv) budding (plants who presented themselves partially or totally with newer, smaller and more tender leaves of a lighter or reddish color). Fruiting was only considered when the fruits became visible due to the transition between flowering and fruiting being gradual.

Monthly flowering and fruiting frequencies were calculated by the number of species with flowers or fruits in each month. Therefore, the number of species with flowers or fruits in each month was divided by the sum of the numbers of species with flowers or fruits in each month. After that, the data was submitted to circular statistical analysis according to Talora and Morellato (2000) and the seasonality in the frequency distribution was tested as described by Morellato et al. (2000).

Climatic indexes were obtained from the online database of *Instituto Nacional de Meteorologia* (INMET), considering monthly averages from the period of observations collected by the meteorological station of the municipality of Machado. The highlighted variables were: Total Heat, Total Precipitation, Average Compensated Temperature.

In order to verify the existence of correlations between flowering and fruiting species frequencies and climatic variables (Total Shock, Total Precipitation, Mean Compensated Temperature), the Spearman correlation test (ZAR, 1999), software R version 3.2.2., was used.

Results and discussion

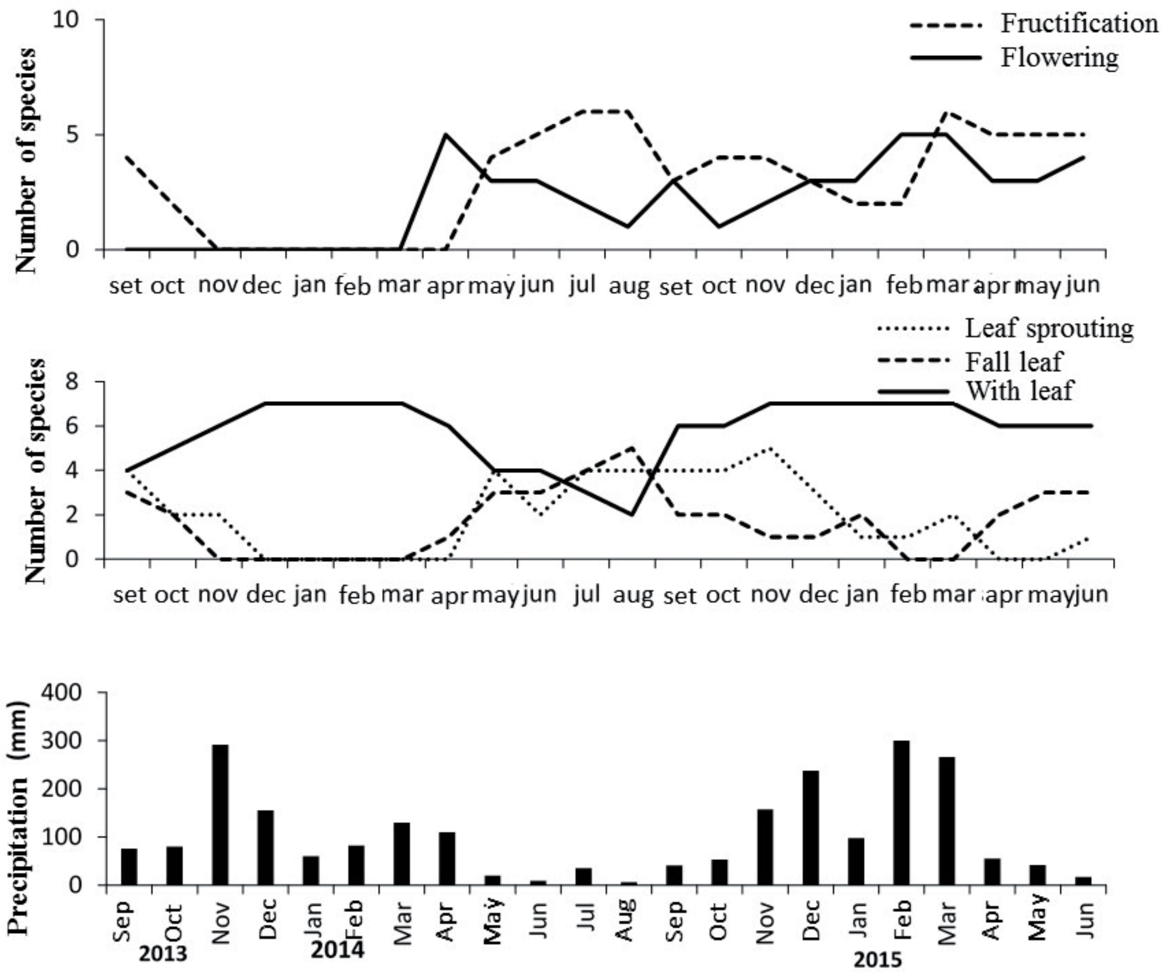
Figure 3 represents the phenological behavior of all species studied. In the first rainy season (end of 2013 and beginning of 2014), the vegetative behavior was predominant among the species.

The reproductive and budding phases and foliar fall ceased from September (2013) to March (2014), when blooming plants and leaf fall could be found.

From the month of May, it is observed the number of species in each phenophase alternated, reaching the peak of fruiting in July (2014) and August (2014) and of flowering in April (2014) and February and March (2015).

The leaf fall pattern was designed following the rainfall index of the study period and the foliar flow curve followed a slight delay in leaf fall.

Figure 3. Phenological behavior by number of species observed in the fragment of Semideciduous Seasonal Forest in Machado, Minas Gerais, and respective studied phenophases. Climogram of the municipality of Machado, with orderly precipitation according to the study period.



Source: Prepared by the authors (2017).

According to Bencke and Morellato (2002), the option of treating the data in a qualitative way, meaning showing the activity peaks of each phenophases, was based on the possibility of presenting feasible relationships in abiotic factors that determine or restrict the occurrence period of each phenophase.

From the representation in Figure 3, it is possible to verify such relation with an abiotic factor. The Spearman correlation test between the variables listed and the frequency of flowering or fruiting presented results that guarantee the influence of abiotic factors on reproductive phenophases, with the exception of Total Sunshine, which did not present significant value that indicated it as a determining factor in the manifestation of flowering or fruiting. The significance values obtained are shown in Table 2.

Table 2. Synthesis of data obtained through Spearman correlation analysis.

	Total Insolation	Total Precipitation	Average temperature
		rho	
Frequency of Flowering/ Fruiting	-0.2717	-0.5169	-0.7237
Value of "p"	Not significant	$p<0.001$	$p<0.001$

Source: Prepared by the authors (2017).

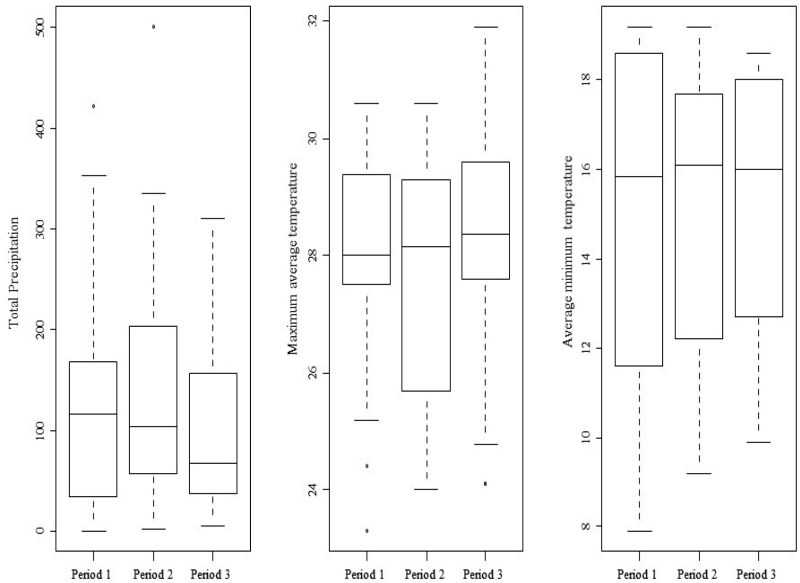
Despite the apparent seasonality in Figure 3 and the evidence of the influence of the abiotic factors on the phenophases manifestation of the observed species, the result obtained by the circular statistical analysis points to an incipient concentration of the data at any time of the year. Vector "r" resulting from the calculations was around 0.12 without statistical significance ($p>0.05$). Thus, reproductive activity responds to environmental factors; however, in the study period, there was no significant seasonal manifestation for the phenophases.

Even though the climatic seasonality characteristic of the southern region of Minas Gerais state is common sense (MOURA et al., 2007), it is worth mentioning that, during the study period, the region went through a drought season with a rainfall regime much lower than normally registered. Therefore, during that period, the climatic conditions did not show double seasonality as it was before.

Figure 4 represents the distribution of the values of each climatic variable of two previous periods equivalent to that of the work developed. The mean monthly values of precipitation in the two periods prior to our study indicate a larger amplitude, as well as the values of maximum and minimum monthly average temperatures. Such representation shows the climate in the studied period was not as seasonally as it was in previous years.

The work of Borchert (1980) suggests that patterns of reproduction and growth in tropical species are determined only secondarily as adaptation to environmental changes, being the predominant endogenous processes, what may explain the fact we do not observe seasonality in the diaspores production. Since climatic conditions were less seasonal, the most influential factors in the manifestation of flowering and fruiting were biotic selective pressures such as herbivore, predator, competitor, pollinator and dispersion pressure (AIDE, 1988).

Figura 3. Boxplot with the values of each variable in the periods of: 1) September 2009 to August 2011; 2) September 2011 to August 2013; 3) September 2013 to August 2015 (this study).



Source: Prepared by the authors (2017).

In spite of non-seasonality, the phenomena of flowering and fruiting were still correlated with environmental variables, demonstrating that, even if there is no evident seasonality, the species studied will respond to temperature and precipitation conditions.

Conclusion

It can be concluded the best season for collecting propagation material of the species studied is the dry season of the year, from May to September based on the observations presented.

According to the data obtained in the present study, strategies for recovering degraded areas can be traced conforming propagation material availability for the studied species and the tree sinus in question. However, we note the data presented here, combined with an investigation of the intensity in which phenological events occur, will provide sufficient basis to determine the role of biotic agents in the manifestation of each phenophases.

Fenologia de espécies arbóreas visando à recuperação de áreas degradadas no município de Machado (MG)

Resumo

Sabe-se que uma das características das matas semidecíduas é a evidente dupla estacionalidade proporcionada por um clima com estações bem definidas: uma de chuvas intensas de verão, seguida por outra com um período de estiagem. Este tipo de clima define as estratégias de floração e de reprodução dos indivíduos. Assim sendo, este trabalho foi realizado com o objetivo de levantar dados comportamentais de dez indivíduos, de seis espécies diferentes (*Euterpe edulis* Mart., *Vernonanthura divaricate* (Spreng.) H.Rob., *Manihot pilosa* Pohl, *Anadenanthera peregrine* Speg., *Piptadenia gonoacantha* J.F.Macbr. and *Miconia chartacea* Triana) e um indivíduo de *Platycyamus regnellii* Benth, observando seus comportamentos ao longo de um período que abrangeu as duas estações, e de testar a sazonalidade de fenofases reprodutivas dos indivíduos em questão. Para isso, fizeram-se observações mensais das fenofases vividas por cada indivíduo relacionando-as com variáveis climáticas. Os dados foram tratados por meio de análises de estatística circular para verificar a sazonalidade reprodutiva e teste de correlação a fim de determinar o índice climático de maior evidência. Os resultados apresentaram uma relação entre precipitação/temperatura e a fase reprodutiva das espécies. A não sazonalidade na produção de diásporos atestada pode ser reflexo da anormalidade climática vivida no período, de forma que a estação seca do ano é a época mais recomendável para coleta das espécies investigadas.

Palavras-chave: Mata Atlântica. Biologia reprodutiva. Fenofases. Sementes florestais. Estatística circular.

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