

Phenology of *Vernonia polyanthes* Less. in native population

Fenología de *Vernonia polyanthes* Less. en población nativa

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ABSTRACT

Vernonia polyanthes Less. stands out as one of plants of interest of the Brazilian Unified Health System. It is known as “assa-peixe” in Brazil and it has therapeutic properties such as antihypertensive and diuretic, antifungal and antimicrobial. Understanding the life cycle of the species can provide information for management programs and the conservation of genetic resources. The objective of this study was to determine the phenological behavior of *V. polyanthes*, in a Cerrado area, to evaluate the effect of the climatic variables of the place during each phenophase, and to evaluate the synchrony of these phenophases among individual plants as well. Forty individuals were evaluated monthly from August 2014 to August 2016, regarding the intensity and synchrony of phenophases of budding, mature leaves, leaf senescence, leaf fall, flowering and fruiting. The species studied showed seasonal phenological behavior with annual periodicity, where synchrony among the individuals evaluated over 24 months was high. This one factor is a facilitator of species management. Mean temperature was the abiotic factor that most influenced the phenophases. Assa-peixe flowered in the period of June to August, while fruiting reaching peak intensity in the month of October.

Keywords: *assa-peixe*, species management, Cerrado.

RESUMEN

Vernonia polyanthes Less. se destaca como una de las plantas de interés en el Sistema Único de Salud de Brasil. Conocida como *assa-peixe*, posee propiedades terapéuticas tales como antihipertensivo y diurético, antifúngico y antimicrobiano. La comprensión del ciclo de vida de la especie puede proporcionar información para programas de manejo y conservación de recursos genéticos. El objetivo de este estudio fue determinar el comportamiento fenológico de *V. polyanthes*, en un área de Cerrado, para evaluar el efecto de las variables climáticas del lugar durante cada fenofase, así como la sincronía de estas fenofases entre plantas individuales. 40 individuos fueron evaluados mensualmente en el período de agosto de 2014 a agosto de 2016, en cuanto a la intensidad y sincronía de las fenofases de brote, hojas maduras, senescencia foliar, caída foliar, floración y fructificación. La especie estudiada presentó comportamiento fenológico cíclico estacional con periodicidad anual, donde la sincronía entre los individuos evaluados a lo largo de los 24 meses fue elevada. Este factor es un facilitador del manejo de la especie. La temperatura media fue el factor abiótico que más influyó en las fenofases. El *assa-peixe* presentó la floración en el período de junio a agosto, mientras que la fructificación alcanzó el pico de intensidad en el mes de octubre.

Palabras clave: *assa-peixe*, manejo de especie, Cerrado.

Introduction

The family Asteraceae has an abundance of diverse specialized metabolites, which have storage or chemical defense functions, and the development of these metabolites is a factor of immeasurable importance in the evolutionary success of the family. Chemically, it is known to produce monoterpenoids, diterpenoids, triterpenoids, sesquiterpenoids and sesquiterpene lactones, polyacetylenes, flavonoids,

phenolic acids, benzofurans, coumarins and pyrrolizidine alkaloids, which are, with few exceptions, restricted to the Senecioneae and Eupatorieae tribes (Anderberg *et al.*, 2007; Calabria *et al.*, 2009).

The genus *Vernonia* (Asteraceae) is composed of more than 1000 species, which can be found in tropical and subtropical areas of the Asian, African and American continents, and of these approximately 350 are located in South America, occurring frequently in southern Brazil, Argentina,

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Paraguay and Bolivia (Robinson, 1999). Many species of this genus have medicinal properties and are used in some African countries for the treatment of malaria, amebiasis, infections and sexually transmitted diseases (Hamill *et al.*, 2000; Tona *et al.*, 2004).

V. polyanthes has diverse pharmacological properties. According to Lorenzi and Matos (2002) its phytochemical composition includes alkaloids, glycosides, flavonoids and essential oils. However, it is important to study the plant's phenology to develop restoration and conservation, which are essential processes for sustainable management and tools for domestication of the species (Ribeiro *et al.*, 1981; Vieira; Alves, 2003). Species of the Cerrado, under seasonal climates, show variations in seasonality with regard to the production of leaves, flowers and fruits, which determines adaptations to biotic and abiotic factors. These adaptations are linked to functional or structural characteristics, which are analyzed by phenology. Despite this, some authors argue that the seasonal limitation of the flowering period and other phenological events are established phylogenetically, that is, per phylogenetic constraints and strongly induced by the way of life, being independent of biotic or abiotic factors such as precipitation (Wright and Calderon 1995).

The annual development of Cerrado plants has well-defined phenophases, where each phenomenon occurs at a given time of year (Mantovani and Martin, 1998). The sprouting of buds in underground organs begins in the spring, after the rapid growth of the aerial part and development of reproductive organs during the summer and until the beginning of autumn. The stem then stops growing and the leaves begin to show the first signs of senescence, which leads to abscission of the aerial parts and dormancy of the plant. Finally, at the end of the winter, there is new budding as dormancy is broken (Carvalho and Dietrich, 1993).

Therefore, the objective of the present study was to observe and describe the phenology of *V. polyanthes*, to obtain important information for the domestication of this species.

Material and Methods

Study Area

The present study was carried out at Lageado Experimental Farm, belonging to the Faculdade

de Ciências Agrônomicas UNESP, Botucatu Campus. The area is located in the Experimental Farm Lageado, of the UNESP, Botucatu Campus, which is about 3 km from the seat of the city of Botucatu - SP, Brazil. The geographical coordinates are 22°52'20" S and 48°26'37" W. According to the Köppen classification (1948), the climate of the region is Cfa (warm humid temperate (mesothermal) climate), with average temperature of the hottest month exceeding 22 °C). The area of Botucatu is predominantly Cerrado, bordered by semideciduous seasonal forest. The only significant watercourse that cuts through the study area is the Lava-pés River, tributary of the Tiete Basin. This watercourse, before going through the Lageado farm, crosses the urban part of Botucatu. The soils of the study area are clayey, dark red in color, with predominantly undulating terrain. In some areas, the topography is smooth, but near the areas of shallow soils (Latosols), the relief becomes more rugged, with a dense drainage network (Sousa; Cavalheiro, 1988).

Phenological Observations

The method of sampling tracks described by d'Eça Neves and Morellato (2004) was used here. We randomly selected 40 adult individuals of *V. polyanthes* that appeared to be in satisfactory phytosanitary condition (absence of diseases and parasites). Observations and collections of the phenological data were performed monthly, from August 2014 to August 2016, totaling 24 months of observation. The entire population was considered adult, since all the individuals flourished and/or fruited during the study period.

The presence or absence and intensity of the following phenophases were recorded: (1) budding: beginning with the appearance of the leaf shoots and until the total expansion of the new leaves; (2) mature leaves: fully expanded leaves, dark green in color; (3) leaf senescence: indicated by the progressive yellowing of the leaves; (4) flowering: appearance of the flower buds until the last flowers; (5) fruiting: indicated by the end of anthesis and subsequent confirmation of the existence of seeds; (6) leaf fall: whenever there were empty spaces on the branches or when fallen leaves were observed on the ground just below the individual.

At the individual level, this method of analysis had a qualitative character. At the population

level, however, it assumed a quantitative character, indicating the percentage of individuals in the population that were manifesting a certain phenological event. This method was also used to estimate the synchrony between individuals of a population, considering that the greater the number of units manifesting the phenophases at the same time, the greater the synchrony of this population.

We used the method proposed by Fournier (1974) to quantify the phenophases, which we then evaluated individually, using a semi-quantitative interval scale of five categories (0 to 4) and 25% interval between each category, where: 0 = absence of the phenophase; 1 = the presence of phenophase with magnitude between 1 and 25%; 2 = presence of phenophase between 26 and 50%; 3 = presence of phenophase between 51 and 75% and 4 = presence of phenophase between 76 and 100%. Considering the intensity of each phenophase, the percentage of Fournier then calculated (Fournier, 1974).

Fournier intensity percentage - In this method, the values obtained in the field through a semi-quantitative interval scale of five categories (0 to 4) allowed us to calculate the percentage of intensity of the phenophases. In each month, we determined the intensity values for all individuals of the species, which was divided by the maximum possible value (number of individuals multiplied by four). The value obtained, which corresponds to the proportion, was then multiplied by 100, to convert it to a percentage value (Fournier, 1974).

Population synchrony in relation to the phenophases evaluated was determined using the method of Bencke and Morellato (2002), who considered the following proportion of individuals manifesting a certain phenological event: <20% asynchronous; 20-60% little synchronous; >60% synchronous. This calculation was estimated in the period of maximum activity of each phenophase.

The meteorological data was provided by the Department of Soils and Environmental Resources and obtained from the Meteorological Station of the Department of Soils and Environmental

Resources, located in the same place as the study area. The normality of data distribution was tested, and since the data did not show a normal distribution, Pearson correlation analysis (r) was used to determine the relationship between the climatic variables (monthly total precipitation, mean temperature and mean relative humidity) and the intensity of the phenophases.

Results

The species studied displayed seasonal phenological behavior with annual periodicity, where synchrony between the individuals evaluated during 24 months was generally elevated (Table 1). The decrease in precipitation, relative humidity and temperature was accompanied by a gradual increase in leaf fall, thereby demonstrating a positive relation with evapotranspiration.

The first shoots of *V. polyanthes* emerge in the first half of August. In relation to mature leaves, maximum intensity was reached in February, exactly one month after the maximum recorded precipitation, in contrast to leaf fall, which showed the highest intensity in the month of June. These phenophases showed opposite behavior, since the mature leaves correlated positively with the climatic variables, while leaf fall and senescence showed a negative correlation (Figure 1).

Flowering was annual with a duration of two months and was negatively correlated (Table 2) with all climatic variables analyzed, but mainly with temperature (Figure 2). However, peak flowering occurred in the month of July, which was in the driest period of the year.

The fruiting phenophase began in August and its maximum intensity occurred in the first half of October.

Discussion

Under conditions of low precipitation, temperature and relative humidity, there is a tendency

Table 1. Degree of synchrony according to phenophase, in percentage of individuals, estimated in the period of maximum activity of the species, Botucatu- SP, 2014/2015.

	Budding	Mature leaves	Leaf senescence	Flowering	Fruiting	Leaf fall
<i>V. polyanthes</i>	90	100	80	100	95	80

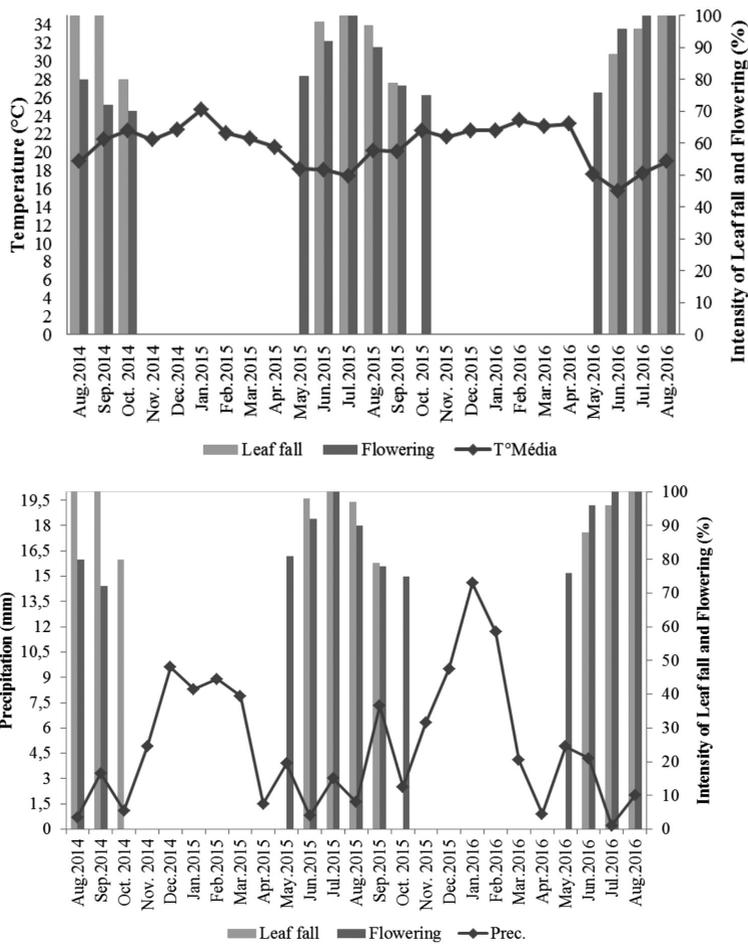


Figure 1. Leaf fall and flowering of *V. polyanthes* in relation to temperature (°C) and precipitation (mm) in Botucatu-SP.

Table 2. Pearson correlations between the evaluated phenophases of *Vernonia polyanthes* Less. and climatic factors (temperature, relative humidity and mean rainfall) at Fazenda Lageado - FCA / UNESP, Botucatu. 2014-2015.

	Budding	Mature leaves	Leaf senescence	Flowering	Fruiting	Leaf fall
T °C, mean	0.11	0.72	-0.81	-0.81	0.12	-0.62
Precipitation (mm)	-0.29	0.61	-0.34	-0.56	-0.28	-0.52
Relative humidity (%)	-0.38	0.55	0.04	-0.49	-0.32	-0.52

for increased evapotranspiration. This increase in evapotranspiration is associated with greater nutrient withdrawal from the soil, where at the end of this season, nutrient absorption is hampered by low air humidity and decreased availability of water in the soil, causing the loss of leaves for most plant species in the Cerrado (Morellato, 1992). It is possible that during the dry season, there

is a diversion of resources from the vegetative phase to the reproductive phase, since these deciduous species invest in flower production and fruit formation during the period of intense leaf senescence (Foster, 1990).

Deciduous species show budding immediately after the first rains, where a small amount of available water is enough to break bud dormancy

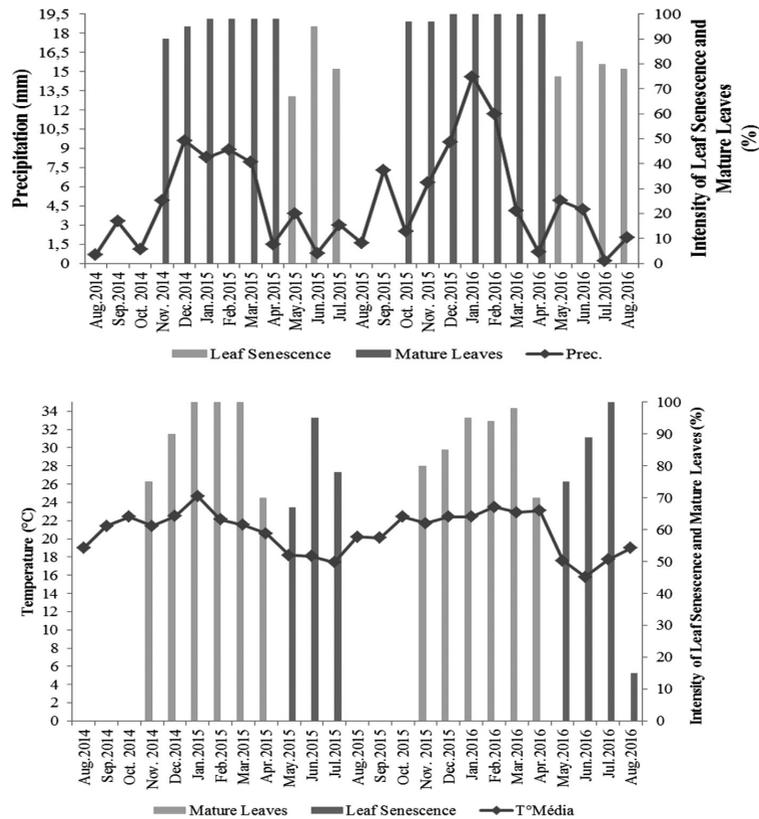


Figure 2. Leaf senescence and mature leaves of *V. polyanthes* in relation to temperature (°C) and rainfall (mm) in Botucatu-SP.

which induces sprouting (Borchert *et al.*, 2002). A decrease in rainfall triggers leaf fall in a Cerrado environment (Santos *et al.*, 2009).

Peak flowering occurs in July in the driest period of the year. This behavior is probably associated with greater protection of the reproductive organs and increased efficiency of pollinators, since intense rains can damage floral parts and hamper the action of pollinators, affecting the production of seeds by plants (Pedroni *et al.*, 2002). Generally, flowering during the dry season occurs after the abscission of the leaves and breaking of dormancy of the apical meristems of the aerial part of the plants, coinciding with the resumption of growth. This sequence of phenological events during the dry period is a typical pattern for deciduous tree species in the savanna and Cerrado (Opler *et al.* 1980, Miranda, 1995), where it is evident that flowering or anthesis is induced by rehydration due to a reduction of transpiration (Borchet, 1994).

The fruiting phenophase begins in August and its maximum intensity occurs in the first half of October. Fruit dehiscence occurs when the climate is conducive to dispersion of the anemochorous propagules (Schaik *et al.*, 1993). In Cerrado vegetation, woody plants disperse their seeds during the dry season, which seem to germinate readily, whereas the seeds of species with dormancy are disseminated predominantly in the rainy season (Oliveira, 2008).

Conclusion

The phenological events of the population of *V. polyanthes* studied were synchronous; that is, occurred in the same period. Growth was periodic and seasonal, and the climatic variable that correlated strongly with phenophases was temperature. The vegetative phenophases were concentrated in October to May and the reproductive ones in June to the first half of October.

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