Iheringia
Série Botânica
ISSN ON-LINE 2446-8231

Floral biometrics and phenological characterization of flowering and fruiting of the passion fruit *Passiflora trintae* in southwestern Bahia, Brazil

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Recebido em 23.X.2020
Aceito em 18.IV.2023

DOI 10.21826/2446-82312023v78e2023016

ABSTRACT – A positive influence of temperature and precipitation was observed on floral and fruit development of *Passiflora trintae* Sacco. This study described the floral biometrics and characterized the reproductive phenology based on local climatic factors (temperature and precipitation) of a natural population of *P. trintae* in southwestern Bahia State, Brazil. According to the floral morphometry results, data were obtained that can be used in future taxonomic studies and for exploring diversity by making interspecific crosses with other species of the same genus. Under the study conditions, a higher production of flower buds and flowers at anthesis, as well as flowering peak, occurred during the summer months, while a higher production of ripe and immature fruits, as well as fruiting peak, coincided and occurred during the spring. The period of floral anthesis begins at around 04:30 a.m. and ends at around 04:00 p.m. Temperature can predict the phenological variables of flowering peak and flower bud rate, while precipitation can predict all phenological variables related to flower bud rate, flowering rate, flowering peak, fruiting rate, and fruiting peak.

Keywords: anthesis, floral descriptors, phenology, passion fruit

RESUMO – **Biometria floral e caracterização fenológica da floração e frutificação para o maracujá *Passiflora trintae* no Sudoeste da Bahia, Brasil.** Foi observada uma influência positiva da temperatura e precipitação no desenvolvimento floral e de frutos em *Passiflora trintae* Sacco. Este estudo descreveu a biometria floral e caracterizou a fenologia reprodutiva a partir de fatores climáticos locais da temperatura e precipitação em uma população natural de *P. trintae* localizada no sudoeste do estado Bahia, Brasil. De acordo com os resultados da morfometria floral, foram obtidos potenciais dados para futuros estudos taxonômicos, além de permitir explorar a diversidade por cruzamentos interespecíficos com outras espécies do mesmo gênero. Nas condições deste estudo, foi registrado que a maior produção de botões florais, incidência de flores em antese e o pico de floração ocorreram durante os meses de verão, enquanto que a maior produção de frutos maduros e imaturos, bem como o pico de frutificação, coincidiram e ocorreram durante a primavera. Foi possível estabelecer o período de antese floral que se inicia em torno de 04h30min e termina em torno de 16h00min. A temperatura pode predizer as variáveis fenológicas do pico de florescimento e taxa de botões florais, enquanto que a precipitação pode predizer todas as variáveis fenológicas relacionadas à taxa de botões florais, taxa de florescimento, pico de florescimento, taxa de frutificação e pico de frutificação.

Palavras-chave: antese, descritores florais, fenologia, maracujazeiro

INTRODUCTION

The family Passifloraceae comprises 17 genera and more than 700 species distributed in tropical and subtropical regions (Feuillet & Macdougal 2007, Perez *et al*. 2007). The most important genus in the family is *Passiflora*, which has the largest number of species, including many of economic interest (Pérez & d'Eeckenbrugge 2017). Brazil is one of the main centers of origin and diversity of *Passiflora* species in South America. The wide variability of these passion fruit species is a promising research field in relation to various aspects of plant breeding (Bernacci *et al*. 2005, Ferreira 2005, Yockteng *et al*. 2011, Esashika *et al*. 2018, Ribeiro *et al*. 2019).

Many passion fruit species are widely used for food, medicinal, and ornamental purposes (Meletti 2011). The ornamental potential of *Passiflora* flowers is of interest due to their beauty, unique shapes, and colors (Abreu *et al*. 2009). The numerous native species and wild varieties may have characteristics of interest that can be used to create interspecific hybrids that provide agronomic gains (Vanderplank *et al*. 2003). *Passiflora trintae* Sacco is among the species native to Brazil and is known locally as the red-flowered passion fruit (*maracujá de flor vermelha*) This plant was first described by Sacco in 1968 and is botanically characterized by its glabrous, cylindrical, creeping stem with deeply trilobed leaves with a subcordate base. It occurs in northern Minas Gerais State and southwestern and western Bahia State (Cervi 1997). The flower buds of *P. trintae* have a distinct shape that is reminiscent of the typical balloons of the *Festa de São João*, a religious and social festival commonly celebrated in northern Minas Gerais and Bahia, as well as throughout the Northeast Region of Brazil (Meira Souza 2014). *Passiflora trintae* is a native species in Planalto da Conquista, a region in southwestern Bahia that is characterized by fragments of *Cipó* forest, a transition zone between the Caatinga, Cerrado, and Atlantic Forest (Cerqueira-Silva *et al*. 2010).

Evaluating characteristics such as floral biometrics and the flowering and fruiting phenology of *Passiflora* species has become increasingly necessary to understand the best use of genetic resources (Ganga *et al*. 2004). Thus, the pre-breeding activity, which corresponds to a precursor stage of plant breeding, is useful to classify the genetic variability of species for genotyping, conservation of genetic resources and characterizing biodiversity through morphological, phenological, and molecular parameters (Faleiro *et al*. 2005, Dempewolf *et al*. 2017).

Researching passion fruit species in different periods and locations, with the goal of associating phenological stages and floral attributes to environmental conditions (e.g., temperature, precipitation, humidity, and solar radiation), is increasingly important. These studies can help explain the behavior of species in relation to reproductive development phases, since the flowering and fruiting phases of *Passiflora* are strongly influenced by the environment (Camillo 2003, Silva *et al*. 2007, Duarte *et al*. 2014, Krosnick *et al*. 2017). Knowledge about phenological patterns and floral morphology is fundamental to understand the reproductive biology of species and is also the basis for the development of breeding programs because these biological parameters can provide information about the behavior of plants in relation to various selective forces determined by the environment. With this information, it is possible to select plants with the highest quantity and quality of flowers, leaves, and fruits (Ramaiya *et al*. 2014).

To date, few studies have been conducted with *P. trintae* to explore interesting questions about the floral morphology and reproductive phenology of this passion fruit. One of these studies was based on molecular markers (Cerqueira-Silva *et al*. 2010) and evaluated the genetic diversity of *P. trintae* individuals from the same population that we studied. Thus, the data generated from this work expand the knowledge of this species and can contribute to future works about conservation, genetic improvement, and floral pollination. For now, studies related to the phenology of this species are incipient.

Based on these observations, the objective of this study was to evaluate floral biometrics in a natural population of *P. trintae* and characterize the reproductive phenology of this species in relation to climatic factors (temperature and precipitation).

MATERIAL AND METHODS

Species and study area

This study was conducted from June 2012 to May 2013 in the municipality of Vitória da Conquista (14º 53’03”S, 40º 48’35”W), in the southwestern region of Bahia State, which has an average elevation of 923 m. Vitória da Conquista has a high altitude, tropical climate with an average temperature of 20ºC and average precipitation of 717 mm (INMET 2013). To understand the meteorological conditions, precipitation and temperature data were obtained from the *Estação Meteorológica da Universidade Estadual do Sudoeste da Bahia* (UESB), which is a partner of the *Instituto Nacional de Meteorologia* (INMET) (INMET 2013). A collection of the botanical material was made for expert consultation and comparison with material deposited in the HUESBVC herbarium at UESB; it was deposited under the code HUESBVC Nº 758.

Floral Descriptors

The measurements of floral descriptors were adapted from the official descriptors for ornamental *Passiflora* (MAPA 2018). For the analysis, 72 flowers at anthesis (flower opening) from 41 plants of *P. trintae* were evaluated by taking 17 floral measurements with a Starrett® digital caliper. The floral characteristics include the length of the peduncle, androgynophore, filament and style, corona diameter, and length and width of the bract, perianth (sepals and petals), anthers, stigmas, and ovary. These floral descriptors are in Tab. 1, which includes vegetative and reproductive parts, and floral parts are also shown in Figs. 1 and 2. The measurements were made on the same day and with fresh material that was not collected due to the importance of conserving the flowers, which are threatened by anthropic activities in their natural environment.

Phenological characterization

For the phenological analysis, biweekly evaluations were made of 15 *P. trintae* plants previously identified from June 2012 to May 2013. Phenological events were observed according to Souza *et al*. (2012) for flower buds, flowers, and fruits; the number of days from the appearance of the flower bud to the complete ripening of the fruit was counted. The time and duration of anthesis were obtained by marking the flower buds with colorful ribbons at the pre-anthesis stage. For each month, the number of flowers was recorded by estimating the flower bud rate (ratio between the total number of flower buds and the number of individuals analyzed), flowering rate (ratio between the total number of flowers at anthesis and the number of individuals analyzed) and flowering peak, which corresponds to the highest number of flowers at anthesis observed in the month of evaluation. In addition, the fruiting rate (ratio between the total number of fruits and the number of individuals evaluated) and fruiting peak, which represents the highest number of immature and mature fruits observed in the month of evaluation, were determined for each month. Means ± SD of these phenological data were obtained for each month.

Data analysis

Each plant represented one biological replicate, and the descriptive statistical parameters (maximum and minimum values, mean, standard deviation, and coefficient of variation) were estimated for the floral descriptors of each replicate. The phenological data were analyzed using a polynomial regression of second order model for phenological events using temperature and precipitation as predictors. The coefficient of determination of regression (R^2) was used as an adjustment measure for the models. The presence of outliers and the model assumptions were verified, and graphs were built with the package ggplot2 (Wickham 2016) in the R environment (R Core Team 2019).

RESULTS

Flowers are commonly used to characterize *Passiflora* species. They are morphologically diverse within this genus (Faleiro *et al*. 2005). The flowers of *P. trintae* are red, solitary, hermaphroditic, radially symmetric and have a corona, a typical structure of Passifloraceae (Figs. 1 and 3). Adult plants produce trilobed leaves, tendrils, flower buds, flowers that constantly stay open, and fruits (Fig. 1). Tab. 1 shows the means and standard deviations for the floral descriptors. The flowers of *P. trintae* have five sepals and five petals. The sepals, which protect the flower bud and form the calyx, make up the outermost parts of the flower. Their average length (SEL) and width (SEW) were 37.05 mm and 6.88 mm, respectively. The corolla, which comprises the petals, had an average length (PEL) and width (PW) of 36.10 mm and 7.29 mm, respectively. Since there is no distinction in the color and shape of the calyx and corolla structures, this flower can be classified as homochlamydeous, with lanceolate and oblong sepals (Fig. 2A). The peduncle (Fig. 2B) had an average length (PL) of 29.14 mm. The bract (Fig. 2B) had an average length (BL) and width (BW) of 14.87 mm and 8.26 mm, respectively.

The corona, a peculiar feature of *Passiflora* (Fig. 2B), had an average diameter (CD) of 4.78 mm and is violet at the base and white at the apex. The androgynophore, which is an extension of the peduncle and supports the sexual organs (androecium and gynoecium) of the flowers (Fig. 2B), had an average length (AL) of 22.90 mm. The stem that attaches the stamen to the floral receptacle, called a filament (Fig. 2B), had an average length (FL) of 10.73 mm. The anther (Fig. 2C) had an average length (ANL) and width (AW) of 7.57 mm and 2.25 mm, respectively, and was light green on the adaxial part. The stigma (Fig. 2C) is olive green and had an average length (SL) and width (SW) of 2.42 mm and 2.41 mm, respectively. The style, which connects the stigma to the ovary (Fig. 2B), had an average length (STL) of 9.84 mm. The ovary, which is oblong and green (Fig. 2B), had an average length (OL) and width (OW) of 6.14 mm and 2.70 mm, respectively.

Table 1. Measurements of the floral morphological descriptors for *Passiflora trintae*.

Descriptor	Maximum	Minimum	Mean±SD	CV (%)
SEL (mm)	48.75	22.77	37.05±4.99	13.46
SEW (mm)	8.46	4.3	6.88±0.84	12.17
PEL (mm)	46.7	27.18	36.10±4.50	12.48
PW (mm)	10.01	5.42	7.29±0.84	11.57
PL (mm)	50.12	16.5	29.14±6.66	22.84
BL (mm)	20.25	7.59	14.87±2.66	17.88
BW (mm)	13.84	4.15	8.26±1.88	2.75
CD (mm)	7.69	2.25	4.78±1.22	25.53
AL (mm)	29.86	14.52	22.90±4.35	18.98
FL (mm)	14.38	6.02	10.73±1.62	15.13
ANL (mm)	13.48	5.89	7.57±1.07	14.20
AW (mm)	6.85	1.36	2.25±0.67	29.93
SL (mm)	3.15	1.25	2.42±0.38	15.78
SW (mm)	3.87	1.37	2.41±0.42	17.59
STL (mm)	13.58	6.42	9.84±1.51	15.34
OL (mm)	8.11	3.43	6.14±0.93	15.13
OW (mm)	3.47	1.73	2.70±0.34	12.58

SD = standard deviation; CV = coefficient of variation; SEL = Sepal Length; SEW = Sepal Width; PEL = Petal Length; PW = Petal Width; PL = Peduncle Length; BL = Bract Length; BW = Bract Width; CD = Corona Diameter; AL = Androgynophore Length; FL = Filament Length; ANL = Anther Length; AW = Anther Width; SL = Stigma Length; SW = Stigma Width; STL = Style Length; OL = Ovary Length; OW = Ovary Width.

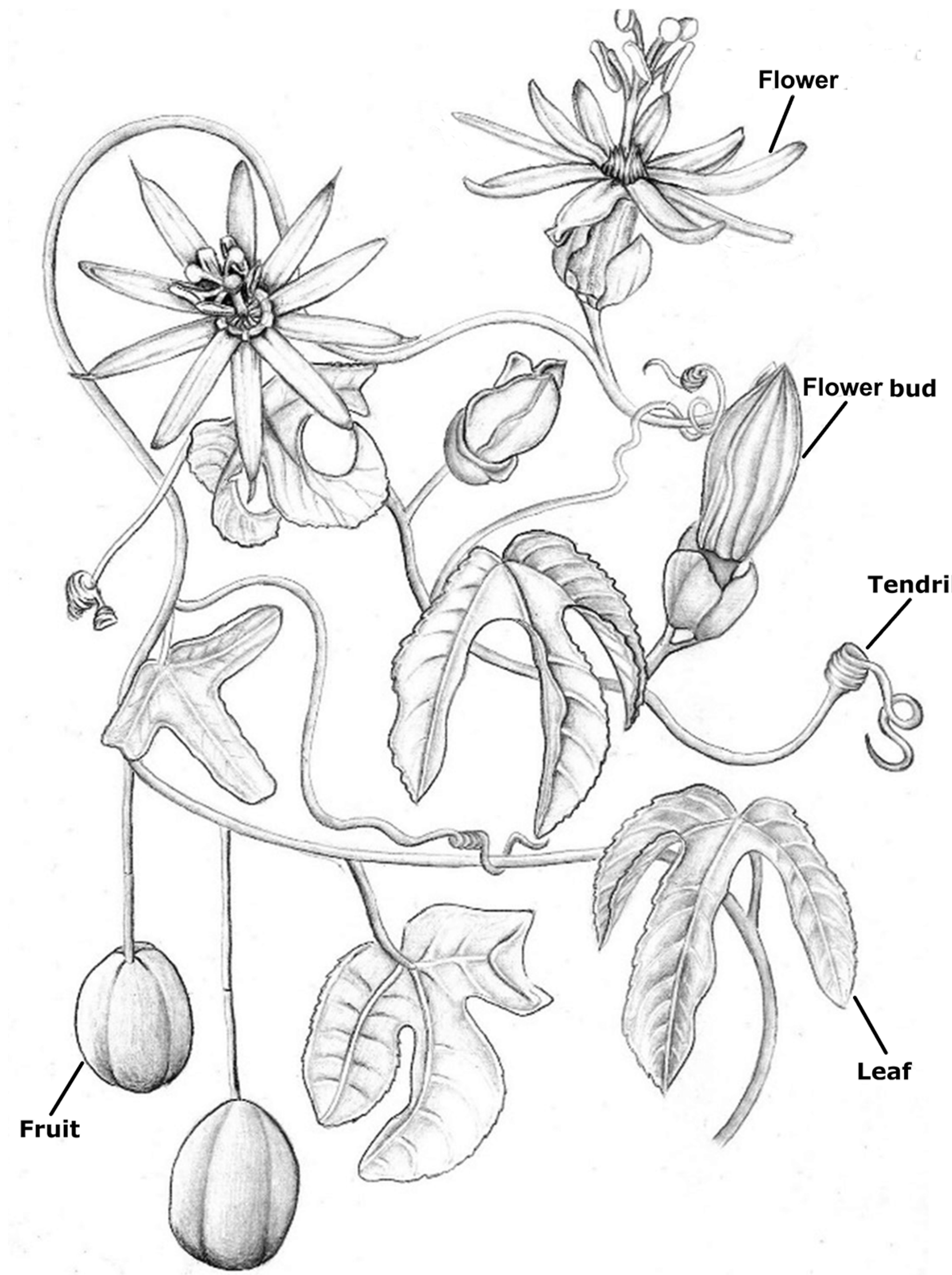

Figure 1. Illustration of *Passiflora trintae* with vegetative and reproductive parts that show the complete structure of an adult plant.

During the study period for the phenological analysis (June 2012 to May 2013), the annual average temperature was 20.12°C. The lowest and highest average temperatures during this evaluated period occurred in August 2012 (17.6ºC) and February 2013 (22.5ºC). The annual average precipitation was 60.9 mm, with the lowest and highest averages in August 2012 (14.6 mm) and December 2012 (134.0 mm) (Fig. 4).

Based on the phenological evaluations, the plants produced a higher number of flowers and flower buds (flower bud rate equal to 18.7) in January 2013 (Fig. 5A), which was one of the months when higher temperature and precipitation values were recorded. Interestingly, the highest flowering peak was 8 flowers on a single plant in February 2013 (the month with the highest average temperature), with a flowering rate of 11.4 (second highest value observed), while the highest incidence of flowers at anthesis was recorded in December 2012 (flowering rate equal to 24.3 and the month with the highest average precipitation) (Fig. 5A). These three phenological floral parameters did not follow the same growth trend; it was only possible to observe the same pattern of decline in the last few months (February 2013 to May 2013) (Fig. 5A). In parallel, it was observed that anthesis occurred

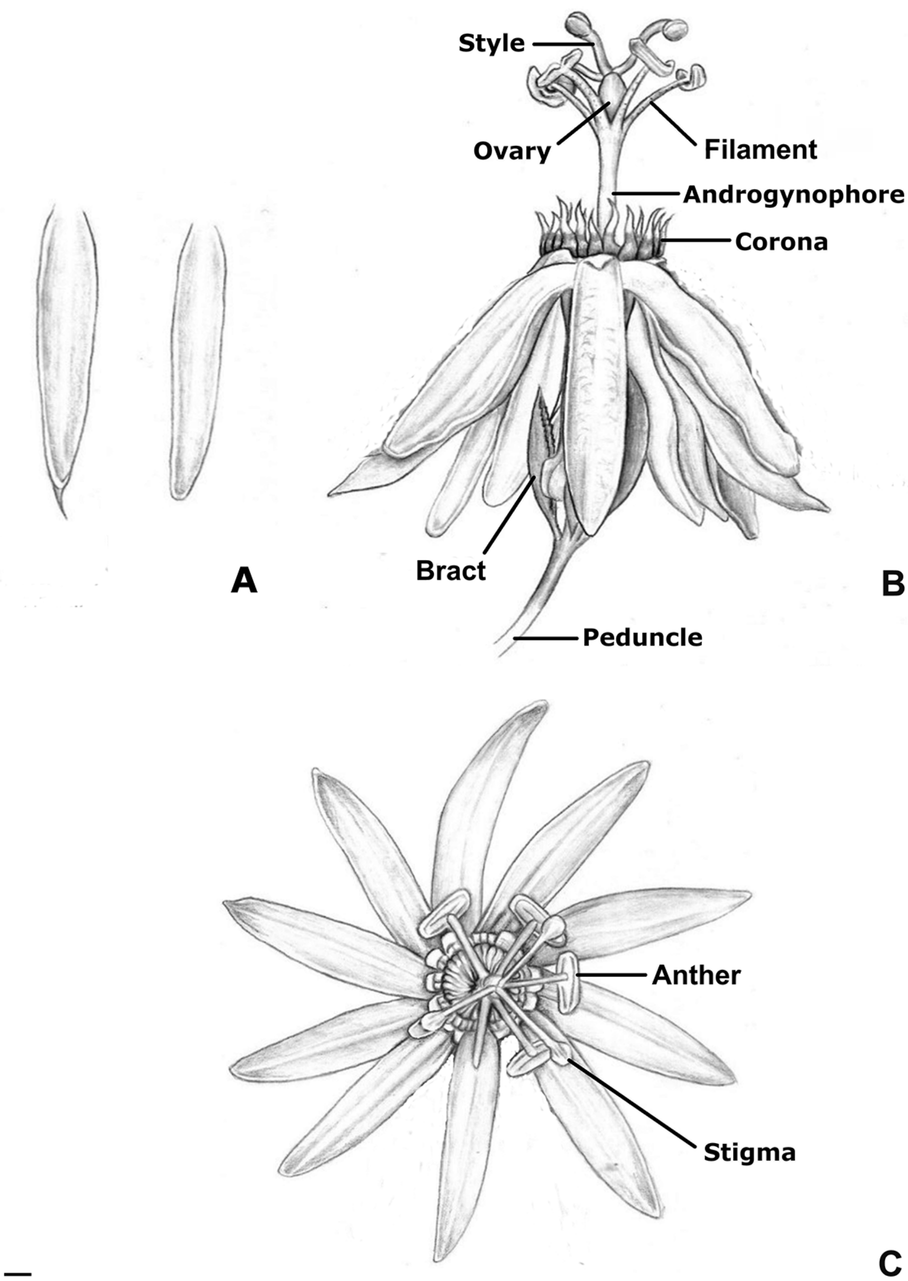

Figure 2. Illustration of *Passiflora trintae* showing the floral parts. **A.** Sepal and petal; **B.** Lateral view of flower. **C.** Apical view of flower. Bar = 1 cm.

at around 04:30 a.m. and lasted approximately 12 hours. The highest fruiting peak was 55 fruits on a single plant in October 2012, with a fruiting rate of 7 (Fig. 5B). A second fruiting peak was observed in March 2013 (48 fruits), with a fruiting rate of 6.5. These two phenological fruiting parameters had the same growth pattern for most of the year; they did not coincide in the last month (May 2013) (Fig. 5B).

From the polynomial regression analysis (Tab. 2), it was possible to verify the influence of environmental factors on the phenological events of floral production. There was a strong prediction between temperature and flower bud rate ($R^2 = 0.64$; $p = 0.009$). In parallel, there was low prediction for the flowering rate based on temperature ($R^2 = 0.37$; $p = 0.124$); however, temperature was a good predictor for flowering peak ($R^2 = 0.77$; $p = 0.001$). Thus, it was found that the higher the temperature, the higher the influence on the emergence of flowers at anthesis and the lower the influence on the number of flowers at anthesis. The highest temperature values were observed during the late spring and throughout the summer (November 2012 to March 2013) (Fig. 4), the period when the highest values for flowering peak were recorded (Fig. 5A), which may justify the strong prediction between these variables.

Figure 3. Flowers of *Passiflora trintae* in the sampling site.

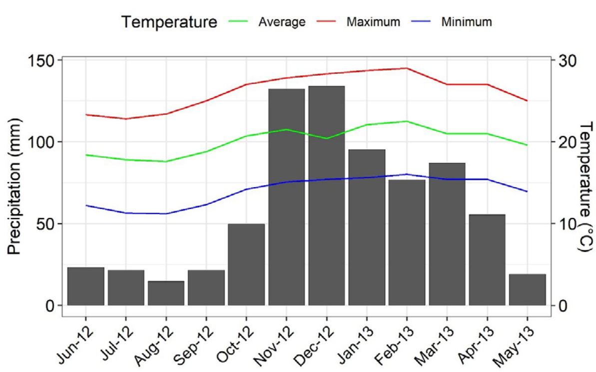

Figure 4. Average, maximum, and minimum temperature and precipitation from June 2012 to May 2013, in Vitória da Conquista, Bahia, Brazil (INMET 2013). The bars represent precipitation data, and the lines represent temperature data.

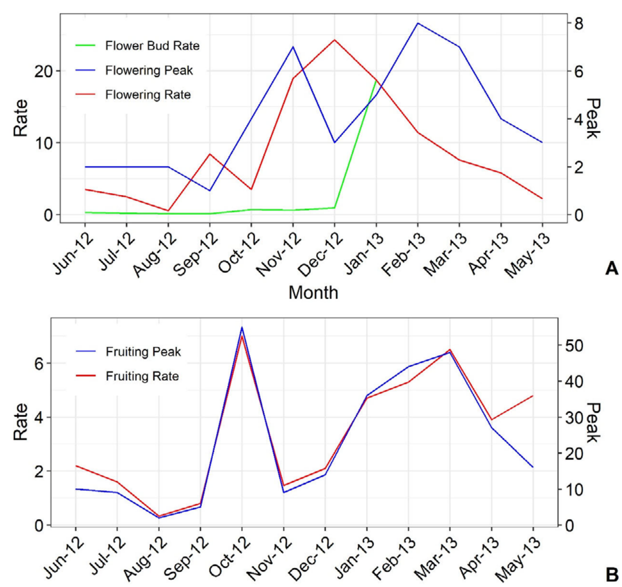

Figure 5. Phenograms of *Passiflora trintae* in an area located in Vitória da Conquista, Bahia, Brazil. **A.** Flower bud and flowering rates, as well as flowering peak ; **B.** Fruiting peak and rate.

In relation to the precipitation factor, flowering also tended to have increasing values with increasing precipitation, in addition to the production of flower buds. There were medium predictions for flower bud rate (R^2 = 0.57; p = 0.021) and flowering peak (R^2 = 0.67; p = 0.006) and a high prediction for flowering rate (R^2 = 0.84; p = 0.000). These expressive values indicate that the floral production and emergence of flowers at anthesis for *P. trintae* are mainly related to rainy periods. In fact, the highest precipitation values were from November 2012 to March 2013 (Fig. 4), when the highest values for flower bud and flowering rates, as well as flowering peak, were also recorded (Fig. 5A), justifying these three strong associations observed.

In relation to fruiting parameters when using temperature as the predictor, there were low predictions for fruiting rate (R^2 = 0.44; p = 0.072) and fruiting peak (R^2 = 0.48; p = 0.050); however, there were significant predictions using precipitation as the predictor for fruiting rate (R^2 = 0.65; p = 0.008) and fruiting peak (R^2 = 0.81; p = 0.000). When the highest values of temperature were recorded (Fig. 4),

Table 2. Coefficient of determination (R^2) from the polynomial regression of second order model using each local climatic factor (temperature and precipitation) as a predictor and the phenological analysis (flower bud rate, flowering rate, flowering peak, fruiting rate, and fruiting peak) as a dependent variable, in a natural population of *Passiflora trintae* in Vitória da Conquista, Bahia, Brazil.

Variable	Average Temp (ºC)	Precipitation (mm)
Flower Bud Rate	$R^2 = 0.64$**	$R^2 = 0.57$*
Flowering Rate	$R^2 = 0.37$	$R^2 = 0.84$**
Flowering Peak	$R^2 = 0.77$**	$R^2 = 0.67$**
Fruiting Rate	$R^2 = 0.44$	$R^2 = 0.65$**
Fruiting Peak	$R^2 = 0.48$	$R^2 = 0.81$**

Coefficient of determination (R^2) at 5% significance. (*significant at 5%; **significant at 1%).

it generally did not mean there were the highest values for fruiting rate and fruiting peak (Fig. 5B), which may have been reflected in the weak association between these phenological parameters and this environmental factor.

DISCUSSION

Studies related to characterizing wild passion fruits are still not common in Brazil, although this country is rich in *Passiflora* species (Mezzonato-Pires & Milward-De-Azevedo 2017). Morphological characterization is very important to find promising characteristics that have ornamental value (Meletti 2011). Native species are highly variable among individuals, for example, the shape, size, and color of flowers (Benevides *et al*. 2009, Siqueira *et al*. 2009). By characterizing the red-flowered passion fruit (*maracujá de flor vermelha*) we aimed to highlight how this species can be recognized at different stages and to obtain more information about it to clarify possible doubts. How this species can be identified using its flowers should be updated, especially for the study region, since the genus exhibits wide genetic variability (Sequeira *et al*. 2006). In addition, exploratory studies related to morphological characterization provide primary information than can be used during pre-breeding, allowing the breeder to explore diversity and use introgression to introduce other alleles of favorable species through interspecific crosses with the goal of producing ornamental hybrids (Abreu *et al*. 2009).

The floral biology data for *P. trintae* could contribute to future taxonomic classification studies. For example, *Passiflora coccinea* Aubl., which is another wild passion fruit, shares some floral characteristics with *P. trintae*, mainly the reddish color of the perianth (Storti 2002). Based on the results of the present study and those for *P. coccinea* in Storti (2002), *P. trintae* has smaller flowers than *P. coccinea*. Similarly, Storti (2002) described the floral morphology of *P. coccinea* in relation to BL (51.6 mm), SEL (48.2 mm), PEL (52.4 mm), CD (14.4 mm), AL (51 mm), FL (15.3 mm), and SL (16.7 mm). These average floral values for *P. trintae* differ greatly from those obtained for *P. coccinea*, mainly in relation to the BL and AL floral parameters. The bract, located just above the peduncle, protects the flowers during development (Cervi 1997, Vanderplank 2000). The androgynophore is an axis that supports the androecium and gynoecium and is associated with a compartment that contains the nectariferous disk. The androgynophore size can help us infer the types of pollinators that are attracted (Cervi 1997, Vanderplank 2000). The difference in the CD value between the two species was approximately 10 mm. The origin of the corona is not precisely known. It seems to be derived from sepals and petals, which form the various filaments that have bright and attractive colors (Vanderplank 2000). This structure has been described as being responsible for attracting pollinators, and it is used a lot in quantitative and qualitative morphological studies to reveal the degree of kinship between passion fruit species and to define taxonomic groups using multivariate analyses (Vanderplank 2000, Feuillet and Macdougal 2007).

Rangel Junior *et al*. (2018) described the floral biology of *Passiflora setacea* DC, which is another species of wild passion fruit commonly called *maracujá-do-sono.* The evaluated characters were PL (79 mm), BL (26 mm), SEL (34 cm), PEL (33 cm), AL (32 mm), and OL (56 mm). Thus, the perianth of *P. trintae* is practically the same length as that of *P. setacea*. The other average flower values for *P. trintae* were shorter than those obtained for *P. setacea*. The greatest differences were mainly in relation to the PL and OL floral parameters; the differences for both characters almost reached 50 mm. Since *P. setacea* has nocturnal anthesis and therefore attracts nocturnal pollinators, its flowers tend to have long peduncles with larger reproductive structures that can easily reach pollinators that hold the flowers with their feet (Gonçalves & Lorenzi 2011). Thus, it is justifiable that we found lower average floral values for *P. trintae*, which has diurnal anthesis and is generally pollinated by species with a diurnal habit. As the plants are immobile and each one has distinct characteristics in its environment, various adaptations have appeared to guarantee reproductive success, for example, attracting specific types of pollinators (Rocha 2015).

In relation to the phenological results, *P. trintae* is a wild passion fruit that can be potentially used as a genitor in interspecific and intraspecific breeding programs. It produces the most flower buds and flowers in late spring and the summer, the period when the highest means for temperature and precipitation in Vitória da Conquista were recorded. Thus, the apex of the reproductive phase of this species probably begins in a warmer and rainier season, with the higher production of flower buds and flowers, and ends in a drier and colder season when its fruits emerge and ripen. This also takes into account the highest production of immature and mature fruits in the spring (October 2012), which therefore did not coincide with the highest production of flower buds and the emergence of flowers at anthesis. Although there were other relevant values for fruiting peak over the evaluated period, especially for the late summer (March 2013), these records may suggest an adaptive advantage of the fruits because they last for longer cycles compared to the flower buds and occur during dry and cold months when they become a resource for local fauna (Machado *et al*. 2007).

Kiill *et al*. (2010) found similar results for *Passiflora cincinnata* Mast., a wild passion fruit from the Caatinga biome that is popularly known as *maracujá-do-mato*. They compared the phenological behavior of this species by estimating flowering and fruiting rates. Compared to our data, these rates did not show the same growth trend and presented different oscillations when recorded throughout the year, which is directly related to the local climatic conditions of the region (Kiill *et al*. 2010). In the city of Petrolina (Pernambuco, Brazil), the rainy season is concentrated between January and April and is characterized by high temperatures (Kiill *et al*. 2010), a condition almost similar to the present study where the hot and rainy season starts in the spring (October or November) and lasts until April (INMET 2013).

In *Passiflora* species, there is a wide variation in the period and duration of anthesis. For example, for the wild passion fruit *P. coccinea*, which also has a reddish flower, there is a record of diurnal and short anthesis during the year that lasts around 4 hours; the flower opens around 05:00 a.m. and closes around 09:00 a.m. (Storti 2002). This is different from *P. trintae*, which has a longer diurnal anthesis (around 12 hours). For *P. setacea* (Rangel Junior *et al*. 2018), although its anthesis is nocturnal, the duration time (around 14 hours) is more similar to *P. trintae*. *Passiflora edulis* Sims, a commercial species of passion fruit popularly called *maracujazeiro-azedo*, has diurnal anthesis that also lasts more than 12 hours under intense luminosity (Camillo 2003). The process of a flower opening is usually characterized by the gradual expansion of floral parts (sepals and petals) caused by the pressure exerted by the stigmas and anthers on the walls of the perianth. The process of a flower closing begins at the end of anthesis and is characterized by the wilting of the petals and corona filaments, as well as the upward movement of the styles (Pezzopane *et al*. 2003, Rangel Junior *et al*. 2018). This information and the record of anthesis for *P. trintae* in the present study will contribute to the identification of possible floral visitors and pollinators of this species in future studies, according to some reports for *Passiflora* (Varassin *et al*. 2001, Krosnick *et al*. 2015, Krosnick *et al*. 2017). In addition to the floral data, the fruiting analyses recorded here can also contribute to research associated with cultivation productivity, prediction of fruit ripening, and breeding programs.

In general, temperature and precipitation interfere with the photosynthetic activity of the plant, which favors vegetative and reproductive development. *Passiflora* species usually require high luminosity, temperature, and precipitation to flower (Faleiro *et al*. 2005). This justifies the positive association found in the present study for the two environmental factors evaluated (temperature and precipitation) with the two estimated flowering parameters (flower bud rate and flowering peak). The production of flower buds and flowering of *P. trintae* occurred mainly in months of the year with higher temperatures and precipitation.

Significant associations were found in the present study between precipitation and all phenological parameters evaluated. The numbers for flower buds and open flowers are probably related to the availability of water in the soil due to the rain. Water stress can cause smaller branches in passion fruit plants, with a lower number of nodes and internodes, and a lack of water is reflected in the formation of floral shoots, open flowers, and fruits (Lima *et al*. 2011; Carr 2013).

The knowledge generated from characterizing the phenological attributes and floral morphology will be important information for parental selection in breeding studies and will contribute to biological and ecological studies (Ramaiya *et al*. 2014). This study provides unprecedented information about the phenology and floral descriptors of *Passiflora trintae*. The individuals of the same population have high phenotypic variability in their floral parts. It was verified that *P. trintae* has potential as an ornamental because it blooms and has fruits at different times of the year. The period with the highest production of flower buds and flowers at anthesis is during the summer months when the temperature and precipitation are high. The highest fruit incidence occurs during the spring and the late summer, and this is strongly influenced by only the precipitation factor. The present study can contribute to future research about genetic breeding, germplasm conservation, and floral pollination.

ACKNOWLEDGMENTS

We thank the following: PETROBRAS - The Human Resources Training Program for the financial support; the Universidade Estadual do Sudoeste da Bahia (UESB) for the transportation logistics for fieldwork; and Diego Alcântara and Ludmila Oliveira for helping with the scientific illustrations of *Passiflora trintae*.

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