Research Square

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Study of the floral phenology of Dacryodes edulis in the Republic of Congo

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Abstract

Dacryodes edulis (G. Don) HJ Lam. is a fruit tree producing edible fruits called safou. Floral phenology is described while situating it in time, in relation to temperature. And illumination. For this, 10 feet are selected in the surroundings of the city of Brazzaville. The qualitative and quantitative characters of the flowers are observed, in order to identify their phenophases. There Flowering lasts 38 days and includes three stages, the initiated flower, the flower bud and the bloomed flower which have lengths respectively 3.52 mm ; 4.742 mm and 5.569 mm. Temperature and lighting positively influence the elongation of the flower. Geographic orientation in relation to sunset and at sunrise does not influence the elongation of the flower.

INTRODUCTION

Plant phenology refers to the study of the distribution over time of events cyclical biological functions of the plant which are influenced by the environment, in particular by temperature variations conditioned by the type of climate (Lebourgeois *and al*., 2008). However, most studies indicate that climate (rainfall, temperature and photoperiod) is an essential factor affecting the phenology of plants in tropical environments (Guira, 1997, Normand, 2002, Badou *and al*., 2017). The study of phenophases and the factors that influence them is therefore important for understanding population dynamics in ecosystems (Dambreville, 2012). For example, the flowering period is very variable for the same species because it depends on several factors including the geographical location of the plant (Grouzis and Sicot, 1980, Awono *and al*., 2002, Tchoundjeu et al., 2002, Iboukoun *and al*., 2021). Thus, flowering periods are often shifted in time between the West and the East, even though the sites are on the same isohyet (Diallo et al., 2016, Fournier, 1990). Tree flowering dates contribute to the reproductive success of the individual and therefore to the sustainability of his descendants, and are therefore strongly subject to the natural selection. Floral phenology is an essential parameter for understanding the tree production schedule. The objective of this work was therefore to describe the floral phenological stages of *Dacryodes edulis* (G. Don) HJ Lam.

MATERIALS AND METHODS

Material

Equipment

An electronic caliper comprising a small battery with a dimension of 15 cm was used during measurements. An Otio brand magnetic thermometer with a range of temperature from 0 to 50°C and a digital luxmeter with a measuring range of 0.01 to 50,000 lux and Voltcraft brand were used for temperature and illuminance recordings around the flower.

Methods

Survey of the study area

The study was carried out in Brazzaville and Kintélé. Several trees were visited during the prospecting in different neighborhoods. The prospecting was used to locate the feet of *Dacryodes edulis* almost identical morphologically at their vegetative stage of development. With the agreement of the owner, each individual chosen has been marked and numbered with the blue marker. Thus, 20 individuals were retained during the survey. At the time of the flowering, 16 plants flowered but 4 did not bear flowers. Among the 16 flowering feet, 6 feet sank and the other 10 feet maintained their flowers. This study was carried out on the 10 trees.

Collection of data

The data was collected over a year. The data collection periods are from July 2021 to April 2022 in the four districts : Makélékélé, Bacongo, Poto-Poto, Moungali, Talangaï, Mfilou, Djiri and in the urban commune of Kintélé. For this purpose, 4 rods inflorescences per reproductive tree were selected. Phenological observations took place every 4 days from floral initiation until the blooming flower stage, in order to to identify the phenological stages of flowering and collect quantitative data linked to the flower. The different flowering stages of *Dacryodes edulis* (G. Don) HJ Lam. (Burseraceae) were identified on the basis of qualitative morphological characters (color and installation of parts) (Badou et al., 2017). These qualitative characteristics have been completed by quantitative characteristics to better characterize the different stages of reproduction. For to do this, 5 flowers per inflorescence stem were observed at each stage identified out of the 10 feet marked beforehand, i.e. 20 flowers per reproductive stage. The data collected focused on the length and diameter of the parts of the organs and these data were supplemented by the factors temperature, illumination and humidity around the flower. The diameter of the flower was taken at the level of the floral receptacle of the organs located on the east side and West relative to sunrise and sunset. All these observations, appreciations and Measurements were made from 10 a.m. to 3 p.m.

in Brazzaville and Kintélé.

1.3. Data analysis methods

SPSS software (Statistical Package for Social Sciences), version 22.0 was used to analyze the collected data. Pearson linear correlations at the risk threshold of 5% have been applied. The averages of length, temperature and illumination have were first compared according to the 1-factor Anova test. Then, when the differences were detected, the comparisons were made two by two according to the Bonferroni test and regression simple linear to see the relationship between flower length, temperature and illuminance around flower at the risk threshold of 5%.

1. Résultats

2.1. Timing and phenophase characteristics of ten-foot flowering *Dacryodes edulis* (G. Don) HJ Lam (Burseraceae) *studied*

Flowering began in July (long dry season) for the three (3) plants located at kintelé, 1 foot in Mfilou, 1 foot in talangai and 1 foot in Djiri and ended in August-September. She has started in August for the feet located in Makélékélé, Bacongo and Poto-Poto and in September for the foot located in Moungali, and it was completed in September and October (rainy period). Of the 100% of tree bases sampled, 60% flowered in July, 30% in month of August and 10% in September (figure 2).

The appearance of buds in all the trees sampled took place between July and September and the flowers opened from August to October. Some open buds/flowers persisted on some trees beyond these months. However, the results showed a significant difference between the 3 sub-zones of the trees sampled, zone 1 : Kinlété, Talangai, Mfilou ; zone 2: Makélékélé, Bacongo and Poto-Poto and Zone 3: Moungali, in terms of the appearance of flowers and their opening during the flowering period (p-value < 0.005).

In total, 3 evolutionary stages of the flower were recorded (Tables I). Considering the 3 month of our study on floral observation in the 10-foot set of *D. edulis* (G. Don) HJ Lam (Burseraceae) sampled, flowering spread during the period from 14 July to October 13, 2021. Considering the floral phenophases, their duration varies from 4 to 12 days for the blooming flower stage. On the other hand, the flower bud stage presents a long duration, 12 to 24 days. Likewise, the initiated flower stage lasts 8 to 16 days (Table I). Flowering lasted 38 days on all 10 plants of *Dacryodes edulis* (G. Don) HJ Lam(Burseraceae) observed.

Table I : Variation in flowering schedule of 10 sampled trees

	Foot 1 (Moungali)		**Foot 2 (Moungali)**		**Foot 3 (Ouenzé)**		**Foot 4 (Talangai)**		**Foot 5 (Kintelé)**	
phenological stages	**Date**	**Duration**	**Date**	**Duration**	**Date**	**Duration**	**Date**	**Duration**	**Date**	**Duration**
Start	30/08/2021	0	06/08/2021	0	30/08/2021	0	03/09/2021	0	21/07/2021	0
Fi	11/09/2021	12	14/08/2021	8	11/09/2021	12	15/09/2021	12	02/08/2021	13
Fb	23/09/2021	12	30/08/2021	16	27/09/2021	16	01/10/2021	20	22/08/2021	19
Bf	05/10/2021	12	03/09/2021	4	05/10/2021	8	13/10/2021	12	30/08/2021	8
Total	**36**		**28**		**36**		**44**		**40**	
	Foot 6 (Kintelé)		**Foot 7 (Kintelé)**		**Foot 8 (Kintelé)**		**Foot 9 (Kintelé)**		**Foot 10 (Kombé)**	
Start	29/07/2021	0	16/07/2021	0	18/07/2021	0	24/07/2021	0	28/07/2021	0
Fi	10/08/2021	11	28/07/2021	12	03/08/2021	16	06/08/2021	13	06/08/2021	8
Fb	26/08/2021	16	17/08/2021	20	23/08/2021	20	30/08/2021	24	22/08/2021	16
Bf	03/09/2021	8	25/08/2021	8	31/08/2021	8	07/09/2021	8	03/09/2021	12
Total	**35**		**40**		**44**		**45**		**36**	

Legend : Flower initiated : Fi. Flower bud: Bf. Blooming flower: Fé.

During flowering, the initiated flower appears in the form of a spherical bud. The Perianth parts are welded to each other with an average length of 3.52 mm and they are colored light yellow (Figure 3 a). They stand out from the flower bud. The flower takes an elongated shape and the parts of the perianth remain welded to each other. But, the limits between the 3 sepals are clearly defined and an increase in the size of the flower whose floral parts are truly distinct with an average length of 4.72 mm (figure 3b). Then, the flower bud stage transforms into the blooming flower stage, which characterized by the opening of the sepals only at the top leading to the acquisition of the average length 5.56 mm (Figure 3 c). It also marks the end of stamen growth.

To compare the length of the flowers of these 3 evolutionary stages during flowering of 10 safoutier feet coded Fi, Bf and Fé, statistical analyzes reveal a difference significant at the 5% threshold. The size of the organ increases during the evolutionary stages, coded Fi, Bf and Fé with respectively 3.522 ± 1.312 mm ; 4.724±1.345mm and 5.569±0.325mm (figure 4).

2.2. Effect of the orientation of the flower in relation to sunset and sunrise on the expression of its length

Table II shows the variations in flower size of *D. edulis* (G. Don) HJ Lam. by relation to their orientation, in particular East and West of the 10 feet of safoutier, the method parametric comparison of means, in particular the 1-factor Anova test was carried out. The results show that the 2 calculated averages linked to sunrise and sunset on the expression of the average length of the flower, are statistically identical to flowers located in the East and West at the 5% risk threshold (Table II).

Table II : Variation in flower size over 10 feet of *D. edulis* (G. Don) HJ Lam. in relation to their orientation (East and West)

Geographic orientation of the flower East	Flower length (mm)
East	4.548
West	4.384

2.3. Effect of temperature on reproductive phenology

2.3.1. Effect of temperature variation on the developmental stages of the flower

To compare the average temperatures around the flower during the 3 evolutionary stages of the flower of *D. edulis* (G. Don) HJ Lam. coded Fi, Bf and Fé, the parametric method of comparison of means, in particular the 1-factor Anova test was applied. The results reveal that temperature varies highly and significantly from one evolutionary stage to another during flowering (p-value = 0.026), initiated flower, flower bud and flower bloomed with respectively 26.15 ± 0.012°C ; 28.045 ±1.024°C and 29.153 ± 0.231°C (Figure 5).

2.3.2. Correlation between flower length and temperature

Table III shows that there is a significant linear relationship between the length of the flower and the temperature around the flower (R > 0.05). The data fit the model satisfactorily. The coefficient of determination is R^2 = 43.37%. Temperature variations explain at least 43.37% of the variations in flower length (Table III).

Table III: Linear correlation coefficient, coefficient of determination and the Dublin-Watson statistic

Model	R	R-squared	R-squared adjusted	dof	Durbin-Watson
1	0,497	0,437	0,432	1	1,523

Table IV shows that when the temperature increases by one unit, the length of the flower increases by 0.225 mm.

Table IV : Model coefficients

Modèle		Unstandardized coefficients		Standardized coefficients	p-value
		B	Standard deviation	Bêta	
1	(Constant)	1,744	0,783		0,027
	Temperature	0,225	0,028	0,497	0,000

2.4. Effect of variation in illumination on the flower

2.4.1. Effect of variation in illumination on the developmental stages of the flower

To compare the variations in lighting during the flowering of 10 feet of safoutier, the 1-factor Anova test was applied. The results revealed that illuminance varies highly and significantly from one evolutionary stage to another (p-value = 0.031). By therefore, 2 classes of average illumination of the three 3 evolutionary stages of the flower can be rated according to the Bonferroni test. This is class 1, represented by the illumination of the initiated flower and the flower bud, characterized by low average illumination around the flower with respectively 7148.842 µmoles.m^{-2} . s^{-1} and 6865.372 µmoles.m^{-2} . s^{-1} . Class 2, represented by the illumination of the blooming flower, marked by a high average illumination (12784.249 µmole.m^{-2}.s^{-1}) (Figure 6).

2.4.2. Correlation between flower length and illumination

There is a significant linear relationship between the length of the flower and their illumination. This correlation coefficient: r = +0.213**. The linear relationship between length and the illumination of the flower is very significant. The data fit the model satisfactorily. The coefficient of determination is R^2 = 59%. Variations in lighting explain 53.37% of the variations in flower length (Table V).

Table V : Linear correlation coefficient, coefficient of determination and the Dublin-Watson statistic

Modèle	Model	R-two	R-squared adjusted	dof	Durbin-Watson
1	0, 213	0, 450	0, 590	1	1,229

Table VI shows that when the length increases by one unit, the illumination of the flower also increases by 2,650.10^{-6} µmoles m^{-2}. s^{-1}.

Table VI : Model coefficients

Model		Unstandardized coefficients		p-value
		B	Standard deviation	
1	(Constant)	4,619	0,094	0,000
	Illuminance	$2{,}650.10^{-6}$	0,000	0,008

DISCUSSION

Floral phenology 10 feet of *Dacryodes edulis* (G. Don) HJ Lam. studied in the different districts of Brazzaville and Kintélé in the Republic of Congo. Flowering varies from foot to another, and 90% of feet of *Dacryodes edulis* (G. Don) HJ Lam. flowered in July and August, that is to say during the dry season. This was also confirmed by the work of Yédomonhan, (2009) and Badou et al. (2017) who reported that the species flowers seasonally dried. Despite this variation in the duration of flowering, it started during the season dries on every ten feet observed in the two flowering study areas. Moreover, the work by Yédomonhan, (2009); Jaouadi *et al.* (2012) and Iboukoun et al., (2021) revealed that flowering of woody plant species often begins in the dry months. Precocity of the flowering observed on the feet of Kintélé, reveals a very slight variation between zones phytogeographic. It can be explained by differences in edaphic characteristics, differences in light exposure and altitude. These explanations corroborate the work by Wahbi *et al.* (2012) who stipulated that the precocity of flowering of the plants of a site by relation to another is due to differences in edaphic characteristics, exposure to light and altitude of these sites. Flowering lasts 38 days for all of these 10 feet. Our work corroborates that of (Kengue, 1990) who showed that the flowering of *Dacryodes edulis* (G. Don) HJ Lam., lasts at least 1 month. The duration of flowering varies from one foot to another as reported (Iboukoun et al., 2021). Our results show that the initiation floral lasts 8 to 16 days, the flower bud appears after 12 or 24 days and the flower as for it blooms 4 to 12 days later. Our results provide producers with valuable indications on the duration of flowering of *Dacryodes edulis* plants (G. Don) HJ Lam. Who is 38 days. Furthermore, the length of the flower was chosen as the most descriptor relevant to describe the 10 feet on which the study was carried out. Indeed, the identity of meaning of variation in the length and diameter of the flower, allowed us to choose a single variable between the two, to avoid a redundant description of the 10 feet. Issali (2008), identified the number of calogenic explants and the average of embryos per embryogenic explant as relevant variables respectively of calogens and somatic embryogenesis to describe hybrid populations of cocoa tree clones and their progenitors. We would benefit from the future to use these 2 variables to describe populations of *Dacryodes edulis* (G. Don) HJ Lam. It also seemed necessary to us to study the effect of the evolutionary stages of the flower on the expression of its length. This was used to compare the length of the different evolutionary stages of the flower. For the flowering of the 10 plants studied, 3 evolutionary stages were defined. Analysis of the evolution of the length of the flower at the different evolutionary stages, shows a variation significant elongation of the flower. Indeed, the initiated flower and flower bud stages had a lower elongation, unlike the blooming flower stage where we recorded the highest elongation. Our results are similar to those obtained by Badou et al. (2017) on the characteristics of the flowering stages in *Syzygium guineense* which stipulate that at the stage of the senescent flower, the latter acquires the maximum length. We also evaluated the effect of geographic orientation on the expression of flower length. This has us allowed us to compare the length of the flower in relation to their geographic orientation East and West. Indeed, the analysis of the comparison of the length of the flower in relation to their geographical orientation East and West, shows that the geographical orientation of the flower does not in any way induce visible variations in the elongations of the flower, whatever their East and West orientation. Our results do not corroborate those obtained by Maloupa *et al.* (1988) on the flowering of *Welgela florid* who affirm that the geographical orientation (East-East) influences the elongation of the flower. It would therefore be appropriate to use the flowers located in the same direction of orientation, to determine the elongation of the flower of the populations, if we wish optimize subsequent fruit quality.

The variation in temperature and lighting around the flower is also a parameter important that we sought in this study. In fact, the air temperature is considered to be the main climatic factor conditioning the appearance of budburst and flowers. When the cold has broken dormancy, the buds need heat to evolve and bud break as reported (Andriaharimalala et al., 2012). Likewise, the phenological phenomena vary in time and space, in relation to the seasons and depending on the condition of each tree (Staggemeilier and Morellato, 2010). As part of our work, the length of the flower is correlated respectively with an increase in the temperature, illumination and humidity. Similar results were reported by (Steiner, 1979) in several species of pine, where he demonstrated a correlation between the bud burst date and average monthly winter temperatures (January to March) original areas, but not with spring temperatures. Some studies have shown that the flowering cycle of plant species is influenced by average temperatures Legave et al., (2009). In our study, we were unable to demonstrate an effect of the orientation of the flower on the expression of its length, the exposure of the flower in relation to the sunset and sunrise on floral phenology. However, some studies have shown that there could be variations in flower size depending on their orientation (Lavarenne-Allary, 1965, Rotzer and Chmielewski, 2001). Similarly, Sparks et al. (1997), Kramer et al. (2000) have showed that the floral phenology of *Pinus pinea* is controlled by climatic factors mainly by temperature and illumination. Indeed, the impact of an increase in temperatures on plant phenology would be direct via, for example, an advancement of flowering date.

This development could lead to ecological problems linked for example to an appearance later pollinating insects or pollinating varieties in the case of cross-pollination (Legave et al., 2009). In fact, cold temperatures induce sort of phenological reset of plants. This results in tropical zones and subtropical, intra-specific phenological asynchronisms of plants of the same species, tend to show a certain independence between the phenology of tropical plants and temperature (Borchert et al., 2005). Plant phenology is clearly linked to climate (Lebourgois et al., 2008), this relationship depends on the species, its genetic variability and its sensitivity to different meteorological factors: thus certain species depend more on the rain, others temperature, some are more sensitive to the limits imposed by the season dry or by the heat of the rainy season.

As part of our work, the results showed that the flowering of *Dacryodes edulis* (G. Don) HJ Lam. is correlated with temperature and illumination.

CONCLUSION

The floral phenology of 10 feet of *Dacryodes edulis* is located in time in relation to temperature and illumination; this phenology includes: the initiated flower, the flower bud and the blooming flower. Temperature and lighting have a positive influence on the elongation of the flower. Geographic orientation in relation to sunset and sunrise does not influence the elongation of the flower and it lasts about 35 days.

Declarations

AUTHOR CONTRIBUTIONS

Attibayeba, Mpika Joseph and Etou Ossibi Grace Jokael designed the research project and corrected the manuscript. Etou Ossibi Grace Jokael, Ongouya Mouekouba Dalcantara Liana and Makoundou Alaric carried out this project and wrote the manuscript. Etou Ossibi Grace Jokael and Mbon Nguékou Chrichina carried out the field studies. Etou Ossibi Grace Jokael analyzed the results obtained.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Figures

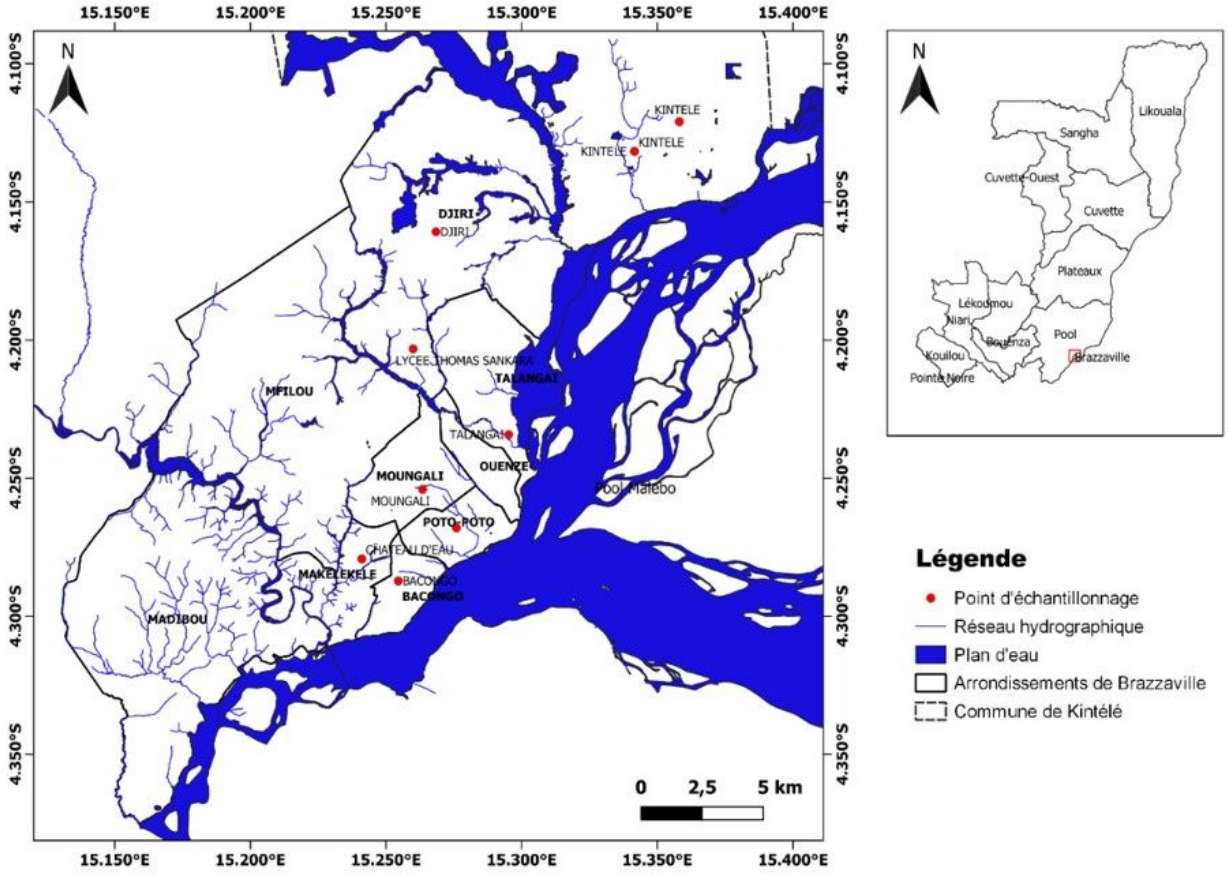


Figure 1

Geographic location of the 10 feet of *Dacryodes edulis* (G. Don) HJ Lam. sampled

in Brazzaville and Kintélé.

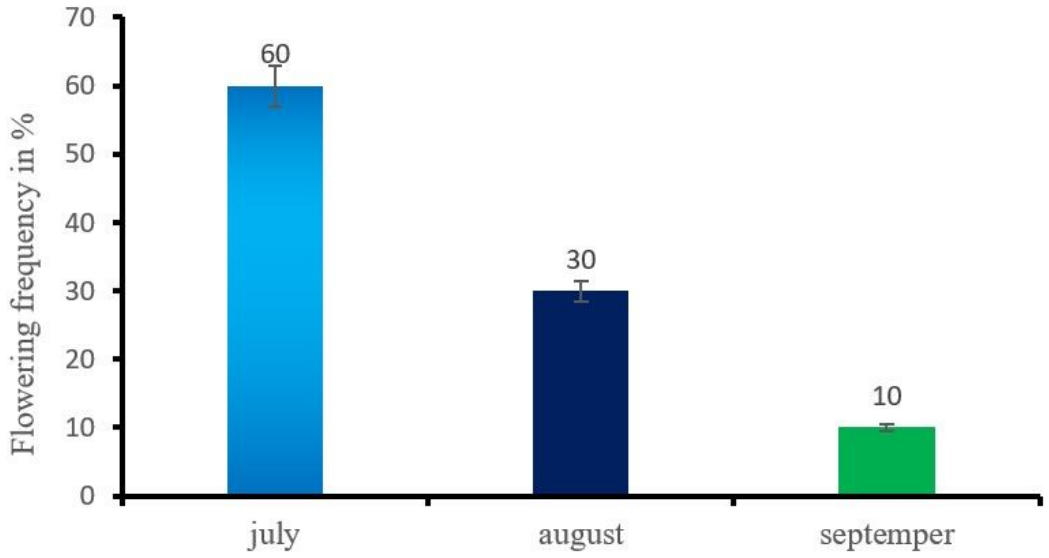


Figure 2

Variation in flowering frequencies

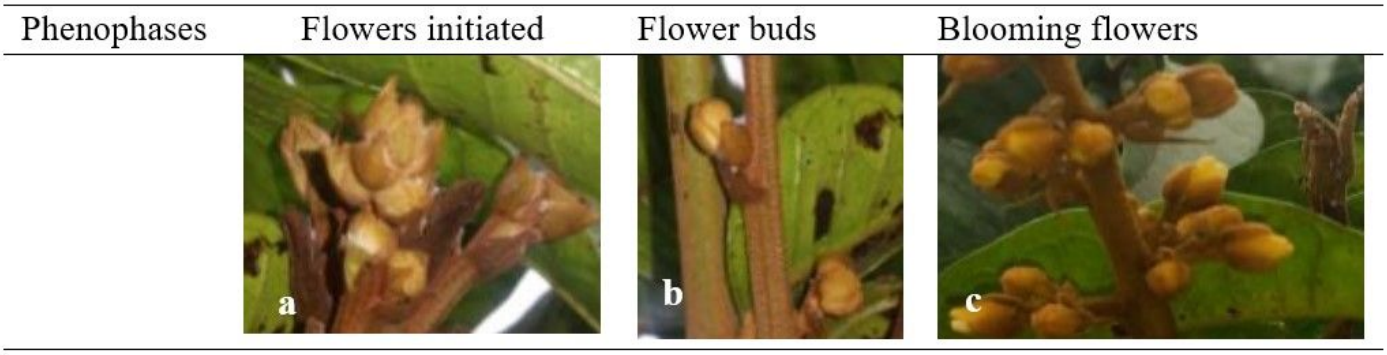


Figure 3

Flowering stages of *Dacryodes edulis* (G. Don) HJ Lam.

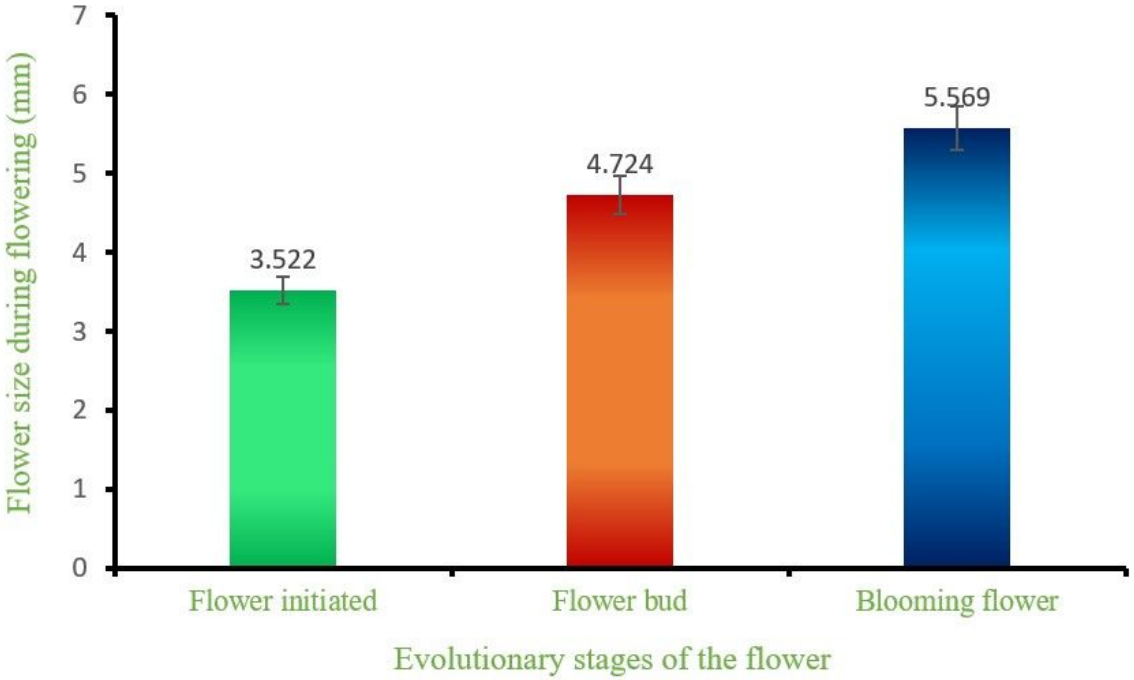


Figure 4

Variation in flower length during flowering

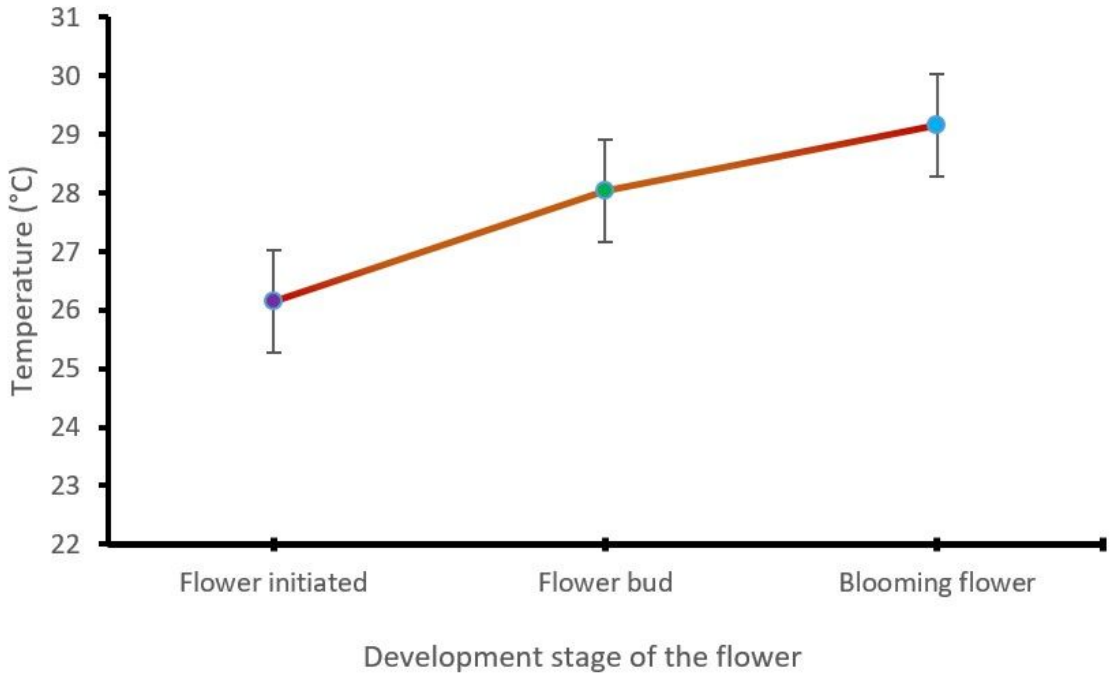


Figure 5

Variation of temperature around flowers during flowering

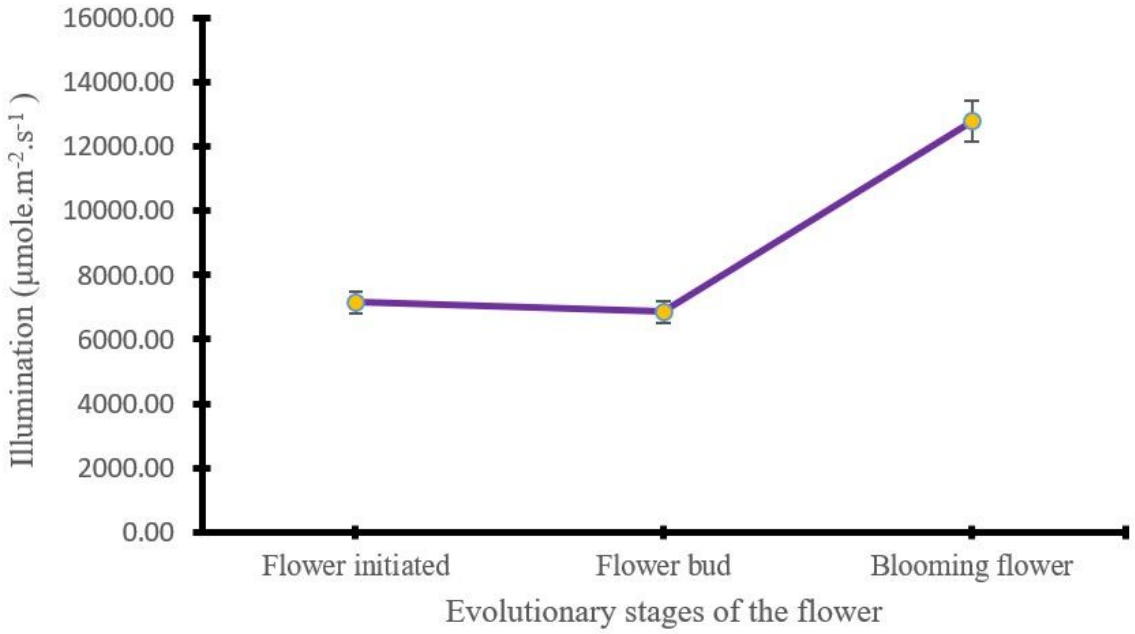


Figure 6

Variation in lighting during flowering