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Botanical Biology

Tree architecture and leaf morphometry of *Qualea grandiflora* Mart. (Vochysiaceae) in a fragment of dry forest and pasture in the State of Goiás, Brazil

Arquitetura arbórea e morfometria foliar de *Qualea grandiflora* Mart. (Vochysiaceae) em um fragmento de mata seca e pastagem no estado de Goiás, Brasil

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ABSTRACT

Investigating the functional traits of plant communities is extremely important for conserving habitats and plant species. This study aimed to evaluate the tree architecture and leaf morphometry of *Qualea grandiflora* (Vochysiaceae) in a fragment of semideciduous dry forest and pasture in the Boa Esperança settlement, municipality of Piracanjuba, State of Goiás, Brazil. Environmental, tree architecture, and foliar morphometry data were collected for seven trees in the semideciduous dry forest and five in the pasture area. We used the Shapiro-Wilk test to assess the normality of the collected data. The student t-test was used to compare the means of the functional traits between the two environments (forest and pasture). The average value of canopy cover was 85% for the semideciduous dry forest and 0% for the pasture. The mean values for leaf length and width were lower in the pasture. There was no significant difference in the petiole length in the two evaluated environments and for none of the functional traits related to the tree architecture. However, individuals of *Qualea grandiflora* grow better in the seasonal semideciduous dry forest, probably as a response to less stressful environmental conditions for this species. Thus, for sustainable exploitation by the local community, it is recommended that the tree matrices be chosen within the semideciduous dry forest area.

Keywords: Brazil; Cerrado; Myrtales; Neotropics; Phenotypic plasticity

RESUMO

A investigação dos traços funcionais de uma comunidade vegetal é de extrema importância para conservação de habitats e espécies vegetais. O presente estudo objetivou avaliar a arquitetura arbórea e a morfometria foliar de *Qualea grandiflora* (Vochysiaceae) em um fragmento de floresta seca semidecídua e pastagem, no assentamento Boa Esperança, Piracanjuba, Goiás, Brasil. Foram coletados dados ambientais, de arquitetura arbórea e de morfometria foliar, consistindo na amostragem de sete indivíduos na floresta seca semidecídua e cinco na pastagem. Para as análises estatísticas, o teste de Shapiro-Wilk foi usado para testar a normalidade dos dados. Para a comparação das médias dos traços funcionais entre os dois ambientes utilizou-se o teste t de Student. O valor médio da cobertura de dossel foi de 85% para floresta seca semidecídua e de 0% para pastagem. Os valores médios para o comprimento e largura da folha foram menores na pastagem. Não houve diferença significativa para o comprimento do pecíolo nos dois ambientes avaliados e para nenhum dos traços funcionais relativos à arquitetura arbórea. Provavelmente, os indivíduos de *Qualea grandiflora* se desenvolveram melhor na floresta seca semidecídua, como resposta às condições ambientais menos estressantes para a espécie. Assim, recomenda-se, para fins de exploração sustentável pela comunidade local, que as matrizes arbóreas sejam escolhidas dentro da área de floresta seca semidecídua.

Palavras-chave: Brasil; Cerrado; Myrtales; Neotrópicos; Plasticidade Fenotípica

1 INTRODUCTION

The Cerrado biome comprises a great diversity of biological endemism, being the characteristic savannic vegetation of Central Brazil (Oliveira et al., 2019). This biome encompasses several savannic phytophysiognomies, such as grasslands and savannas, and different dry and humid forest phytophysiognomies (Ribeiro and Walter, 2008). The main environmental factors that explain the occurrence of these different phytophysiognomies are climate, soil type, and seasonal fire, in addition to the water availability in the soil and the depth of the water table (Palhares et al., 2010).

Among the studies to evaluate the adaptation of plant species in the Cerrado biome, those addressing functional traits consist of morphological or physiological properties of organisms directly related to a functional property related to their environment (Valladares et al., 2006, 2007). The study of functional traits consists of any measurable morphological, physiological or phenological trait at the individual level, indirectly interfering with biological efficacy and affecting growth, reproduction and survival (Violle et al., 2007).

Diversity patterns of functional traits in a plant community can be vital for understanding the dynamics of their habitats and for species conservation (Mayfield et al., 2006). In this context, the relevance of studies that aid in understanding functional traits is related to the functional approach, comprising relationships between quantitative variables that allow the identification of patterns. Furthermore, functional traits are intimately intrinsic to acquiring and allocating energy and matter (Brasil & Huszar, 2011).

An example of a trait commonly used as a functional attribute is the leaf area. Among morphological characters, the variation of leaf traits plays an essential role in species performance in different habitats, allowing individuals to have the ability to respond to different environmental pressures (Valladares et al., 2006, 2007). Variations in leaf aspects allow different species to occupy different environmental conditions, denoting different environmental survival capabilities (Costa et al., 2022). For tree species, traits such as leaf area, crown size and height have helped to understand how vegetation fragments respond to current anthropogenic pressures (Prado Júnior et al., 2014).

Qualea grandiflora Mart. (Vochysiaceae; also known as pau-terra, pau-terra-do-campo, pau-terra-do-cerrado, pau-terra-da-folha-larga, ariavá, among others) is a deciduous anemochoric, heliophyte pioneer tree species of up to 15 m tall, with a tortuous trunk with dark, rough, not very thick bark (Silva Júnior, 2005; Buzatti et al., 2019). This tree species is native and widely distributed in the Brazilian cerrado, being the main woody species in this biome and found both in savannic and forest phytophysiognomies (Eiten, 1972; Shimizu et al., 2024). *Qualea grandiflora* has recently been listed as one of the ten most common species in legal reserve areas in the Cerrado biome (Aquino et al., 2007; Almeida et al., 2021). This species is widely distributed in the municipality of Piracanjuba, State of Goiás, being abundant in the area of the legal reserve of the Boa Esperança rural settlement (Guimarães et al., 2022).

The infusion or decoction of *Q. grandiflora* leaves treats bloody diarrhoea, intestinal colic, and amebiasis (Hiruma-Lima et al., 2006; Ayres et al., 2008) and as an antiprotozoal (Cordeiro et al., 2017). The ethanolic extract of the leaves has an antibacterial, antioxidant, analgesic and central nervous system depressant effect with anticonvulsant potential (Ayres et al., 2008). The bark is used as an infusion for the external cleaning of ulcers and wounds and in treating inflammatory diseases (Almeida et al., 1998). The ethanolic extract of the barks exhibits antiulcerogenic action, and the methanolic extract has antibacterial action (Ayres et al., 2008). From the cooking of the green fruits and the root, yellow dye is extracted and used to dye cotton threads for weaving. Wood is generally used for boarding, making linings, toys, furniture structures, plywood cores, crates, etc. (Lorenzi, 1992). Dried fruits are used in local crafts (Silva Júnior, 2005). It can be used in heterogeneous reforestation intended for recomposing degraded areas, including permanent preservation (Lorenzi, 2002; Dousseau et al., 2013).

Despite representing an important source of functional diversity, variations in intraspecific functional traits in plant communities are constantly neglected due to a lack of data (Dias et al. 2013; Kattge et al. 2011). Much of the knowledge about functional traits in tropical ecosystems comes from studies in humid forests (Kattge et al. 2011; Lohbeck et al. 2015), with little information on savanna ecosystems.

Given this species' ecological and economic importance for human livelihoods, we evaluated tree architecture and leaf morphometry of *Qualea grandiflora* in a fragment of semideciduous dry forest and a pasture in Piracanjuba, State of Goiás. Our main goal is to subsidise the proper selection of tree matrices for the different human uses identified in this municipality.

2 MATERIAL AND METHODS

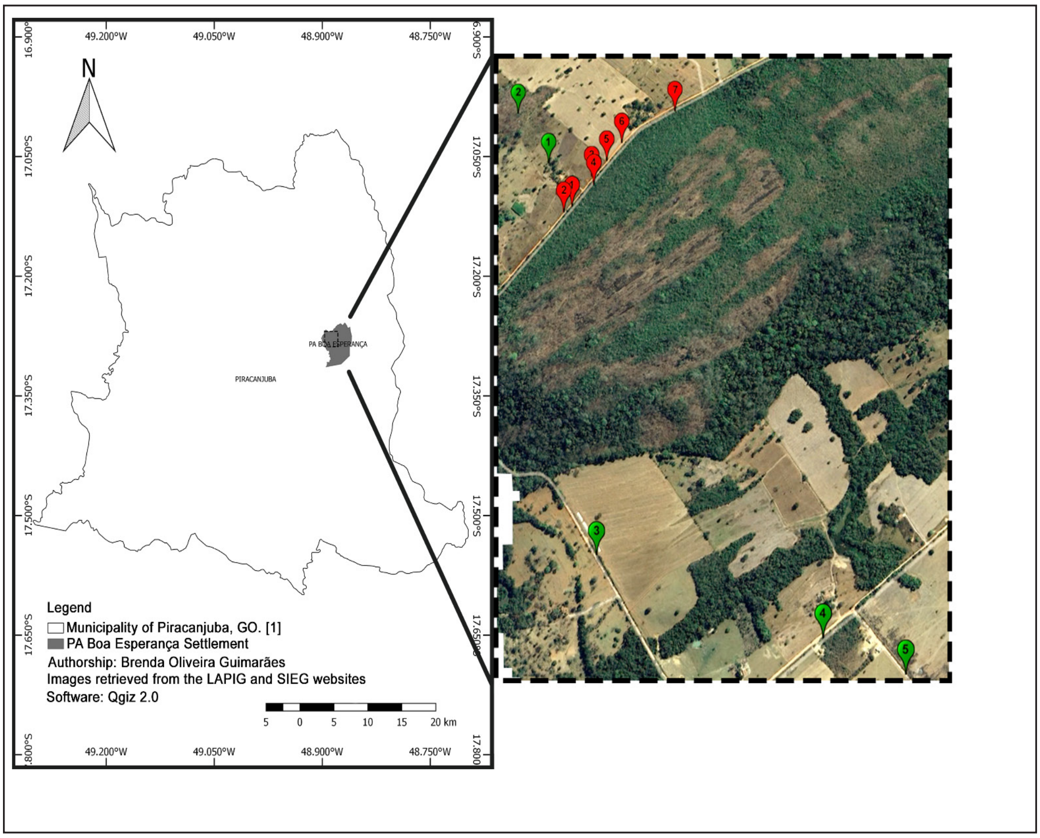
2.1 Study Area

The Boa Esperança rural settlement was created in 1995 with a total area of 1,743.1 ha (INCRA, 2018; Figure 1) in the municipality of Piracanjuba, State of Goiás, benefiting 53 families. Each legally settled family received a plot of approximately 5 ha. The settlement has two churches and a local association. As the lots are called, the plots are used for agriculture and livestock in a family economy regime. The access distance from the settlement to the urban area is about 14 km.

The settlement is inserted in the Cerrado phytogeographical domain, with the predominant vegetation being the semideciduous dry forest, mainly restricted to the legal reserve. At the top of the hill, there is a deciduous dry forest on rocky outcrops and, at the base, a semideciduous dry forest fragment. The legal reserve also has poorly preserved gallery forests, small fragments of cerrado *stricto sensu* in the lots/parcels, and isolated trees in the pasture areas.

The settlement generates income from agriculture and livestock in a family economy regime, with the main economic activity being the production of milk and crop farming for subsistence, such as vegetables, corn, tobacco, and, to a lesser extent, cassava, with the production of starch and flour (Guimarães et al., 2022).

Figure 1 – Map of the Boa Esperança settlement in Piracanjuba, State of Goiás, Brazil. RGB Classification (7,5,4) and location of the selected trees for sampling



Source: Adapted from Guimarães et al. (2022)

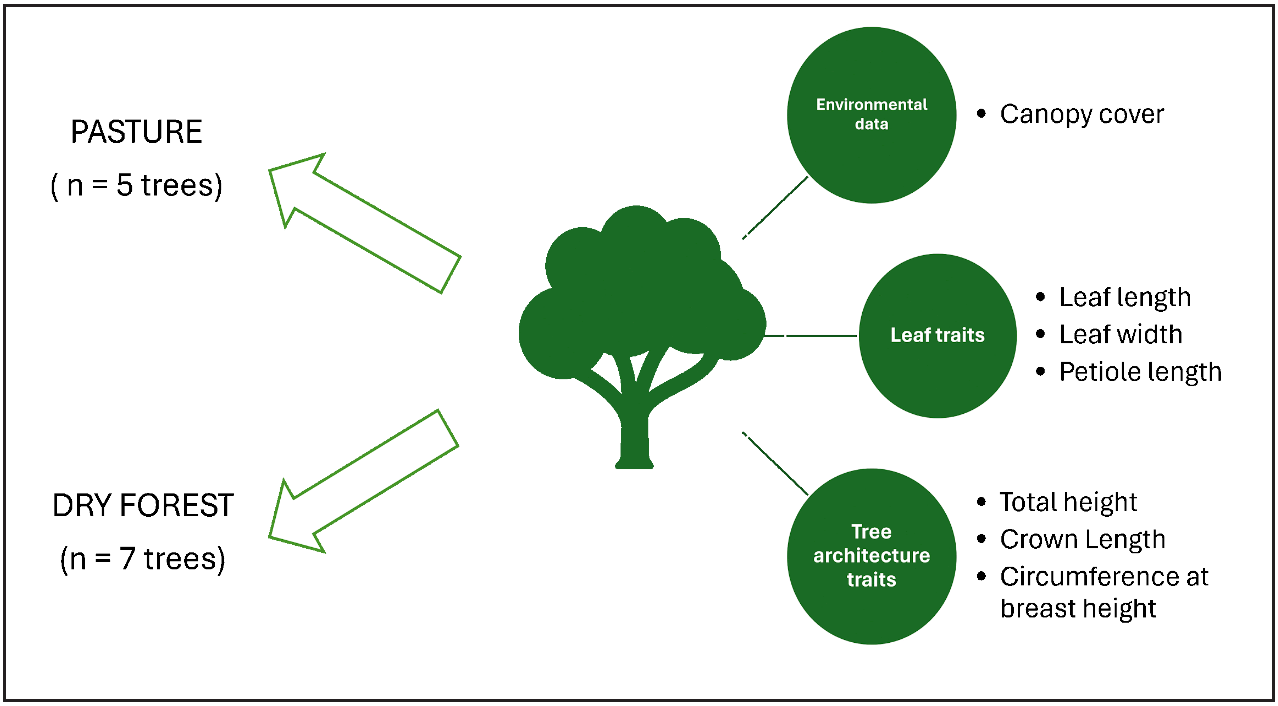
2.2 Studied species

We have chosen *Qualea grandiflora* because, besides being one of the most cited species in the literature, it is the most used for medicinal purposes in the Boa Esperança settlement (Guimarães et al., 2022). Additionally, it was the only species, among the most used ones in the settlement, that showed individuals in the pasture and the semideciduous dry forest fragment during data collection.

2.3 Sampling

Data was collected in August 2018 at two environmental conditions: dry forest edge (n = 7 trees) and pasture (n = 5 trees), totalling twelve adult trees (Figure 2). The inclusion criteria were adult reproductive individuals with at least 15 cm in trunk circumference at chest height. According to these criteria, all individuals located in the study area were sampled.

Figure 2 – Sampling design



Source: Authors (2024)

2.4 Environmental data

We estimated the canopy cover in both environments with a concave spherical densitometer at 1.30 m above the ground in the north, south, east and west points. The average value of each point was multiplied by 1.04 to obtain the percentage of the area not occupied by the canopy for each individual. The difference between this value and 100 is the estimate of the percentage of canopy cover. We collected the geographic coordinates for each individual with the aid of a GPS.

2.5 Leaf traits

We collected ten fully expanded and healthy leaves for each individual from the third node, starting from the apical bud. We packed the leaves in plastic bags, which were closed to prevent water content loss until the leaf functional traits were measured. For each leaf, we measured the length and width of the leaf blade and the length of the petiole using a digital calliper.

2.6 Tree architecture traits

We estimated, for each tree: total height (At), with a Haglof clinometer, model EC II; first branch height (Ar), with a measuring tape; Crown Length (C1 and C2), considering the most extended crown length (C1) with the crown projection on the ground, and the measurement of the perpendicular length to the most significant length (C2), with a measuring tape; and the circumference at breast height (CBH) with a measuring tape.

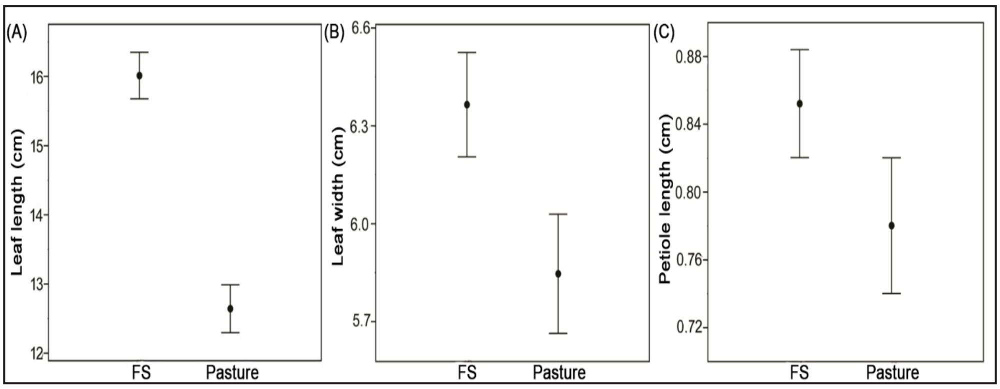
2.7 Statistical analyses

We used the Shapiro-Wilk test to test data normality (Shapiro and Wilk, 1965), which takes statistical values from the W test, in which values lower than 0.05 indicate a non-normal sample data set and associated p probability values (Hammerø et al., 2001).To compare the means of the functional traits between the two environments (FS and pasture), we used the Student t-test, which assumes a null hypothesis (H0), having a normal distribution and equal variances. In this case, the test recognises that two samples, when compared, come from populations with equal means (Hammerø et al., 2001). We performed all tests using the Past software, version 3.17 (Hammerø et al., 2001), at a significance level of 0.05.

3 RESULTS

For the environmental data, the average canopy cover value for the FS was 85%, while for the pasture, it was 0%. Individuals of *Qualea grandiflora* had a more significant number of leaves in FS than in the pasture. In the latter environment, the leaves were more predated and damaged by the sun. Individuals from *Qualea grandiflora* had lower mean values for length ($t = 6.835$; $p = 0.0001$) and leaf width ($t = 2.122$; $p = 0.03$) in the pasture compared to those from FS, there was no significant difference in petiole length ($t = 1.419$; $p = 0.15$) (Figure 3).

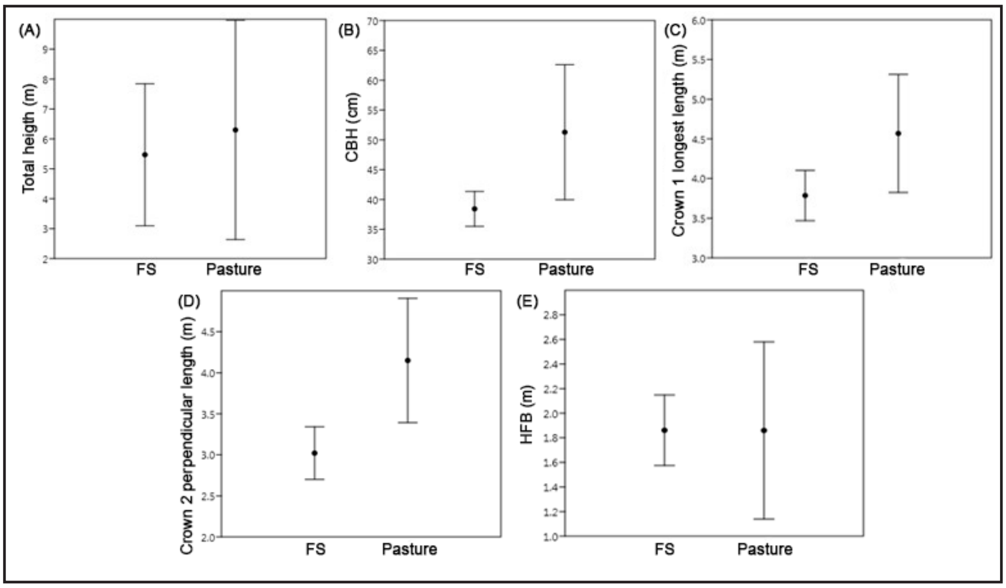
Figure 3 – Functional traits of leaf blade length (A), leaf blade width (B) and petiole length (C) of individuals sampled in the semideciduous dry forest and pasture fragments in the Boa Esperança settlement, Piracanjuba, State of Goiás, Brazil



Source: Authors (2023)

There was no significant difference in the tree architecture of the individuals ($p > 0.05$) in the two evaluated environments (Figure 4). The analysed individuals presented similar structural parameters with mean values (± standard deviation) of the circumference at breast height (CBH), total height (TH) and height of the first branch (HFB) of, respectively, 47.78 cm (± 17 .58 cm), 5.82 m (± 2.85 m) and 1.86 m (± 0.48 m), in addition to the longest crown length (C1) and its perpendicular length (C2) with average values of, respectively, 4.11 m (± 1.24 m) and 3.49 m (± 1.33 m) (Table 2).

Figure 4 – Tree architecture traits of total height (A), circumference at breast height (B), crown length (C), two perpendicular crown lengths (D), and height of the first branch (E) of individuals sampled in the semideciduous dry forest and pasture fragments in the Boa Esperança settlement, Piracanjuba, State of Goiás, Brazil



Source: Authors (2023)

Table 2 – Tree architecture data in the two analysed environments. HFB= height of first branch, TH= Total height, CC1= length of crown 1, CC2= length of crown 2, CBH= Circumference at breast height

(continue)

Dry Forest					
	HFB	TH	CC1	CC2	CBH
Average	1.86	5.47	3.79	3.02	38.4
Standard deviation	0.29	2.37	0.84	0.85	7.7
Maximum value	2	9.5	5.1	4.5	47.5
Minimum value	1.5	3.4	2.25	1.65	23
Pasture					

Table 2 – Tree architecture data in the two analysed environments. HFB= height of first branch, TH= Total height, CC1= length of crown 1, CC2= length of crown 2, CBH= Circumference at breast height

(conclusion)

Pasture					
	HFB	TH	CC1	CC2	CBH
	HFB	TH	CC1	CC2	CBH
Average	1.86	6.3	4.57	4.15	51.28
Standard deviation	0.72	3.67	1.66	1.69	25.3
Maximum value	2.5	8	4.7	6.85	94.4
Minimum value	1.1	3.5	3.3	2.4	28.2

Source: Authors (2023)

4 DISCUSSION

Since the present study took place in the dry season, the tree cover of the semideciduous dry forest varied from 50 to 60% (Ribeiro and Walter, 2008). However, the result found in the present study was close to that obtained by Venturoli et al. (2012) in the municipality of Pirenópolis, State of Goiás, in which the tree cover of FS was 86% in the dry season and higher than that found by Meira Neto et al. (2005) in the municipality of Viçosa, State of Minas Gerais, which was 65 to 70%.

Individuals of *Qualea grandiflora* had greater leaf traits (leaf length, leaf width and petiole length) in the FS than in the pasture. This phenotypic behaviour was expected since shaded leaves show greater limb area and high chlorophyll content to maximise light absorption than leaves exposed to full sun, as in the pasture (Evans and Poorter, 2001). As vegetation density increases with shading, leaf area increases for better light capture. Since leaves in a shaded environment transpire less than leaves exposed to direct light, an increase in leaf area can occur without necessarily causing excessive water loss through transpiration (Faleiro and Saiki, 2007). This result is also corroborated by the study by Rossatto et al. (2010) and Ronquim et al. (2013). The lowest values observed in the pasture area are in response to the higher incidence of UV light and, consequently, higher temperature values and lower relative humidity. These conditions are stressful for the individuals, with plants in areas subject to anthropic impacts tending to have smaller leaf areas and greater deciduousness than in areas with a higher degree of conservation (Prado Júnior et al., 2014). According to Pessoa et al. (2019), species of *Qualea* Mart. (Vochysiaceae) have adaptive leaf attributes to deal with environmental variations in their habitat.

Due to the criteria for including individuals in our sampling, all the analysed reproductive individuals had already reached crown, height, and circumference values closer to those expected for populations with a larger size structure (Lorenzi, 2002; Silva Júnior, 2005). These parameters are related to competitive vigour and the ability to persist in the environment after ecological disturbances. The chemical attributes of the soil, associated with the level of anthropisation, can influence the natural occurrence, species diversity and development, as well as height, DBH and shape, which are good indicators of the growth of tree species (Calgaro et al., 2015). Furthermore, *Q. grandiflora* is not very demanding regarding the level of luminosity and nutrients in the soil for its development (Paulilo and Felippe, 1995). This relationship with little environmental restriction regarding resource levels and conditions corroborates its wide geographic range in the Cerrado biome (Costa and Santos, 2011).

5 CONCLUSIONS

Based on our results, we can conclude that the individuals of *Qualea grandiflora* develop better in the semideciduous dry forest fragment than in the pasture fragment, probably as a response to the less stressful environmental conditions for this species. In pastures, leaves were more predated and damaged by the sun, having lower mean values for length and leaf width. The better development can also be regarded as adaptive, as it contributes to the stability of these plants in their environments.

Since the leaf traits (length and leaf width) were higher in individuals located in the forest area, it is recommended that leaf collection for medicinal uses should be prioritised in the semideciduous dry forest if the native vegetation protection law (Brasil, 2012) is respected regarding the management of the legal reserve. Given the low number of individuals sampled, more studies will be needed to corroborate the results found here. Furthermore, genetic diversity and other environmental factors must be considered.

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