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Floral biology of candeia (*Eremanthus erythropappus*, Asteraceae)

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Abstract - Floral biology and pollinators of candeia (*Eremanthus erythropappus*) were analyzed in a natural population. We studied anthesis, flower morphology, stigmatic receptivity, pollen viability and floral visitors. The small flowers (10.17 mm in length) are pink, hermaphrodites and organized in dense capitula (mean = 29 flowers). We observed a large percentage of viable pollen (77.25%) and relatively scarce nectar availability for floral visitors (0.63 µL). The bees *Apis mellifera* and *Trigona* sp. were the most frequent visitors. The length of the bud, style and flowers varied significantly among plants.

Biologia floral da candeia (Eremanthus erythropappus, Asteraceae)

Resumo - O objetivo deste trabalho foi examinar e documentar a biologia floral e os polinizadores da candeia (*Eremanthus erythropappus*) em uma população natural, sendo estudados a antese, a morfologia floral, a receptividade estigmática, a viabilidade de pólen e os visitantes florais. As flores pequenas (10,17 mm de comprimento) são cor de rosa, hermafroditas e organizadas em densos capítulos (média = 29 flores). Foi observada alta porcentagem de pólen viável (77,25%) e relativamente pouca disponibilidade de néctar para os visitantes florais (0,63 µL). As abelhas *Apis mellifera* e *Trigona* sp. foram os visitantes mais frequentes. Os comprimentos dos botões, estiletes e flores variaram significativamente entre plantas.

Eremanthus erythropappus (DC.) MacLeisch (Asteraceae), commonly known as "candeia", is an important timber and essential oil tree with antimicrobial properties (Bohlmann et al., 1981). Besides the quality of its wood (Scolforo et al., 2004), the extraction of the α-bisabolol oil from the tree for pharmaceutical and cosmetic industries gives the species a high economic value (Lopes et al., 1991). This species is an abundant pioneer tree forming dense populations in fields and open pastures, known as candeal, after forest disturbance (Oliveira Filho & Fluminhan Filho, 1999). The species is found predominantly in the states of Bahia, Minas Gerais and Rio de Janeiro, Brazil.

Due to its economic value, *Eremanthus erythropappus* has been subjected to intensive and unrestricted exploitation (Souza et al., 2007). To avoid the negative effects of such exploitation, sustainable management plans are needed, such as the inclusion of genetic improvement practices and *in situ* and *ex situ* conservation. For effective management planning programs, information about the floral biology of the species from natural populations are necessary (Maués, 2002).

Asteraceae plants present flowers on a common receptacle delimited by bracts, forming inflorescences at the terminal capitulum (Barroso, 1991). In general, they are pollinated by several insect groups (Philipp & Nielsen, 2010; Powell et al., 2011). However, data about the floral biology and visiting insect species of *E. erythropappus* are rare (Freitas & Sazima, 2006). Therefore, this work aims to document the floral biology of *E. erythropappus* in a natural population in Lavras, Minas Gerais state, Brazil, in order to provide this basic, but significant information about the species.

The study was carried out in the Biological Reserve of Parque Quedas do Rio Bonito (21°19' S and 44°59' W), at altitude ranging from 950 m to 1,200 m. The local climate, according to Köppen classification, is transitional between Cwb and Cwa, or temperate, with dry winters, average annual precipitation of 1,529.7 mm and annual temperature of 19.4 °C (Oliveira Filho & Fluminhan Filho, 1999). At the study site, the candeal is a forest formation with predominantly *E. erythropappus* individuals. Such formations normally occur in the transition zones between forests and more open landscapes, particularly mountain grassland. We sampled all 20 identified reproductive plants within a 50 m × 200 m plot. Plant height was recorded and flowers (n = 40) preserved in 70% ethanol for morphological study. The reproductive phenological periods (absence or presence) were recorded, from June to November 2006, to describe initial anthesis and final seed dispersal via anemochory.

We counted the number of inflorescences per branch (just the final 50 cm of the branch) and the number of flowers per inflorescence (capitulum), at ten individuals. Buds and newly opened flowers (i.e., when anthesis had started) were collected randomly (n = 40) from individuals in the population (Figure 1A) and measured with digital calipers to record the dimensions of the style and all flower length. Fruits and seeds were also measured. Stigmatic receptivity was determined through the peroxidase activity technique (Kearns & Inouye, 1993), in ten trees, from 08h00 to 17h00.

Nectar volume (µL) was measured randomly from ten trees; inflorescences were bagged at the bud stage to prohibit visitors. We chose 26 random flowers ($\mu L.\ flower^{-1}$) to quantify the nectar using graduated micro-capillaries and the PIPETMAN® Micro-Volume Kit (Gilson Inc., Middleton, WI, USA). The volume of the accumulated nectar was estimated between 08h00-09h00, when anthesis began. We did not estimate the concentration of the accumulated nectar due to the scarce quantity.

Pollen viability was estimated from the flowers in anthesis of four individuals, using the acetocarmine staining technique (1.2%) under an optical microscope (Kearns & Inouye, 1993). The percentage of viable pollen was obtained by calculating the number of viable grains divided by the total number of pollen grains counted (Kearns & Inouye, 1993). The occurrence of dichogamy and secondary pollen presentation was not evaluated.

Floral visitors activity was recorded over three days of field observations (between 08h00 to 17h00) during mass flowering, thus enabling the recording of approximately 27 hours of focal observations. For all visitors, resource gathering and movements resulting in contact with stigma were recorded. Individuals of each visitor morphospecies were captured for identification and recorded by photographs. Photos were taken using a 0.01 m to ∞ super macro lens (Olympus America Inc., Center Valley, PA, USA). Floral biology and morphometrics were analyzed using univariate statistics of position and dispersion measurements. The differences in floral morphology between individuals were evaluated by Kruskal-Wallis (H) analysis of variance and the mean values compared using the Dunn test (Ayres et al., 2007).

E. erythropappus flowering and fruiting occur from July to November. Flowering occurs in the drier and colder period (July-September) and fruiting coincides with increasing temperatures and wind intensity (August-November). Reproductive plants have irregular and short trunks with a mean height of 4.09 m (ranging from 1.8 m to 7.1 m). This species presents hermaphrodite flowers. Capitula are purple at the extremities of the branches. The flowers (10.17 mm length) are organized in dense inflorescences (mean = 29 open flowers in total; Table 1). Anthesis started in the early morning and flower opening occurred during the day. The flowers are odorless.

Morphometric flower characteristics differed significantly among plants: bud length (H = 13.95, P = 0.003); style length (H = 20.53, P = 0.0001); and flower length (H = 13.97, P = 0.003), suggesting genetic variation among plants. Asymmetry (*S*) was generally positive (asymmetric distribution to the right), showing that the characteristics with smaller values were most common in the analyzed sample (Table 1). For the number of capitula, kurtosis ($K > 3$) indicates little variation from the mean (Table 1). This could be used in future studies as a marker in phylogenetic relationships with sympatric species that occur in the study site: *Eremanthus glomerulatus* Less. and *Eremanthus incanus* (Less.) Less.

E. erythropappus have a large percentage of viable pollen (77.25%, Figure 1B and C) and relatively scarce nectar for floral visitors (mean = 0.63 µL) coinciding with the receptive diurnal phase of the stigma. Flowers were visited primarily by *Apis mellifera* and *Trigona* sp. (Hymenoptera, Apidae), although other Meliponini species also can visit flowers of *E. erythropappus* (Freitas & Sazima, 2006). Foraging bees remained for about three-five seconds per flower and then flew to the next flower. Bees inserted part of their head into the flower (Figure 1D and E) causing pollen grains to adhere to the head and allowing pollen dispersal as the bee made contact with the stigmatic area. Thus, bees can be considered pollinators because of the significant contact with anthers and stigmas, although the fruit set was not part of this study. In many habitats the observed bees (e.g. *A. mellifera*) have been associated with plant and inflorescence densities (Dick et al., 2003; Vieira et al., 2010) which is consistent with the large number of *E. erythropappus* flowers per capitulum (mean = 29±1.74) observed in this study, and high number of capitula produced by individuals (personal observation). Mating system studies revealed that *E. erythropappus* is predominantly allogamous, with high multiloci outcrossing rate, $t_m = 0.963$ (Barreira et al., 2006). Data on the incompatibility system is necessary.

Dispersal of *E. erythropappus* fruits overlaps the beginning of the rainy season. Accordingo to Lane (1996), the fruit is known as cypsela, an achene derived from an inferior ovary. Fruits possess an anemochoric structure (known as *pappus*) of 2-5 mm in length, with approximately ten edges that are brown in color (Figure 1F and G). The majority of seeds are well-formed (Figure 1F), unlike nonviable seeds (Figure 1G). Floral biology data are important as a foundation on which to develop sustainable management programs for *E. erythropappus*. Likewise, provide correlation with taxonomy, phylogeny and pollination systems between populations of congeneric species of *Eremanthus* Less. (Asteraceae).

Table 1. Characteristics of reproductive plants of *Eremanthus erythropappus* in the Biological Reserve of Parque Quedas do Rio Bonito, Lavras, Minas Gerais, Brazil.

Characteristic	*n*	Minimum	Mean ± S.E.	Maximum	*C.V.* (%)	*S*	*K*
Height (m)	20	1.80	4.09±0.38	7.10	41.90	0.36	-1.09
Capitulum number[1]	30	5.00	20.13±1.64	48.00	44.50	1.61	3.91
Flowers per capitulum	27	16.00	29.00±1.74	48.00	31.11	0.80	0.30
Bud length (mm)	40	1.66	2.57±0.07	3.70	16.44	0.12	0.45
Style length (mm)	40	7.43	8.81±0.10	9.96	7.32	-0.58	-0.57
Flowers length (mm)	40	8.14	10.17±0.13	12.09	8.13	-0.12	0.68
Pollen viability (%)	445	63.16	77.25±8.16	99.18	21.12	1.01	-0.19
Nectar volume (µL)	26	0.40	0.63±0.08	0.78	27.66	-0.52	-2.31

[1] At final 50 cm of branch. *n*, sample size; S.E., standard error; *C.V.*, coefficient of variation; *S*, asymmetry; *K*, kurtosis.

Photos: F.A. Vieira

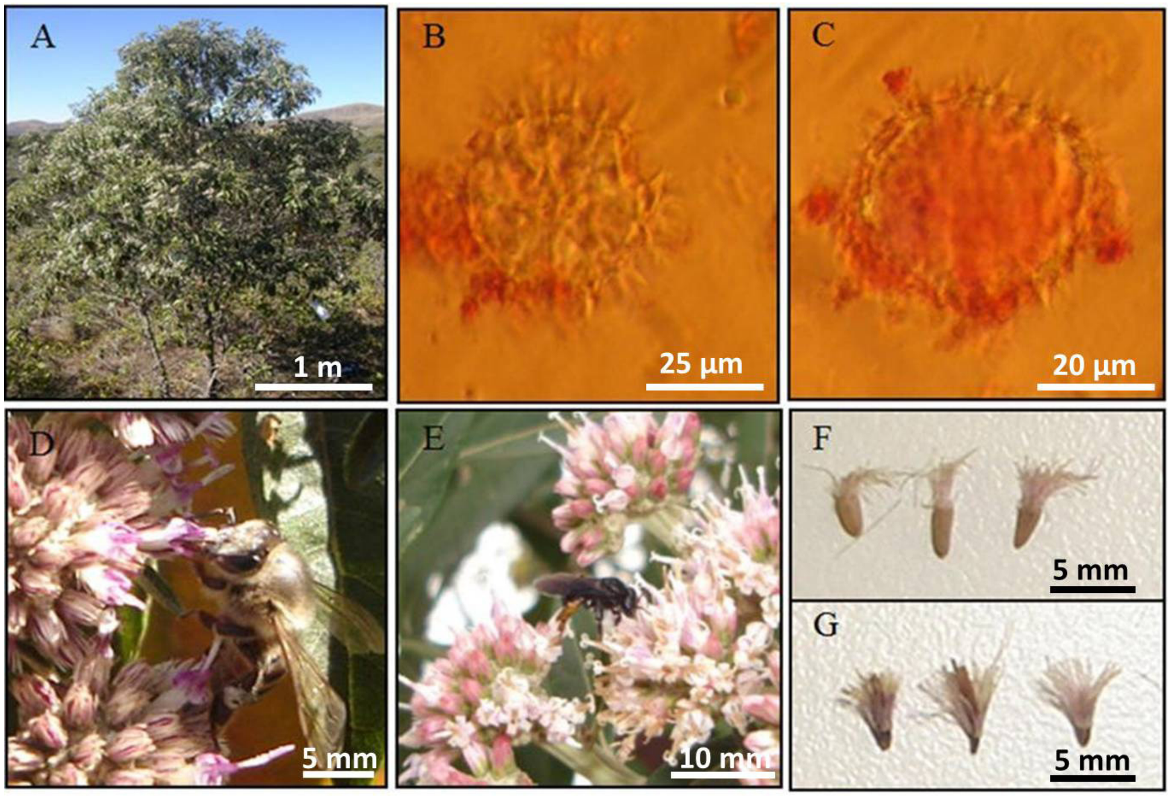

Figure 1. Floral biology of *Eremanthus erythropappus* in the Biological Reserve of Parque Quedas do Rio Bonito, Lavras, Minas Gerais, Brazil. (A) Habit in a natural population, (B) nonviable pollen grains, (C) viable pollen grains, (D) *Apis mellifera* visiting, (E) *Trigona* sp. visiting, (F) viable anemochoric seeds and (G) nonviable seeds.

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