



Three diurnal patterns of anthesis in *Ipomoea carnea* subsp. *fistulosa* (Convolvulaceae): Implications for temporal, behavioral and morphological characteristics of pollinators?

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ABSTRACT

Flowers of *Ipomoea* are characterized mainly by being ephemeral and showy. They attract many floral visitors of different taxonomic groups, whose activity is generally synchronized with opening and closing times of flowers. In this study we tested whether flowering, morphology and floral biology of *Ipomoea carnea* subsp. *fistulosa* were related to pollinator dynamics and environmental factors, emphasizing temporal and behavioral aspects in different months of the year, in an area shaped by human activities of the semi-arid region of Bahia, northeastern Brazil. Observations were made for three days each month, from October 2009 to August 2010 in the campus of the State University of Feira de Santana. We investigated morphology, floral biology, reproductive system, and flowering of *I. carnea*, and collected floral visitors. Flowering occurred in all months. Flowers opened during three periods of the day: morning, afternoon and night, with life-time of the respective flowers being 11, 19, and 16 h in each period, respectively. The study species is self-incompatible. Flowers were visited predominantly by bees and moths, and exhibit morphological traits related to the syndromes of melittophily and phalaenophily. The conspicuous pink flowers attracted bees and the strong sweet scent produced during the night attracted moths. The bees *Apis mellifera*, *Melitomella murihirta*, *Melitoma* aff. *segmentaria* and *Pseudaugochlora pandora* were considered as potential diurnal pollinators, and the hawkmoth *Agrius cingulata* as a potential nocturnal pollinator. The 24 h flower display increases the chance of pollination, especially for ruderal and weedy species such as *I. carnea* subsp. *fistulosa* © 2013 Elsevier GmbH.

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Introduction

The family Convolvulaceae is well represented in Brazil by 18 genera and ca. 340 species (Simão-Bianchini and Ferreira, 2010). It occurs in several vegetation types and is predominant in open environments such as the Cerrado and Caatinga biomes. *Ipomoea* L. is the largest genus, with ca. 140 species (Bianchini and Pirani, 2005), including many ruderal and broadly distributed species such as *Ipomoea carnea* subsp. *fistulosa* (Mart. ex Choisy) D.F. Austin (Antoniassi et al., 2007).

In general, the flowers of *Ipomoea* are colorful, showy and very attractive to several groups of flower visitors, offering nectar and pollen as a reward. Besides, characteristics of floral biology, such

as flower longevity, time of opening and resource availability, can influence species composition and activity time of flower visitors. *Ipomoea* spp. have ephemeral flowers, which usually open early in the morning and close late in the morning or in the afternoon, and last less than 12 h (Kiill and Ranga, 2003; Maimoni-Rodella and Yanagizawa, 2007). However, the group also exhibits species with flowers that open in the late afternoon and in the early evening, and last approximately 12 h (Galletto and Bernardello, 2004; McMullen, 2009). Opening time, in general, is related to the habits of potential pollinators (Gimenes et al., 1993).

Ipomoea species that open during the day are pollinated mainly by bees (Kiill and Ranga, 2003; Maimoni-Rodella and Yanagizawa, 2007), but also by hummingbirds and butterflies (Machado and Sazima, 1987; Pacheco Filho et al., 2011). *Ipomoea* species that open at night are generally pollinated by moths (Galletto and Bernardello, 2004; McMullen, 2009). These observations evidence synchronization between opening of flowers and activity time of potential pollinators. Hence, there might be a selective advantage in the

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synchronization of plants and flower visitors, since it enables coupling activity time of visitors with opening time of flowers (Gimenes et al., 1993), higher pollen availability (Gimenes et al., 1996), higher nectar volume, or even with the time of liberation of volatile compounds (Raguso et al., 2003).

Considering the importance of coupling time of flower opening with habits of flower visitors, the present study aimed at analyzing the interaction between *I. carnea* subsp. *fistulosa* and its flower visitors, as well as the influence of climatic factors. Moreover, we assessed temporal, morphological and behavioral aspects of both flowers and visitors, in an area of the semi-arid region of Brazil, with emphasis on diurnal and nocturnal pollination.

Materials and methods

Study species

I. carnea subsp. *fistulosa* is a shrub of fistulose stems and branches, ruderal, perennial, which may reach from 1.5 to 2.0 m of height. Flowers are actinomorphic, gamopetalous, tubular-infundibuliform (Maimoni-Rodella and Yanagizawa, 2007), pink-magenta, and are gathered in axilar inflorescences. The anthers are bithecal, with longitudinal dehiscence. It exhibits the nuptial nectary located around the ovary, and extranuptial nectaries in the calyx and leaves (Fidalgo, 1997). This species is native to South America, and was introduced or is cultivated in many countries (Shaltout et al., 2006). In Brazil, it exhibits broad distribution: it is abundant in Pantanal, state of Mato Grosso (Antoniassi et al., 2007), and in the Caatinga (Milet-Pinheiro and Schlindwein, 2008). This plant is very abundant in Brazil because it is cultivated as an ornamental plant, due to the beauty of its flowers (Buono, 2008).

Study area

The present study was carried out on the campus of State University of Feira de Santana (UEFS) in Feira de Santana, Bahia,

Northeastern Brazil (12°11'56.3"S and 38°58'07.6"W, ca. 243 m a.s.l.). The native vegetation of the study area is a transition between Caatinga and seasonal forest (SEI, 2011), but currently it also has introduced and invasive plants (Santana and Santos, 1999), where individuals of *I. carnea* subsp. *fistulosa* are found in vegetation edges and roadsides. In the present study we assessed a population with 17 individuals of *I. carnea* subsp. *fistulosa*, located in an area of 90 m × 10 m, along the sides of a secondary road on the campus of UEFS. The regional climate is semi-arid (Köppen's classification), with average temperatures varying between 20.7 and 26.8 °C and annual rainfall varying from 500 to 800 mm (SEI, 2011). During the study, April and July 2010 were the rainiest months, whereas September and October 2009 and February 2010 were the driest (Fig. 1).

Methods

Data were collected monthly from October 2009 to August 2010, during three days (72 h) each month, for 30 min every hour of observation, for a total of 792 h of sampling and observation. Data on temperature and relative air humidity were obtained with a digital thermohygrometer fixed at 1.5 m above the ground. Data on light intensity (insolation) were measured with a luxmeter at intervals of 30 min during field observations. Macroclimatic data on rainfall, average temperature and relative humidity were obtained at the weather station of UEFS.

For the characterization of floral morphology, 10 flowers (from different individuals and periods of the day) were placed in 70% alcohol. We measured the largest diameter and length (from the base to the opening) of each corolla, length of reproductive structures (stamen and stigma) and length of floral tube. The size of the flower was classified following Machado and Lopes (2004). The color of the flower, and the location and type of floral resource offered to visitors were recorded; and the typification of the floral shape followed Gonçalves and Lorenzi (2007). To test for the presence of osmophors, ten flowers were submerged in a solution of

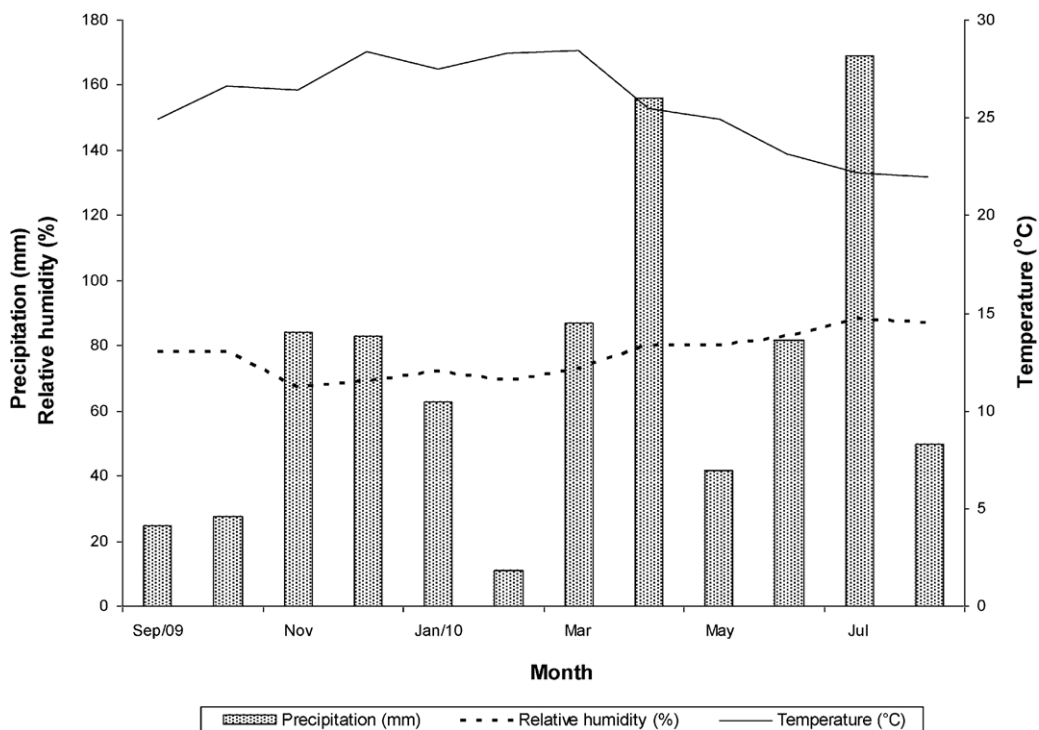


Fig. 1. Rainfall, relative humidity and temperature (monthly averages) between September 2009 and August 2010 in the campus of State University of Feira de Santana. Source: Weather Station of UEFS.

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