

CALYX-WATER CONSUMPTION BY BLUE-AND-YELLOW MACAWS IN *SPATHODEA CAMPANULATA* (BIGNONIACEAE) FLORAL BUDS

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Consumo de água do cálice por Araras Canindé em botões florais de *Spathodea campanulata* (Bignoniaceae).

Key words: Amino acids, anthropogenic environment, *Ara ararauna*, bird-plant interaction, calyx water, dry season, exotic plant, *Spathodea campanulata*, water source.

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INTRODUCTION

Birds of different feeding guilds visit the flowers of plants in the Neotropics (Rocca & Sazima 2010). The use of flowers can be an important strategy to obtain water, especially when there is low or no precipitation (Janzen 1980). For example, several parrot species were reported to visit flowers to cover some of their daily water demands during the dry season (Ragusa-Netto 2005). Additionally, floral rewards, such as nectar, provide a valuable source of calories and nutrients to visitors, e.g., sugars and amino acids (e.g., Heil 2011). In some plants (c. 11 species), floral buds contain water, called calyx water

(Endress 1996). One example is *Spathodea campanulata* P. Beauv. (Bignoniaceae), whose calyx water from buds provides a valuable source of nutrients (e.g., amino acids) to birds (Bahadur *et al.* 1986), including parrots (Rangaiah *et al.* 2004). Additionally, in *S. campanulata* calyx water is also available in open flowers, but mixed with nectar (Rangaiah *et al.* 2004).

Large Neotropical parrots, such as macaws of the genus *Ara*, are very mobile birds, commuting daily from communal roosts to feeding areas and vice versa (Roth 1984, Tubelis 2010, Santo & Ragusa-Netto 2014). These birds have high energy and nutritional requirements (Koutsos *et al.* 2009,

Gilardi & Toft 2012), and appear to search for highly profitable food resources to compensate for the cost of daily trips (Santos & Ragusa-Netto 2014). They feed mainly on seeds and solid matter from fruits, such as pulp (Roth 1984, Gilardi & Toft 2012, Lee *et al.* 2014), which provide a valuable source of energy and nutrients (Barbosa *et al.* 2009, Koutsos *et al.* 2009). Floral resources can also be important in the diet of macaws, contributing to the daily supply of nutrients and water (*sensu* Ragusa-Netto 2005). However, the exploitation of flowers by macaws has been reported only through fortuitous foraging records (e.g., Munn 1988, Tubelis 2009, Gilardi & Toft 2012, Silva 2013, Lee *et al.* 2014). Here, we report on observations of Blue-and-yellow Macaws (*Ara ararauna*) consuming nectar and calyx water from open flowers and calyx water from the floral buds of *S. campanulata*. We discuss the importance of buds as a source of water and nutrients for this large seed-eating parrot.

METHODS

Study area and macaws in the region. This study took place in Ilha Solteira (20°25'S, 51°20'W; 380 m a.s.l.), in the northwest of the State of São Paulo, southeastern Brazil, bordering the State of Mato Grosso do Sul. Detailed descriptions of the area can be obtained from Silva & Melo (2013). Wild Blue-and-yellow Macaws have been increasingly seen occupying the urban area in the region, where they feed on several native and exotic plants (Silva 2013, Santos & Ragusa-Netto 2014). Macaws breeding in the urban areas of northwestern São Paulo have also been increasingly reported, especially on television news (PAS pers. observ.). Macaws in these areas use dead *Roystonea oleracea* palm trees (Arecaceae) for nesting (PAS pers. observ.). This exotic palm species is widely planted in urbanized areas of the Ilha Solteira, and many are used by Blue-

and-yellow Macaws as roosting sites (Silva 2013).

Specific observation site. Feeding activity of Blue-and-yellow Macaws on blooming *S. campanulata* were observed in a gardened cemetery (approx. 4 ha) located in the suburban area of Ilha Solteira (20°26'12.04"S, 51°20'31.55"W, 361 m a.s.l.). This public space is surrounded by residential, commercial, and horticultural areas, vacant lots, reforestation, and riparian forest dominated by exotic invasive plants, e.g., *Leucaena leucocephala* (Fabaceae). Although being diverse, the plant composition in the cemetery is dominated by exotic tree species, including *Magjifera indica* (Anacardiaceae), *Schefflera actinophylla* (Araliaceae), *Cupressus* spp. (Cupressaceae), *Tipuana tipu* (Fabaceae), *Callistemon viminalis* (Myrtaceae), and *S. campanulata*.

Feeding plant and floral traits. *Spathodea campanulata* (syn. *S. nilotica* Seem.) is an African tree (15–20 m tall) introduced to Neotropical region for ornamental purposes (e.g., Francis 2000, Lorenzi *et al.* 2003). It is a potential invader in several tropical habitats, such as undisturbed forests, secondary forests, deforested lands, ruderal areas, agricultural areas, and abandoned agricultural lands (Francis 2000, Labrada & Díaz Medina 2009, Larrue *et al.* 2014). This plant is ranked as one of the 100 worst invasive exotic species in the world (Lowe *et al.* 2000), thus threatening native tropical biodiversity (Larrue *et al.* 2014). It creates a shading effect that can reduce native plant species' richness under its canopy (Weber 2003).

Spathodea campanulata blooms for up to nine months per year, from January to September (Silva 2013). The floral bud stage consists of a conical closed calyx (Fig. 1A), which is rich in water (Rangaiah *et al.* 2004). This water reservoir supplies the development of floral organs (Rangaiah *et al.* 2004) as well as

protects them against herbivorous arthropods (cf. Carlson & Harms 2007). The mean water volume in the calyx varies with its size, from 0.54 ml in a 2.5 cm-long calyx to 2.96 ml of water in a 6.5 cm-long calyx (Rangaiah *et al.* 2004). Calyx water has a constant 1-% sugar concentration, though its production stops just before anthesis (Rangaiah *et al.* 2004). A small amount of the calyx water drops off during flower opening, but a portion of the water remains accumulated in the open flowers (Rangaiah *et al.* 2004). In addition to calyx water, large open flowers (9 cm long, 6 cm in diameter) produce a large amount of nectar (Rangaiah *et al.* 2004). On average, the total volume of nectar and calyx water is 1 ml per flower (Rangaiah *et al.* 2004). Due to the evaporation of water content, the nectar-sugar concentration increases throughout the day with a mean of 9.5% in the early morning to 25.3% in the late afternoon (Rangaiah *et al.* 2004).

Observations. The observation of floral exploitation by Blue-and-yellow Macaws was made during a systematic parrot study conducted in nine 5-km long transects from March 2010–February 2012 (Silva 2013). As the open flowers contain nectar and a remaining amount of calyx water (Rangaiah *et al.* 2004), we assumed that the macaws ingested these two liquids.

Ad libitum observations (Altman 1974) of macaws consuming calyx water were obtained in May 2014. This month corresponds to autumn in southeastern Brazil, and it also represents the second month of the dry season (which lasts for a total of six months). When a flock of macaws perched on an individual of *S. campanulata*, we recorded the number of birds, number of floral buds exploited, and the time of floral bud exploitation until the parrots flew away. A single observation, defined as foraging bout, can include multiple feeding flocks. Details of the feeding behavior

were obtained using 8 x 40 binoculars as well as by videotaping and photographing at least one macaw in the flock that explored the buds.

RESULTS

On 26 July 2011 at 08:20 h, a flock of four Blue-and-yellow Macaws was observed visiting an individual of *S. campanulata* blooming in the cemetery. Each macaw cut 4–6 open flowers with the beak, removing the petals and consuming the nectar and calyx water. This feeding activity lasted ca. 5 min, and birds left afterwards.

In the late afternoon (mainly between 17:20 and 18:00 h) on 1–3 and 9–10 May 2014, we observed 10 foraging bouts, during which 13 groups of Blue-and-yellow Macaws (mean = 2.54, SD = 0.97 macaws/flock, range 2–5 birds) were exploiting buds in two *S. campanulata* plants. The Blue-and-yellow Macaws exploited 54–117 floral buds (mean = 87.0, SD = 23.8, n = 5 macaws) for 6 to 24 min (mean = 14.5, SD = 6.4, n = 8 foraging bouts). In the following we describe in more detail typical foraging events based on video analysis.

Upon arrival to the plant, all macaws searched for floral buds, ignoring the open flowers. After finding the clustered floral buds (Figs 1A, B), the macaws removed one floral bud at a time with their beaks. Then, puncturing the floral bud with their beaks, they tilted their head up (Fig. 1B), squeezing the bud repeatedly so that water flowed out. A copious amount of water ran down the tongue of the macaw, which then swallowed. The macaw then licked the inside and outside of the floral bud before discarding it. The macaws of a flock stopped feeding activity on floral buds synchronously, leaving the *S. campanulata* tree and heading towards a roost probably located on a *R. oleracea* palm tree some 1–3 km from the cemetery.

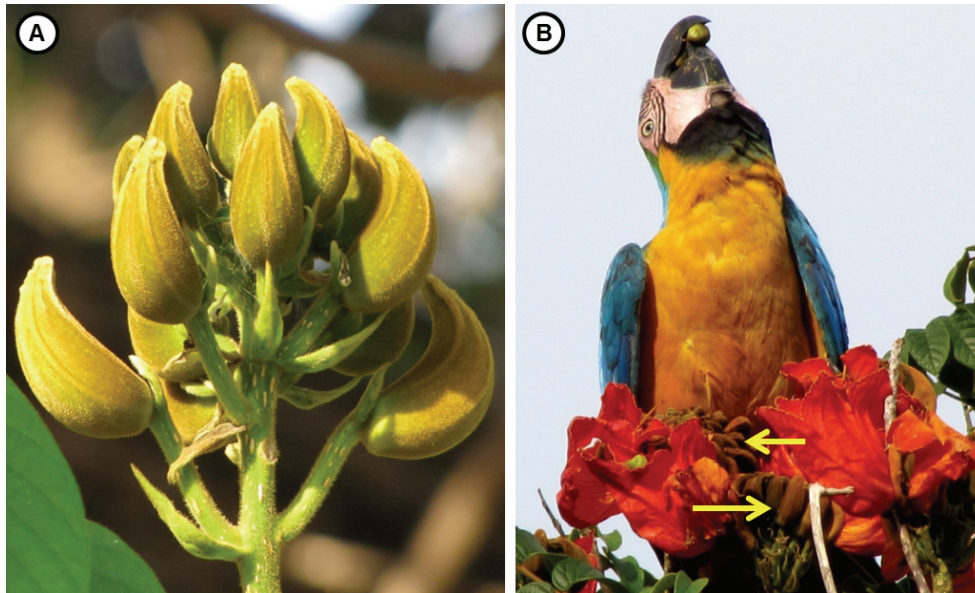


FIG. 1. A) Floral buds of *Spathodea campanulata*. B) A Blue-and-yellow Macaw drinking water from a *S. campanulata* floral bud in Ilha Solteira, State of São Paulo, SE Brazil; buds are indicated by yellow arrows. Photographs by Paulo Antonio Silva.

DISCUSSION

The exploitation of calyx water has not previously been reported for any Neotropical parrot. Thus, this study provides a novel observation and a new food item for the Blue-and-yellow Macaw. However, we note that calyces containing water are rare in plants (Endress 1996). In fact, calyx-water ingestion has only been reported for the Afro-Asian Ring-necked Parakeet (*Psittacula krameri*), also in *S. campanulata* (Rangaiah *et al.* 2004). However, pictures of another Neotropical parrot, the Blue-winged Macaw (*Primolius maracana*), consuming calyx water on buds of *S. campanulata* can be found on a Brazilian website (Brazil 2015; <http://www.wikiaves.com.br/1656672&p=7&t=s&s=10416>). Collared Lories (*Phigys solitarius*) feed on the flowers of this plant in Fiji (Forshaw 1989) while the Neotropical Peach-fronted Parakeet (*Eupsit-*

tula aurea) feeds on its nectar (Previatto *et al.* 2013), and the Yellow-chevroned Parakeet (*Brotogeris chiriri*) feeds on petals, pollen, and nectar (PAS pers. observ.).

Despite several opportunities to observe foraging macaws from 2010 to 2012, they were only recorded visiting open flowers of *S. campanulata* once. In contrast, in only five days of observation in May 2014, we observed substantial calyx-water consumption by macaws on the floral buds of this introduced plant. It should be noted that during these observations the open flowers with large amounts of nectar were ignored by the macaws. This suggests that they prefer calyx water from floral buds. Notably, the calyx water was consumed in the dry season. Because parrots usually drink rainwater that builds up in holes in tree trunks (Sick 1997), they may struggle to find water in the dry season. Sometimes, parrots can also go

down to the ground to drink water (Sick 1997), but the risks of predation can be high. It has been previously suggested that flowers can be important water sources for animals in the dry season (Janzen 1980). In this sense, flowers high up in the crowns of tree seem to be safer places to obtain water. Therefore, it is possible that the exploitation of *S. campanulata* floral buds allows Blue-and-yellow Macaws to safely obtain water during the dry season.

The consumption of calyx water may also provide nutritional benefits as well as provide physiological advantages for Blue-and-yellow Macaws. Macaws tend to consume nutritious-rich parts of plants, such as seeds, which are high in protein and thus amino acids (Koutsos *et al.* 2009, Gilardi & Toft 2012). The calyx water of *S. campanulata* floral buds is also rich in amino acids (Bahadur *et al.* 1986), and consequently of high nutritional quality. Therefore, it is not surprising that our observation of the large number of floral buds exploited (c. 87) and prolonged time invested in this feeding activity (c. 15 min) may be associated with nutritional benefits. It is noteworthy that macaws spend a similar amount of time when feeding on the large and nutritious seeds of *Terminalia catappa* (Combretaceae) and *Platypodium elegans* (Fabaceae) trees (PAS pers. observ.). It must also be emphasized that the calyx water of *S. campanulata* floral buds contains sugar, even though it is greatly diluted (Rangaiah *et al.* 2004). In this case, by exploiting many floral buds the macaws can supplement their energy intake by consuming large quantities of calyx water (cf. Martinez del Rio *et al.* 2001).

The calyx water of *S. campanulata* floral buds constitutes a novel food source for the Blue-and-yellow Macaw (*sensu* Rodriguez 2006). However, this parrot is a floral-bud predator. Like other parrots that damage flowers (e.g., Ragusa-Netto 2005), it may inhibit fruit and seed production in *S. camp-*

nulata. Since this exotic plant is considered to be highly invasive in Brazil (Zenni & Ziller 2011), and thus a threat to local native plants (*sensu* Weber 2003), at least at the local level the Blue-and-yellow Macaw could reduce the spreading of *S. campanulata*.

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