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Effects of traditional extractive management on the seedling recruitment dynamics of *Comanthera elegantula* (Eriocaulaceae) in Espinhaço mountain range, SE Brazil

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ABSTRACT

The intense harvesting of inflorescences prior to seed setting and the persistent use of fire to boost flowering are considered to be the main factors driving starflower species to extinction along the Espinhaço mountain range, in eastern Brazil. In this study we experimentally reproduced these traditional management practices upon a natural population of the starflower *Comanthera elegantula* (Ruhland) L.R. Parra & Giul. (Eriocaulacece) using eight distinct treatments consisting of 'fire', "harvest" and the combined absence of these interventions over two years, in order to assess their effects on seedling recruitment. The study was conducted at the central Espinhaço range region, in Minas Gerais State, Brazil. Our results show that the extractive management practices interfere with the recruitment dynamics of *C. elegantula*, with fire significantly reducing the competing herbaceous cover and stimulating seedling recruitment. An intermittent fire regime seem to favor seedling establishment and growth, while sequential fire episodes seem to negatively impact the progression of seedling cohorts and the regrowth of the herbaceous cover. Additional seed input took place at local scale, probably through dispersion from outer sources and/or from seed banks. Seed pool depletion isto be expected under a persistent and efficient inflorescence collection regime and may ultimately contribute to population senescence.

1. Introduction

The harvesting of Eriocaulaceae inflorescences aimed at supplying the dried ornamental flower market attains expressive economic importance along the Espinhaço mountain range, which spans over 1000 km through the eastern Brazilian States of Minas Gerais and Bahia, and constitutes a seasonal source of revenue for a large number of low-income families (Giulietti et al., 1988, 1996). These are popularly known as "starflowers" or "everlasting flowers", terms referring to parts of plants, such as flower stalks and inflorescences that maintain the living appearance after being extracted and dried. Species belonging to the genus *Comanthera* are particularly valued for their capitula with showy involucral bracts. Inflorescence overharvesting to supply demands from both the national and international markets figures among the main drivers of extinction threat to several other Eriocaulaceae species, including many rare endemics (Giulietti et al., 1988, 1996; Saturnino et al., 1977).

In an assessment comprising interviews with 66 experienced starflower harvesters and merchants along the central Espinhaço range, Instituto Terra Brasilis (1999) reports that the traditional starflower management practices involve the use of fire in the late dry season (i.e., September–October), with the aim to stimulate flowering, and the early harvesting of inflorescences (i.e., by mid – April to May for *Comanthera elegans* (Bong.) L.R. Parra & Giul. and *Comanhera elegantula* (Ruhland) L.R. Parra & Giul.), which attain higher market prices shortly after anthesis. Although these empirically established management practices clearly aim at the short-term boosting of inflorescence production and income maximization, a consistent long-term declining trend of starflower exports has been documented since a peak production occurred

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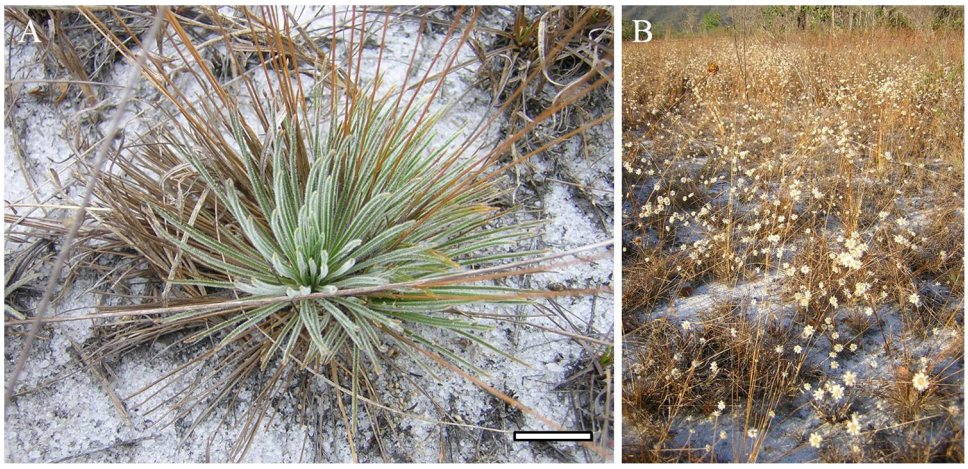

Fig. 1. A) Genet of *Comanthera elegantula* and B) Natural population of *Comanthera elegantula* (Eriocaulaceae). Scale bar: 1 cm.

around the late 1970's and the early 1980's (Instituto Terra Brasilis, 1999). The intense harvesting of inflorescences prior to seed setting (Giulietti et al., 1988, 1996; Oliveira et al., 2014) and frequent fires (Neves et al., 2011) are considered to be the main factors driving starflower species to extinction.

Despite the economic importance of many ornamental starflower species in Brazil, quite little is known about the effects of the traditional extractive management practices upon the exploited populations. It is well known that fire induces flowering and fruiting in many plant species adapted to fire-prone environments (Abrahamson, 1999; Coutinho, 1977; Hartnett and Richardson, 1989) and that fire can directly or indirectly stimulate seed germination and seedling establishment (Keeley and Fotheringham, 2000). On the other hand, fire may cause important mortality effects upon seedlings (Bond and Keeley, 2005; Frost and Robertson, 1987; Whelan, 1995) and the harvesting of inflorescences may ultimately impact seedling recruitment (Hall and Bawa, 1993). Understanding the recruitment dynamics of starflower populations subjected to extractive management practices is, therefore, an essential element towards their conservation and sustainable management.

In this study we experimentally reproduced the referred traditional management practices upon a natural population of the starflower *C. elegantula*, in order to assess whether such management practices affect seedling recruitment and, if so, whether the effects are ultimately related to environmental changes (e.g., elimination of competing herbaceous cover by fire), or to direct demographic changes (e.g., mortality of seedlings or their mother plants; seed pool depletion from inflorescence harvesting).

Comanthera elegantula is a small herbaceous clonal plant with cylindrical, densely hairy to glabrescent leaves, displaying great variation in leaf length (from 2 to 10 centimeters) and flower stalk size (from 14 to 60 centimeters; Fig. 1). It occurs in the rupestrian grasslands in Minas Gerais State and is morphologically and ecologically similar to *C. elegans* – which is the most important species of Eriocaulaceae in the national and international starflower market (Parra et al., 2010) and figures as Endangered among Brazil's red-listed Eriocaulaceae (CNCFlora, 2017). Like *C. elegans* and *C. elegantula*, several other *Comanthera* species with similar habitat requirements are targeted for inflorescence harvesting and subjected to similar management practices along the Espinhaço range, such as *C. bisulcata* (Körn.) L.R. Parra & Giul., *C. dealbata* (Silveira) L.R. Parra & Giul., *C. aciphylla* (Bong.) L.R. Parra & Giul., *C. vernonioides* (Kunth) L.R. Parra & Giul., and *C. centauroides* (Bong.) L.R. Parra & Giul.

2. Material and methods

2.1. Study site

The experimental study was carried out at the Lapa creek area (18° 05′24" S; 43° 20′27" W), within the Rio Preto State Park, in the municipality of São Gonçalo do Rio Preto, Minas Gerais (Fig. 2A). The Park's 10.755 ha are predominantly covered by Cerrado (Brazilian savanna) formations, including campos rupestres (rupestrian grasslands) at higher elevations, in association to quartzite-arenite outcrops, where the soils are generally sandy, shallow, acidic and nutrient poor (Giulietti and Pirani, 1997). The habitat of *C. elegantula* consists mostly of plateaus above 900 m of elevation formed by the accumulation of sediments eroded from quartzite-arenite rocks. The local climate is classified as Köppen's Cwa (warm temperate, with dry winter and warm summer; Kottek et al., 2006). Mean temperatures vary between 17.4 °C and 19.8 °C and the mean annual rainfall is 1500 mm. The target *C. elegantula* population had been protected from fires and inflorescence harvesting for over five years prior to this study.

2.2. Experimental study

Recruitment data were obtained from a small-scale experimental study reproducing the traditional extractive management practices used in the region, as assessed by Instituto Terra Brasilis (1999) – which involve inflorescence harvesting (H) in the early dry season, from early April through early May, and the burning of the fields (F) in the late dry season, between September and early October. Between April 1999 and April 2001, experimental treatments consisting of eight combinations of H, F and the absence of these interventions (Ø) were conducted using a randomized block design consisting of eight 40 m^2 blocks set upon a natural population of *C. elegantula* (Fig. 2B). The perimeter of each block was delimited by tall fencing poles in order to avoid disturbance from stray cattle or horses and the distance between blocks varied between 5–120 meters. Each block contained eight 2.5 m^2 lots, delimited with short poles and strings (64 lots in total, with eight independent replicates per treatment; Fig. 2C). The final treatment combinations tested over two consecutive years were: HF-HF; HF-ØF; HØ-HØ; HØ-FØ; FØ-HØ; FØ-FØ; Control(ØØ)-HF and Control–Control (Table 1). Fire was set manually to each of the assigned 2.5 m^2 lots and kept within the defined boundaries by trained park rangers using water sprays. Care was taken during inflorescence harvesting to avoid the uprooting of plants by pluck-

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