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Adventitious buds on roots of *Siphanthera arenaria* (DC.) Cogn. (Melastomataceae), an annual plant from the cerrado biome

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Abstract Plants from Brazilian tropical grasslands of the cerrado biome (also referred to as the Cerrado region) are characterized by the possessing of belowground bud-bearing organs that may be of stem or root origin that enhance the likelihood of surviving a dry season or fire. The root-derived bud bank is referred to when speaking about adventitious sprouting from roots. Root buds or root sprouts allow rapid regrowth after a disturbance or a period of adverse climatic conditions and have the potential to generate clonal populations. Adventitious sprouting from roots is well known to occur in Brazil in perennial species, mainly woody plants. In the present study, we investigate the occurrence of adventitious buds on roots of the annual species *Siphanthera arenaria* (DC.) Cogn., which is endemic to the Serra do Espinhaço range in Brazil and grows in an area of the cerrado biome. Shoots emerging from the root system of *S. arenaria* were assessed in a microscopic analysis and classified as reparative-type buds emerging from the cortical parenchyma. The presence of root buds in *Siphantera arenaria* represents the first record for the Melastomataceae family in the cerrado biome and also the first record of a root bud in an annual species for this biome.

Keywords Underground system · Bud banks · Annual species · Belowground buds

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Introduction

Bud banks on belowground organs, such as xylopodia, rhizomes and rhizophores, are widely reported in the literature as occurring in Brazilian tropical grasslands of the cerrado biome in Brazil (Rawitscher and Rachid 1946; Rachid-Edwards 1956; Rizzini and Heringer 1961, 1966; Eiten 1972; Eiten 1994; Coutinho 1982; Hayashi and Appezzato-da-Glória 2009; Simon et al. 2009; Appezzato-da-Gloria 2015). They include adventitious buds on roots, which can sprout into aerial shoots, making it possible to survive disturbance events or enabling the development of a clonal population (Raju et al. 1966; Bosela and Ewers 1997; Appezzato-da-Gloria 2015; Pausas et al. 2018). From cerrado vegetation, root buds have been reported since the middle of the twentieth century (e.g. Rizzini and Heringer 1961, 1966; Hayashi 1998; Rodrigues et al. 2004) usually for eudicots with a huge variety of growth habits, from perennial herbs to woody plants (Hayashi 1998, 2005; Rodrigues et al. 2004; Vilhalva and Appezzato-da-Glória 2006; Hayashi and Appezzato-da-Glória 2009; Imatomi et al. 2014; Chaves Filho and Borges 2018).

In this study, we present morphoanatomical data on root buds in *Siphanthera arenaria* (DC.) Cogn, an annual herbaceous species found on rocky outcrops in the Brazilian cerrado. *Siphanthera* Pohl ex DC. is a small genus belonging to the family Melastomataceae, consisting of fifteen species, eight of which occur in Brazil, six being endemic to the

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country. They can be found in different environments of the Brazilian cerrado biome. All of the species have a herbaceous habit, and the life cycle is annual in eleven species and perennial in four (Romero 1997; Almeda and Robinson 2011).

Material and methods

Three specimens of *Siphanthera arenaria* were collected in an area of rocky outcrops in a rupestrian grassland environment (19° 14′ 44″ S – 43° 32′ 34″ W, 1,398 m a.s.l.) in the Serra do Cipó National Park in Minas Gerais, Brazil. The whole belowground structure was extracted from a sandy and shallow soil. Photographs of the morphology were taken both in the field and in the laboratory. The collected material was fixed in 50% FAA and stored in 70% ethanol.

Three samples from the median part of roots of each specimen were consecutively dehydrated with ethyl/butyl alcohol and embedded in Paraplast (Ruzin 1999, modified). Cross-sections (10–18 µm) were prepared using a Reichert–Jung AutoCut 2040 microtome and stained with 1% Astra Blue and 1% safranin (Kraus and Arduin 1997, modified). After these procedures, the material was permanently placed on slides with Canada balsam or colourless stained-glass varnish 500® (Acrilex, São Paulo, Brazil; Paiva et al. 2006). The slides produced were analysed and the structures were registered with the help of an IM50 imaging system connected to a Leica DMLB microscope (Leica Microsystems, Welzar, Germany).

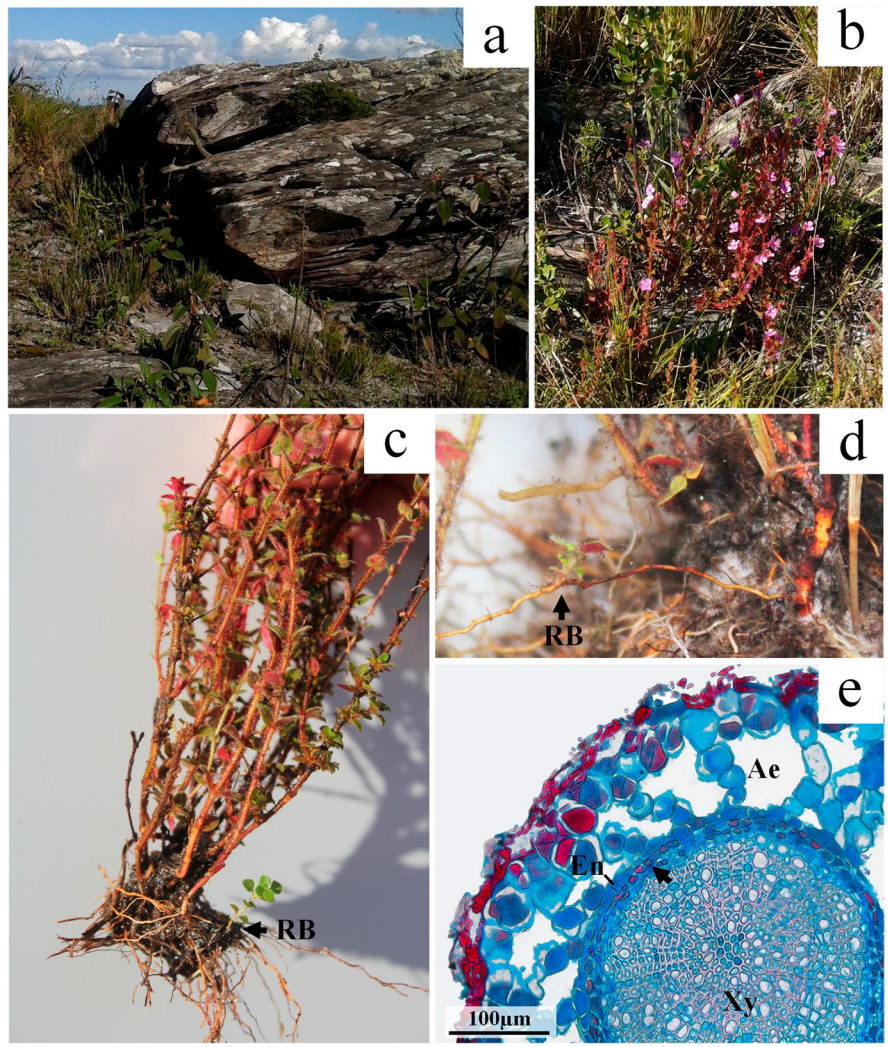

Fig. 1 A – Rocky outcrops from where the specimens where collected. **B** – Individual of *Siphanthera arenaria*. **C**, **D** – Individuals of *Siphanthera arenaria* with an underground system formed by adventitious roots, from which buds emerge (arrows). E – Transverse-sections of *Siphanthera arenaria* root, showing phenolic content in pericycle cells (arrow) and intercellular spaces in the cortical region. Ae – aerenchyma, En – endoderm, Xy – xylem

Results

All samples were collected on one rocky outcrop (Fig. 1A). The underground system of *Siphanthera arenaria* (Fig. 1B) is characterized by adventitious roots with buds (Fig. 1C, D). The roots are protostelic with centripetal maturation in the primary xylem, which occurs in the centre. Secondary growth can be observed (Figs. 1E, 2A, B) in the vascular cylinder, with secondary xylem cells of different diameters accompanied by fibres and parenchyma cells. The development of the shoot buds on adventitious roots occurs from the outermost layers of the cortex (Fig. 2C, D).

Discussion

According to anatomical traits, we found that the adventitious root buds observed in *Siphanthera arenaria* are of a reparative type, as there is no trace connecting the forming bud with the centre of the root. This may indicate that the bud was formed in response to injury, senescence, or some environmental disturbance (Bosela and Ewers 1997). Such buds differ from root buds formed during the initial growth of the roots, which are of an endogenous origin and are distinguished by the presence of contiguous lines within the centre of the root (Bosela and Ewers 1997; Appezzato-da-Gloria 2015). Lack of a connection between

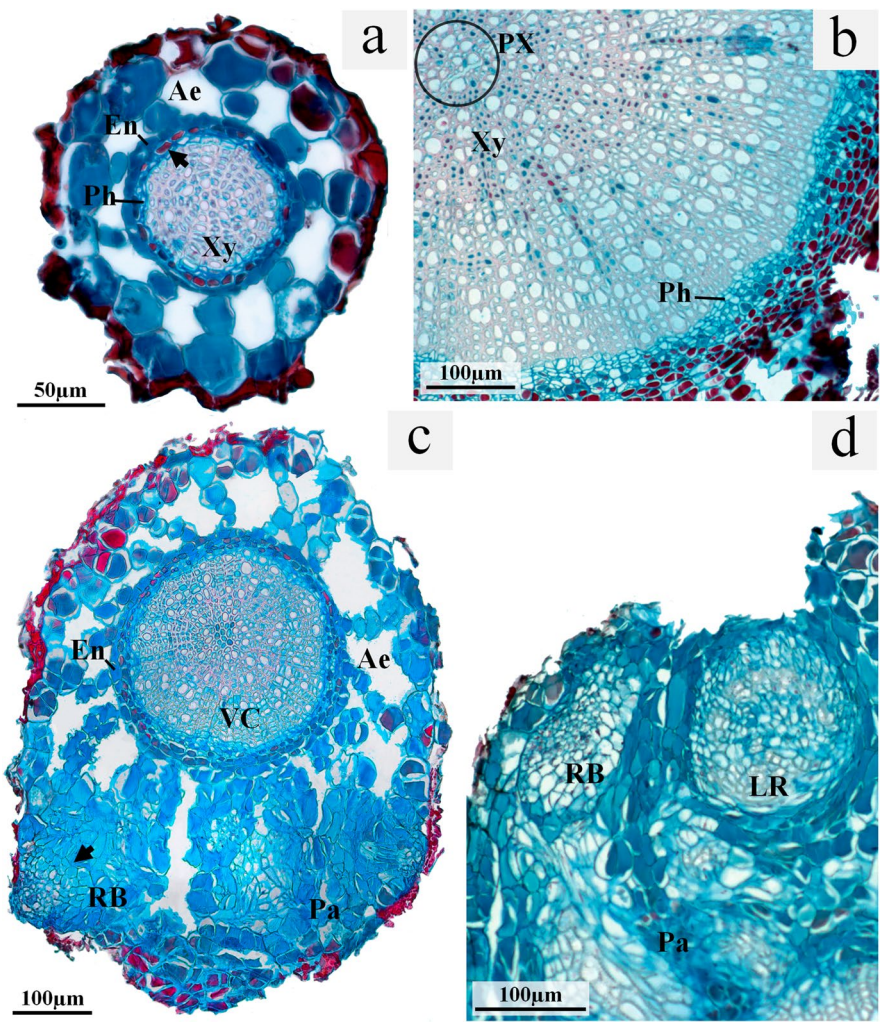

Fig. 2 Transverse sections of the root of *Siphanthera arenaria*: **A** – Phenolic content in pericycle cells (arrow) and aerenchyma in the cortical region. **B** – Protostelic vascular cylinder (highlighted). **C** – Region with the presence of buds (arrow) at the beginning of development. **D** – Details of the root bud at the beginning of development phase. Ae – aerenchyma, En – endoderm, Ph – phloem, PX – primary xylem, LR – lateral root, Pa – parenchyma, RB – root bud, VC – vascular cylinder, Xy – xylem

the bud and root centre is probably not a problem for the further development of the sprouting adventitious shoot in the species under study, because the connection may be established later in herbaceous tissues, unlike in woody roots (Bartušková et al. 2021).

The presence of root buds allows the plant to survive disruptive events such as herbivory or fire, even if the main structure has suffered severe damage. In previous studies, it was pointed out that this type of vegetative reproduction can prevail over sexual reproduction both before and after wildfires (Rodrigues et al. 2004; Imatomi et al. 2014) and can lead to the formation of clonal populations, which can have some adaptive advantage, as they grow from already developed individuals and have more energy reserves compared to plants that reproduce exclusively by seeds, resulting in increased long-term survival (Miller and Kauffman 1998; Simões and Marques 2007). In light of this, it is possible that the specimens collected in this study were actually ramets of a single clonal individual because they grew close to each other and their underground systems were tangled.

Species with root buds reported in previous studies conducted from cerrado vegetation are perennial, often arboreal (Hayashi et al. 2001; Rodrigues et al. 2004; Hayashi and Appezzato-da-Glória 2009; Appezzato-da-Gloria 2015). However, *Siphanthera arenaria* does not fit this profile, as it is described as an annual herbaceous species (Almeda and Robinson 2011). In studies conducted in other countries, the presence of root buds has been recorded extensively (McAllister and Haderlie 1985; Klimešová and Klimeš 2003; Klimešová and Martínková 2004), even in annual species (Bartušková et al. 2017).

This is the first report recording the presence of root buds in an annual species of the Brazilian cerrado. Considering the extensive literature that reports this characteristic from other floras, the occurrence of root buds might be more common in the cerrado biome than assumed and therefore deserves further study.

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Data Availability Data available within the article or its supplementary materials.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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