

Conservation actions for the microendemic plant *Grazielanthus arkeocarpus* (Monimiaceae, Laurales)

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Abstract *Grazielanthus* is a monotypic, dioecious and microendemic plant genus of the Brazilian Atlantic Forest. Its only species, *Grazielanthus arkeocarpus*, is categorized as Critically Endangered on the IUCN Red List and comprises only one small population, in the Poço das Antas Biological Reserve, Rio de Janeiro State. Collaborative activities have been developed since 2013 to implement in situ and ex situ conservation actions for this species. Successful in situ planting has increased the number of individuals in its natural population. Ex situ conservation efforts have resulted in the cultivation of the species in two Brazilian living plant collections, and this will soon increase to three collections.

Keywords Botanic gardens, flora of Brazil, *Grazielanthus arkeocarpus*, narrow endemic, point endemic, protected areas, Red List, threatened species

Botanic gardens have been encouraged to focus their efforts on the regional flora where they are located and to adopt measures for species conservation both in the natural environment (in situ) and in cultivation (ex situ; Botanical Garden Conservation International, 2014; Costa et al., 2016). The role of botanic gardens in these fields is well known, although much remains to be done, especially in tropical countries with a high diversity of environments and species, such as Brazil (Silveira et al., 2018).

Microendemic plants are of great interest for conservation because of their often reduced, isolated and threatened populations. Conservation actions for microendemic plants include research on artificial propagation, genetic diversity, ecophysiology and pollination, monitoring, threat mitigation,

reintroduction and ex situ conservation (Zhang et al., 2014; Kraaij et al., 2016; Médail & Baumel, 2018).

Some microendemic species of Monimiaceae have been objects of study and conservation actions, focused mainly on fieldwork, with some recently rediscovered species (*Mollinedia stenophylla* Perkins and *Mollinedia myriantha* Perkins; Lirio et al., 2018a, Lirio et al., in press). Another project that is still ongoing, led by EJD, aims to bring together the local community, germination protocols and fieldwork to conserve two threatened Monimiaceae, *Mollinedia dolichotricha* Lirio & Peixoto and *Mollinedia ruschii* Lirio & Peixoto, with the latter being microendemic (Lirio & Peixoto, 2015; Lirio et al., 2021).

Grazielanthus Peixoto & Per.-Moura (Monimiaceae, Laurales) is a monotypic genus and has unexpected characteristics for a Neotropical Monimiaceae: a shrub or lianoid habit, pistillate flowers without a circumscise apex and numerous fruitlets closed in the fruiting receptacle until maturation, when it opens with irregular slits. This unique set of characteristics probably reflects the evolutionary distinctiveness of this taxon (Peixoto & Pereira-Moura, 2008; Lirio et al., 2018b).

Grazielanthus arkeocarpus Peixoto & Per.-Moura is a microendemic species from Rio de Janeiro State, characterized by having an average height of 2–10 m, with simple, opposite and serrated leaves. The staminate flowers are yellow and organized in triflorous inflorescences, with an urceolate receptacle, four tepals and 35–37 rounded stamens opening through slits. The pistillate flowers are solitary and have 35–37 free carpels. The fruiting receptacle has persistent tepals at the apex and is yellowish-green externally and yellow internally. It remains closed until the fruitlets mature, when it then dehisces irregularly. The fruitlets with their fleshy pericarp are probably adapted to zoochoric dispersal (Plate 1a–g).

With the aid of the National Centre for Flora Conservation (the Brazilian IUCN Red List Authority for plants) we categorized the species as Critically Endangered on the basis of criteria B2ab(ii,iii); C2a(ii); D: area of occupancy estimated to be 4 km² (B2), known to exist at only a single location (a), with continuing decline (b) in area of occupancy (ii), area, extent and/or quality of habitat (iii); population size estimated to be c. 32 mature individuals and continuing decline inferred, in numbers of mature individuals (C2) with 100% of mature individuals in one

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PLATE 1 *Grazielanthus arkeocarpus*: (a) habit, (b) branch, (c) staminate inflorescence, (d) staminate flower in longitudinal section showing the stamens and detail of the apex, showing the tepals, (e) post-anthesis pistillate flower, with persistent blackened tepals, (f) immature fruiting receptacle, closed, (g) open fruiting receptacle with exposed mature drupelets, (h) seedlings in a nursery, and (i) young planted specimen. Photographs (c) and (d) are from the Rio de Janeiro Botanical Garden; all others are from the Poço das Antas Biological Reserve. (a) A.L. Peixoto; (b,c) E.J. Lirio; (d) M. Nadruz, detail A. Machado; (e) D. Zavatin; (f) R. Gabriel; (g) D. Ferreira; (h,i) G.L. Peixoto.

subpopulation (ii); population size estimated to be c. 80 individuals, of which c. 40% are mature and reproductive (D) (Lirio et al., 2018b). This recommendation will be included on the IUCN Red List in due course.

Grazielanthus arkeocarpus inhabits a flood prone alluvial forest in the Atlantic Forest, in the Poço das Antas Biological Reserve, a fully protected area (IUCN category Ia) created in 1974 in Silva Jardim County (Fig. 1). Alluvial forests occupy c. 894 ha (c. 18%) of the Biological Reserve (Lima et al., 2006). The c. 4,856 ha Biological Reserve is home to several threatened species, including the Endangered golden lion tamarin *Leontopithecus rosalia*, its flagship species.

Actions for the conservation of the golden lion tamarin, such as reforestation, were started in 1993 by the Rio de Janeiro Botanic Garden and continued by the Golden Lion Tamarin Association and other partners. These actions benefitted the population of *G. arkeocarpus* by minimizing the risk of forest fires in its area of occupancy. Guided by the Global Strategy for Plant Conservation (CBD, 2010) and the Botanic Garden Conservation International recommendations (BGCI, 2014), we developed actions for the conservation of *G. arkeocarpus* that involved population monitoring, research, ex situ conservation and the expansion of the in situ population.

We began monitoring in 2013 with the marking of individual plants, to investigate their phenology, especially the opening of the receptacles and fruitlet release, and for subsequent collection of seeds. We developed this work in collaboration with researchers, technicians, field assistants and students from the Biological Reserve and the Rio de Janeiro Botanic Garden. The process of exchanging knowledge regarding seedling production was key to consolidating commitment to the conservation of rare and endemic plant species in the region, where some of the team members live. We then began ongoing research that included studies on genetic diversity, genome size estimation, morphology, phylogenetics and seed germination under controlled conditions.

In 2014 we began our first attempt to cultivate *G. arkeocarpus* outside its natural area. We planted six seedlings in an arboretum as part of the Brazilian species conservation initiative developed by the Rio de Janeiro Botanic Garden (Fig. 1). These seedlings were produced in the Biological Reserve nursery and brought to the Botanic Garden nursery, where they underwent quarantine before planting. Only one individual survived, and since 2017 it has bloomed annually. This staminate specimen suggests that species can be successfully cultivated ex situ. In October 2017 we planted

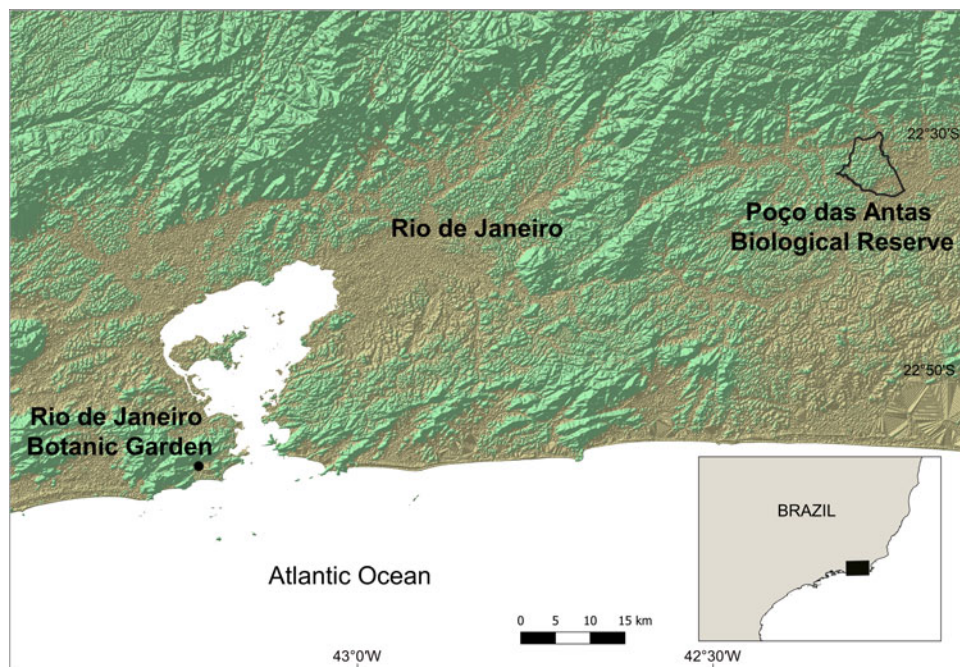


FIG. 1 Location of Poço das Antas Biological Reserve in Rio de Janeiro State, Brazil, the only known in situ location of the microendemic plant *Grazielanthus arkeocarpus*, and of the Rio de Janeiro Botanic Garden, where *G. arkeocarpus* is in cultivation.

two new seedlings in the same plot from a new batch of seeds, but they did not survive. The seedlings of *G. arkeocarpus* that we planted in 2021 came from yet another batch of seeds as we continue to attempt to cultivate both staminate and pistillate plants in the Botanic Garden.

In situ conservation efforts involved the expansion of the area of occupancy of the species. During May–June 2019 we collected seeds that we planted immediately in plastic bags and kept in the Biological Reserve nursery for 8 months until the seedlings reached a minimum height of 20 cm. In February 2020, during the rainy season, we planted 84 seedlings in an area of the Biological Reserve c. 1 km from the original location of the species but in similar habitat. The current survival rate in the field is 56%, with a mean height of 52 cm for the 47 surviving seedlings (range 24–96 cm). We continue to monitor these seedlings, seeking information on the beginning of the reproductive period of both staminate and pistillate individuals. As reported previously (Portal ICMBio, 2020), the success of this planting is demonstrated by the health of the developing plants, which are already fully established. This also indicates the species could be used for restoration projects in the Biological Reserve (Plate 1h,i).

To expand these in situ and ex situ conservation actions, we continue to carry out seed collection and seedling production in the Biological Reserve nursery. We have sent *G. arkeocarpus* seeds and seedlings to two other living plant collections: the University of São Paulo in São Paulo County, São Paulo State, at c. 750 m altitude, where the species is already part of the collection; and the Rio de Janeiro Federal Rural University Botanic Garden, at a low altitude (27 m) in Seropédica County, Rio de Janeiro State, where planting will take place in 2023.

The development of conservation actions for the species will continue. The goals of the in situ and ex situ cultivation are to minimize the risks of the extinction of this species and to facilitate future research that will fill in gaps in our current knowledge of this microendemic species.

Microendemic species are best conserved through integrated in situ and ex situ conservation (BGCI, 2014; Costa et al., 2016), and increasing local commitment to conservation is essential (Crain et al., 2015). The actions we carried out for *G. arkeocarpus* demonstrated the importance of persistence and local community involvement in achieving meaningful results. We hope this research will inspire other initiatives focused on microendemic plants in Brazil and other countries, help support the management of in situ protected areas where such species occur, and expand the representation of rare, microendemic and threatened species in ex situ living plant collections.

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Author contributions Collection, identification, marking of specimens in the field and risk assessment: ALP, EJD; monitoring of phenophases, collection of seeds and monitoring the development of seedlings in situ: GLP; monitoring ex situ: THMdA, DRG; data management for the ex situ collection: THMdA; plate preparation: DRG; writing: all authors.

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards.

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