

Found and lost again: Rediscovery of *Mollinedia myriantha* (Monimiaceae) after 123 years and perspectives for conservation of the family in Brazil

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Abstract

Mollinedia myriantha Perkins (Monimiaceae) is a tropical tree described by Perkins (1900) based on a collection of the French botanist Auguste F. M. Glaziou collected in 1892 in the mountainous region of Rio de Janeiro state, Brazil. The species was rediscovered in 2015 after 123 years from Glaziou's report in the type locality, however, in subsequent fieldworks (2018-2019) the sole rediscovered individual was found dead. In this study, we report this rediscovery and discuss the possible pressures that lead the individual to death, also we provide a lectotypification, along with morphological description, geographic distribution map and conservation comments for this species. Besides we discuss the conservation status of Monimiaceae in Brazil.

Introduction

Global biodiversity in the Anthropocene is decreasing very fast (Butchart et al. 2010; Pena Rodrigues & Lira 2019). The rate of animal and plant species extinction has increased worldwide in the last centuries, being deforestation and fire a global concern to conserve biodiversity (Ceballos et al. 2015; Humphreys et al. 2019; Mortara et al. 2020). The IUCN Red List of Threatened Species is regarded as the most effective tool to identify which species are facing high extinction risk and which are the main drivers of species' population declines, similarly to a "barometer of life" (Stuart 2010; IUCN 2019). A recent study estimates that 39.4% of all vascular plant species are threatened with extinction in the world, but only 10.5% were assessed until 2020 (Lughadha et al. 2020). Rare species are a key component of plant biodiversity yet most of them are poorly known because they are hard to find and study. As we lack basic information about any given species, it is challenging to understand its threat status and propose evidence-based conservation actions. Consequently, many rare species that have their extinction risk assessed are categorized as Data Deficient because there is not enough information to understand their conservation status.

Analysing a global dataset of presumed extinct plant species (1,002 species excluding synonyms), Humphreys et al. (2019) concluded that 571 species have become extinct in the last centuries, while 431 species were erroneously declared extinct and therefore rediscovered. Recently, many species have been rediscovered, mainly due to the extensive fieldwork aimed at finding them (Almeida et al. 2018; Bochorny et al. 2017; Pellegrini & Almeida 2016; Guedes et al. 2019; Marcusso et al. 2019; Guimarães et al. 2020; Mello Rolim & Oliveira 2020). Species that were erroneously declared extinct are often known from only a few or even a single historical locality, which results from their inherent rarity or lack of adequate sampling effort, a phenomenon known in conservation biology as 'Romeo error' or 'Lazarus species' (Collar 1998; Ryan & Baker 2016; Lírío et al. 2018a). In those cases, where possibly extinct species have been collected only once, intensive targeted search at the type locality may be the best way to find new individuals, if they still exist, and improve knowledge on the species and its threat status.

Monimiaceae is a pantropical family of flowering plants, with 28 genera and about 200 species, occurring mainly in humid and well-preserved forests (Renner et al. 2010; Lírío et al. 2020a). The genus *Mollinedia*

has about 50 species and occurs from south Mexico to the south of South America, the richest domain being the Brazilian Atlantic rainforest, with 31 species (Lírio et al. 2020a). The Atlantic forest has a vegetation cover estimated from 11–28% and it is known to be the home of 15,499 species of Angiosperms, of which 54% are considered endemic to this biome (Ribeiro et al. 2009; Rezende et al. 2018; Flora do Brasil 2020). This biome also has a high endemism for *Mollinedia*, with 28 endemic species (Lírio et al. 2020a).

Thirteen species of Neotropical Monimiaceae are rare or restricted to narrow areas (Peixoto & Pereira-Moura 2008; Peixoto et al. 2009; Guimarães et al. 2014; Lírio et al. 2018a,b; 2020b; 2021). So far, 28 out of the 46 species of Monimiaceae known as native to Brazil have been assessed on national level, and nine of them have been considered as threatened of extinction (CNCFlora 2012; Ministério do Meio Ambiente 2014; Martinelli et al. 2018). As an example, *Mollinedia stenophylla* Perkins (1900: 669) has been recently rediscovered within its type locality, after 122 years of the last collection (Lírio et al. 2018a). It is found only in the Environmental Protection Area (APA) of Macaé de Cima, Nova Friburgo, in the state of Rio de Janeiro, and is one of the Brazilian species assessed as Critically Endangered (Lírio et al. 2018a).

Studies also conducted in APA of Macaé de Cima in 2015 by our research group aiming to collect data on threatened species of Monimiaceae revealed the presence of only one individual of *Mollinedia myriantha* Perkins (1900: 655), a species last collected in 1892 by the French botanist Auguste F. M. Glauziou. After fieldwork conducted in 2018–2019 to find new individuals and collect more data about the species, we observed that the only known individual was dead and no new one was found. Here we present an updated morphological description, a geographic distribution map, photographs, lectotypification and extinction risk assessment for *M. myriantha*, and discuss the possible reasons for the loss of this individual. In addition, we present the perspectives for conservation of Monimiaceae in Brazil.

Materials and methods

The EPA of Macaé de Cima covers 350,370m² of mountain landscapes within the upper part of the Macaé river watershed (Map 1). It is located in the Central Corridor of the Serra do Mar mountain range, which includes some of the largest and best preserved vegetation remnants of the Brazilian Atlantic forest (Ribeiro et al. 2009). Mean annual temperature is 18°C and annual precipitation is 2,128mm (Lima & Guedes-Bruni 1997). Altitude ranges from 200 to 1,700m above sea level and predominant vegetation is montane rainforest in various stages of vegetal succession (Guedes-Bruni et al. 1997). The local flora is very rich, with 964 recorded species of vascular plants (INEA 2014).

Branches of the individual containing flowers were collected in 2015 in the APA Macaé de Cima (Map 1) and deposited in the herbarium RB (acronym follows Thiers 2021). We analyzed specimens of the herbaria C, F, GH, K, NY, P and RB. We calculated the Extent of Occurrence (EOO) using the area of the minimum convex polygonum and the Area of Occupancy (AOO) using a grid of 4 km² cells (IUCN 2019). The analyses were performed using the geospatial conservation assessment tool GeoCat (Bachman et al.

2011) for extinction risk assessment. To assess the conservation status of the species, we followed the Categories and Criteria of IUCN Red List of Threatened Species (thereafter, IUCN Red List) (IUCN 2012; 2019).

Results

The species was found in an anthropized area of Atlantic forest (a private property called Sítio do Cedro), next to the roads and residences and without undergrowth (Map 1, Fig. 1A-B). The collection was made in 2015 during a fieldwork carried out under a taxonomic revision of Monimiaceae and also the Brazil Flora Online project (Lírio et al. 2020a). In 2018 and 2019 we did new fieldworks to recollect the species and to search for more individuals, however, the only known individual was found dead (Fig. 1C) and no other new individuals have been found. Despite this setback, the present study led us to an update of the species taxonomy and description because some characteristics were unknown in the protologue, which can help in the rediscovery of new individuals. Furthermore, we were able to confirm and better describe the species habitat and to assess its risk of extinction.

Mollinedia myriantha Perkins (1900:655). Type: Brazil, Rio de Janeiro, Nova Friburgo, Alto Macaé, 16 Feb. 1892, *Glaziov* 19859 (Lectotype P00080080! Here designated; isolectotypes C!, F!, GH!, K!, P!). (Fig. 2)

Tree up to 8 m, 40 cm DAP, bark corky, dioecious, cylindrical branches, young branches white-tomentose, then glabrous as they grow. *Leaves* opposite, 8.5–10 x 3–4 cm, elliptical, obovate or oblong, apex long acuminate to acute, base cuneate, entire, rigid-chartaceous, discolour, brownish-dark in the adaxial surface and brownish-light in the abaxial surface when dry, glabrous in the adaxial surface and white-strigose in the abaxial surface, except in the veins where the trichomes are dense and longer, five to six secondary veins, barely apparent in the adaxial surface and protuding in the abaxial surface, white-hirtelous, petiole 0.9–1 cm, canaliculate, white-puberulous. *Staminate inflorescences* in triflorous cymes organized in long thyrses up to 24 flowers, axillary or terminal, trichomes white-tomentose, rachis (0.2–0.4) 2.2–5 cm, peduncle 0.3–0.9 cm, pedicel 0.4–0.6 cm. *Staminate flowers* greenish-yellow, 3–3.5 x 4–7 mm, bracts 3.5–4 mm, oblong, apex acute, bracteole 1.5–2 mm, ovate, apex acute, receptacle flat, tepals about 3/4 of the length of the flower, ovate, external with rounded apex, internal with truncated apex and denticulate margin, stamen 22–23, ovate, non-confluent locule at the apex. *Pistillate flowers* and *fruits* remain unknown.

SPECIMENS EXAMINED. Brazil, Rio de Janeiro, Nova Friburgo, Macaé de Cima, 29 Jan. 2015, *E. J. Lírio et al.* 1196 (NY!, RB!, P!).

TAXONOMIC COMMENTS. The species resembles *Mollinedia gilgiana* Perkins (1900: 656) due its staminate flowers with a flat receptacle and leaves shape and length, and resembles *Mollinedia triflora* (Spreng.) Tulasne (1855: 394) due its staminate flowers with a flat receptacle and corky stem. *Mollinedia myriantha* can be differentiated from both species by the diameter of its flowers (4–7 mm in *M. myriantha* vs. 8–10 mm in *M. gilgiana* and 3–4 mm in *M. triflora*). The species can be differentiated of *M. gilgiana* by its corky stems and by the canescent leaves with trichomes densely distributed in the

secondary veins (vs. striate stems, leaves glabrous or glabrescent, not canescent in *M. gilgiana*). Also, it differs from *M. triflora* by its white-tomentose multiflorous staminate flowers and bracts with 3.5–4 mm long (vs. white-strigose triflorous staminate flowers and bracts with c. 1 mm long in *M. triflora*).

DISTRIBUTION AND HABITAT. The species is endemic to the Atlantic montane forest, only found in Macaé de Cima, an Environmental Protection Area located in Nova Friburgo municipality, Rio de Janeiro state. The patch where we found the specimen was a disturbed secondary forest at 850 m elevation, without understory and a canopy of about 10 m of sparse trees. We found the individual in the superior left side of the fragment of forest. The site where the individual was collected was bordered to the north by a dirt road, to the south by residences and banana crops, to the east by a second dirt road, and to the west by residences (Map 1B). The region is also impacted by invasive species, small farmlands and leisure residences.

EXTINCTION RISK ASSESSMENT. *Mollinedia myriantha* is a dioecious species and has a very restricted distribution, known only from the type collection made in 1892 (staminate flowers) and from a recent collection made in 2015 in a private area (also staminate flowers), on the border of a small disturbed secondary forest fragment located within the region of the type locality (Macaé de Cima), at 850m elevation. Its estimated extent of occurrence (EOO) and area of occupancy (AOO) based on records is 4km², falling within the thresholds of Critically Endangered category under criterion B. There is only one known location for this species and the major threats are the habitat loss and habitat degradation due to edge effects caused by fragmentation, expansion of roads, residential areas related to tourism and recreational activities, agriculture and invasive species. A continuing decline of area of occupancy, number of locations and mature individuals is inferred based on the threats mentioned, and also considering that since the species rediscovery in 2015, the single individual alive recorded was later in 2018 noticed as dead. Therefore, this species is assessed here as Critically Endangered as it meets the criterion B2ab (ii, iii, iv, v), and we suggest that it could be in the future tagged as “Possibly Extinct” (IUCN 2019), after targeted fieldwork to complete the documentation since the findings from the previous fieldworks carried out in 2015, 2018 and 2019, which include the local threats, and the information that the species was last recorded alive in 2015. As the cause of death for this individual is unknown, new surveys must be provided including searches for this species on potential habitats (considering the type of forest and altitudinal range within its native distribution) in different months and seasons. Financial support and resources are strongly needed to provide the targeted searches and according to the IUCN Standards and Petitions Committee (IUCN 2019), once the status of taxa is assigned with a ‘Possibly Extinct’ tag, its status should preferably be reviewed at five-year intervals.

CONSERVATION OF MONIMIACEAE IN BRAZIL. Nowadays, out of the 46 species of Monimiaceae family occurring in Brazil, 34 species were evaluated following the IUCN Red List assessment at national or global level (1998–2021) (Suppl. 1). Eleven (23.9%) out of the 34 species assessed are threatened; among these, 4 (8.7%) are considered Critically Endangered (CR), 5 (10.9%) are Endangered (EN) and 2 (4.3%) are Vulnerable (VU) of extinction, besides 4 (8.7%) are Near Threatened (NT) and 1 (2.1%) Data Deficient (DD). The major threats are deforestation, fragmentation and fire in the Atlantic forest (Suppl.

1). Twelve of the 46 species still need a formal assessment, including the assessment for *M. myriantha* which is here rated as Critically Endangered, and we suggest it to be tagged as Possibly extinct. The results of the assessments are summarized in the Supplementary material (Figure S1).

Discussion

Over the past decades, there have been many efforts to catalogue the flora of Macaé de Cima. In 1996, a book about its flora with a chapter dedicated to Monimiaceae was published treating the species of the family occurring in the area, with taxonomic descriptions, notes and illustrations (Peixoto & Pereira-Moura 1996). Also, researchers from the Rio de Janeiro Botanical Garden sampled more than 4,500 trees in two 1-ha plots in the area from 1989 to 1993 (Lima & Guedes-Bruni et al. 1997). Despite this substantial sampling effort, neither *M. myriantha* nor *M. stenophylla* were found. After intense fieldwork to find species of Monimiaceae - with five visits to the area of Nova Friburgo - our team managed to discover new individuals of *M. myriantha* and *M. stenophylla* from 2015 to 2019.

Mollinedia stenophylla was found with 49 mature individuals, between staminate and females, and many young individuals, which indicates that the species is reproducing and growing in its habitat. It is a dioecious shrub with blackish-purple fruits, occurring only in old-growth forests on the Macaé river bank (Lírio et al. 2018a). On the other hand, *M. myriantha*, a species first collected by Auguste F. M. Glaziou at 'Alto Macaé' (1892) (#19859 deposited in the herbaria P, K and A) and described by Janet R. Perkins (1900) was rediscovered in the same expedition with a single individual. This rediscovery happened 123 years after of its last collection (E.J. Lírio *et al.* #1196 deposited in RB). The species was located next to roads and residences, out of a fragment of forest (Map 1). The tree was about eight meters tall and had villose leaves, with trichomes concentrated along the rib. Even though the species is dioecious, only one staminate individual was found. It had long masculine inflorescences, and flowers with a flat receptacle. On the other hand, the discovery of a single individual of *M. myriantha* in a disturbed forest edge and its subsequent standing death suggests that this species may occur preferentially in undisturbed forests. Indeed, there is evidence that Monimiaceae species are strongly associated with old-growth forests in Macaé de Cima. For example, in a 1-ha plot placed in a 30-year-old secondary forest, only a single individual of *Mollinedia salicifolia* Perkins (1900: 659) was sampled (Pessoa et al. 1997), while in an old-growth forest plot of the same size, 136 individuals from seven species of Monimiaceae were sampled (Guedes-Bruni et al. 1997).

Mollinedia myriantha was found in the Environmental Protection Area of Macaé de Cima, Nova Friburgo, an extremely important area for conservation, because of the existence of endemic and threatened species (Diniz et al. 2017). An Environmental Protection Area aims to conciliate the conservation of biodiversity with a certain degree of human occupation and a sustainable use of natural resources. Main economic activities in the APA of Macaé de Cima include tourism, cattle raising and small-scale agriculture, and these occupy about 40% of the total area (INEA 2014). Among the 16 species of Monimiaceae found there (Peixoto & Pereira-Moura 1996), seven are endemic to the area, and two had not been recorded since the 19th century (Lírio et al. 2018b).

Integrated studies consisting of field expeditions, taxonomy and status conservation still bring new scientific knowledge of the flora in Brazil. As previously mentioned, field expeditions can change the conservation status of species while taxonomic studies are fundamental for the knowledge of the conservation status. Investments in the assessment of the risk of extinction for the species not included in the IUCN Red List are necessary, as well as the 12 species that have never been assessed at National or global level, and the reassessment of many species evaluated more than 10 years ago. These assessments are important to demonstrate the conservation status of the Monimiaceae family in Brazil, to attract attention to the species threatened with extinction and the priority areas for the conservation of this taxonomic group.

Brazil is the richest country of the world in flora, with 49,993 known species (native, cultivated and naturalized) (Flora do Brasil 2020) and with approximately 18% of its flora assessed at National level (Peixoto et al. 2013; Guimarães et al. 2014; Lirio et al. 2018b; Martins *et al.* 2018, and inedited data in partnership with BGCI, forthcoming). The country has carried out conservation actions including listings of threatened species at global level and Conservation Planning to prevent the extinction of species; however, this work is being compromised due to the reduction of investments in research and conservation of the environment in recent years (Rosa et al. 2018; Escobar *et al.* 2019). Additionally, the Brazilian megadiverse forests are decreasing from habitat conversion/alteration for cattle ranching, fires, mining, and agricultural expansion (Moraes et al. 2014; Mortara et al. 2020). Projects like this, focused on the conservation of Monimiaceae bring significant contributions to the knowledge of the native, endemic and rare flora of the country. It also highlights the importance of investment on field expeditions for mapping the global flora and still collaborating with several national and international goals such as the Convention of Diversity Biological and Global Strategy of Plant Conservation (CBD 2020; Sharrock 2020).

This work shows the importance of targeted fieldwork and herbaria visits for the conservation of rare and endangered plant species and urgent need of conservation actions and monitoring for those species, especially in megadiverse countries such as Brazil. Rare plant species are difficult to find in the wild and without monitoring them, the same outcome that we find here is likely to be repeated. Otherwise, we expect that by doing intense fieldwork focused on this species we have a chance to find other individuals and propose conservation actions such as *ex situ* conservation, seedlings production and reintroduction in the wild. Regarding the perspectives of conservation of the family Monimiaceae in Brazil, we found here that 30% of the assessed species are threatened with extinction and urgent actions are needed to assess the remaining species, propose actions to conserve them and contribute to avoid biodiversity loss in the most diverse plant country.

Declarations

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Figures

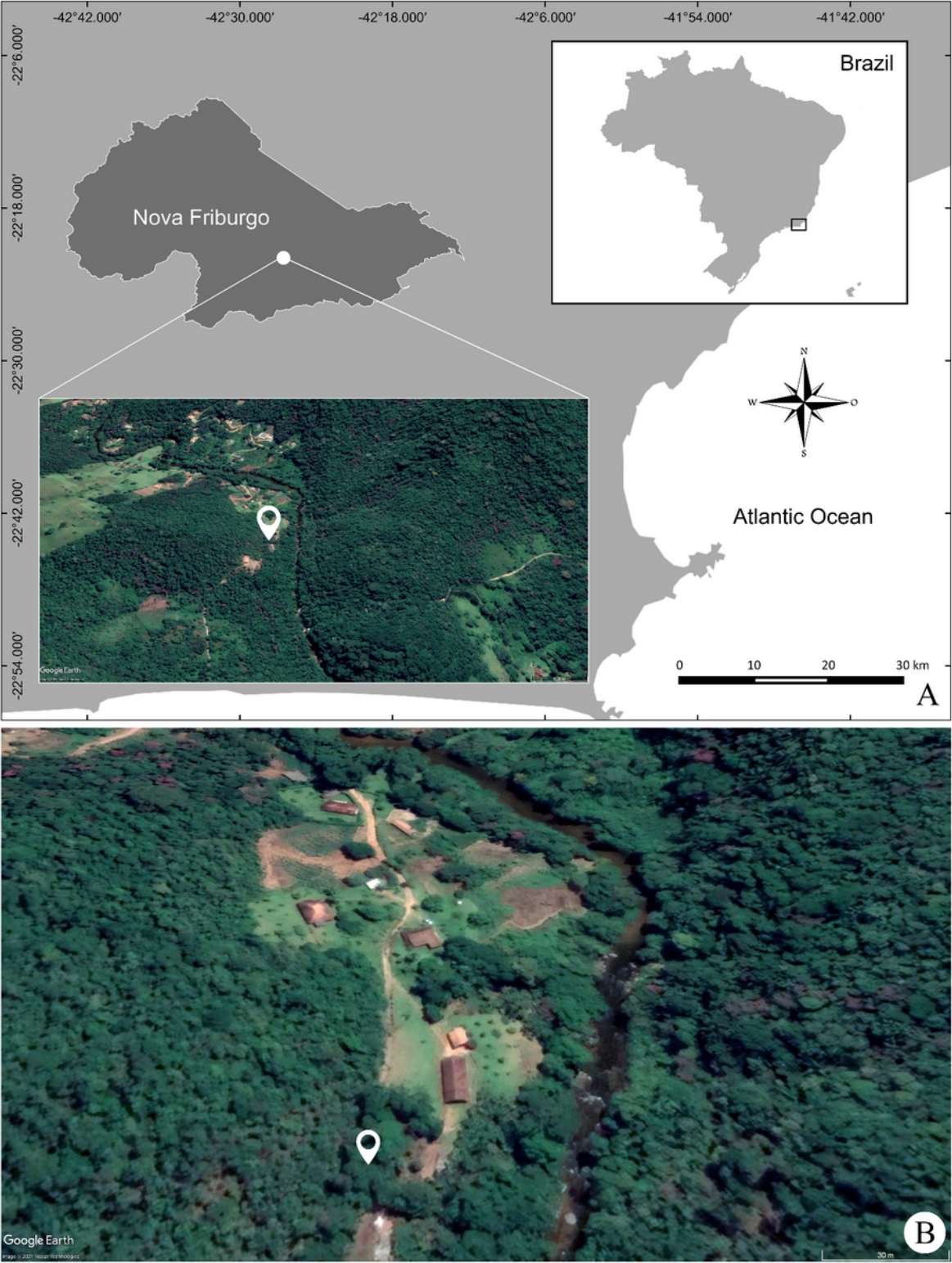


Figure 1

Map of the Geographic distribution. **A** *Mollinedia myriantha* Perkins represented by a white dot in the map and by a white marker icon in the image (Image Google Earth); **B** Detail of the occurrence area of *M. myriantha*.

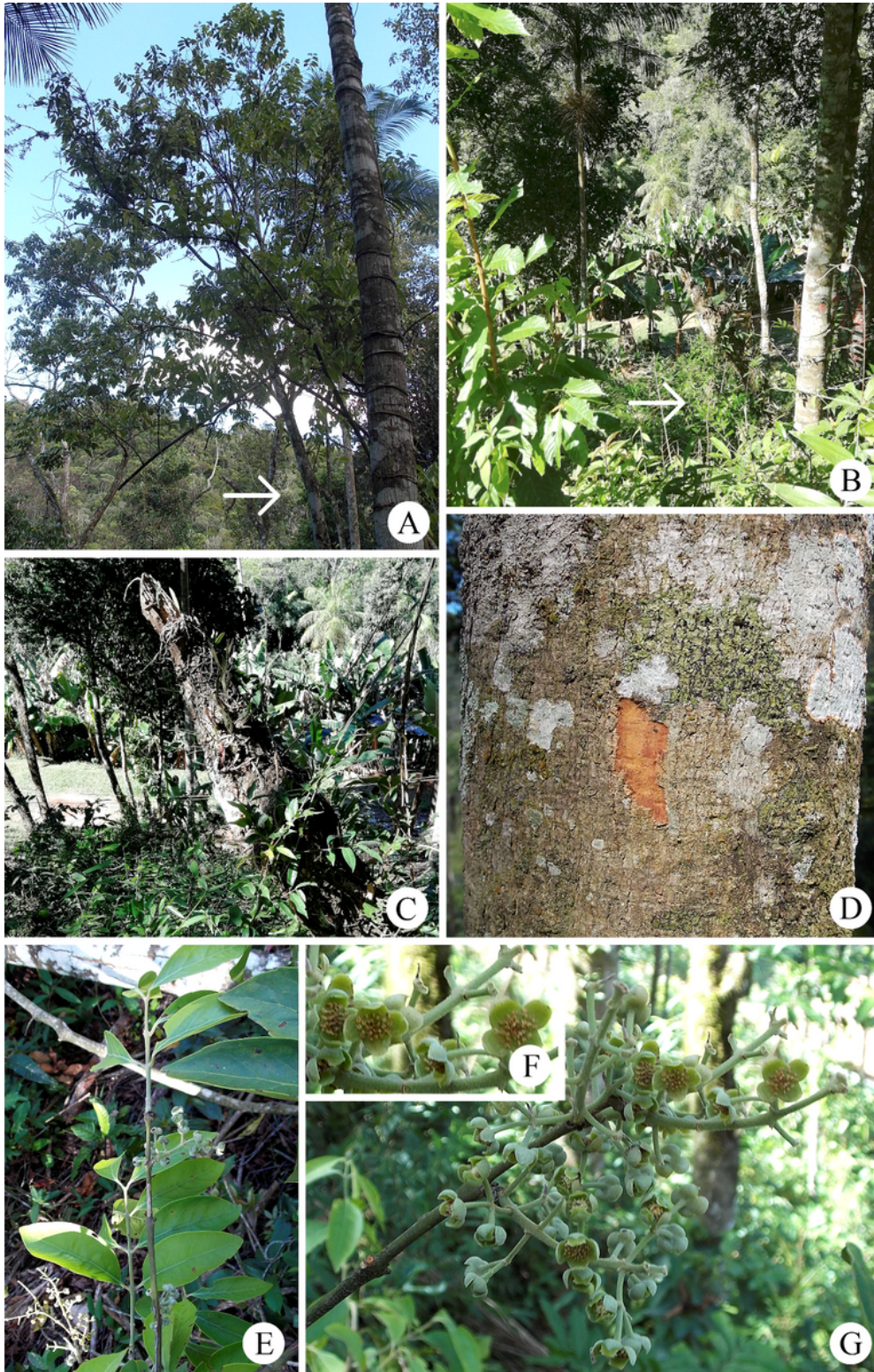


Figure 2

Habitat and morphology of *Mollinedia myriantha* Perkins. **A – B** are the comparison of the individual of *Mollinedia myriantha* found in 2015, alive, and 2018, dead; **C** trunk of the individual; **D** details of the corky bark; **E** branch with leaves of the individual; **F – G** are the staminate yellow-greenish flowers. (E.J. Lírio et al. n. 1196)



Figure 3

Herbaria specimens of *Mollinedia myriantha* Perkins. **A** Type collected in 1892 by *A.F. Glaziov* 19859; **B** – **C** vouchers of the rediscovered individual collected in 2015 by *E.J. Lírío et al.* n. 1196.

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