Nature Conservation 49: 131–136 (2022)
doi: 10.3897/natureconservation.49.89237
https://natureconservation.pensoft.net

LETTER TO THE EDITOR

A peer-reviewed open-access journal
Nature Conservation
Launched to accelerate biodiversity conservation

Cerrado Rupestre is not Campo Rupestre: The unknown and threatened savannah on rocky outcrops

Cássio Cardoso Pereira[1], Geraldo Wilson Fernandes[1]

1 *Programa de Pós-Graduação em Ecologia, Conservação e Manejo da Vida Silvestre, Departamento de Genética, Ecologia e Evolução, Universidade Federal de Minas Gerais, 31270-910, Belo Horizonte, Minas Gerais, Brazil*

Corresponding author: Cássio Cardoso Pereira (cassiocardosopereira@gmail.com)

Academic editor: C. de Castilho | Received 23 June 2022 | Accepted 14 July 2022 | Published 21 July 2022

https://zoobank.org/6F6F2459-578E-457B-B93F-5D15945A600C

Citation: Pereira CC, Fernandes GW (2022) Cerrado Rupestre is not Campo Rupestre: The unknown and threatened savannah on rocky outcrops. Nature Conservation 49: 131–136. https://doi.org/10.3897/natureconservation.49.89237

The Cerrado Domain (Cerrado *sensu lato*) covers about two million km^2 of Brazilian territory and consists of forest, savannah and grassland biomes, having dozens of phytophysiognomies that usually occur in mosaic, varying within this spectrum of different biomes (Ribeiro and Walter 2008; Batalha 2011). Amid so much diversity of species, life forms and geological aspects, some of its phytophysiognomies are not well known, being lost in the wide spectrum of vegetation present in the Cerrado.

In general, the Cerrado is physiognomically characterised by typical savannah vegetation, with a lower occurrence of forest and grassland formations (Ribeiro and Walter 2008; Overbeck et al. 2022). Amongst the savannah phytophysiognomies, the Cerrado *sensu stricto* stands out, the savannah with the greatest biodiversity in the world (Fernandes et al. 2016), which is subdivided into Cerrado Denso, Cerrado Típico, Cerrado Ralo and Cerrado Rupestre, based on the densities of the shrub-tree and subshrub-herbaceous components and substrate properties (Ribeiro and Walter 2008). The first three savannah subdivisions show higher floristic similarity and occur in deep soils with vegetation cover ranging from 70% to 5%, respectively (Ribeiro and Walter 2008).

The Cerrado Rupestre is the rarest and most unknown Cerrado *sensu stricto* subdivision, occurring to a lesser extent in rocky outcrops, mainly in reliefs above 800 m of altitude along the Serra do Espinhaço range (Minas Gerais and Bahia States), in the Central Plateau in Goiás and in the Serra dos Carajás, in the State of Pará. The Cerrado's mountaintops occupy an estimated area of only 7% of the Cerrado Domain (Reatto et al. 1998), where the Cerrado Rupestre often occurs together with the Campo Rupestre, a grassland phytophysiognomy with which it is often confused. Both share the same climate conditions, according to the classification of Köppen, varying from subtropical altitude (Cwb), tropical altitude (Cwa) and humid tropical (Aw), the first two with dry winters and mild summers and the last one hot and humid (Alvares et al. 2013). The soils are litholic and originated from the decomposition of sandstones, iron ores and quartzites. They are poor in nutrients and acids, with low levels of organic matter (Ribeiro and Walter 2008). The vegetation of these rupestrian environments is characterized by the occurrence of species typical of savannah and grassland formations of the Cerrado Domain, but also by restricted species due to the different microhabitats such as cracks, fissures and exposed rocks, providing a high degree of endemism, with several species threatened with extinction (Fernandes et al. 2020).

Although Cerrado Rupestre and Campo Rupestre can occur in mosaics in rocky outcrops (Fig. 1), both on quartzitic soils and on canga (ferruginous soils) (Fig. 2A–D), they differ in the density of shrub-tree and subshrub-herbaceous components (Ribeiro and Walter 2008) and floristically (Fernandes et al. 2020). The Cerrado Rupestre is a savannah phytophysiognomy and presents a tree cover varying from 5% to 20%, an average height of 2 m to 4 m and a highlighted shrub-tree stratum (Fig. 2A, C), while the Campo Rupestre is a grassland phytophysiognomy, with a predominance of an herbaceous-shrub stratum with less than 5% tree cover (Fig. 2B, D). As they are in an ecotone, they share some species, but have floristic differences and many different indicator species. Amongst the indicator species of the Cerrado Rupestre, we can highlight woody species, such as *Mimosa setosissima* Taub., *Tibouchina papyrus* (Pohl) Toledo, *Wunderlichia mirabilis* Riedel ex Baker, amongst others (Ratter et al. 2000; Ribeiro and Walter 2008; Pinto et al. 2009), while for the Campo Rupestre, we can highlight *Coccoloba cereifera* Schwacke, *Comanthera elegantula* (Ruhland) L.R.Parra & Giul., *Paepalanthus bromelioides* Silveira, amongst others (Brazilian Flora 2022).

These floristic and tree cover differences between Cerrado Rupestre and Campo Rupestre can be explained by different microclimatic variables and factors, such as soil depth and amount of exposed rock (Gianotti et al. 2013). Although they can occur in nearby areas, the Campo Rupestre usually occurs at the top of the hill at higher altitudes (Fig. 1) and is significantly distinguished from the Cerrado Rupestre mainly concerning the higher wind speed, lower relative humidity, lower water vapor pressure, and lower thermal amplitude, factors that limit a higher tree cover (Gianotti et al. 2013). In addition, the Campo Rupestre generally presents a more stony and shallow soil. Consequently, the soil texture of the Campo Rupestre is sandier and retains less water than the Cerrado Rupestre, which receives water from the leaching of soluble materials from the rains, accumulating higher contents of organic matter and clay, two elements that have a noticeable influence on the water holding capacity of the soil (Gianotti et al. 2013).

Finally, the plant species in these environments can also vary in their fire resistance (Neves and Conceição 2010). Fire is known to be one of the most important factors in the dynamics of Cerrado plants and these two environments present several species adapted to fire, presenting characteristics, such as thick rhytidome, xylopodia, tubers,

Figure 1. View of a quartzite rocky outcrop showing Cerrado Rupestre (at the bottom of the hill) and Campo Rupestre (top of the hill) vegetation occurring in a mosaic on Serra de São José, Prados, Minas Gerais, Brazil. Photo credit: Cássio Cardoso Pereira.

bulbs, corms and underground rhizomes (Coutinho 1982). However, the Campo Rupestre presents a higher number of species sensitive to the action of fire that survive in rocky areas, where the restriction of fuel prevents the arrival of fire in individuals isolated by the rock. As a result, the invasion of exotic grasses increases fire on mountain tops, putting these species at risk (Neves and Conceição 2010).

However, despite being side by side in the same environment, occupying less than 2% of the national territory, harbouring about 1/3 of the plant biodiversity, being a cradle of Brazilian waters and suffering the same type of threats, mainly due to economic activities, such as livestock and mining (Reatto et al. 1998; Silveira et al. 2016), the Cerrado Rupestre remains even more unknown and neglected than the Campo Rupestre. In a survey in the SCOPUS and Web of Science databases, searched by the names "Campo Rupestre" and "Cerrado Rupestre" in the title, abstract and keywords, 808 publications were found about Campo Rupestre and only 35 about Cerrado Rupestre between 1989 and 2022. Could it be that part of the work with rocky outcrops considered the vegetation to be from Campo Rupestre without taking into account its differences with the Cerrado Rupestre? Or could part of the work carried out in the Cerrado Rupestre environment have been indistinguishable from the Cerrado *sensu stricto*? In any case and regardless of the physiognomic nomenclature used, publications about Cerrado Rupestre are scarce and mostly restricted to floristic works, lacking information on local fauna, ecological interactions, ecosystem services, restoration and conservation (Pereira et al. 2022).

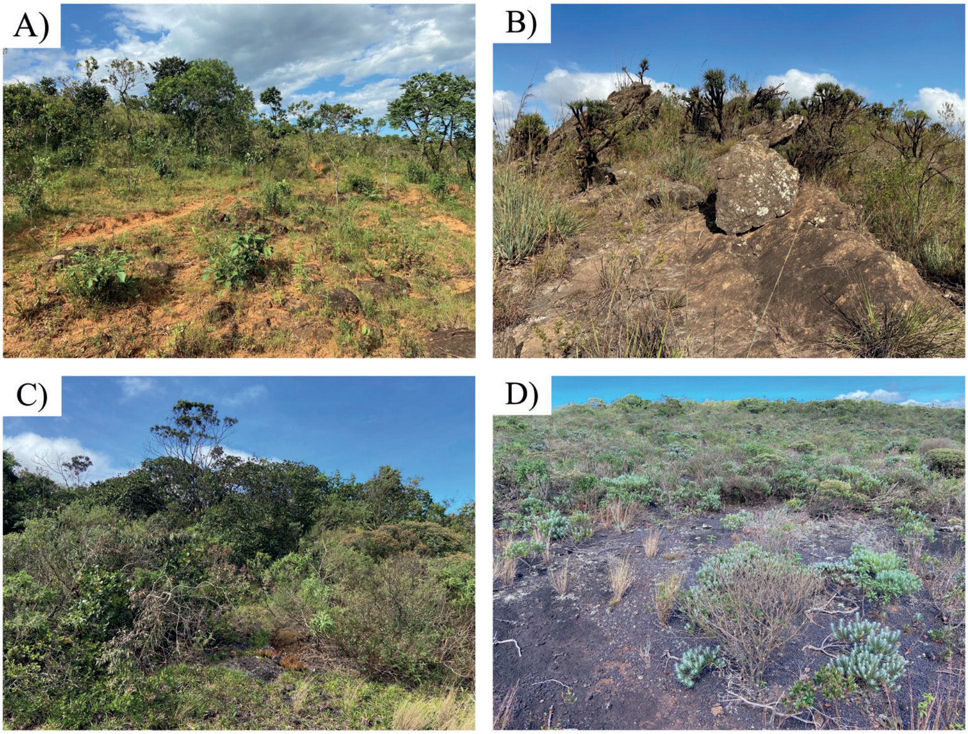

Figure 2. Phytophysiognomic differences between Cerrado Rupestre and Campo Rupestre. Although they can occur in mosaics on rocky outcrops, both on quartzitic soils (**A** and **B**) and on canga (ferruginous soils, **C** and **D**), the Cerrado Rupestre is a savannah phytophysiognomy and presents a tree cover between 5 and 20%, while the Campo Rupestre is a grassland phytophysiognomy, with a predominance of a herbaceous-shrubby stratum with less than 5% tree cover **A** Cerrado Rupestre over quartzitic soil in the Municipality of Congonhas, Minas Gerais, Brazil **B** Campo Rupestre over quartzitic soil in Serra do Ouro Branco State Park, Ouro Branco, Minas Gerais, Brazil. Cerrado Rupestre (**C**) and Campo Rupestre (**D**) on canga soil in Serra do Rola Moça State Park, Nova Lima, Minas Gerais, Brazil. Photo credits: Cássio Cardoso Pereira.

Restoring rupestrian environments is fundamental, but represents a major challenge, as we still do not know how to restore these ecosystems, which are often considered degraded forests by decision-makers (Veldman et al. 2019). As a result, many restoration actions in these areas mistakenly use tree planting (Veldman et al. 2019). Furthermore, the recovery of these rupestrian environments after a disturbance is extremely slow (Le Stradic et al. 2014). In Cerrado Rupestre, after use for pasture or forestry, there is a successful recovery of the tree component, but the native subshrub-herbaceous layer does not recover (Overbeck et al. 2022). This characteristic is very alarming because there are practically no seeds of native species on the seed market. Therefore, it is still very challenging to restore these ecosystems (Veldman et al. 2019).

Studies show that these environments may disappear in the coming decades due to ever-growing agribusiness and mining practices that replace native vegetation with extensive areas of monoculture, livestock and ore extraction (Fernandes et al. 2016;

Fernandes et al. 2018). Furthermore, we cannot forget that these environments are also being impacted by global warming (for example, increasing temperatures, fire frequency and changes in the amount of rainfall), which have been affecting the reproductive success of plants (Vilela et al. 2017) and indirectly affecting the dynamics of communities (Memmott et al. 2007). Unfortunately, this scenario has been intensifying frighteningly in recent years. Coupled with the need for more studies to better understand these environments and restore them, there is an urgent demand to expand the current shameful 8.21% of legally protected areas in the Brazilian Cerrado (Pereira and Fernandes 2022), so that the Cerrado Rupestre can be properly studied before it will be destroyed.

References

Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM, Sparovek G (2013) Köppen's climate classification map for Brazil. Meteorologische Zeitschrift 22(6): 711–728. https://doi.org/10.1127/0941-2948/2013/0507

Batalha MA (2011) The Brazilian Cerrado is not a biome. Biota Neotropica 11(1): 21–24. https://doi.org/10.1590/S1676-06032011000100001

Brazilian Flora (2022) Brazilian Flora. http://floradobrasil.jbrj.gov.br/

Coutinho LM (1982) Ecological effects of fire in Brazilian cerrado. In: Huntley BJ, Walker BH (Eds) Ecology of tropical savanas. Springer, Berlin, 273–291. https://doi.org/10.1007/978-3-642-68786-0_13

Fernandes GW, Coelho MS, Machado RB, Ferreira ME, Aguiar LMS, Dirzo R, Scariot A, Lopes CR (2016) Afforestation of savannas: An impending ecological disaster. Perspectives in Ecology and Conservation 14(2): 146–151. https://doi.org/10.1016/j.ncon.2016.08.002

Fernandes GW, Barbosa NPU, Alberton B, Barbieri A, Dirzo R, Goulart F, Guerra TJ, Morellato LPC, Solar RRC (2018) The deadly route to collapse and the uncertain fate of Brazilian rupestrian grasslands. Biodiversity and Conservation 27(10): 2587–2603. https://doi.org/10.1007/s10531-018-1556-4

Fernandes GW, Bahia TDO, Almeida HA, Conceição AA, Loureiro CG, Luz GR, Neves ACO, Oki Y, Pereira GCN, Pirani JR, Viana PL, Negreiros D (2020) Floristic and functional identity of rupestrian grasslands as a subsidy for environmental restoration and policy. Ecological Complexity 43: 100833. https://doi.org/10.1016/j.ecocom.2020.100833

Gianotti ARDC, Souza MJHD, Machado ELM, Pereira IM, Vieira AD, Magalhães MR (2013) Análise microclimática em duas fitofisionomias do cerrado no alto Vale do Jequitinhonha, Minas Gerais. Revista Brasileira de Meteorologia 28(3): 246–256. https://doi.org/10.1590/S0102-77862013000300002

Le Stradic S, Buisson E, Fernandes GW (2014) Restoration of Neotropical grasslands degraded by quarrying using hay transfer. Applied Vegetation Science 17(3): 482–492. https://doi.org/10.1111/avsc.12074

Memmott J, Craze PG, Waser NM, Price MV (2007) Global warming and the disruption of plant-pollinator interactions. Ecology Letters 10(8): 710–717. https://doi.org/10.1111/j.1461-0248.2007.01061.x

Neves SPS, Conceição AA (2010) Campo rupestre recém-queimado na Chapada Diamantina, Bahia, Brasil: Plantas de rebrota e sementes, com espécies endêmicas na rocha. Acta Botanica Brasílica 24(3): 697–707. https://doi.org/10.1590/S0102-33062010000300013

Overbeck GE, Vélez-Martin E, da Silva Menezes L, Anand M, Baeza S, Carlucci MB, Dechoum MS, Durigan G, Fidelis A, Guido A, Moro MF, Munhoz CBR, Reginato M, Rodrigues RS, Rosenfield MF, Sampaio AB, Silva FHB, Silveira FAO, Sosinski Jr EE, Staude IE, Temperton VM, Turchetto C, Veldman JW, Viana PL, Zappi DC, Müller SC (2022) Placing Brazil's grasslands and savannas on the map of science and conservation. Perspectives in Plant Ecology, Evolution and Systematics 53: 125687. https://doi.org/10.1016/j.ppees.2022.125687

Pereira CC, Fernandes GW (2022) Cerrado conservation is key to the water crisis. Science 377(6603): 270–270. https://doi.org/10.1126/science.add4719

Pereira CC, Arruda DM, Santos Soares FF, Fonseca RS (2022) The importance of pollination and dispersal syndromes for the conservation of Cerrado Rupestre fragments on ironstone outcrops immersed in an agricultural landscape. Neotropical Biology and Conservation 17(1): 87–102. https://doi.org/10.3897/neotropical.17.e79247

Pinto JRR, Lenza E, Pinto AS (2009) Composição florística e estrutura da vegetação arbustivo-arbórea em um cerrado rupestre, Cocalzinho de Goiás, Goiás. Brazilian Journal of Botany 32(1): 1–10. https://doi.org/10.1590/S0100-84042009000100002

Ratter JA, Bridgewater S, Ribeiro JF, Dias TAB, Silva MR (2000) Estudo preliminar da distribuição das espécies lenhosas da fitofisionomia cerrado sentido restrito nos estados compreendidos pelo bioma Cerrado. Boletim Herbário Ezechias Paulo Heringer 5: 5–43.

Reatto A, Correia JR, Spera ST (1998) Solos do Bioma do Cerrado: aspectos pedológicos. In: Sano SM, Almeida SP (Eds) Cerrado: ambiente e flora. Embrapa/CPAC, Planaltina, 47–86.

Ribeiro JF, Walter BMT (2008) As principais fitofisionomias do bioma Cerrado. In: Sano SM, Ameida SP, Ribeiro JF (Eds) Cerrado: Ecologia e Flora. Embrapa-CPAC, Planaltina, 151–212.

Silveira FAO, Negreiros D, Barbosa NPU, Buisson E, Carmo FF, Carstensen DW, Conceição AA, Cornelissen TG, Echternacht L, Fernandes GW, Garcia QS, Guerra TJ, Jacobi CM, Lemos-Filho JP, Le Stradic S, Morellato LPC, Neves FS, Oliveira RS, Schaefer CE, Viana PL, Lambers H (2016) Ecology and evolution of plant diversity in the endangered campo rupestre: A neglected conservation priority. Plant and Soil 403(1): 129–152. https://doi.org/10.1007/s11104-015-2637-8

Veldman JW, Aleman JC, Alvarado ST, Anderson TM, Archibald S, Bond WJ, Boutton TW, Buchmann N, Buisson E, Canadell JG, Dechoum MS, Diaz-Toribio MH, Durigan G, Ewel JJ, Fernandes GW, Fidelis A, Fleischmann F, Good SP, Griffith DM, Hermann JM, Hoffmann WA, Le Stradic S, Lehmann CER, Mahy G, Nerlekar AN, Nippert JB, Noss RF, Osborne CP, Overbeck GE, Parr CL, Pausas JG, Pennington RT, Perring MP, Putz FE, Ratnam J, Sankaran M, Schmidt IB, Schmitt CB, Silveira FAO, Staver AC, Stevens N, Still C, Stromberg CAE, Temperton VM, Varner JM, Zaloumis NP (2019) Comment on "The global tree restoration potential". Science 366(6463): eaay7976. https://doiorg/101126/scienceaay7976

Vilela AA, Del-Claro VTS, Torezam-Silingardi HM, Del-Claro K (2017) Climate changes affecting biotic interactions, phenology, and reproductive success in a savanna community over a 10-year period. Arthropod-Plant Interactions 12(2): 215–227. https://doi.org/10.1007/s11829-017-9572-y