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Natural Vegetation of Mountainous Environments: Morraria do Urucum and Serra do Amolar, Pantanal, Brazil

Vegetação Natural de Ambientes Montanhosos: Morraria do Urucum e Serra do Amolar, Pantanal, Brasil

Vegetación Natural de Entornos de Montaña: Morraria do Urucum y Serra do Amolar, Pantanal, Brasil

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Abstract: Mountainous environments are considered unique habitats with distinct ecosystem characteristics. Therefore, more studies must understand and characterize these habitats to improve their preservation. Therefore, this paper aims to characterize two mountainous areas in Central Brazil, Morraria do Urucum and Serra do Amolar to address a discussion about the '*Campos de Altitude*' (altitude grasslands) vegetation above 700 m altitude. Differently from Serra do Amolar, Morraria do Urucum does not have Conservation Units in its territory, raising concerns related to its preservation. Actions are urgent to prevent the loss of mountainous biodiversity, but these must reflect ecological properties and successional processes and, therefore, allow adequate management practices.
Keywords: Conservation, Altitude Grasslands, Wetlands, Mountainous Ecosystems.

Resumo: Os ambientes montanhosos são considerados um habitat único com características ecossistêmicas distintas. Portanto, necessita-se mais estudos para entender e caracterizar esses habitats para sua preservação. Por conta disso, esta pesquisa teve como objetivo caracterizar duas áreas montanhosas, a Morraria do Urucum e a Serra do Amolar, a fim de discutir sobre os Campos de Altitude (vegetação montanhosa) presentes acima de 700 m de altitude. Diferentemente da Serra do Amolar, a Morraria do Urucum não possui Unidades de Conservação em seu território, levantando preocupações sobre sua preservação. Ações de conservação são urgentes para prevenir a perda da biodiversidade dos Campos de Altitude, mas estas ações devem refletir propriedades ecológicas e processos sucessionais e, portanto, permitir práticas de manejo adequadas.
Palavras-chave: Conservação, Campos de Altitude, Áreas Úmidas, Ecossistemas Montanhosos.

Resumen: Los entornos montañosos se consideran un hábitat único con características ecosistémicas diferenciadas. Por lo tanto, se necesitan más estudios para comprender y caracterizar estos hábitats para su preservación. Por esta razón, esta investigación tuvo como objetivo caracterizar dos zonas montañosas, la Morraria do Urucum y la Serra do Amolar, con el fin de discutir los Campos de Altitud (vegetación de montaña) presentes por encima de los 700 m de altitud. A diferencia de la Serra do Amolar, la Morraria do Urucum no cuenta con Unidades de Conservación en su territorio, lo que hace temer por su preservación. Se necesitan urgentemente acciones de conservación para evitar la pérdida de biodiversidad en los Campos de Altitud, pero estas acciones deben reflejar las propiedades ecológicas y los procesos sucesionales y, por lo tanto, permitir prácticas de gestión adecuadas.
Palabras clave: Conservación, Campos de Altitud, Humedales, Coinas, Ecosistemas de montaña.

INTRODUCTION

Tropical mountain ecosystems are considered vulnerable to climate change due to the large percentage of endemic flora with limited distributions that are sometimes restricted to a single mountain range (Kattan *et al.*, 2004; Ramirez-Villegas *et al.*, 2014). Plant species restricted to certain altitudinal distribution ranges must have narrow habitat tolerances to those ranges in the elevation profile. High rates of loss and renewal of plant species are expected with the warming of the climate in mountain ecosystems (Ramirez-Villegas *et al.*, 2014), mainly in tropical zones where the climate undergoes greater changes, and with the expectation that 60% of the flora may be lost or seriously threatened by 2050 (Leon-Garcia & Lasso, 2019).

In 1992, the United Nations Conference on Environment and Development took place in Rio de Janeiro, Brazil, in which a series of issues related to sustainable development was addressed as a means of reducing human-induced environmental degradation/degradation, characterized by a document called '*Agenda 21*' (UN, 1992; Beniston, 2003). This document, especially chapter 13, is dedicated exclusively to mountainous regions and describes the importance of conserving these environments. There, for the first time, there is an official and explicit recognition that mountains and plateaus are an important component of the global environment, stating that there is an expressed concern for the conservation of these habitats, illustrating the scenario of decline in the general environmental quality of many mountains (Beniston, 2003; Dimitrovska *et al.*, 2015). An excerpt from Chapter 13 of Agenda 21 stated:

> Mountains are important sources of water, energy, minerals, forest and agricultural products, and recreation areas. They are storehouses of biological diversity, home to endangered species, and an essential part of the global ecosystem. Most mountainous areas are suffering from environmental degradation (UN, 1992, Chapter 13).

The management of natural resources in mountainous environments emerges as one of the most significant challenges for human understanding and organizational capacity in the current century. Mountains and plateaus constitute a small portion of the Earth's surface, around 20%, however, it is difficult to find an area that is not affected or under the influence of mountainous environmental characteristics (Bandyopadhyay, 1989; Biswas *et al.*, 2012; Dimitrovska *et al.*, 2015). Since the 20th century, it has been observed that the human impact on mountain environments has increased considerably, and these interventions have a direct impact causing disturbance to these natural habitats. The negative impact of such interventions is due to the relatively low level of understanding of the ecosystem particularities of the mountain habitat (Bandyopadhyay, 1989).

Mountain environments are sources of fresh water, hydroelectric power, alluvial enrichment of floodplain soils, and ecotourism, functioning as reservoirs of unique biodiversity (Biswas *et al.*, 2012; Viviroli *et al.*, 2007; Lama & Sattar, 2002). Much of the world's forest remnants are relegated to mountains (Price, 2003; Biswas *et al.*, 2012), and mountain environments become the source of many values related to forest reserves, including timber, non-timber forest products, and ecosystem services (Appanah & Ratman, 1992; Biswas *et al.*, 2012).

Mountainous habitats translate into a wide diversity of ecosystem types, particularly specific forest types present at high altitudes, including forests, savannas, grasslands, rocky outcrop vegetation, and swamps (Scarano, Ceotto & Martinelli, 2016). The vegetation cover of *Campos de Altitude* (grassland mountainous vegetation) is predominantly formed by shrubs, herbs, and grasses in interspersed rocky outcrops, shallow soils, and occasional swamps (Ribeiro, Medina, & Scarano, 2007), and has been the vegetation with higher sensitivity to conversion of use (Pillar, Müller, Castilhos & Jacques, 2009; Barros, 2014).

Among Brazilian plant physiognomies present in mountainous regions, subject to loss of vegetation cover, *Campos de Altitude* is present, in Brazil, in the Atlantic Forest, Amazon, Cerrado, and Pantanal (wetlands) biomes (Scarano, Ceotto, & Martinelli, 2016; Urbanetz *et al.*, 2012; Zucco *et al.*, 2011), in an altitudinal range from 1,200 m to 3,000 m. There are also '*Campos Rupestres*' in higher altitudes within the Cerrado biome ranging from 1,000 to 2,000 m (Scarano, Ceotto & Martinelli, 2016; Fernandes *et al.* 2014; Zucco *et al.*, 2011).

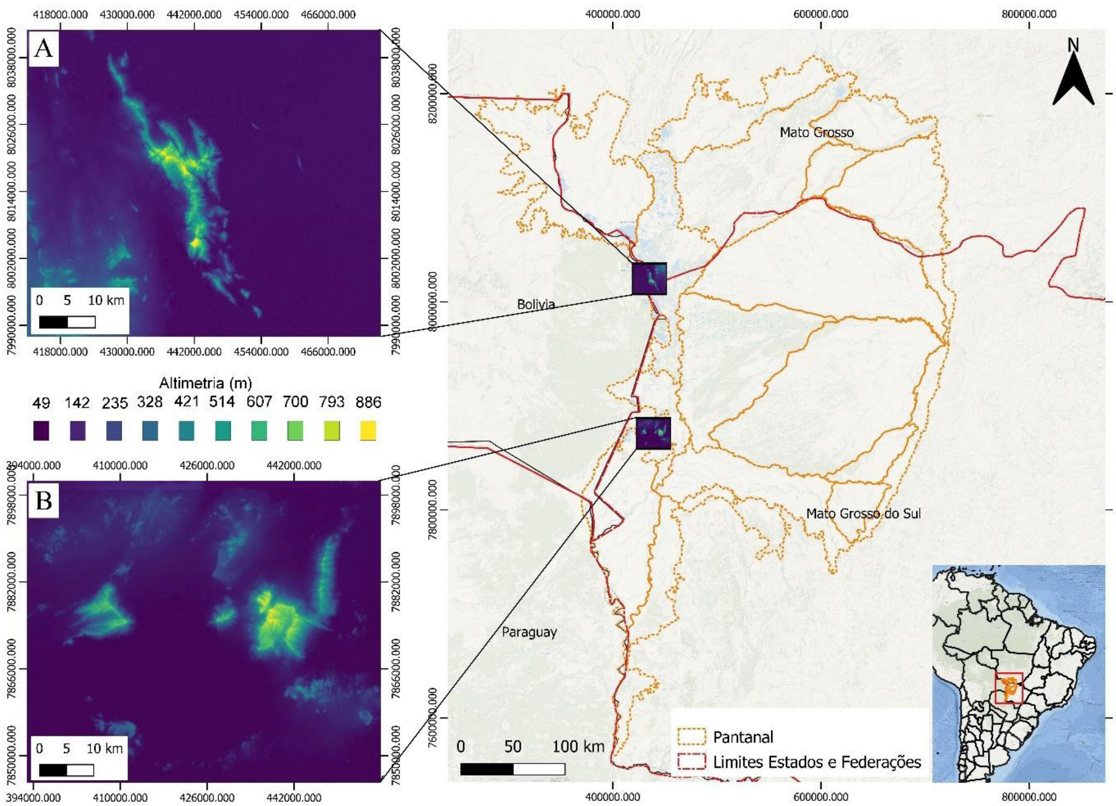
Among the priority actions of the National Program for Research and Conservation in Mountain Ecosystems (CONABIO, 2008) is to promote long-term studies for monitoring mountain ecosystems. Currently, within the Sustainable Development Goals (SDGs), there is a specific target for mountains, objective 15.4 targets until 2030 to ensure the conservation of mountain ecosystems, including their biodiversity, and improve their capacity to provide benefits essential for sustainable development. Compiling this work will help relevant stakeholders, such as environmental agencies, prioritize their environmental monitoring activities, and decision-making actors in the country for sustainable environmental development for mountainous regions.

Considering the importance of the conservation of this rare mountainous environment in the Brazilian Pantanal region, this work aimed to synthesize the existing knowledge and write a historical-bibliographical review of the Morraria do Urucum and the Serra do Amolar vegetation.

METHODOLOGY

We use qualitative and descriptive methods whose approach consisted of a bibliographical survey of information from the two important mountainous areas in Brazilian Pantanal, Serra do Amolar and Morraria do Urucum (Figure 1). For this purpose, Google Scholar, SciElo, Science Direct, Mendeley, and Scopus were used to search for material, using the combined keywords "*Campos de Altitude*" or "Serra do Amolar", or "Morraria do Urucum", followed by the word either "altitude vegetation", or "Pantanal", or "mountain ecosystems", including all information published up to 2022. Each document was peer-reviewed to discard those that are not directly related to the topic. For this study, it was filtered 1,006 documents containing information relevant to the topic and 120 were revised for 23 final use. Vegetation classification followed the IBGE (2012).

Figure 1: Location of the studied areas in the Pantanal system, Brazil. A) Serra do Amolar; B) Morraria do Urucum.



Pantanal vector data (Mioto, Paranhos Filho & Albrez, 2012); Vector data of States and municipalities (IBGE, 2019); Elevation data (TOPODATA, 2018)[1]; UTM SIRGAS 2000, 21S coordinate system.

RESULTS AND DISCUSSION

Serra do Amolar

The western region of the Brazilian Pantanal is characterized by the occurrence of landscape units that are repeated along the Paraguay River. These units are composed of hills of residual relief such as the Urucum and Amolar hills, flanked by large lakes, which are regionally known as bays, and by the floodplain (Damasceno Júnior, 2005).

The Pantanal complex is inserted in the Brazilian, Bolivian, and, to a lesser extent, Paraguayan territories (Mioto, Paranhos Filho & Albrez, 2012), characterized as a plain (Damasceno Júnior, 2005), with an approximate area of 140,640 km² (Mioto, Paranhos Filho & Albrez, 2012). In Brazil, it is largely located in the Brazilian Midwest region, covering approximately 132,768 km², in Bolivia with 7,515 km², and in Paraguay, with the smallest area, 356 km². The Pantanal is an integral part of the BAP (Upper Paraguay River Basin), which has an area of 361,666 km² in Brazilian territory, divided into Plateau (64%) and

1 Geomorphometric database for Brazil. Local geomorphometric variables. São José dos Campos: INPE.

Pantanal Plain (36%) (Silva & Abdon, 1998). The Upper Paraguay Basin has its boundaries demarcated by various elevation systems of the Pantanal plateau, such as plateaus, mountain ranges, and hills (Rabelo *et al.*, 2012; Damasceno Júnior, 2005; Magalhães, 1992). Some examples are Chapada dos Guimarães, Serra de Maracajú, Morraria do Urucum, Serra do Amolar, and Bodoquena. The plain is composed of several rivers, such as the Cuiabá, Piquiri, Taquari, Paraguai, and Aquidauana, all of which belong to the BAP (Rabelo *et al.*, 2012). For all these characteristics, the Pantanal is considered one of the largest continuous wetlands on the planet (Pearson & Beletsky, 2005). Among all the elevation systems of the Pantanal plateau, Serra do Amolar is one of the most important areas.

Serra do Amolar presents diverse elements in terms of flora, edaphic, climate, topography, and aspects ranging from the number of water bodies (drainage) to the surrounding formations (Rabelo *et al.*, 2012). It is in a sub-region of the Pantanal called Paraguay, due to the presence of the Paraguay River, which runs through the west of the Pantanal, the same region where Serra do Amolar is located (Silva & Abdon, 1998; Junk *et al.*, 2006), adding the areas of the municipalities of Corumbá and Ladário, MS. The area of this sub-region comprises 8,147 km², representing about 6% of the Brazilian Pantanal and bordering Bolivia (Rabelo *et al.*, 2012). Serra do Amolar is located about 180 km from the municipality of Corumbá and continues the mountain ridges oriented in a southeast and northwest direction, extending for another 40 km along the border with Bolivia, until it reaches the border with the State of Mato Grosso (Figure 1A).

Its hillocks have Precambrian origins, and function as a geological control of the fluvial flow of the Pantanal and play an important role in the intricate ecological network that integrates rivers, plains, and biotic communities (Collischonn *et al.*, 2005; Zucco *et al.*, 2011). The highest point in Serra do Amolar is called *Pico do Amolar*, with an altitude of approximately 900 m (Figure 2). The peculiar characteristic of this region is the presence of this relatively isolated mountainous formation associated with the influences of the Paraguay River, and with specific vegetation at the highest points, *Campos de Altitude*, which has previously been named and classified by other authors (Alves *et al*., 2014) as "*Campos Rupestres*". According to Alves *et al*. (2014), *Campos Rupestres* are a complex type of vegetation endemic to Brazil, azonal, neotropical, inserted in a matrix of zonal vegetation, being mainly inserted in the Cerrado and Caatinga biomes (Southeast, Northeast, and Center-West regions), being present mainly in an altimetric profile above 900 m altitude, up to altitudes above 2,000 m.

Figure 2: Image taken by the real-time monitoring camera of *Instituto Homem Pantaneiro* on the highest peak of Serra do Amolar. These images present a vegetation mosaic of environments ranging from *Campo Sujo de Cerrado* to *Campos Rupestres* with the presence of *Vellozia variabilis* Mart. ex Schult.

Images credit: Instituto Homem Pantaneiro (IHP).

The climatic characteristics of the site are collected by a rainfall station installed by the CPRM (Mineral Resources Research Company) and currently maintained by the ANA (National Water Agency), inserted in the Amolar community, located 9 km upstream of the Private Natural Heritage Reserve *RPPN Engenheiro Eliezer Batista* (6 km of linear distance). It was installed in 1968, but it presents a continuous and faultless multi-year series only for the period from 1995 to 2007 (Zucco *et al.*, 2011). The climate in the mountain region is typical of the tropics, with very hot and humid summers, abundant rainfall between the months of October and March (monthly averages of 300 mm), and a dry period in winter between the months of April and September (monthly averages of 100 mm), average temperatures between 25ºC and reaching 40ºC (Zucco *et al.*, 2011).

The sedimentary aspects of Serra do Amolar predominantly have Quaternary sediments, which occupy approximately 80% of the total area of Serra do Amolar. The highlands and hills are formed by sedimentary units of conglomerates and sandstones, which are preferably located in the Center-North portion, forming morphologically elongated ridges with a Northwest-Southeast direction. Extensive detrital deposits of the colluvial type border the hills, preferably on the edge of the hills, where the configuration of a rocky escarpment can be seen at the top of the sequences. In the domain of hillocks, sandstones with intercalations of conglomerates also occur (Zucco *et al.*, 2011). The sedimentation of the Urucum Formation type found largely in Serra do Amolar, dates from the Precambrian period and occurred in climatic conditions different from those of today and prior to tectonic processes such as the uplift of the Andean chain (Zucco *et al.*, 2011).

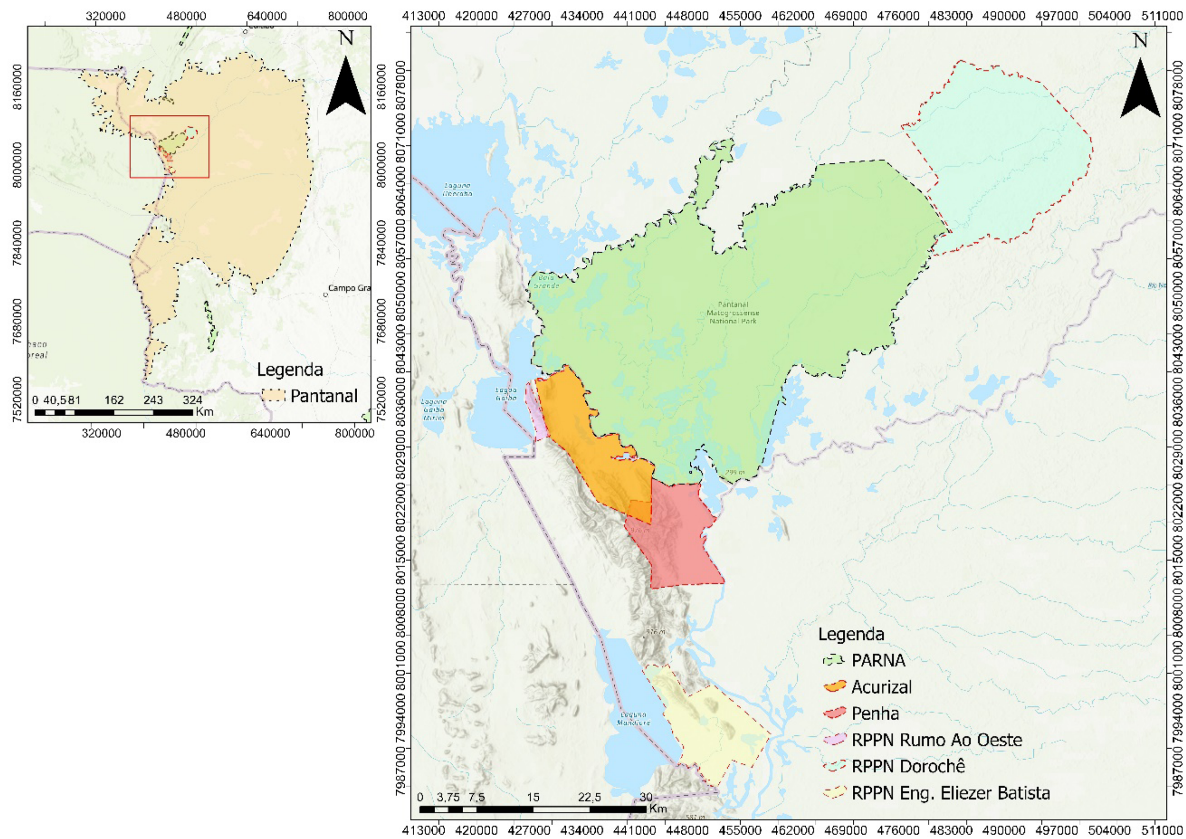
Serra do Amolar has a wide protection network (Figure 3), with an approximate total area of 272,952 hectares (Moreira, 2011). It comprehends a National Park and several private preservation areas as RPPN, which is defined by the SNUC (National System of Conservation Units) as "*a private area, recorded in perpetuity, with the objective of conserving biological diversity*". In these areas, only scientific research activities and visits for tourist, recreational, and educational purposes are allowed[2]:

- RPPN Engenheiro Eliezer Batista (W 57º18'29", S 18º05'26"), about 20,000 hectares managed by Instituto Homem Pantaneiro;
- RPPNs that are owned and managed by the Ecotropica Foundation (Ecotropica, 2003; Moreira, 2011):

Rumo ao Oeste (W 57º38'35", S 17º49'52") - 900 hectares;
Penha (W 57º30'09", S 17º54'34") - 13,100 hectares;
Acurizal (W 57º33'13", S 17º49'52") - 13,200 hectares;
Estância Dorochê (W 17°27'08", S 57°01'28") - 26,500 hectares.

- The Pantanal Matogrossense National Park (W 57º24'11", S 17º50'47") is a 135,000-restricted area managed by ICMBio (Chico Mendes Institute for Biodiversity Conservation).

Figure 3: Serra do Amolar Protection and Conservation Network



Source: Biome vector data: IBGE (2019). Vector Data Conservation Units ICMBio (2020).

2 https://www.planalto.gov.br/ccivil_03/leis/l9985.htm#:~:text=LEI%20No%209.985%2C%20DE%2018%20DE%20JULHO%20DE%202000.&text=Regulamenta%20o%20art.%20225%2C%20%C2%A7,Natureza%20e%20d%C3%A1%20outras%20provid%C3%AAncias

Morraria do Urucum

Morraria do Urucum is located on the outskirts of the city of Corumbá, in the west of the state of Mato Grosso do Sul, at coordinates 19°13'18.92" S and 57°35'8.12" W (Figure 1B).

The altitude of Morraria do Urucum varies from 100 m to 1,065 m (Morro Santa Cruz is the highest point of Morraria do Urucum) (Neves & Damasceno Júnior, 2011). A part of the Morraria do Urucum area has been mined for decades, being carried out by Mineração Urucum, a Vale group company (Freitas, 2010).

The climate of the region is type Koeppen Aw. The average annual temperature is around 25.1°C, with 30.6°C average in the hottest month and 19.8°C in the coldest month. The absolute maximum temperature reaches around 40°C from October to January, and the absolute minimum is close to 0°C from May to August. Annual rainfall is around 1,070 mm with an annual water deficit of 318 mm (Urbanetz *et al.*, 2012). Morro São Domingos presents a tabular structural surface with steep edges in which the bedrock is mainly composed of Precambrian lithologies from the Jacadigo Group, Urucum Formation (Franco & Pinheiro, 1982; Urbanetz *et al.*, 2012). According to Urbanetz *et al.* (2012), some of the soils found in Morraria do Urucum are Planosol (at 100 m altitude), Eutrophic Argisol (at 200 m altitude), Dystrophic Cambisol (between 300 m and 500 m altitude), and Eutrophic Neosol (above 700 m altitude).

The limestone hills of Corumbá, MS, Brazil, together with the Morraria do Urucum, are formations of residual hills located along the border with Bolivia, west of the Paraguay River, with a maximum altitude of up to 1,060 m recorded by Tomas *et al.* (2010), constituting the highest point in Mato Grosso do Sul, covering an area of approximately 1,311 km (Silva *et al.*, 2000; Tomas *et al.*, 2010). As highlighted by Tomas *et al.* (2010), the Morraria do Urucum region is unique in Brazil in several ways, depending on the influences it receives from neighboring ecosystems, the endemism present, and the occurrence of species with a restricted distribution.

The specific richness in some taxonomic groups is considerable when compared to others in the territory of Mato Grosso do Sul. Similar with the widespread lack of knowledge about fungi, lichens, invertebrates, speleofauna, ichthyofauna, algae, and bryophytes, in mountainous areas of Mato Grosso do Sul there are a lack of detailed surveys. Therefore, without a more complete assessment of the region's biodiversity, it ends up enormously limiting the assessment of the impacts of anthropic activities and the definition of conservation strategies (Tomas *et al.*, 2010).

The vegetation typology that is observed in Morraria do Urucum varies from Seasonal Deciduous Forest at about 100 m of altitude, Seasonal Semideciduous Forest from 400 m altitude, and *Campos de Altitude* at the top of the hills at 1,000 altitude) (Neves & Damasceno Júnior, 2011; Damasceno Júnior, 2005), as well as Seasonal Deciduous Forest in limestone areas (Tomas *et al.*, 2010; Urbanetz *et al.*, 2012; Lima *et al.*, 2019). There are also gradations with Evergreen Forest and Gallery Woodlands and a narrow strip of Cerrado in the transition to *Campos de Altitude*. There are small islands of xerophytic vegetation in lateritic stands located at the foot of Morraria do Urucum and on some slopes (Figure 4). The composition of the flora and fauna of the region has elements from the Chaco (wetlands), the Cerrado biome, and the Amazon biome, and the botanical richness of the area is high, with more than 973 species from 116 families (Pott *et al.*, 2000; Tomas *et al.*, 2010), justified mainly by the wide variety of Phytophysiognomies. *Campos de Altitude* are present in the Morraria do Urucum according to the survey and cataloging of studies carried out by Urbanetz *et al.* (2012) and Damasceno Júnior *et al.* (2005), where it was numbered 63 species with greater frequency of the botanical family Poaceae of Campos Sujos typologies. Urbanetz *et al.* (2012) found 1,295 individuals belonging to 32 families and 74 species from Fabaceae, Myrtaceae, Rubiaceae, Verbenaceae, among others.

Figure 4: *Campos de Altitude* distributed in an altitude zone above 700 m in Morraria do Urucum.

Image credit: Vale – Mina Urucum.

Morraria do Urucum does not have Conservation Units. Monitoring these areas enables initiatives for the preservation and conservation of natural resources and the mountainous environment, since the importance of mountainous biodiversity is demonstrated by the presence of endemic species in these areas, which are so scarce in the State of Mato Grosso do Sul.

Studies performed by Sonoda *et al.* (2021) and Pinto *et al.* (2015) show that the Brazilian Pantanal does not have a large area with conservations units, which is something of concern since protected areas are recognized as the main strategy for the *in-situ* conservation of biodiversity (Sonoda *et al.*, 2021; Chape *et al.*, 2005). The establishment of protected areas is an important action for valuing and maintaining the environment and existing natural resources, and Sonoda *et al.* (2021) reaffirm that protected areas, in addition to being essential for the conservation of biodiversity, are vital to responding to emerging challenges, such as water protection, health, disaster risk reduction, and climate change.

Therefore, the Morraria do Urucum deserves special attention regarding its conservation, either through public policies in the creation of Conservation Units, or through scientific study initiatives that demonstrate the endemic biodiversity of these regions and its role in maintaining the Pantanal ecosystem.

Campos de Altitude

Natural mountain environments usually differ from their surroundings, due to the different environmental characteristics of these habitats, such as the soil and climate, directly reflecting on the characteristics of the flora and fauna. Many of these areas have rural environments, especially in mountain areas, or plateaus, which receive different names in Portuguese, such as *Campos de Altitude*, *Altimontanos*, *Campos Rupestres*, or *Páramos* (Vasconcelos, 2014; Alves *et al*., 2014).

Campos de Altitude are natural ecosystems with a high diversity of plant and animal species (Figure 5). They guarantee important environmental services, such as the conservation of water resources, the availability of pollinators, and the provision of genetic resources. In addition, they harbor high biodiversity and offer scenic beauty with important touristic potential (Pillar, Müller, Castilhos, & Jacques, 2009; Vasconcelos, 2011).

Figure 5: Grassy-herbaceous in Morraria do Urucum: A) *Aristida setifolia* Kunth; B) *Panicum trichoides* Sw.; C) Golden grass - *Axonopus aureus* P.Beauv.; D) Bobó grass - *Ctenium cirrhosum* (Nees) Kunth

In general, *Campos de Altitude* occurs mainly above 900 m of altitude, in mountain ranges whose rocks are of Precambrian origin and that were remodeled by tectonic movements from the Paleogene, being associated mainly with the outcrop of quartzite, sandstone, and iron ore (Vasconcelos, 2011). Brazil presents several other areas already treated as rocky fields, but some are not associated with high altitudes. *Campos de Altitude* are typical of the highest points of mountains that rose mainly during the Cenozoic, being generally located above 1,500 m of altitude, but could also occur above 700 m (Morraria do Urucum and Serra do Amolar), associated with igneous or metamorphic rocks, such as granite and gneiss (Vasconcelos, 2011). Therefore, the name *Campos de Altitude* is the nominal classification given to the countryside vegetation that occurs in the highest parts (above 700 m), however, just as there is the name Campos *Rupestres*, it is also called *Campos de Altitude* of mountains, these habitats are represented by a set of predominantly herbaceous-shrub communities that vary depending on the relief, microclimate, soil depth and the nature of the substrate, which gives these types of vegetation a mosaic character (Alves *et al*., 2007; Rapini *et al*., 2008; Vasconcelos, 2011).

Brazil is among the so-called megadiverse countries (Barthlott *et al*., 1996, Lewinsohn & Prado, 2005; Gomes-Da-Silva *et al*., 2022; Overbeck *et al*., 2007), however there are threats to fauna, flora, and natural landscapes (Brandon *et al*., 2005, Mittermeier *et al*., 2005; Overbeck *et al*., 2007). According to the current official classification of biomes in Brazil (IBGE, 2019), the country has six terrestrial biomes: Amazon Forest, Caatinga, Cerrado, Pantanal, and Pampa, in addition to coastal areas. The *Campos de Altitude* vegetation, also described as grassland vegetation in Brazil, can be found in the Pampa, in the Atlantic Forest, in the Cerrado, and in the Pantanal. This type of vegetation forms mosaics with the forests in the lower part of the altimetric profile, and in the higher areas there is the presence of *Campos de Altitude*. This work offers a review of the ecological characteristics of *Campos de Altitude* and their importance in the context of the Brazilian Pantanal, and their current state of conservation. Grassland vegetation in mountainous regions is still not treated as a priority area for conservation, as well as other non-forest formations in Brazil.

Campos de Altitude deserves more attention from the scientific community, not only for its biological and geological connotation but also for being the first drainage area for the water supply of a large part of the Brazilian population, justifying its preservation. Therefore, the current threats and challenges to its conservation must be studied to list public policies and scientific methods for the conservation of these priority areas, such as the creation of conservation units.

CONCLUSIONS

Aiming at conserving these mountainous habitats, the creation of protected areas in the less rigorous categories, such as Sustainable Use Conservation Units which only allow low-impact land use, would, therefore, be more appropriate and effective than areas of Integral Protection thus being able to reconcile economic proposals and sustainable management practices such as pasture and mining, encouraging the reintroduction of native forage grasses and deferral.

Management is essential for the conservation of *Campos de Altitude*, on the other hand, areas of *Campos de Altitude* within Conservation Units under Integral Protection would provide a unique opportunity for research on vegetation dynamics and successional processes that are still not well understood. The results of studies on succession would provide an essential basis for the development of sustainable management strategies for *Campos de Altitude* in Brazil. Conservation actions are urgent to curb the loss of mountainous habitats and avoid extinction processes, but the conservation of biodiversity in *Campos de Altitude* needs to reflect ecological properties and successional processes and, therefore, allow for adequate management practices.

Other important initiatives comprehend a socio-environmental political agenda for *Campos de Altitude* that allows (i) the dissemination of knowledge and appreciation of their ecological, socioeconomic, and cultural attributes to society as a whole through scientific work and research by research groups from the Brazilian academy; (ii) carrying out inventories of biodiversity and periodic monitoring of vegetation cover; (iii) the definition of territorial planning instruments; (iv) the promotion of activities that promote the sustainable use of *Campos de Altitude*, such as rural tourism and ecotourism; (v) support for research and extension activities focused mainly on biology, ecology and sustainable use, and (vi) greater integration among institutions with common objectives.

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