# Plant-pollinator interaction in a peatland ecosystem in Minas Gerais, Brazil

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# Interações entre plantas e visitantes florais em ecossistemas de turfeiras em Minas Gerais, Brasil

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**Abstract:** The Espinhaço Mountain Range is an important complex of mountains and plateaus within the Brazilian Cerrado. Within this area we can found peatlands ecosystem, which are important carbon reservoirs and home of a variety of plants and their floral visitors. We investigated if there are differences in the planta-visitor community between protected peatlands(Rio Preto State Park) and unprotected peatlands (Araçuai river). To conduct the research, six field trips of three days each (between October 2021 and November 2022) were conducted to sample plants and their Floral visitors. For comparison, the areas were divided into wet (peatlands) and dry grasslands. We sampled 284 individuals of floral visitors from 107 species visiting 45 plant species. In the protected area we found 62 floral visitors species visiting 33 plant species and in the non-protected area 58 floral visitor's species in 26 plant species. We also found higher Floral visitors richness in the wet areas (peatlands) (82 species) compared with dry areas (grasslands) (36 species). Furthermore, wet areas show higher abundance and richness of Floral visitors. Plant communities show some similarities, although they have different blooming periods.

**Keywords:** plant-animal interactions, grasslands, pollinators.

**Resumo:** A Serra do Espinhaço é um importante complexo de terras altas dentro do bioma Cerrado, um hot spot de biodiversidade. Nessa área encontramos ecossistemas de turfeiras, importantes reservatórios de carbono e hábitat de muitas espécies. Investigamos se existem diferenças na comunidade de plantas e seus visitantes florais entre turfeiras protegidas (Parque Estadual do Rio Preto) e não protegida (turfeiras do Araçuai). Para condução da pesquisa, seis campanhas de campo de três dias cada (entre outubro de 2021 e novembro de 2022) foram realizadas para amostragem de plantas e seus polinizadores. Para comparação, as áreas foram divididas entre campo limpo úmido (turfeiras) e seco. Foram amostrados 284 indivíduos de polinizadores de 107 espécies visitando 45 espécies de plantas. Na área protegida, foram encontradas 62 espécies de polinizadores visitando 33 espécies de plantas; enquanto na área não protegida foram encontradas 58 espécies de polinizadores em 26 espécies de plantas. Também foi observada maior riqueza de polinizadores nas áreas de campo úmido (turfeiras) (82 espécies) em comparação com as áreas de campo limpo seco (36 espécies). Adicionalmente, o campo úmido apresentou maior riqueza e abundância de polinizadores. As comunidades de plantas apresentam similaridades, ainda que com diferenças nos períodos de floração.

**Palavras-chave:** interação animal-planta, campos rupestres graminosos, polinizadores.

## 1. Introduction

Peatlands are ecosystems formed by histosols, which have high levels of organic matter because of their slow decomposition. The conservation of peatlands ecosystems is especially important as they aid as carbon sinks (Page et al., 2011). With a global land cover of around 3%, they store more carbon than the entire global forest mass (Joosten, 2015). Their involvement in the global water and carbon cycles is significant (Minayeva, 2012). Therefore, protection can help mitigate global atmospheric change but also to preserve its rich biodiversity (Joosten, 2015, Littlewood et al., 2010).

In Brazil, peatlands are geographically distributed in several biomes and total more than fifty thousand square kilometers. In the Cerrado biomes, peatlands, experience threats through the agricultural industry (Fernandes, 2016; Littlewood et al., 2010). Because conservation efforts are mainly concentrated on the rainforests, the Cerrado is one of the most threatened biomes in South America (Fernandes, 2016), with 50% of its vegetation destroyed during the last four decades (Fernandes et al., 2016). Meanwhile, only ~2.2% of the biome is under legal protection (Fernandes, 2016).

In the Southern Espinhaço Mountain Range (SdEM), we can find a tropical mountain peatland ecosystem. These ecosystems are particularly important for (i) biodiversity; (ii) global carbon cycle; (iii) regional water resources and (iv) paleoenvironmental reconstitution (Christófaro Silva et al., 2022). Those peatlands can be found in the depressions of these surfaces, formed where lithotypes most susceptible to weathering (phyllites) occur confined between quartzite (Campos et al., 2017). The predominant vegetation of these ecosystems is the wet grassland and dry speckled by "islands" of seasonal semideciduous forest, locally known as "capões de mata", formed mainly by species from the Atlantic Forest and the Cerrado (Gonçalves et al., 2020). So, we can find a rich community of plant species that provide resources for many pollinators, but little is known about the components of the plant-pollinators in peatlands ecosystems.

Interactions between plants and animals play an important role in shaping biological diversity (Thomson, 2010; Bascompte et al., 2003). The study of mutualistic networks provides important information about the mechanisms that contribute to the structural organization of plant-animal interactions and facilitates the understanding of the impact on the ecosystem of loss of species interactions and extinction (Bascompte and Jordano, 2007). These studies are important because the extinction of interactions can occur before the extinction of species due to changes in habitat (Santamaria, 2018), thus providing a useful indicator of functionality losses at large scales. By studying networks of interactions, we can also explore the resilience of ecosystems in the face of temporal variations and disturbances (Costa et al. 2018, Lopes et al., 2020).

Without ongoing research, the understanding of pollen transportation, functional ecology of floral traits, pollinator-service competition and the specialization and generalization of interactions between flowers and their visitors would not be at the level it is at today (Mitchell et al., 2009).

The goal of this work is to describe plant-floral visitors interactions, predict differences in the community structure in the peatlands systems in mountain region. For this, it should be determined if protected peatlands ecosystem show more abundance and richness of floral visitors and their host plants species by comparing with unprotected peatlands ecosystems. The wet and dry areas of the protected and unprotected areas should be analyzed in such a way that their biodiversity can be compared.

For this, it is to be expected that the protected areas show a higher richness and abundance of pollinators and flowering plants since the unprotected area are under the impacts of fire and grazing by cattle. Secondly it is to be expected that wet areas (peatlands) show a higher richness and abundance of pollinators and of flowering plant species – since the dry areas are dominated by grasslands (Felfili and Silva-Jr., 2009), the richness of flowering plants will be lower because of the competition with the grass, and finally we expect that plant families with higher species richness will be visited by more pollinators.

## 2. Methods

### *2.1 The Study Area*

The Parque Estadual do Rio Preto, a protected state park covered in Cerrado vegetation, is in the Diamantina plateau, in the mid-southern region of the Espinhaço Range, Minas Gerais, Brazil (Gonçalves et al., 2017). Within the Parque Estadual do Rio Preto and the Araçuaí basin, unique peatlands (turfeiras) are found (Bispo et al., 2015). Peat material is formed by the partial decay of plants, mostly in wetlands. It is spongy of texture. The soil texture in this area can change within one step forward from solid to being covered in moist soil knee-deep. Peatlands are important carbon sinks, and they require protection (Bispo et al., 2015), to mitigate climate change and to preserve their biodiversity (Joosten, 2015).

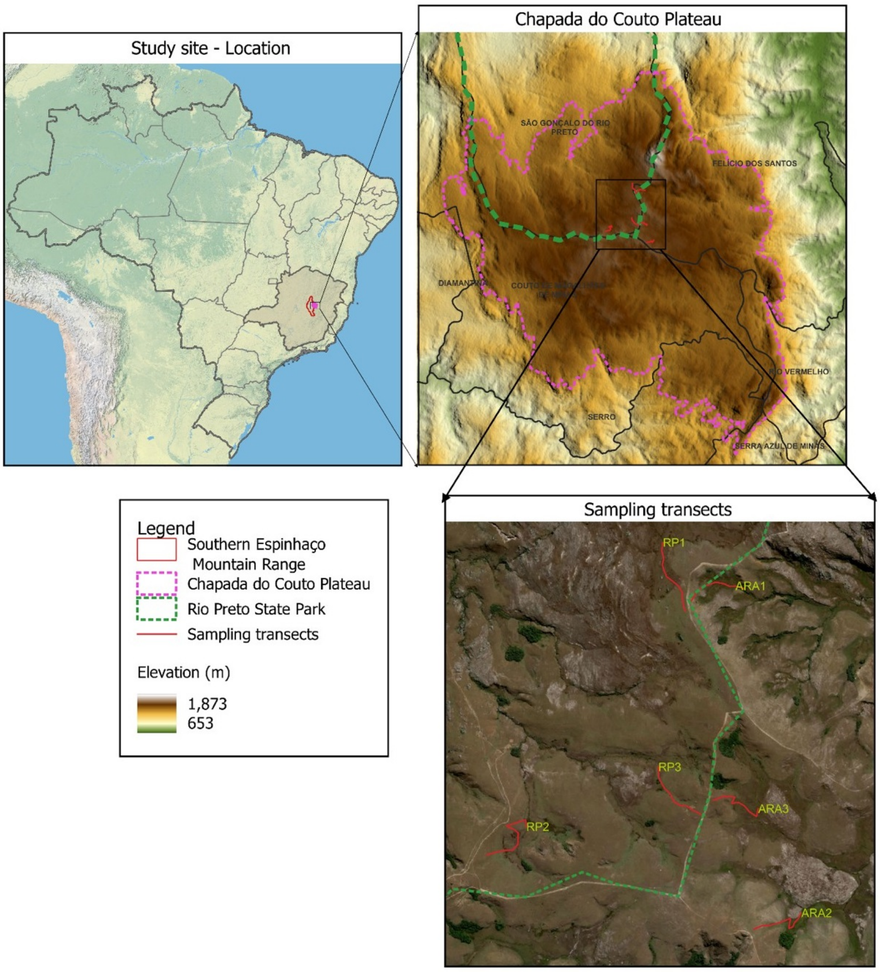


Figure 1. Location of the study site in the Chapada do Couto Plateau, along the eastern border of the Southern Espinhaço Mountain Range, detailing the location of the transects used for sampling plants and pollinators during the field campaigns. RP: transects in the protected peatlands of Rio Preto and ARA: transects in the unprotected peatlands of Araçuai.
Source: IBGE (2010)

There are three different main vegetation types covering the park (Oliveira and Linares, 2013). The forest vegetation is distinguished in three types: riparian forests (forest that are characterized through being located close to rivers, streams, wetlands, ponds, or lakes (Riparian Forests, 1998), seasonal semi deciduous forests, and cloud semi deciduous forest in higher altitudes (Oliveira and Linares, 2013). Many endemic, rare and endangered species call this savannah-biome their home.

The local climate can be classified as Cwb according to the Köppen climate classification (Alvares et al., 2013): there is a distinct difference between rainy summers and dry winters, as found in most tropical countries in higher altitudes. The dry season lasts from typically late April/early May until October while during the rest of the year, about 90% of all annual rainfall occurs (1,500 millimetres average annual rainfall). The average annual mean temperature is 18°C (Oliveira, 2013). The altitude varies between 800 and 1,600 meters with multiple outcrops (Fernandes et al., 2016).

### *2.2 Sampling*

The study area is divided into two ecosystems: I) the dry grassland and II) peatlands in the protected area (named RP), unprotected areas (named ARA) (Figure 1). These areas are further divided into wet (peatlands) and dry. ARA is an acronym for the Araçuaí Basin (outside the park boundaries) while RP stands for the Rio Preto Basin (inside the park).

The experimental design comprehends three sites in RP and three sites in ARA. In each site a 1000 m transect covering wet areas (peatlands) and dry grasslands was installed.

Field samplings were done in six campaigns (in October 2021and in March, May, July, September and November of 2022). To collect pollinators, flowering plants were observed during five minutes, until an insect was spotted. This was then captured with a net and then carefully transferred into a vessel containing ethyl acetate. Then, they were transferred to small paper bags on which the date, location and flower of collection were noted down. The insects were stored in a fridge/freezer until preparation. Visited flowering plant species were photographed and collected. Collected plant species were deposited in the Herbarium DIAM of UFVJM.

### *2.3 Data analysis*

Descriptive statistics were conducted to estimate richness and abundance of pollinators as well as for visited plant species (only richness). We also compared the absolute values of total richness and abundance of pollinators in dry and wet areas. Richness of visited plants in ARA (dry and wet) and RP (dry and wet) were described. A linear regression was applied to evaluate if the richness of pollinators is related to the richness of flowering plant species.

## 3. Results

We found 317 individuals of pollinators from 110 species from the Coleoptera (s=22), Diptera (s=31), Lepidoptera (s=14) and Hymenoptera (s=43) groups visiting 45 species of plants from 16 families. Higher richness of pollinators (s=62) and abundance (n=147) was found in the protected peatlands in RP compared with the sites in the ARA (s=58, n=137 respectively) (Figure 2) besides this difference are not significant.

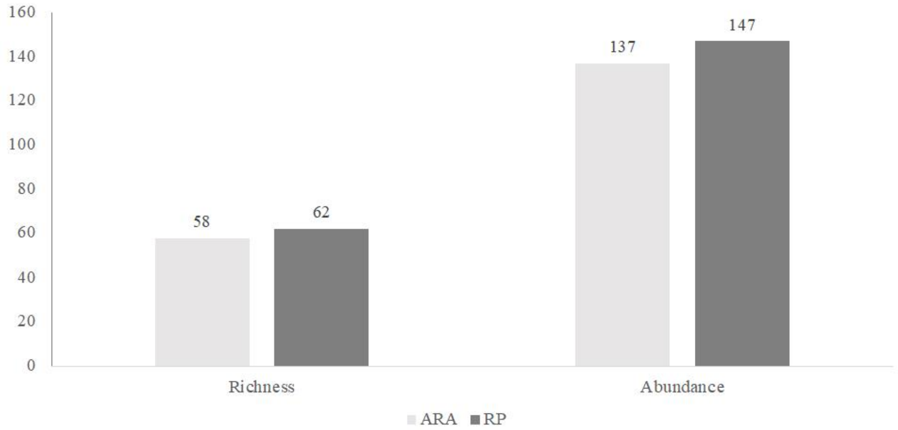


Figure 2. Pollinators richness and abundance in flowering plants in the impacted peatlands of Araçuai Basin (ARA) and in the protected peatlands of Rio Preto Basin (RP).
Source: Authors.

In RP we found higher richness of bees and beetles and in ARA we found higher richness of flies, wasps and lepidoptera (Figure 3). We also found higher richness of visited plant species in RP (s=32) compared to ARA (s=22). In RP bees represented 38% of all pollinators and in ARA 21%. On the contrary, we found higher proportion of diptera in ARA (28%) than in RP (23%).

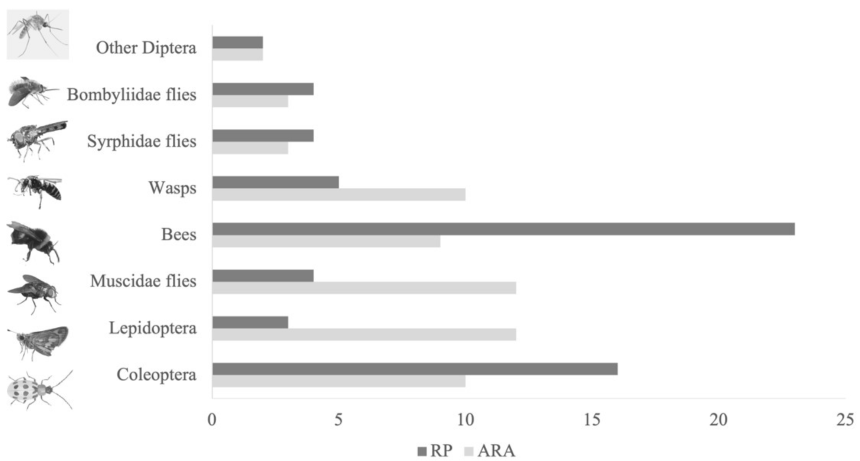


Figure 3. Richness of species of pollinators in different groups, in the protected sites of the Rio Preto Basin (RP) and in the unprotected sites of the Araçuai Basin (ARA).
Source: Authors.

Higher plant species richness was found in the families Asteraceae, Eriocaulaceae, Melastomataceae and Rubiaceae. Plants belonging to Rubiaceae received the visits from 30 pollinators species, followed by Eriocaulaceae, Euphorbiaceae and Asteraceae (Figure 4). These four families accounted to 26 species of pollinators (58% of the total).

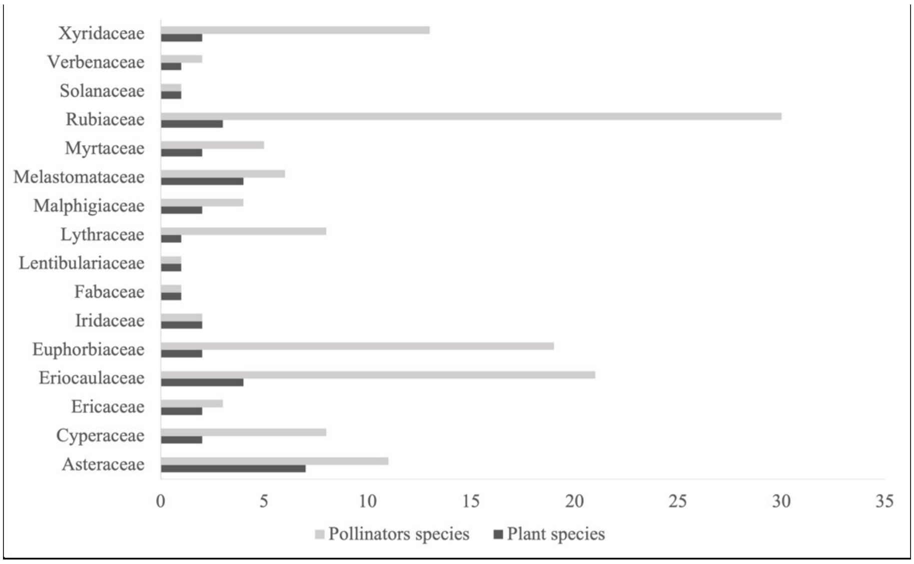


Figure 4. Richness of plant species by family and richness of pollinators species in each plant family in the protected sites of the Rio Preto Basin (RP) and in the unprotected sites of the Araçuai Basin (ARA).
Source: Authors.

The richness of visited plants species as well as the richness of pollinators increased with the number of samplings (Figure 5 a and b).

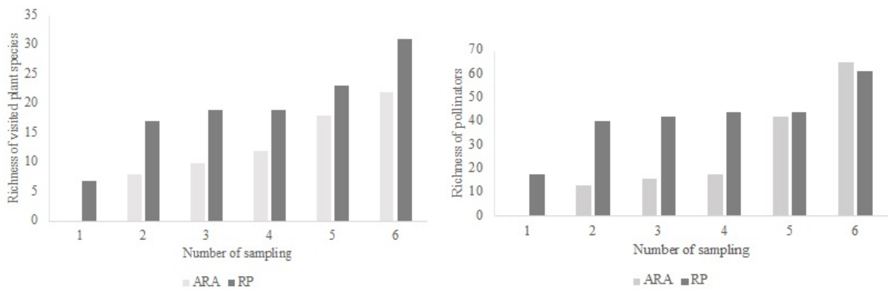


Figure 5. Cumulative number of visited plant species and richnnes of pollinators in the protected sites of the Rio Preto Basin (RP) and in the unprotected sites of the Araçuai Basin (ARA).
Source: Authors.

We found a high correlation between the total richness of visited plant species and the total richness of pollinators both in ARA (r2=0.88; p=0.005) and RP (r2=0.95; p=0.0006) (Figure 6 a and b)

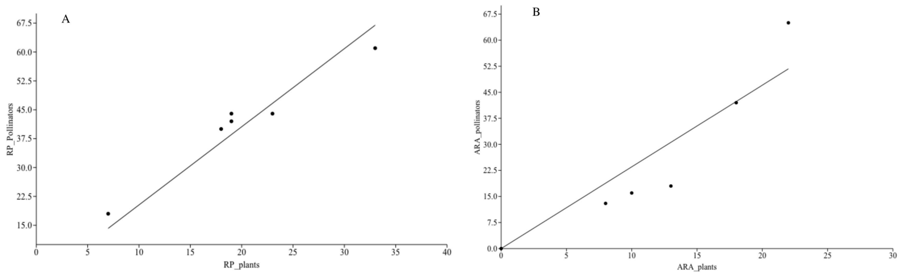


Figure 6. Relation between the number of pollinators visiting the flowers with the richness of flowering plants (a) in the protected sites of the Rio Preto Basin (RP) and (b) in the unprotected sites of the Araçuai Basin (ARA).
Source: Authors.

## 4. Discussion

When assessing the reliability of results, it becomes evident that the low richness and abundance of flower visitors reflect the environmental conditions in the mountain system, with milder temperatures all over the year, constant wind, and heavy rains (Fernandes, 2016). Other studies conducted in mountain systems also find similar results, with lower richness and abundance of visitors in flowering plant species. For example, a recent study conducted in mountains in the extreme south of SdMR, found lower richness and abundance of flowering plants and pollinators (Rocha, 2023). Another reason for the lower species richness could be derived from the impacts of fire and grazing, in ARA sites. For example, in the first field trip, all the sites from ARA had experienced fire and the vegetation was still recovering and the plants had no flowers at the time.

As expected by the first hypothesis we found a slightly higher richness and abundance of flowering plants and pollinators in the sites of the protected area RP than in ARA sites but there. The Rio Preto State Park is protected by law since 1998. Before that the grasslands were used to raise cattle. On the other hand, the unprotected sites of ARA are still under human impact with frequent fires and grazing. Worldwide research conducted in 2016 concluded that, in protected areas, species richness is 10.6% higher and abundance is 14.5% higher than in unprotected areas (Gray et al., 2016). In the case of the studied sites, both in ARA as in RP pollinator abundance and richness and abundance are slightly different and this could be explained by the presence of invasive plants species (mostly in ARA) that can be visited by many different groups of pollinators. In fact, invasive plant species or ruderals plant species, are described as important to bee species. According to Kovács-Hostyánszki et al. (2022) besides invasive alien plant species are usually disliked due to their high pressure on native communities their ecological effects on pollinators are complex: some species provide abundant floral resources, boosting the number of pollinators, while they often disrupt plant-pollinator interactions by outcompeting native plants. Also, during their flowering, invasive plants integrate into plant-pollinator communities and are utilized as a resource by many native pollinators (Morales and Traveset 2009; Stout and Morales 2009).

Besides the low number of flowering plant species in both sites, we observed that some families are of great importance, and this may explain the low difference in abundance of pollinators between ARA and RP (48% and 52% of all collected specimens, respectively). And contrary to our expectations, not all families with higher species were more visited. In Euphorbiaceae, for example, with only two flowering species, we sampled 20 pollinators species. On the other hand, Asteraceae, with eight flowering species, we found 10 pollinators. It is important to notice that Euphorbiaceae and Rubiaceae, were by far the most visited group (visited by pollinators from 24 different genera of all included orders) recorded in the state park. Only one species of Rubiaceae, found in ARA were visited by nine species of insects. Blooming plant species are an important food source for insects, in special in highly impacted areas, as the case of ARA (Kovács-Hostyánszki e al.,2022).

Bees represented the highest percentage of pollinators, mostly in RP, corroborating studies that demonstrate the relevance of bees for mutualistic interactions in rupestrian fields (Carstensen et al., 2016; Monteiro et al., 2021). Flies and beetles also play important role as pollinators and were responsible. As described by some authors (Perillo et al., 2017; Santos et al., 2020), the increase elevation and abiotic filters imposed by the altitude of mountain environments favor higher frequency of pollinators such as flies (Diptera), probably due to flies' greater tolerance to cold compared to bees (Hoiss et al., 2012). Although they are not the most relevant pollinators for most plant species (bees are the most important) in mountain systems, like the peatlands, flies performed a large percentage of interactions.

One can observe that there is a higher abundance of Lepidoptera in the unprotected areas (15 out 18) and again, Rubiaceae was the most visited family (nine visits recorded). However, both the richness and abundance of Lepidoptera was generally low in the study areas. In other areas of campos rupestres was lower at high altitudes (Fernandes et al., 2016). Temperature strongly regulates and acts directly on lepidoptera physiology, metabolism, life cycle, behavior, development and survivor (see Bale et al., 2002; Sanders et al., 2007) and ultimately influences their distribution. Besides, seasonality and spatial and temporal variation of the food resources are crucial factors determining their diversity, composition, and dispersion (e.g. Baguette et al. 2011).

The total richness of plants was higher in the protected areas (RP), as hypothesized. However, the richness in dry areas (protected and unprotected) is equal. There was also a higher recorded plant richness in ARA dry grasslands than there is in ARA peatlands, although higher general richness was expected in wet areas. although the higher general richness was expected in the wet areas. The wet protected area (RP peatlands) still presented the highest plant richness, as hypothesized This unexpected result could be explained by pollinators not visiting the plants in the exact moment of fieldwork. The plants are only recorded if a pollinator visiting them is caught. Thus, some plant species might just not have been recorded. What is also significant is that for plants only richness and not abundance was determined. Thus, there might be a much higher abundance in the protected areas which is not reflected in the results.

These unexpected finding could be explained further by the theory of intermediate disturbance (Bendix et al., 2017). The theory implies that if some intermediate disturbance frequency is present, levels of richness should rise as only few species can tolerate extreme disturbance while, simultaneously, only few can compete in an environment that undergoes low levels of disturbance (Bendix et al., 2017). Therefore, if low or high levels of disturbance are present in the dry areas, it may cause the plant richness to be lower compared to the wet areas, where levels of disturbance could be more intermediate. In addition, most plant species in the unprotected areas are endemic which is an interesting fact if the fraction of endemic species in all areas was to be analysed. It is more likely that the number of endemic species is higher in the unprotected areas as, for example, mammals can disperse seeds when grazing.

Looking at the interactive network concepts (Bascompte and Jordano, 2007), it is common that there are more specialized interactions from the pollinators side than from the plants side as pollinators are not spatially bound like plants. We found several connections from Coleoptera species to plants of the family Eriocaulaceae and Asteraceae. Also, Rynchospora speciosa is exclusively visited by Coleoptera suggesting a preference. Cuphea ericoides is visited by exclusively Hymenoptera and Lepidoptera and the most visited flower is of the family Rubiaceae.

Our results show that the peatland ecosystem in Parque do Rio Preto harbor a richness community of plants and by consequence, their pollinators. Also, the impact of grazing and fire, as observed in the peatlands of the unprotected sites, can disrupt important plant animal interactions.

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