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RESEARCH ARTICLE

Save the survivors: the remarkable ant diversity of the last protected fragment of savanna in Southern Brazil

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Abstract

The Brazilian savanna (Cerrado biome), now reduced to about 173,500 km^2 of its original two million km^2 range, is one of the most threatened biomes in the world. In the meridional limit of this biome is the Cerrado State Park (CSP), state of Paraná, Brazil, the only savanna conservation unit in Southern Brazil. This survey of the arboreal and ground-dwelling ants of the park obtained 136 species in 36 genera and eight subfamilies, an expressive diversity given the size, degree of isolation and location of the park. There was a high stratification of the ant community with a dominance of ground-dwelling species. *Camponotus crispulus*, *Pheidole exigua*, and *Pheidole scapulata* are new records for Southern Brazil. The ponerine genus *Mayaponera* and 13 species from several genera are recorded for the first time for the state of Paraná. The great number of ant species found and the presence of rarely collected elements of the Neotropical ant fauna indicate that this is one of the most diverse areas of savanna in Brazil. However, the CSP is severely threatened by anthropic activities, such as monocultures, cultivation of exotic plants, and livestock. Even more concerning is a recent new law approved by the government of Paraná that allows the touristic exploitation of reserves like the CSP by private companies. If an effective conservation effort to preserve the park area is not taken, we will certainly witness the extinction of the last assembly of ants from the Brazilian Cerrado in Southern Brazil, along with other elements of the biodiversity associated with the CSP.

Keywords Neotropical region · Formicidae · Conservation · Species list

Introduction

The Brazilian savanna encompasses a diagonal dry region in the country, including three open vegetation biomes: the Chaco in the southwest, the Cerrado in the central region, and the Caatinga in the northeast. These biomes form a diagonal corridor of dry habitats in South America and represent a biogeographical barrier between two forest biomes, the Amazon rainforest in the northwest and the Atlantic Forest in the southeast (Werneck 2011).

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The Cerrado biome, representing the second largest biome of Brazil after the Amazon Rainforest, originally encompassed ca. 23% of the Brazilian territory, covering approximately two million km^2 (Bridgewater et al. 2004). More than half of the Cerrado's original area in Brazil has been lost, and only approximately 8.5% (173,500 km^2) of it is under protected areas (MMA 2020). The Cerrado is a global biodiversity hotspot, with high levels of endemism, including 44% of the plant species and 10% of the vertebrate species (Myers et al. 2000). Inventories of invertebrate fauna are relatively sparse in the Cerrado, but estimates indicate that there about 90,000 species of insects throughout the biome (Dias 1991).

The southern limit of the Cerrado in Brazil is in the northeast portion of the state of Paraná, where this biome is deeply fragmented, especially due to anthropic activity. All the remnants and islands of Cerrado in this region are smaller than 100 km^2, not protected by any conservation unit, and are historically separated from northernmost portions of biome (Maack 2012). The sole conservation area of Cerrado in Southern Brazil is the *Parque Estadual do*

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Cerrado, hereafter Cerrado State Park (CSP), a 420 ha preserve under sustainable use in the municipalities of Jaguariaíva and Sengés (MMA 2020). Despite the great relevance of the CSP for the Cerrado biome, few scientific studies have been conducted there. There have been a few inventories of insects (Casagrande et al. 2011; Gonçalves et al. 2009; Sari and Ribeiro-Costa 2011), gastropods (Colley 2011), amphibians (Caramaschii et al. 2009), birds (Straube et al. 2005), mammals (Vidolin and Braga 2004), and plants (Linsinger et al. 2006; Uhlmann 1995, Uhlmann et al. 1997, 1998).

Ants (Hymenoptera: Formicidae) are an important and very conspicuous animal group distributed throughout the world, occurring in most terrestrial ecosystems. Currently, there are more than 13,850 species distributed in 337 genera and 17 subfamilies (Bolton 2020). Along with termites, they are considered the most important group of insects in Brazilian savannas in terms of abundance and ecological impact (Elizalde et al. 2020; Lach et al. 2010; Silva et al. 2004). Ants are susceptible to different levels of ecological changes, climate variations and other disturbances, including those associated with human activities. These characteristics, associated with their wide distribution, local abundance, easy sampling, and good taxonomic resolution makes ants an excellent model for bioindication studies (Andersen and Majer 2004; Arnan et al. 2006; Hoffmann 2010; Leal et al. 2012; Majer et al. 1984; Silva et al. 2009; Vasconcelos et al. 2000).

Comprehensive studies have been conducted in the Cerrado, including ant community ecology in conservation areas (Maravalhas and Vasconcelos 2019; Ribas and Schoereder 2004; Vasconcelos et al. 2018, 2019), urban areas (Pacheco and Vasconcelos 2006), species lists (Camacho and Vasconcelos 2015), ant–plant interactions (Dáttilo and Vasconcelos 2019; Schoereder et al. 2010), and impacts of the land use on the ant fauna (Queiroz et al. 2017). However, as far as we know, there are no studies exclusively addressing the ant assemblies of the southern edge of the biome.

The primary aim of this study is to provide a survey of the arboreal and ground-dwelling ant species of the Cerrado State Park. Our secondary goal is to reveal the importance of this isolated and severely threatened area for the conservation of the last Cerrado ant assembly in Southern Brazil.

Materials and methods

Study area

Sampling was carried out in January 2015 at the Cerrado State Park (CSP) in the municipality of Jaguariaíva, state of Paraná (Fig. 1). The park has 420 ha and is located 10 km northeast of the urban perimeter of Jaguariaíva (24° 10′ S 49° 39′ W) (IAP 2002). The sampling was carried out at the most typical savanna physiognomy in this region, the Cerrado sensu stricto, which is composed of an open canopy of 3–8 m tall trees, grasses, herbs, and shrubs (Oliveira-Filho and Ratter 2002). The climate of the CSP is warm, with significant rainfall throughout the year. The driest month is August, with an average precipitation of 59 mm, whereas the wettest month is January (205 mm precipitation on average). The hottest month is February (23 °C average) while June is the coldest month (12 °C average). The climate is Cfa (humid temperate climate with hot summer) according to the Köppen–Geiger climate classification. Climate information was obtained by Climate-Date.org, licensed by Creative Commons Attribution-ShareAlike 2.0.

Ant sampling

We established three 380 m transects, separated from each other by 1 km. Along each transect, we marked 20 sampling points, spaced by 20 m. The points were alternated to sample the ground-dwelling ants on the soil surface and the arboreal ants on the trees, totaling 60 samples, 30 on soil and 30 arboreal. In both strata, we used pitfall traps, which consisted of a small plastic cup of 250 ml, 8.5 cm high, and 7.8 cm in diameter. To collect the ground-dwelling ants, four pitfall traps containing water and detergent were arranged in the soil in a square grid of 2.5 m × 2.5 m. In the arboreal stratum, four pitfall traps, containing human urine diluted 1:2 in water and detergent, which is a highly attractive bait for arboreal ants (Powell et al. 2011), were fixed on the trees at approximately 2.5 m high.

The pitfall traps remained installed for 48 h; after that, the contents of the four pitfalls in each point were combined into a single plastic bag, making up a single composite sample. The sampling method follows Vasconcelos et al. (2014).

Data processing

The samples were transported to the *Laboratório de Sistemática e Biologia de Formigas* at *Universidade Federal do Paraná* (UFPR), Curitiba, Brazil, where the collected ants were sorted, mounted, and identified to species whenever possible. Ants were firstly identified to genus using the *Guia para os Gêneros de Formigas do Brasil* (Baccaro et al. 2015) and the literature recommended therein for the identification of the species in each genus (Albuquerque 2014; Brandão and Mayhé-Nunes 2001; Camacho et al. 2020; De Andrade and Baroni Urbani 1999; Feitosa 2011; Ješovnik and Schultz 2017; Kugler 1994; Kugler and Brown 1982; Longino 2003; Longino and Fernández 2007; Ortiz-Sepulveda et al. 2019; Schmidt and Shattuck 2014; Ward 1990; Watkins 1976; Wild 2017). Ant specialists were also consulted (see the "Acknowledgments" section). Voucher specimens were

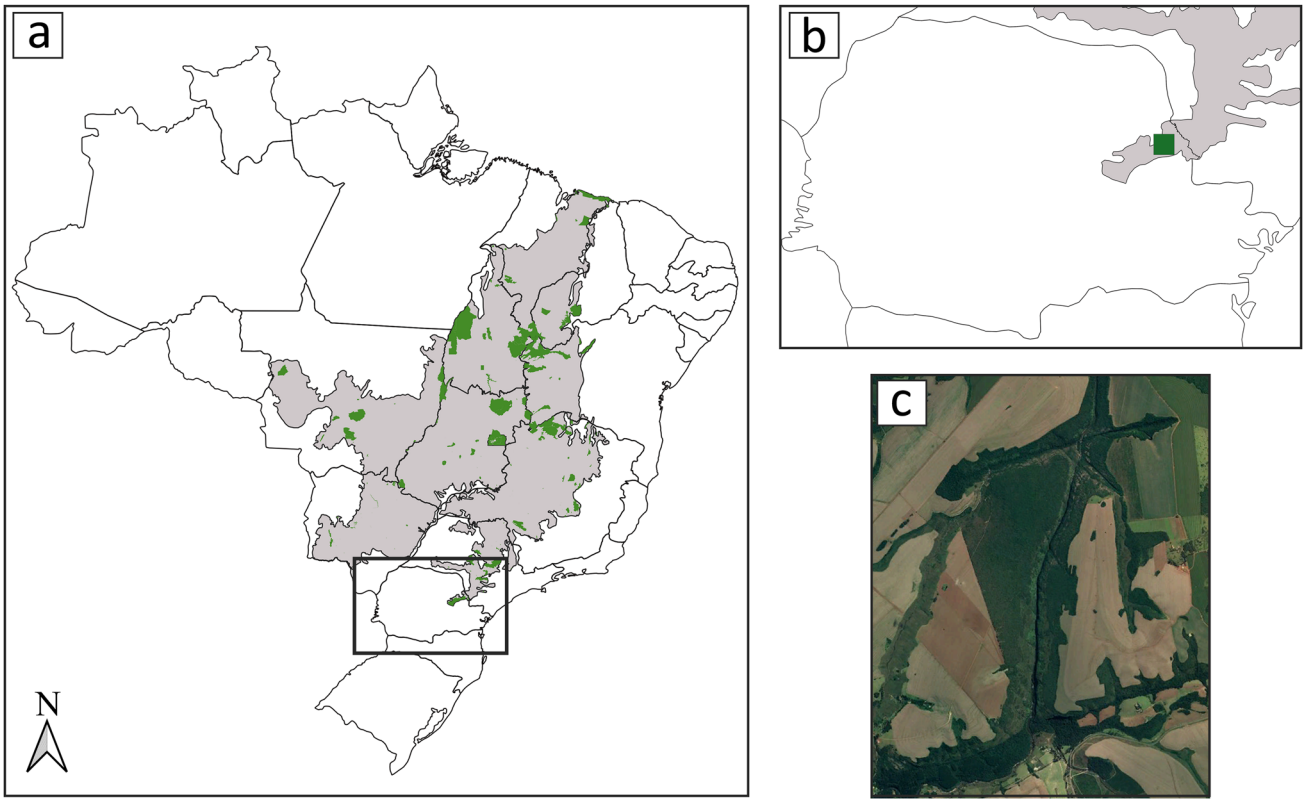

Fig. 1 **a** Map of Brazil, showing the original distribution of the Cerrado (gray) and the current conservation areas (green), with emphasis on state of Paraná (black square). **b** Map of Paraná, with the Cerrado State Park location (square green). **c** Cerrado State Park area

deposited at the Entomological Collection Padre Jesus Santiago Moure (DZUP) at UFPR, Curitiba, Brazil.

The collected species were separated by habitat affinity, into "savanna specialists", "forest-associated" and "habitat generalists", based on Vasconcelos et al. (2018). In addition, we classified the species collected by strata preference, using exclusively the occurrence on the pitfalls as: (1) "ground-dwellers", considering those collected exclusively on the ground, and those collected predominantly on the ground and only eventually from a single vegetation point; (2) "arboreal", using the same criteria that for "ground-dwellers", including species that were collected from one or more points on the ground, but are well-known arboreal ants; and (3) "strata generalist", those species consistently collected from both strata.

We estimated the species' richness of the CSP based on their frequency of occurrence, using two richness estimators: "Jackknife2", based on the number of species that occur in two samples, and "Bootstrap", based on all species collected to estimate total richness, thus not influenced by the infrequent species (Chao et al. 2005; Magurran 2004). We also analyzed the sampling effort by plotting the number of species collected and the number of samples on species-accumulation curves for the total survey and for each stratum, which rises steeply at first and then more rises more slowly increasingly rare species are added (Ugland et al. 2003). The dataset used for these analyses (presence-absence matrix) is available as Supplementary Information and deposited in FigShare (Oliveira and Feitosa 2020).

The map in Fig. 1 was generated in QGis v. 3.2.3, the shapefiles were obtained from the Brazilian Institute of Geography and Statistics database—IBGE, and from Google Earth Pro v. 7.3.3.7786. Richness estimators and species-accumulation curves were performed in the R environment, using the package Vegan (R Core Team 2020; Oksanen et al. 2019). Images of Fig. 2 were obtained with a Zeiss Stereo DiscoveryV20 stereomicroscope attached to a Zeiss Axiocam 305 color video camera. Graphs in figures S1 and S2 were performed on Microsoft Excel. All figures were edited in Photoshop CS6 (Adobe) to enhance parameters of brightness and contrast.

Results

We recorded 136 ant species at the Cerrado State Park (CSP). In relation to the sampling method, 120 species were captured in ground pitfalls, and 45 in arboreal pitfalls

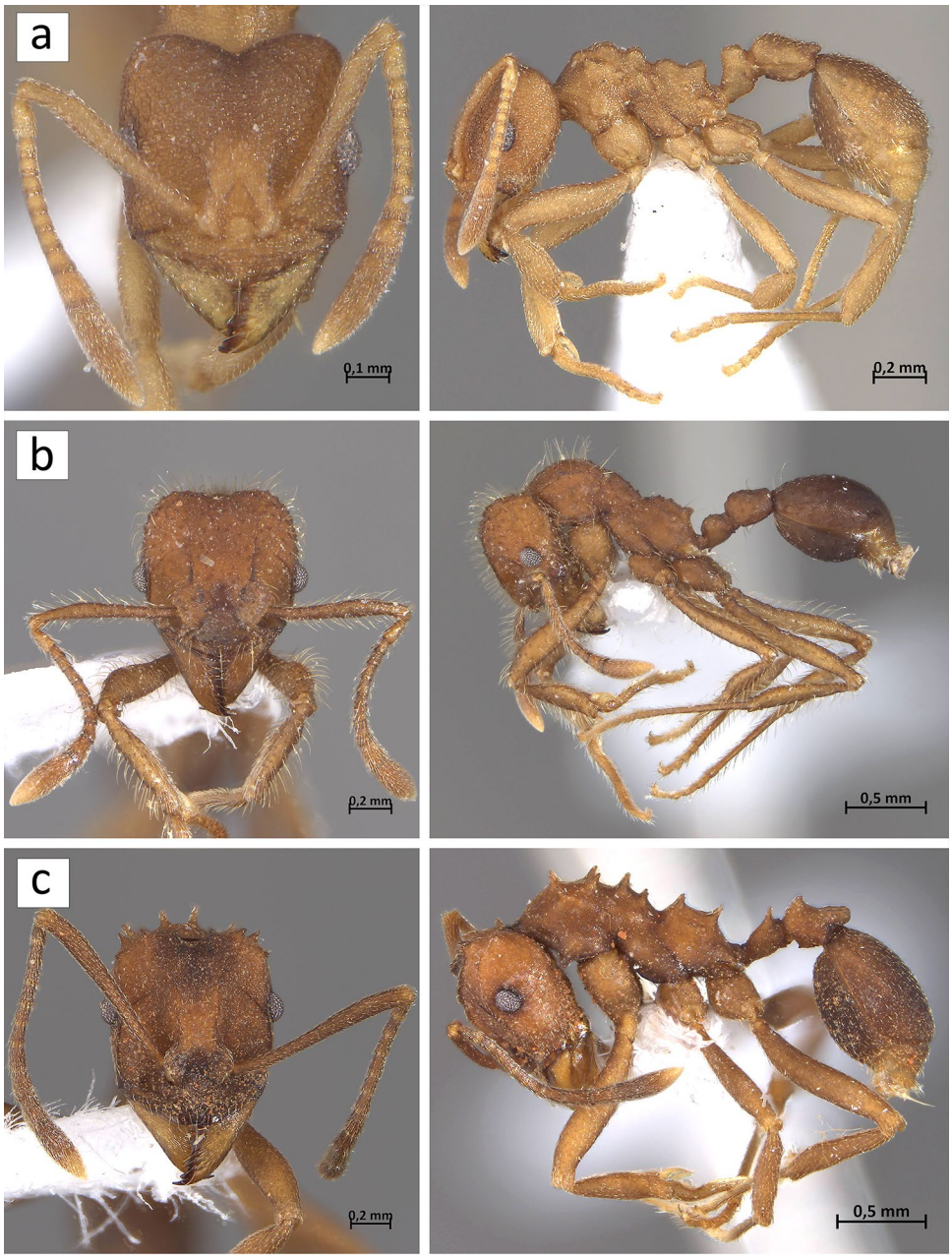

Fig. 2 Frontal and lateral view of **a** *Cyatta abscondita*, **b** *Mycetagroicus cerradensis* and **c** *Mycetarotes senticosus*. The three species are rarely collected savanna-specialist ants recorded in the Cerrado State Park, Paraná, Brazil

(Table S1). From these, 91 species were exclusively collected in the ground, 16 were exclusively collected on the trees, and 29 were collected in both strata. In relation to strata preference, we considered 101 (74.2%) as "ground-dwellers", 22 species (16.2%) as "arboreal", and 13 species (9.6%) as "strata generalists" (Fig. S1). The most abundant species in ground samples were *Pheidole oxyops*, *Linepithema micans* and *Wasmannia auropunctata* (Roger, 1863); whereas on the vegetation samples, the most abundant species were *Pseudomyrmex gracilis* (Fabricius, 1804), *Camponotus novogranadensis*, *Camponotus atriceps* (Smith, 1858) and *Cephalotes pusillus* (Klug, 1824) (Fig. S2). We were able to identify 73 species (54%), which were classified by habitat affinity. From these, 47 (64.3%) are habitat generalists, 12 (16.7%) are savanna specialists, and 14 (19%) forest-associated species (Table S1).

The 136 species sampled at CSP comprise 36 ant genera, and eight subfamilies (Table 1). More than 90% of the species collected belong to three subfamilies: Myrmicinae, with 89 species (65.4%); Formicinae, with 23 species (17%); and Ponerinae, with 10 species (7.3% of the total). The four most diverse genera, representing more than 54% of the collected species, were: *Pheidole*, with 34 species (25%); *Solenopsis*, with 17 species (12.5%); *Camponotus*, with 15 species (11%); and *Crematogaster*, with eight species (5.8%). The most common species, collected in 38 of

Table 1 Number of genera and species recorded by subfamily at the Cerrado State Park (CSP)

Subfamily	Genera	Species
Myrmicinae	20	89
Formicinae	4	23
Ponerinae	5	10
Pseudomyrmecinae	1	6
Dolichoderinae	2	3
Ectatomminae	2	3
Dorylinae	1	1
Heteroponerinae	1	1
Total	36	136

the 60 samples, was *Camponotus novogranadensis* Mayr, 1870, followed by *Brachymyrmex pictus* Mayr, 1887, *Linepithema micans* (Forel, 1908), and *Pheidole oxyops* Forel, 1908 all collected in 29 samples.

The formicine species *Camponotus crispulus* Santschi, 1922 and the myrmicine species *Pheidole exigua* Mayr, 1884 and *Pheidole scapulata* Santschi, 1923, are recorded for Southern Brazil for the first time. In addition, the genus *Mayaponera* and 13 species were recorded for the first time from the state of Paraná: *Brachymyrmex fiebrigi* Forel, 1908, *Brachymyrmex pictus*, *Camponotus zenon* Forel, 1912, and *Myrmelachista nodigera* Mayr, 1887 (Formicinae); *Cephalotes depressus* (Klug, 1824), *Crematogaster erecta Mayr*, 1866, *Mycetarotes senticosus* Kempf, 1960, *Nesomyrmex spininodis* (Mayr, 1887), *Pheidole aper* Forel, 1912, *Rogeria pellecta* Kempf, 1963 and *Wasmannia sigmoidea* (Mayr, 1884) (Myrmicinae); *Ectatomma tuberculatum* (Oliver, 1792) (Ectatomminae); and *Mayaponera constricta* (Mayr, 1884) (Ponerinae).

The richness estimators predicted a tendency towards an increase in species richness if more samples were sampled. Bootstrap estimated 151 species, and Jackknife2 188 species. According to the estimators, the 136 species collected represent, respectively, 90%, and 72% of the expected species richness for ants in the CSP. The species-accumulation curve for the total survey shows a tendency to an asymptote, while the curves for each stratum separately shows that the ground-dweller community tends to reach the asymptote faster than the arboreal community (Fig. S3).

Discussion

In this study, we reveal an impressive diversity of ants in the Cerrado State Park by conducting the first comprehensive inventory for the park. Besides the high richness found (136 species), the CSP draws attention for the presence of rarely collected and typically savanna-specialist species, like the fungus-farming ants *Cyatta abscondita* Sosa-Calvo et al. 2013, *Mycetagroicus cerradensis* Brandão & Mayhé-Nunes, 2001, and *Mycetarotes senticosus* (Fig. 2). Considering Southern Brazil (which includes the states of Paraná, Santa Catarina, and Rio Grande do Sul), *C. abscondita* and *M. cerradensis* are only found in the CSP, according to the literature (Brandão and Mayhé-Nunes 2001; Oliveira et al. 2016). *Mycetarotes senticosus*, although rarely found in scattered localities of southeastern Brazil (Mayhé-Nunes and Brandão 2006), is recorded for the state of Paraná for the first time in this study.

In addition, other biogeographically remarkable species were collected at the CSP, namely the rarely collected myrmicine species *Rogeria pellecta*, known only by two sampling events, in the states of Santa Catarina (Southern Brazil) and São Paulo (Southeastern Brazil); *Pheidole breviseta* Santschi, 1919, restricted to Argentina and Southern Brazil; and three species first recorded for Southern Brazil, *Camponotus crispulus*, *Pheidole exigua*, and *Pheidole scapulata* (Guénard et al. 2017; Janicki et al. 2016, available in https://antmaps.org/). *Camponotus crispulus* was known from Bolivia, Paraguay, and Argentina. In Brazil, the only record known is for the state of Mato Grosso do Sul (Midwest region). Here, we extended its distribution in 600 km east. *Pheidole exigua* was known from forest habitats in Central America and north of South America, reaching Bolivia in its southernmost distribution. Now, the southern limit for its distribution is CSP, 1500 km southeast of the previous nearest record and includes the Cerrado biome. Finally, *Pheidole scapulata* has been recorded from Paraguay and Argentina; in Brazil, the only record known is for the state of Minas Gerais (Southeastern Brazil). Here, we expand its distribution in Brazil by 600 km to the south (Guénard et al. 2017; Janicki et al. 2016, available in https://antmaps.org/).

Of the 63 species for which we were not able to attribute a name (morphospecies), more than 57% (36 morphospecies) belong to the myrmicine genera *Pheidole* and *Solenopsis*. This high level of unidentified species is due to the taxonomic status of these genera, since both are widely distributed, morphologically challenging, and species-rich, with 1161 and 194 extant species described, respectively. However, many morphospecies of *Pheidole* recorded here are new species in the process of being described (Alexandre Casadei-Ferreira, pers. comm.). This fact, along with the elevated number of new records for the state (13 species) and for Southern Brazil (three species), is evidence of the potential of the CSP to reveal taxonomic novelties.

The elevated number of habitat generalist and forest-associated species was somewhat expected, due to the relatively recent geologic origin of the Brazilian savanna, during the tertiary and the quaternary periods (about 10 mya) (Pinheiro and Monteiro 2010; Vasconcelos et al. 2018). Compared to different arid ecosystems in the world, the Neotropical

savanna presents relatively few arid-adapted ant species and the species composition is probably derived from an ancient species pool that inhabited forested habitats (Branstetter et al. 2017; Leal et al. 2017; Vasconcelos et al. 2018; Price et al. 2014, 2016).

We found a considerable ant fauna stratification at the CSP, with only 7.3% of the species collected in both soil and vegetation strata, while almost 76% of the species are ground-dwellers and 17% were arboreal (Fig. S1). This high level of stratification is also reflected in the faunal composition, since the most common species on the ground do not occur on the trees, and vice versa (Fig. S2). These results are congruent with other studies in tropical savannas and forests (Brühl et al. 1998; Rodrigues et al. 2019; Vasconcelos et al. 2019). According to Campos et al. (2008) the great number of ground species may be due to the physiognomy of the Cerrado, where there is no interconnection between treetops, making the arboreal habit less complex and precluding easy dispersion and colonization of this environment as opposed to the ground. In addition, Camarota et al. (2016) have shown that interspecific competition is more influential than habitat structure on distribution pattern in arboreal ants in Neotropical Savannas. The vertical stratification induces the adapted fauna to exploit different types of resources, thus reducing competition and increasing the number of species that can co-exist in the same place, even in small areas, as the CSP (Campos et al. 2008). It is known that ground-dwelling ants are also more common than arboreal ants in forests (Brühl et al. 1998). This is directly associated with the greater complexity of the ground in forested environments, which is usually characterized by a well-developed leaf-litter layer that provides several microhabitats for ant foraging and nesting (Barroso et al. 2020).

Comparing the ant richness found in this study with other studies that applied a similar sampling protocol (a total of 29 localities of Cerrado sampled by Vasconcelos et al. (2018, 2019) and Maravalhas and Vasconcelos (2019) throughout the entire biome), the CSP is the third richest area of Cerrado in Brazil. The first is a legal reserve of 158 ha in Patrocínio (state of Minas Gerais) and the second is a legal reserve of 114 ha in Nova Xavantina (state of Mato Grosso), both with 144 species. In a local scale, the CSP can be considered the richest area of Cerrado, with an average of 23 species per sampling point, followed by Nova Xavantina and Patrocínio, with 20 and 14 species per sampling point, respectively (Maravalhas and Vasconcelos 2019). Also, the number of species collected in a single sampling point (singletons) in the CSP is the second highest in the Brazilian savannas, along with Patrocínio, both with 12 species, after a legal reserve in São Carlos, state of São Paulo, southeastern Brazil, with 19 singletons species. On the other hand, a comparison of the ant richness of the CSP with another Cerrado location that is similar in size but more exhaustively sampled, suggests that the richness of the CPS may have been underestimated. The Panga Ecological Station (PES) is a 402 ha Cerrado reserve in the state of Minas Gerais, in the heart of the Brazilian Cerrado. Camacho and Vasconcelos (2015) presented a list of ant species for the PES based on ten different studies conducted for nine years, using different sampling methods. As a result, the authors recorded 277 species in the PES. Considering that our study is the first ant comprehensive inventory for the CSP, in which we employed a single collection method (pitfall traps in soil and vegetation), the 136 ant species recorded here can be considered an expressive sampling. In this sense, an increase in sampling effort associated with the use of different methods in distinct seasons of the year could reveal an even greater ant diversity for CSP. Furthermore, the richness estimators used here showed that we have not collected between 14 and 52 of the species potentially occurring at CSP, and the species-accumulation curves has not reached an asymptote. Therefore, this first sampling effort was an important step to access the ant fauna of the park, but more surveys are needed to reveal the complete local ant diversity.

This high ant diversity in the southernmost areas of the biome, and especially at the CSP, can be explained mainly by the location of the park at a high latitude (−24.1785). This is because the diversity of ant fauna in the Cerrado is directly correlated with higher latitudes, which determine a heavier rainfall during the warmest months of the year and increased plant productivity (Vasconcelos et al. 2018). However, when we compare the species richness of CSP and Águas de Santa Barbara, the second higher latitude between localities sampled by Vasconcelos et al. (2018, 2019), the richness found in the latter is significantly lower than CSP, with 103 ant species. Thus, besides latitude, the ant species pool of the CSP may be strongly influenced by other ecosystems known to occur in Southern Brazil, as the natural grasslands and *Araucaria angustifolia* forests (Ketterl et al. 2013; Maack 2012; Franco and Feitosa 2018).

The Cerrado State Park, along with other Cerrado fragments in Paraná, is considered a relict of the quaternary period, when the savanic formations originated and started to expand throughout the Neotropical region (Pinheiro and Monteiro 2010; Maack 2012). Thus, these fragments are historically separated from the central portion of the Cerrado in Brazil (Maack 2012). This fragmentation and isolation processes may have influenced the local and regional patterns of diversity, including loss of unique microhabitats, changes in dispersion and migration patterns, and the appearance of barrier effects (Aguiar et al. 2016; Fernández et al. 2019). All these factors may lead to the local loss of several species, many of which are not formally described and thus are not known to science.

Besides being a conservation area, the CSP is an island of natural vegetation in the middle of a region severely marked

by anthropic activity. The park is completely surrounded by farms, most of which practice monocultures (soybean, corn, wheat, and oats) (Fig. 1c). Those crops require extensive use of pesticides, which are able to reach areas of the park and cause important damage to native species. In addition, there are planted areas of exotic species for logging (*Pinus* and *Eucalyptus*). These species are able to invade the park area through wind dispersion. Without proper control, these invasive plants can rapidly suppress native species, and consequently affect the ant fauna. Finally, livestock rearing, especially cattle, in the surrounding farms, causes deforestation of Cerrado remnants adjacent to the park (IAP 2002).

More recently, in 2019, the legislative assembly of the state of Paraná approved law number 19.913, which allows private companies to explore areas destined for public use in conservation units of the state, including the CSP. In fact, in 2020, an important conservation unity in the state, the Vila Velha State Park, became the first park to suffer the effects of this law and has been explored for ecotourism and related activities since then. After that, Iguaçu National Park, one of the most important protected areas of Atlantic Forest in Brazil, located at the western limit of state of Paraná, also started being exploited by a private company. The inappropriate use of these conservation areas by private companies may promote an accelerated loss of native ecosystems and their associated biodiversity. This is concerning when we consider that the current Brazilian Federal government is openly promoting and enhancing the deforestation and illegal exploitation of natural areas in Brazil by drastically reducing the number of environmental inspectors and slashing the funds for research and development (Thomé and Haddad 2019). The government of the state of Parana is going against environmental protection guidelines by not implementing protective measures and also by handing over the few existing preservation areas to be exploited by private companies. The conservation efforts at the state, national, and international levels are fundamental to the preservation of the Cerrado, and its unique biodiversity (Françoso et al. 2019; Rosa 2020).

Studies in the Cerrado have shown that fragments located at the southern portions of the biome, specifically in the states of Paraná and São Paulo, are potentially suitable for faunal displacement in climate change scenarios (Aguiar et al. 2016; Marini et al. 2009; Siqueira and Peterson 2003). This highlights the importance of ensuring the preservation of the original vegetation of the CSP, which can be a refuge for many species in short to long terms.

Cerrado fragments in the Brazilian Southeast and South are the most fragmented and degraded by man, and the least protected by conservation measures (Aguiar et al. 2016; Françoso et al. 2019). In the 1990s and 2000s, the Brazilian Cerrado lost 0.6% of its natural vegetation annually, which represents 1700 ha per day, due to livestock and intensive agriculture expansion (Françoso et al. 2019). This makes the creation of conservation unities essential and urgent, especially in the southern portions of the Cerrado. Additionally, ecological corridors need to be created to increase a connectivity between the fragmented areas of the South, including public and private protected unities, to preserve the fauna of the Cerrado (Aguiar et al. 2016; Rosa 2020).

Conclusion

Here, we recorded 136 species for the Cerrado State Park, the only and extremely threatened fragment of savanna in Southern Brazil. We present 13 new records for the state of Paraná and three new records for the South region. In addition to records of three rarely collected and typical savanna-specialist species. The CSP is the fourth most diverse area of savanna in Brazil.

The southern fragments of Cerrado are potentially suitable areas which could be used as a refuge to the specialized fauna in light of climate changes, favoring the maintenance of the biodiversity of the savanna biome in Brazil. However, the CSP is severely threatened by anthropic activity and is surrounded by farms that practice monoculture, logging of exotic species, and livestock. Additionally, it is threatened by the recently approved law in the state of Paraná that allows the exploitation of conservation areas by tourist companies.

This study draws attention to the importance of preserving the CPS, an isolated but highly important fragment of savanna in Southern Brazil with an enormous biological value, including a considerable ant diversity and several rarely collected and ecologically important species. Our results show that even relatively small fragments may hold levels of biodiversity comparable to those of much larger areas and therefore deserve more visibility, research effort, and effective conservation policies.

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