Species list of ground-dwelling ants (Hymenoptera: Formicidae) in the Nhecolândia, Pantanal, Mato Grosso do Sul, Brazil

Mila Ferraz de Oliveira Martins¹; Mariane Aparecida Nickele¹; Rodrigo Machado Feitosa¹; Marcio Roberto Pie³; Wilson Reis-Filho²

¹ Universidade Federal do Paraná (UFPR). Curitiba, PR, Brasil.
² Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). Colombo, PR, Brasil.
³ Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina (EPAGRI). Florianópolis, SC, Brasil.
⁴ ORCID: http://orcid.org/0000-0003-4322-148X. E-mail: milafomartins@gmail.com
⁵ ORCID: http://orcid.org/0000-0002-5784-6328. E-mail: nickele.mariane@gmail.com
⁶ ORCID: http://orcid.org/0000-0001-9042-0129. E-mail: rsmfeitosa@gmail.com
⁷ ORCID: http://orcid.org/0000-0002-2949-4871. E-mail: marcio.pie@gmail.com
⁸ ORCID: http://orcid.org/0000-0002-0293-4144. E-mail: desinfeste@gmail.com

Abstract. This study provides a list of the ground-dwelling ant species in Nhecolândia, Pantanal, Mato Grosso Sul, Brazil. The Pantanal is the largest tropical wetland in the world and is currently under strong anthropic pressure. Ground-dwelling ants were collected in three sites: (1) a forest regeneration area; (2) a pasture area; and (3) an area of secondary native vegetation. In each site, 120 samples were collected using pitfall traps in the dry and rainy seasons of 2016. Additional samplings were performed with Winkler extractors (30 leaf-litter samples) and manually, also in dry and rainy seasons of 2016. In total, we collected 172 species, which, summed with the additional records from literature, raise the number of ant species recorded in Nhecolândia to 184 in 42 genera and nine subfamilies. Eleven species were recorded for the first time in the state of Mato Grosso do Sul. Also, the survey adds two new species records to Brazil. Besides contributing to the inventory of the ant species present in the Pantanal biome, the present study provides an important resource for future conservation plans for this threatened ecoregion.

Keywords. Ant sampling; Conservation; Diversity; Epigaeic ants.

INTRODUCTION

The Pantanal is the largest tropical wetland in the world, distributed across three countries: Brazil, Bolivia, and Paraguay. The largest portion of the biome is located in Brazil, with approximately 150,000 km² (Uehara-Prado, 2005; Junk et al., 2006; Mioto et al., 2012). The biome is recognized as a natural heritage by the Brazilian constitution, and a natural heritage of humanity by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Boin et al., 2019; Correa et al., 2019). Despite its remarkable biodiversity, the Pantanal is restricted to a relatively small area compared to other Brazilian biomes, being only bigger than the Pampa biome (Correa et al., 2019; MMA, 2020). Until recently it was considered the most preserved Brazilian biome (with approximately 83% of the natural area preserved until 2018) (MMA, 2020), but this is no longer the case after the expansion of agricultural frontiers (Grasel et al., 2019), and the 2020 arson that devastated about 30% of it (Arréllaga et al., 2020; Einhorn et al., 2020; INPE, 2020a).

The high species diversity of the Pantanal results from its morphological and phytophysiological diversity (Junk et al., 2006, 2013; Alho et al., 2019; Louzada et al., 2020). In fact, some researchers have proposed that the Pantanal is not a biome, but a mosaic of phytophysiognomies (Demétrio et al., 2017; Boin et al., 2019) that differ according to their degree of similarity between the Cerrado and the Chaco in the South, and the Cerrado and the Amazon in the North (Junk et al., 2006), forming different wetlands. The Brazilian Pantanal is a sedimentary basin surrounded by plateaus, forming a set of terrestrial and aquatic ecosystems (Boin et al., 2019). It is divided into subregions that have distinct physiomorphological (flood, relief, soil, and vegetation) and ecological characteristics (Silva & Abdon, 1998; McGlue et al., 2017). Mioto et al. (2012) identified 18 subregions, Nhecolândia being the largest, accounting for 14% of the Pantanal area.
Located in the state of Mato Grosso do Sul (Brazil), Nhecolândia is characterized by the coexistence of thousands of lakes called baías (fresh water) and salinas (waters of alkaline composition), in addition to the cordilheiras (sand banks with at least two meters, covered by cerradão – a type of forested Brazilian savanna) (Rodela & Queiroz-Neto, 2007; Mioto et al., 2012). The uniqueness of this location is due to the fact that salinas and baías are the main formations (Oliveira et al., 2018). This region is socially and economically important because it is one of the largest cattle pastures in the Pantanal (Rodela & Queiroz-Neto, 2007). Besides that, Nhecolândia has one of the highest wild vertebrate densities in the Pantanal (Alho, 2008; Alho & Sabino, 2011), especially of threatened species (Alho et al., 2019), and a high floral heterogeneity (Oliveira et al., 2018). A large number of studies have assessed the vertebrate and floral diversity in Nhecolândia (Alho, 2008; Alho & Sabino, 2011; Junk et al., 2013; Alho et al., 2019), but invertebrate inventories for the region are scarce (Lewinsohn et al., 2005; Junk et al., 2006; Demétrio et al., 2017).

Invertebrates constitute the greatest part of the tropical forest biomass corresponding to approximately 75% of the terrestrial biomass (Fittkau & Klink, 1973; Bar-On et al., 2018). Due their high density, shorter life cycle (in relation to vertebrates), and high frequency of occurrence in samplings, terrestrial invertebrates can be used as bioindicators, and can contribute to the understanding and establishment of environmental conservation measures (Lewinsohn et al., 2005). Ants are the most abundant component of the invertebrate biomass (Fittkau & Klink, 1973; Demétrio et al., 2017). They are conspicuous organisms and live in almost all environments (Folgarait, 1998), from the arboreal strata to the underground (Lucky et al., 2013; Jacquemin et al., 2016).

Despite the fact that the Pantanal is a hotspot and ants are relatively easy to sample (Myers et al., 2000), there have been few studies on the ants of this biome when compared to other biomes (see Oliveira et al., 1987; Adis et al., 2001; Batirolla et al., 2005; Orr et al., 2003 Uehara-Prado, 2005; Corrêa et al., 2006; Ribas & Schorderer, 2007; Lange et al., 2008; Pereira et al., 2013; Soares et al., 2013; Neves et al., 2014; Cuissi et al., 2015; Meurer et al., 2015; Aranda et al., 2016; Yamazaki et al., 2016; Demétrio et al., 2017; Dambros et al., 2018), and most of them deal with the vertical flow of ants following the hydrological cycle. In addition, if we rank the Brazilian biomes according to the loss of natural cover – et al., 2020 – Mato Grosso Sul, Brazil.

**MATERIAL AND METHODS**

**Sampled areas**

The sampled areas were part of the Biomas Project, which was carried out between 2014 and 2019 in partnership with Confederação da Agricultura e Pecuária do Brasil (CNA), and Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). The study areas are located in the Nhecolândia subregion, in the Taquari megafan (between the Taquari and Negro rivers) (Oliveira et al., 2018). The differences in salinity between salinas and baías, and within salinas, are the result of their different levels of interconnectivity. Salinas do not connect and are surrounded by cordilheiras (areas with a predominance of xeromorphic vegetation over sandy strands, old river dikes), whereas baías may connect, forming vazantes (runoff channels formed during the rainy season) (McGlue et al., 2017; Oliveira et al., 2018; Boin et al., 2019). Due to their saline composition, the lakes can also be distinguished by color (Oliveira et al., 2018). According to Oliveira et al. (2018), the climate in Nhecolândia is more semi-arid than tropical, with annual average temperature of 24°C and accumulated rainfall of 1,100 mm. The concentrated rains occur between October and March, with irregular distribution in the East-West direction (higher volumes in the west). The temperature varies greatly and may oscillate from 1°C to 40°C in the same day (during the Winter, from June to August), due the influence of cold air masses originated in the Andean region (Oliveira et al., 2018).

The following sites were selected for this study: (A1) an area undergoing forest regeneration (18°58′45″S and 56°38′33″W), where a cultivated pasture (Brachiaria spp.) was reforested with arboreal species, such as Sterculia apetala (Jacq.) H. Karst., Dipterx alata Vog., Hymenaea stigonocarpa Mart. ex Hayne and Handroanthus impetiginosus (Mart. ex DC) in 2015 by the Biomas Project; (A2) a degraded area used as pasture (covered by Brachiaria spp. (19°15′00″S and 57°03′25″W); and (A3) an area with secondary native vegetation (cerradão) (18°57′53″S and 56°37′33″W), without human intervention for at least 25 years, located at the Private Reserve of Natural Heritage Fazenda Nhümirim (18°59′17″S and 56°37′08″W), which was created in 1990, owned by EMBRAPA Pantanal.

Additional qualitative samplings were obtained in areas of primary native vegetation, present in the cordilheiras (close to the areas systematically sampled, especially in Fazenda Nhümirim), whose floristic composition is quite heterogeneous, with reference to the species Attalea phalerata Mart. ex Spreng., Diospyros lasiocalyx (Mart.) B. Walln. and Annona dioica A. St.-Hil. (Freitas et al., 2011).

**Sampling methods**

We carried out two expeditions: one in the dry season (January) and one in the rainy season (July) of 2016. The methodology followed the ALL protocol for ant sampling proposed by Agosti & Alonso (2000), with modifications. In each area, we allocated three transects of 200 m, spaced by 10 m, forming a grid. Along each transect, we installed 20 epigaeic pitfall traps spaced by 10 m, totaling 60 pitfalls per area (per expedition) that remained in the field for 48h. Pitfall traps consisted of 200 ml plastic cups, half filled with water, detergent, and salt (NaCl),...
buried at the ground level. Additional qualitative sampling was carried out manually (on soil and vegetation) and through Winkler extractors, both without a specific sampling design. We collected 30 Winkler samples (15 per season), for which only the leaf-litter was sieved, excluding the soil surface (for details about Winkler extractor see Fisher, 1999).

The sampled material was processed at the Entomology Laboratory at EMBRAPA Florestas (Colombo, PR) and at the Laboratório de Sistemática e Biologia de Formigas at Universidade Federal do Paraná (UFPR). The ants were mounted and identified at the genus level using the identification key in Baccaro et al. (2015). For species classification, specific literature was used (Gonçalves, 1961; Andrade & Baroni-Urbani, 1999; Longino & Fernández, 2007; Cuezzo et al., 2015), and specialists (Alexandre C. Ferreira, Natalia M. Ladino, Thiago S.R. da Silva and John E. Latke) were consulted. The material was deposited at the Padre Jesus Santiago Moura Entomological Collection (DZUP) and the duplicates were stored in the Entomology Laboratory of EMBRAPA Florestas.

To confirm species occurrences in the Nhecolândia, we used AntMaps (Janicki et al., 2016; Guénard et al., 2017). The following combination of words: “ants”, “Pantanal”, “floodplains”, “Nhecolândia”, and “Brazilian wetlands”, was searched in Google Scholar, Scielo, and Web of Science databases for data on ant species recorded in the Pantanal available on literature. We gathered 17 papers: Oliveira et al. (1987), Adis et al. (2001), Batirolla et al. (2005), Orr et al. (2003), Uhlera-Prado (2005), Corrêa et al. (2006), Ribas & Schorer (2007), Lange et al. (2008), Pereira et al. (2013), Soares et al. (2013) Neves et al. (2014), Cuiissi et al. (2015), Meurer et al. (2015), Yamazaki et al. (2016), Aranda et al. (2016), Demétrio et al. (2017), and Dambros et al. (2018). The species associated with these bibliographies, for the Nhecolândia subregion, were listed and identified as “literature data” (see Tables 1 and 2: L1 and L2). For the sake of taxonomic precision, species identified as near (“nr.” and “aff.”) nominal taxa in the literature were here considered morphospecies, but are treated as species for comparison purposes, even that not formally described. The taxonomic classification of the taxa names obtained from the literature was updated according to the most recent proposal (Bolton, 2021).

We used the richness estimators Jackknife 1, and Bootstrap, with the pitfall traps data, to evaluate if the species sampled are nearest to the expected with this

### Table 1. Coordinates from the sampled areas in this study (A1, A2, A3, and Faz. Nhumirim), and the literature referred to in Pantanal. (*) samplings performed by Biomas Project in Nhecolândia; (S) others studies in Nhecolândia.

| Papers | Longitude GMS | Latitude GMS | Longitude GD | Latitude GD |
|--------|--------------|--------------|--------------|-------------|
| (A1) Biomas * | 56°38'13"W | 18°58'45"S | -56.6425 | -18.9791667 |
| (A2) Biomas * | 57°03'25"W | 19°15'00"S | -57.0594444 | -19.25 |
| (A3) Biomas * | 56°37'31.65"W | 18°57'53.37"S | -56.6258333 | -18.9647222 |
| (Faz. Nhumirim) Biomas qualitative * | 56°37'08"W | 18°59'17"S | -56.6188889 | -18.9808556 |
| (L1) Uhlera-Prado (2005)* | 56°19"W | 19°34"S | -56.2333333 | -19.5666667 |
| (L2) Cuiissi et al. (2006)* | 56°14"W | 19°34"S | -56.2333333 | -19.5666667 |
| Adis et al. (2001) | 56°22'12"W | 16°15'12"S | -56.37 | -16.2533333 |
| Aranda et al. (2016) | 57°36'17"W | 19°11'05"S | -57.6047222 | -19.1847222 |
| Batirolla et al. (2005) | 56°36'24"W | 16°15'24"S | -56.6071723 | -16.2570973 |
| Batirolla et al. (2005) | 57°56'23"W | 17°54'32"S | -57.9404147 | -17.9993228 |
| Cuiissi et al. (2015) | 53°11'Y | 20°59"S | -55.1833333 | -20.9833333 |
| Dambros et al. (2018) | 56°32'W | 16°18"S | -56.5333333 | -16.3 |
| Dambros et al. (2018) | 56°24'W | 16°30"S | -56.4 | -16.3 |
| Demétrio et al. (2017) | 57°29'18"W | 18°06'44"S | -57.4833333 | -18.1122222 |
| Demétrio et al. (2017) | 57°01'08"W | 19°34'35"S | -57.0188889 | -19.5676888 |
| Demétrio et al. (2017) | 57°49'30"W | 21°15'20"S | -57.825 | -21.2555556 |
| Demétrio et al. (2017) | 57°36'04"W | 19°12'10"S | -57.6011111 | -20.2027778 |
| Lange et al. (2008) | 57°01'06"W | 19°28'4"S | -57.0183333 | -19.4677778 |
| Meurer et al. (2015) | 58°08'25"W | 16°28'49"S | -58.1402778 | -16.4802777 |
| Neves et al. (2014) | 57°01'37.6"W | 19°58'56.4"S | -57.0276297 | -19.6494299 |
| Neves et al. (2014) | 57°02'32.40"W | 19°22'20.28"S | -57.0428516 | -19.3727419 |
| Oliveira et al. (1987) | 56°59'18.4"W | 17°16'5.6"S | -56.9834455 | -17.2671006 |
| Orr et al. (2003) | 57°01'W | 19°34"S | -57.0166667 | -19.5666667 |
| Pereira et al. (2013) | 57°52'33"W | 21°40'19"S | -57.8813889 | -21.6719444 |
| Pereira et al. (2013) | 57°53'10.00"W | 21°41'40.86"S | -57.8861111 | -21.6948333 |
| Pereira et al. (2013) | 57°52'51.81"W | 21°41'10.39"S | -57.8810583 | -21.6862194 |
| Pereira et al. (2013) | 57°53'10.6"W | 21°40'27.0"S | -57.8918333 | -21.6741666 |
| Pereira et al. (2013) | 57°54'58.7"W | 21°45'56.0"S | -57.9160556 | -21.7655556 |
| Ribas & Schorer (2007) | 57°45'00"W | 19°34'34"S | -57.0125 | -19.5761111 |
| Ribas & Schorer (2007) | 57°10'00"W | 19°34'57"S | -57.0166667 | -19.5825 |
| Soares et al. (2013) | 56°30'22.8"W | 20°10'30.4"S | -56.5063333 | -20.1751111 |
| Yamazaki et al. (2016) | 56°24'W | 16°26"S | -56.4000515 | -16.4337652 |
sampling effort (Hortal et al., 2006). A map (Fig. 1) was made to indicate the distribution of sampling areas in Pantanal gathering the coordinates of the sampled areas of this study (A1, A2, A3, Faz. Nhumirim) and the literature compiled here (L1, L2, Other studies) (Table 1). All the coordinates referring in the literature were included in the map after conversion from GMS-SAD69 to GD-SIRGAS2000 using the calculator provided by Instituto Nacional de Pesquisas Espaciais (INPE, 2020b). The map was generated using the software QGis 3.0.3, and shapefiles provided by the Instituto Brasileiro de Geografia e Estatística (IBGE) and Instituto Nacional de Pesquisas Espaciais (INPE) (Assis et al., 2019).

Ant collecting was authorized by the Brazilian Biodiversity Information and Authorization System – SISBIO (license number 55313-1) and the access to the genetic heritage was registered in the National Management System of the Genetic Heritage – SisGen (register number ACDFB38).

RESULTS

Considering the samplings from this study and the literature information, we registered 184 species in 42 genera and nine subfamilies for the Nhecolândia subregion of Pantanal (Table 2). Specifically for the samplings carried out in this study, we collected 172 species belonging to 42 genera and nine subfamilies. Of these species, 81 were formally named (corresponding to 47.1% of the total recorded), while the remaining unnamed species were here treated as morphospecies. Myrmicinae was the most species-rich subfamily (86 species), followed by Formicinae (32) and Dolichoderinae (19), which accounted for 50%, 18.6% and 11% of the total species, respectively. Pheidole Westwood, 1839 was the most species-rich genus, with 28 species (16.2%), followed by Brachymyrmex Mayr, 1868, and Solenopsis Westwood, 1840 with 16 species (9.3%, each) and Camponotus Mayr, 1861 with 12 (7%). The most frequent species were Pheidole sp. 1, Dorymyrmex pyramicus (Roger, 1863), Solenopsis invicta Buren, 1972 and Forelius sp. 1. A total of 66, 45, and 85 species were sampled in areas 1, 2, and 3, respectively. This is less than the number estimated by Jackknife 1 (76%, 73%, and 68.5%) and bootstrap (86%, 88% and 84%) (Table 3).

Regarding the registers from the literature, only two papers added species to the local list: (L1) Uehara-Prado (2005) with three species – Dorymyrmex aff. goeldii, Solenopsis globularia (Smith, 1858), and Solenopsis
Table 2. Species list in the Nhecolândia, subregion of the Pantanal, Mato Grosso do Sul, Brazil. (Qual.) qualitative: manual and Winkler samplings; (A1) forest regeneration area; (A2) pasture area; and (A3) secondary native vegetation. Literature data: (L1) Uehara-Prado, 2005; and (L2) Corrêa et al., 2006.

| Species Qual. | A1 | A2 | A3 | L1 | L2 |
|---------------|----|----|----|----|----|
| Amblyoponinae |    |    |    |    |    |
| 1 Pniopelta antillana Forel, 1909 | X | X |    |    |    |
| Dolichoderinae |    |    |    |    |    |
| 2 Azteca sp. 1 | X | X | X |    |    |
| 3 Azteca sp. 2 | X |    |    |    |    |
| 4 Azteca sp. 3 |    |    |    |    |    |
| 5 Azteca sp. 4 | X |    |    |    |    |
| 6 Dolichoderus diversus Emery, 1894 | X |    |    |    |    |
| 7 Dorymyrmex brunneus Forel, 1908 | X | X | X |    |    |
| 8 Dorymyrmex aff. goeldii |    |    |    |    | X |
| 9 Dorymyrmex panamensis Santschi, 1922 | X | X |    |    |    |
| 10 Dorymyrmex pyramicus (Roger, 1863) | X | X |    |    |    |
| 11 Dorymyrmex sp. 1 | X |    |    |    |    |
| 12 Dorymyrmex sp. 2 | X | X |    |    |    |
| 13 Dorymyrmex sp. 3 | X |    |    |    |    |
| 14 Dorymyrmex sp. 4 | X | X |    |    |    |
| 15 Dorymyrmex sp. 5 | X |    |    |    |    |
| 16 Dorymyrmex sp. 6 | X |    |    |    |    |
| 17 Forelius brasiliensis (Forel, 1908) | X | X | X |    |    |
| 18 Forelius sp. 1 | X | X |    |    |    |
| 19 Forelius sp. 2 | X | X | X |    |    |
| 20 Forelius sp. 3 | X |    |    |    |    |
| 21 Gnamptogenys pamboro Wild & Cazzaro, 2006 | X | X |    |    |    |
| Dorylinae |    |    |    |    |    |
| 22 Eschscholtzia burchelli Westwood (1842) |    | X |    |    |    |
| 23 Exochorinthus umbratus Forel, 1912 |    | X |    |    |    |
| 34 Labidus caucus (Latreille, 1802) |    | X |    |    |    |
| 25 Labidus mops (Forel, 1912) | X | X | X |    |    |
| 26 Labidus praedator (Smith, 1858) |    | X |    |    |    |
| 27 Neivamyrmex sp. 1 | X |    |    |    |    |
| 28 Neivamyrmex sp. 2 | X | X |    |    |    |
| 29 Neivamyrmex sp. 3 | X |    |    |    |    |
| 30 Neivamyrmex sp. 4 | X | X |    |    |    |
| 31 Neivamyrmex hartigii (Westwood, 1842) | X |    |    |    |    |
| Ectatomminae |    |    |    |    |    |
| 32 Ectatomma brunnneum Smith, 1858 | X | X | X |    |    |
| 33 Ectatomma edentatum Roger, 1863 | X | X | X |    |    |
| 34 Ectatomma luginis Emery, 1894 | X | X | X |    |    |
| 35 Ectatomma opaciventer (Roger, 1861) | X | X | X |    |    |
| 36 Ectatomma pernigrum Forel, 1908 | X | X | X |    |    |
| 37 Ectatomma plundens Borgmeier, 1939 | X | X | X |    |    |
| 38 Ectatomma tuberculatum (Olivier, 1792) | X | X | X |    |    |
| 39 Gnaptogenys striatula Mayr, 1884 | X | X |    |    |    |
| Formicinae |    |    |    |    |    |
| 40 Brachymyrmex pilius Mayr, 1887 | X | X | X |    |    |
| 41 Brachymyrmex sp. 1 | X |    |    |    |    |
| 42 Brachymyrmex sp. 2 | X | X | X |    |    |
| 43 Brachymyrmex sp. 3 | X | X | X |    |    |
| 44 Brachymyrmex sp. 4 | X |    |    |    |    |
| 45 Brachymyrmex sp. 5 | X | X | X |    |    |
| 46 Brachymyrmex sp. 6 | X |    |    |    |    |
| 47 Brachymyrmex sp. 7 | X |    |    |    |    |
| 48 Brachymyrmex sp. 8 | X |    |    |    |    |
| 49 Brachymyrmex sp. 9 | X | X | X |    |    |
| 50 Brachymyrmex sp. 10 | X |    |    |    |    |
| 51 Brachymyrmex sp. 11 | X |    |    |    |    |
| 52 Brachymyrmex sp. 12 | X |    |    |    |    |
| 53 Brachymyrmex sp. 13 | X |    |    |    |    |
### Table 3. Species richness observed ($R_{OBS}$), estimated by Jackknife 1 ($R_{JACK1}$), and Bootstrap ($R_{BOOT}$). Areas: (A1) forest regeneration area; (A2) pasture area, and (A3) control area (secondary native vegetation).

| Area | $R_{OBS}$ | $R_{JACK1}$ | $R_{BOOT}$ |
|------|-----------|-------------|-------------|
| A1   | 66        | 87          | 76          |
| A2   | 45        | 61          | 51          |
| A3   | 85        | 124         | 101         |
**DISCUSSION**

We recorded a total of 184 ant species in the Nhecolândia ecoregion. From those species recorded in this study (172), 53% were collected using only epigaeic pitfalls, 26.7% using only qualitative sampling (Winkler extractor, and manual sampling), and 20.3% using both methods. The emphasis on the sampling method used in this work is important because there is a great number of studies focusing on the arboreal ants of the Pantanal biome (exclusively arboreal ants: Oliveira et al., 1987; Adis et al., 2001; Batirolla et al., 2005; Ribas & Schoeder, 2007; Soares et al., 2013; Aranda et al., 2016; Yamazaki et al., 2016; and combined methods which includes arboreal ants: Cuiissi et al., 2015; Demétrio et al., 2017; Dambros et al., 2018). It could be explained by the fact that vertical migrations are considered the main survival strategy for arthropods that inhabit floodplains (Adis et al., 2001).

However, Adis & Junk (2002) listed other two strategies for floodplain organisms: temporary flight to the uplands, and horizontal migration following the higher waterline. Only the latter is applicable to ants, at least in a major part of the year.

Studies on the ground-dwelling ants of the Pantanal are important because this fauna has been partially neglected in favor of arboreal ants. When studying the ground-dwelling fauna, it is important to outline the association between the sampling method and the ground-dwelling community. For example, a previous study found 205 species in four distinct subregions of the Pantanal Biome (Miranda, Abobral, Nabileque, and Tuiuiú) using at least seven sampling methods (Demétrio et al., 2017), while the total species number in studies, in subregions other than Nhecolândia, that sampled only the vegetation or the canopy varies from 20 to 75, approximately (see Oliveira et al., 1987; Batirolla et al., 2005; Ribas & Schoeder, 2007; Pereira et al., 2013; Soares et al., 2013; Yamazaki et al., 2016). A few more species of ants were found by Dambros et al. (2018), who used fogging to obtain arboreal species and recorded 105 ant species in the Poconé subregion.

Beyond the differences between the species richness present in canopy and soil, sampling ground-dwelling ants allow us to access a completely distinct ant community (Yanoviak & Kaspari, 2000). When we compare the species listed in most of the studies carried out in the region and the species sampled here, the differences between the compositions are evident. Once the arboreal species are mainly represented by the genera Crematogaster Lundi, 1831, Cephalotes Latreille, 1802, Pseudomyrmex Lundi, 1831, and Camponotus Mayr, 1861 (Ribas & Schoeder, 2007; Yamazaki et al., 2016; Dambros et al., 2018), our samplings registered a higher diversity of other, ground-related, genera as Pheidole, Solenopsis, and fungus-farming ants.

The richness recorded in the present study, considering just the species sampled in pitfalls, is consistent with the results of another work carried out in capões, also in the Nhecolândia subregion, which registered 71 species sampled with epigaeic pitfall traps (Corrêa et al., 2006). However, the species richness here is highest than that found by Uehara-Prado (2005) in distinct pasture areas (12 morphospecies), as expected for such ecologically simplified environment. The richness of ground-dwelling ants found in these inventories, indicate the importance of sampling this community to understand the ant diversity of the Pantanal as a whole. Beyond the epigaeic species, investigated in the present research, we also need to improve our knowledge about the hypogaeic species. The only study that investigated the subterranean strata in the Brazilian Pantanal found eight morphospecies (Lange et al., 2008). This number may seem low if compared with the ant species on the soil surface, but the subterranean ants correspond to approximately 15% of a total species in an extensively sampled area (Martins et al., 2020).

The eleven species recorded for the first time in the state of Mato Grosso do Sul had already been found in the neighboring states or in Cerrado areas (see Camacho & Vasconcelos, 2015; Oliveira et al., 2016; Franco & Feitosa, 2018; Vicente et al., 2018). This can be explained by the fact that, even though the predominant phytophysiology of the cordileira is the cerradão, other phytophysiology are occur in the area, for example the more typical Cerrado formation. Therefore, species that had been previously registered in localities where the typical Cerrado occurs were also expected to occur in our sampling site. Of the first record of two ant species to Brazil, C. silvicola also occurs in Bolivia, and P. obscurifrons also occurs in Argentina. The locality of C. silvicola in the neighboring country is approximately 460 kilometers from our site. Likewise, our record of P. obscurifrons is 1,047 km to the north.

Even though ants seem to be resilient to natural burning regimes in studies carried out in Australian or African savannas (Philpott et al., 2010), this may not be the case of the Pantanal (Vasconcelos et al., 2017). In the Brazilian Cerrado, Maravalhas & Vasconcelos (2014) found considerable differences among ant assemblages sampled in areas with distinct fire frequencies, indicating considerable variation in species composition. Since the phytophysiology of the Pantanal is similar to the Cerrado, ants from the Pantanal may have a similar behavior to the ants in the cerradão. Future studies are necessary to test this hypothesis, since the entire Pantanal has lost around 30% of its natural coverage in 2020 (INPE, 2020a) due to arson. Also, flooded forests can be the most impacted by wildfires, in tropical Brazilian savannas, with significative losses on the seed banks and biomass (Flores et al., 2020). Besides fires, the ants (and other terrestrial invertebrates) live under the pressure of environmental modifications caused by livestock. About 93% of the Brazilian Pantanal corresponds to private areas (Tomas et al., 2019). These facts are extremely worrying, because the main regional activity there is livestock, especially in the Nhecolândia subregion (Rodela & Queiroz-Neto, 2007).

Dívieso et al. (2020) have called attention to the importance of sampling ants in ecoregions that are conservation priority areas on a more refined scale. Even though they did not outline the Pantanal subregions
as ecoregions, the Pantanal subregions can be characterized as ecoregions according to the characteristics of their soil composition (Silva & Abdón, 1998), phytophysiognomies (Mioto et al., 2012), and hydrological regime and climate (Rodela & Queiroz-Neto, 2007). The large number of ant species assembled here for a unique subregion of the Pantanal, and the fact that 84 morphospecies of this study have no scientific name and are potential new species, highlight the importance of conducting more researches in Pantanal. Our study contributes to the inventory of species present in the Nhecolândia, Pantanal, and is an important ant sampling resource for the future choices for sampling areas, and future conservation plans in this biome.

ACKNOWLEDGMENTS

We thank the Confederação da Agricultura e Pecuária do Brasil (CNA) for financial support, and the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) for granting the study area. MFOM would like to thank Alexandre Casadei Ferreira, and Thiago S.R. da Silva for our friendship and for reading and contributing to the manuscript. The authors thank the two anonimous reviewers and Monica Ulisséa (second reviewer) which greatly contributed to the improvement of this paper. In “normal” times it is difficult to be a reviewer, and in a pandemic period this task becomes even more arduous. Thank you very much for your disposal.

AUTHORS’ CONTRIBUTIONS

MFOM and MAN elaborated the project, wrote the manuscript, participated in the sampling expeditions, and identified the ant species. RMF, MRP, and WRF helped with the project elaboration, support the discussions, and corrected the manuscript. Also, RMF identified the species, and WRF participated in the sampling expeditions.

REFERENCES

Adis, J. & Junk, W.J. 2002. Terrestrial invertebrates inhabiting lowland river floodplains of Central Amazonia and Central Europe: a review. *Freshwater Biology*, 47(4): 711-731.

Adis, J.; Marques, M.I. & Wantzen, K.M. 2001. First observations on the survival strategies of terricolous arthropods in the northern Pantanal wetland of Brazil. *Andrias*, 15: 127-128.

Agosti, D. & Alonso, L.E. 2000. The ALL protocol: selected case studies. In: Agosti, D.; Majer, J.D.; Alonso, L.E. & Schultz, T.R. (Eds.). *Ants: standard methods for measuring and monitoring biodiversity*. Washington, Smithsonian Institution. p. 204-206.

Alho, C.J.R. 2008. Biodiversity of Pantanal: response to seasonal flooding regime and to environmental degradation. *Brazilian Journal of Biology*, 68(4): 947-966. https://www.scielo.br/pdf/bjb/v68n4a0/a05v68s4.pdf.

Alho, C.J. & Sabino, J. 2011. A conservation agenda for the Pantanal’s biodiversity. *Brazilian Journal of Biology*, 71(1): 327-335.

Alho, C.J.R.; Mamede, S.B.; Benites, M.; Andrade, B.S. & Sepúlveda, J.J.O. 2019. Ameaças à biodiversidade do Pantanal Brasileiro pelo uso e ocupação da terra. *Ambiente e Sociedade*, 22: e01891.

Andrade, M.L. & Baroni-Urbani, C. 1999. Diversity and adaptation in the ant genus Cephalotes, past and present. *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie)*, 271: 893. Adapted and available in: https://antwiki.org/wiki/Key_to_Cephalotes_Species.

Aranda, R.; Olivier, R. & Ferraro, A. 2016. First record of *Pseudomyrmex acaanthobius* Emery in Brazilian Pantanal. *Entomobrasisil*, 9(1): 56-58.

Arrêllaga, M.M.; Londoño, E. & Casado, L. 2020. Brazil fires burn world’s largest tropical wetlands at ‘unprecedented’ scale. Available: https://www.nytimes.com/2020/09/04/world/americas/brazil-wetlands-fires-pantanal.html. Accessed: 19/10/2020.

Assis, L.F.F.G.; Ferreira, K.R.; Vinhas, L.; Maurano, L.; Almeida, C.; Carvalho, A.; Rodrigues, J.; Maciel, A. & Camargo, C. 2019. *TerraBrasilis*: A spatial data analytics infrastructure for large-scale thematic mapping. *International Journal of Geo-information*, 8(513): 27p. DOI

Baccaro, F.B.; Feitosa, R.M.; Fernandes, F.; Fernandes, I.O.; Izzo, T.J.; Souza, J.L.P. & Solar, R. 2015. *Guia para os gêneros de formigas do Brasil*. Manaus, Editora INPA. 388p.

Bar-On, Y.M.; Phillips, R. & Milo, R. 2018. The biomass distribution on Earth. *Proceedings of the National Academy of Sciences*, 115(25): 6506-6511. DOI

Batrolla, I.D.; Marques, M.I.; Adis, J. & Delahie, J.H.C. 2005. Composição da comunidade de Formigas (Hymenoptera: Formicidae) em capões de *Attalea phalerata* Mart. (Arecaceae), no Pantanal de Poconé, Mato Grosso, Brasil. *Revista Brasileira de Entomologia*, 49(1): 107-117.

Boin, M.N.; Martins P.C.S.; da Silva C.A. & Salgado A.A.R. 2019. Pantanal: The Brazilian Wetlands. In: Salgado, A.; Santos, L. & Paisani, J. (Eds.). *The physical geography of Brazil*. Geography of the physical environment. Cham, Springer. DOI

Bolton, B. 2021. An online catalog of the ants of the world. Available: https://antcat.org. Access: 25/03/2021.

Camacho, G.P.; Vaszconcelos, H.L. 2015. Ants of the Panga Ecological Station, a Cerrado reserve in Central Brazil. *Sociobiology*, 62(2): 281-295. DOI

Correa, C.M.A.; Braga, R.F.; Louzada, J. & Menéndez, R. 2019. Dung beetle diversity and functions suggest no major impacts of cattle grazing in the Brazilian Pantanal wetlands. *Ecological Entomology*, 44(4): 524-533. DOI

Corrêa, M.M.; Fernandes, W.D. & Leal, I.R. 2006. Diversidade de formigas epigeicas (Hymenoptera: Formicidae) em Capões do Pantanal Sul mato-grossense: Relações entre riqueza de espécies e complexidade estrutural da área. *Neotropical Entomology*, 35(6): 724-730.

Cuzzo, F.; Calcaterra, L.A.; Chifflet, L. & Follett, P. 2015. *Wasmannia Forel* (Hymenoptera: Formicidae: Myrmicinae) in Argentina: Systematics and distribution. *Sociobiology*, 62(2): 246-265.

Cuiissi, R.G.; Lasmar, C.I.; Moretti, T.S.; Schmidt, F.A.; Fernandes, W.D.; Falleiros, A.B.; Schoereder, J.H. & Ribas, C. 2015. Ant community in natural fragments of the Brazilian wetland: species-area relation and isolation. *Journal of Insect Conservation*, 19(3): 531-537. DOI

Dambros, J.; Vindica, V.F.; Delabie, J.H.C.; Marques, M.I. & Batrolla, L.D. 2018. *Canopy ant assemblage* (Hymenoptera: Formicidae) in two vegetation formations in the northern Brazilian Pantanal. *Sociobiology*, 65(3): 358-369. DOI

Demétrio, M.F.; Silvestre, R.; Souza, P.R. & Aoki, C. 2017. Inventário da fauna de formigas (Hymenoptera: Formicidae) no Mato Grosso do Sul, Brasil. *Iheringia, Série Zoologia*, 107(sup1): 1-12. e2017126. DOI

Divieso, R.; Rorato, A.; Feitosa, R.M.; Meyer, A.L.S. & Pie, M.R. 2020. How to prioritize areas for new ant surveys? Integrating historical data on species occurrence records and habitat loss. *Journal of Insect Conservation*, 24: 901-911. DOI

Einhorn, C.; Arrégala, M.M.; Migliozzi, B. & Reinhard, S. 2020. The world’s largest tropical wetland has become an inferno. *New York Times*. Available:
Longino, J.T. & Fernández, F. 2007. Taxonomic review of the genus Wasmannia. *Memoirs of the American Entomological Institute*, 80: 271-289.

Louzada, R.O.; Bergier, I. & Assine, M.A. 2020. Landscape changes in avulsive river system: Case study of Tiquari river on Brazilian Pantanal wetlands. *Science of the Total Environment*, 723: 13807. DOI

Lucky, A.; Trautwein, M.; Guérand, B.; Weisser, M. & Dunn, R. 2013. Tracing the rise of ants – Out of ground. *PLOS One*, 8(12): 1-8. DOI

Maravalhas, J. & Vasconcelos, H.L. 2014. Revisiting the pyrodiversity-biodiversity hypothesis: long-term fire regimes and the structure of ant communities in a Neotropical savanna hotspots. *Journal of Applied Ecology*, 51(6): 1661-1668. DOI

Martins, M.F.M.; Thomazini, M.J.; Baretta, D.; Brown, G.G.; Zagatto, M.R.G.; Santos, A.; Naldony, H.S.; Cardoso, G.B.X.; Niva, C.C.; Bartz, M.C. & Feitosa, R.M. 2020. Accessing the subterranean ant fauna (Hymenoptera: Formicinae) in native and modified subtropical landscapes in the Neotropics. *Biota Neotropica*, 20(1): e20190782. DOI

McGlynn, M.M.; Guerreiro, R.L.; Bergier, I.; Silva, A.; Pupim, F.N.; Oberc, V. & Assine, M.L. 2017. Holocene stratigraphic evolution of saline lakes in Nhecolândia, Southern Pantanal wetlands (Brazil). *Quaternary Research*, 88(3): 472-490. DOI

Meurer, E.; Battiol, L.D.; Marques, M.I. & Delebarie, J.H.C. 2016. New records and the Neotropical ant genus Ochetomyrmex Mayr (Hymenoptera, Formicidae). *Sociobiology*, 62(2): 266-269. DOI

Ministério do Meio Ambiente (MMA). 2020. Pantanal. Available: https://antigo.mma.gov.br/biomais/pantanal. Access: 18/10/2020.

Miotto, C.L.; Paranhos-Filho, A.C. & Albrez, E.A. 2012. Contribution to the characterization of Pantanal’s sub-regions. *Entre-lugares*, 3(6): 165-180.

Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; Da Fonseca, G.A.B. & Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature*, 403(6772): 853-858. DOI

Neves, A.C.; Bernardo, C.T. & Santos, F.M. 2014. Co-existence of ants and termites in *Cercropia pachystachya* Trécul (Urticaceae). *Sociobiology*, 61(1): 88-94. DOI

Oliveria, A.M.; Feitosa, R.M.; Vasconcelos, H.L. & Maravalhas, J. 2016. New distributions records of the savana specialist fungus-farming ant *Cyatta* Sosa-Calvo et al. (Hymenoptera: Formicidae: Myrmicinae). *Biodiversity Data Journal*, 4: e10673. DOI

Oliveria, A.P.G.; Machado, R.; Ribeiro, A.A.; Miotto, C.L.; Marcato-Jr., J.; Saad, A.R.; Sigolo, J.B. & Paranhos-Filho, A.C. 2018. The expression of neotectonics in the Pantanal da Nhecolândia, state of Mato Grosso do Sul – Brazil. *Annals of Brazilian Academy of Sciences*, 90(2): 1293-1308. DOI

Oliveria, P.S.; Oliveira-Filho, A.T. & Cira, R. 1987. Ant foraging on ant-inhabited *Triplaris* (Pogonaceae) in Western Brazil: a field experiment using live termite-baits. *Journal of Tropical Ecology*, 3(3): 193-200.

Orr, M.R.; Dahlsen, D.L. & Benson, W.W. 2003. Ecological interactions among ants in the genus Linepithema, their phorid parasitoids, and competitor. *Ecological Entomology*, 28(2): 203-210.

Pereira, M.C.; Delabie, J.H.C.; Súarez, Y.R. & Antonialli-Jr., W.F. 2010. Spatial connectivity of aquatic macrophytes and flood cycle influence species richness of an ant community of a Brazilian floodplain. *Sociobiology*, 60(1): 41-49. DOI

Philpott, S.M.; Perfecto, I.; Armbrrecht, I. & Parr, C.L. 2010. Ant diversity and function in disturbed and changing habitats. In: Lach, L; Parr, C.L. & Abbott, K.L. (Eds). *Ant ecology*. New York, Oxford University Press. p. 137-156. DOI

Ribas, C.R. & Schroeder, J.H. 2007. Ant communities, environmental characteristics, and their implications for conservation in Brazilian Pantanal. *Biodiversity Conservation*, 16(5): 1511-1520. DOI

Rodela, L.G. & Queiroz-Neto, J.P. 2007. Estacionalidade do clima no Pantanal da Nhecolândia, Mato Grosso do Sul, Brasil. *Revista Brasileira de Cartografia*, 59(1): 101-113.
Silva, J.S.V. & Abdon, M.M. 1998. Delimitação do Pantanal brasileiro e suas sub-regiões. Pesquisa Agropecuária Brasileira, 33(n. espec.): 1703-1711.

Soares, S.A.; Suarez, Y.R.; Fernandes, W.D.; Tenório, P.M.S.; Delabie, J.H.C. & Antoniali-Jr., W.F. 2013. Temporal variation in the composition of ant assemblages (Hymenoptera, Formicidae) on trees in Pantanal floodplain, Mato Grosso do Sul, Brazil. Revista Brasileira de Entomologia, 57(1): 84-90.

Tomas, W.M.; Roque, F.O.; Morato, R.G.; Médici, P.E.; Chiaravalloti, R.M.; Tortato, F.R.; Penha, J.M.F.; Izzo, T.J.; Garcia, L.C.; Lourival, R.F.F.; Girard, P.; Albuquerque, N.R.; Almeida-Gomes, M.; Silva-Andrade, M.H.; Araújo, F.A.S.; Araújo, A.C.; Arruda, E.C.; Assunção, V.A.; Batirolla, L.D.; Benites, M.; Bolzan, F.P.; Boock, J.C.; Bortolotto, I.M.; Brasil, M.S.; Camilo, A.R.; Campos, Z.; Camiello, M.A.; Catella, A.C.; Cheida, C.C.; Crawshaw-Jr., P.G.; Crispim, S.M.A.; Junior, G.A.D.; Desbiez, A.L.J.; Dias, F.A.; Eaton, D.P.; Faggione, G.P.; Farinacio, M.A.; Fernandes, J.F.A.; Ferreira, V.L.; Fischer, E.A.; Fragoso, C.E.; Freitas, G.O.; Galvani, F.; Garcia, A.S.; Garcia, C.M.; Graciolli, G.; Guariento, R.D.; Guedes, N.M.R.; Guerra, A.; Herrera, H.M.; Hoogesteyn, R.; Ikeda, S.C.; Juliano, R.S.; Kantek, D.L.Z.K.; Keuroghlian, A.; Lacerda, A.C.R.; Lacerda, A.L.R.; Landeiro, V.L.; Laps, R.R.; Layme, V.; Leimgruber, P.; Rocha, F.B.; Nascimento, S.; Marques, D.K.S.; Marques, M.I.; Mateus, L.A.F.; Moraes, R.N.; Moreira, T.A.; Mourão, G.M.; Nicola, R.D.; Nogueira, D.G.; Nunes, A.P.; Cunha, C.N.; Oliveira, M.D.; Oliveira, M.R.; Paggi, G.M.; Pellegrin, A.O.; Pereira, G.M.F.; Peres, I.A.H.F.S.; Pinho, J.B.; Pinto, J.O.P.; Pott, A.; Provete, D.B.; Reis, V.D.A.; Reis, L.K.; Renaud, P.-G.; Ribeiro, D.B.; Rossetto, O.C.; Sabino, J.; Rumiz, D.; Salis, S.M.; Santana, D.J.; Santos, S.A.; Sartori, A.L.; Sató, M.; Schuchmann, K.-L.; Scremin-Dias, E.; Seixas, G.H.F.; Severo-Neto, F.; Sigrist, M.R.; Silva, A.; Silva, C.J.; Siqueira, A.L.; Soriano, B.M.A.; Sousa, L.M.; Souza, F.L.; Strusmann, C.; Sugai, L.S.M.; Tocantins, N.; Urbanetz, C.; Valente-Neto, F.; Viana, D.P.; Yanosky, A. & Junk, W. 2019. Sustainability agenda for the Pantanal Wetland: Perspectives on a collaborative interface for Science, Policy, and decision-making. Tropical Conservation Science, 12: 1-30. DOI

Uehara-Prado, M. 2005. Effects of land use on ant species composition and diaspore removal in exotic grasslands in the Brazilian Pantanal (Hymenoptera: Formicidae). Sociobiology, 45(3): 915-923.

Vasconcelos, H.L.; Maravalhas, J. & Cornelissen, T. 2017. Effects of fire disturbance on ant abundance and diversity: a global meta-analysis. Biodiversity Conservation, 26(1): 177-188. DOI

Vicente, R.E.; Casadei Ferreira, A.; Santos, R.C.L.; Prado, L.P. 2018. Ants (Hymenoptera: Formicidae) from an Amazonian fragmented landscape, Juara, Mato Grosso, Brazil, with new records of ant species. Papéis Avulsos de Zoológia, 58(40): e20185840. DOI

Yamazaki, L.; Dambros, J.; Meures, E.; Vindica, V.F.; Delabie, J.H.C.; Marques, M.I. & Batirolla, L.D. 2016. Ant Community (Hymenoptera, Formicidae) associated with Callisthene fasciculata (Spr.) Mart. (Vochysiaceae) Canopies in the Pantanal of Poconé, Mato Grosso, Brazil. Sociobiology, 63(2): 735-743. DOI

Yanoviak, S.P. & Kaspari, M. 2000. Community structure and the habitat template: ants in the tropical forest canopy and litter. OIKOS, 89(2): 259-266. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.5 26.213&rep=rep1&type=pdf.