

Ants (Hymenoptera: Formicidae) from an Amazonian fragmented landscape, Juara, Mato Grosso, Brazil, with new records of ant species

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Abstract. The state of Mato Grosso is the 3rd largest Brazilian state, is covered with three major Brazilian biomes, including the Pantanal, Cerrado, and Amazonia. To date, 449 ant species are recorded in literature for the state. In the present work, we documented the ants sampled along a fragmented landscape, in the municipality of Juara, in the Cerrado-Amazon transition zone in the state of Mato Grosso, Brazil. The ant species were captured with Pitfall traps installed in 20 trails with 10 traps in each (totaling 200). Our results show 151 species, belonging to 43 genera and eight subfamilies, of which 28 species were recorded for the first time in the state and five species recorded for the first time in Brazil. Most genera collected were *Pheidole* Westwood, 1839 (45 species) followed by *Crematogaster* Lund, 1831 (11 species). By highlighting species recorded for the first time in state of Mato Grosso and Brazil, we hope to encourage new discoveries and increase the general knowledge of the ant fauna of different biomes in the region.

Key-Words. Distribution; Neotropical fauna; Pitfall trap; Sampling method; Species inventories.

INTRODUCTION

The state of Mato Grosso is the 3rd largest Brazilian state (IBGE, 2017) and as well as the Amazon and Cerrado, there is still the Pantanal in its political-geographic limits (Silva *et al.*, 2013; Mateus *et al.*, 2016; Vicente *et al.*, 2016). In the region of Meridional Amazon present in the north of the state of Mato Grosso, there is a great extension of Forest of transition between Amazonia and Cerrado (Paolucci *et al.*, 2016; Vicente *et al.*, 2016). The biodiversity of southern Amazonia is sparsely known (Santos-Silva *et al.*, 2016; Vicente *et al.*, 2016) especially in these transition areas (Paolucci *et al.*, 2016; Vicente *et al.*, 2016).

In relation to regional ant fauna, 449 species were recorded for the Mato Grosso state, belonging to 78 genera and nine subfamilies (Janicki *et al.*, 2016). In recent years the number of inven-

tories published in the region has increased (*e.g.*, Battirola *et al.*, 2005; Rocha *et al.*, 2015; Vicente *et al.*, 2016). This scenario has been reversed due to Formicidae characteristics such as ease of sampling because of its high abundance, species richness and relatively well-known taxonomy, biology and ecology, added to the role of biodiversity in ecosystem functioning making ants an attractive group to evaluate and monitor environmental attributes (Agosti *et al.*, 2000; Ribas *et al.*, 2012). In addition, online tools are available for species identification and distribution (*e.g.*, Antweb.org, AntMaps.org [Janicki *et al.*, 2016], AntWiki and others) increasing the number of taxonomists and consolidating working groups.

Considering that strategies for the conservation and knowledge of Brazilian biodiversity are based mainly in species richness, the role of species lists is central for knowledge of the ant fauna

(Ulysséa *et al.*, 2011; Suguituru *et al.*, 2013). For this reason, and due to the vegetation formations of the region, this work aimed to describe the richness and composition of the ant fauna between an Amazon-Cerrado ecotone landscape in the city of Juara, MT, Brazil. We intend to present a list of the ant species of the region with new records for the state of Mato Grosso and to Brazil.

MATERIAL AND METHODS

Study area

Samples were carried out on four fragments in a whole fragmented Amazon landscape immersed in a pasture matrix on the banks of the Arinos river, municipality of Juara, north of Mato Grosso state, Brazil (09°28'S, 55°50'W). Juara has an area of 22,622 km² with 34.87% of its original area deforested (INPE, 2015; IBGE, 2017). The vegetation of the region is characterized by the transition of Cerrado-Amazon areas (Ávila & Kawashita-Ribeiro, 2011) and by secondary forests, with the presence of rocky outcrops and agricultural activities. The sampling protocol used in this study is the RAPELD methodology (Costa & Magnusson, 2010). Each Module has sets of five trails of 250 m in length at a minimum distance of 1 km from each other, totaling twenty trails (Fig. 1). Module 4 is the nearest to the urban center, about 8.5 km in distance, and Module 2 and 3, the farthest, at about 29.5 km.

Data sampling

The ant inventory was conducted in February 2015 in four areas (denominated here as a module). In each module we collected in five trails, with a distance of 1,000 meters between them (Fig. 1), totalizing 20 sample units. Of these 20 trails, four were planted on the islands of the Rio Arinos. In each trail, we used two sampling methods, the first consisting of ten solo pitfall traps, distributed with a distance of 15 m between them. The traps remained for 72 consecutive hours in each sampling area.

In addition to pitfall traps, we use a second method, attractive baits of sardine and honey. The baits placed on 20cm × 10cm paper napkin 10 meters distance from each other in an intercalated manner on the ground and vegetation. We randomized the first stratum to be sampled. We put about 5 g of sardines on the ground and in understory trees we put a teaspoon of bee's honey. Therefore, we had 20 sub-sample baits in each trail that remained exposed for approximately one hour. Unfortunately, the information on the type of bait and the stratum in which it was placed was not recovered.

Ant identification

To identify subfamilies and genera of sampled ants we used the dichotomous key available in Baccaro *et al.* (2015). Thereafter, we used several taxonomic keys

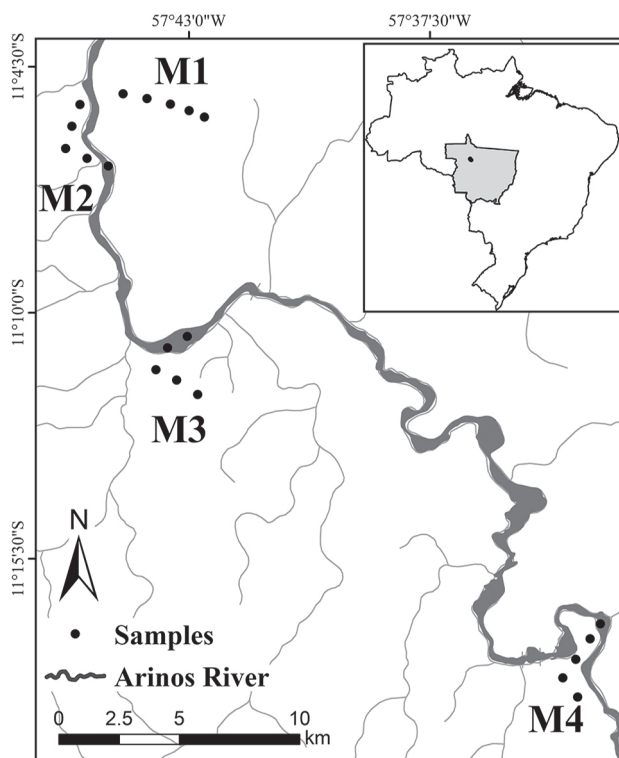


Figure 1. Map indicating the Modules (M) where the samples were collected in the municipality of Juara, north of Mato Grosso state, Brazil. The four points on the Arinos River represent samples taken on islands.

(Brandão, 1990; Fernández, 2003; Longino, 2003; Wilson, 2003; Mackay & Mackay, 2010; Fernandes *et al.*, 2014) to identify to a specific level or to separate into morphospecies. We also made comparisons with specimens deposited at the Entomological collections of the Museu Paraense Emílio Goeldi (MPEG) and Padre Jesus Santiago Moure of the Departamento de Zoologia da Universidade Federal do Paraná (DZUP) and consulted specialists to confirm species identification (see Acknowledgements).

Repositories

The ant vouchers were deposited at the Laboratório de Ecologia de Comunidades of the Centro de Biodiversidade da Universidade Federal de Mato Grosso (UFMT), Entomological Collection of the Museu Paraense Emílio Goeldi (MPEG) and Coleção Entomológica Padre Jesus Santiago Moure of the Departamento de Zoologia da Universidade Federal do Paraná (DZUP).

RESULTS

We recorded a total of 151 species and morphospecies of ants belonging to 43 genera and eight subfamilies (Table 1). The most speciose genus was *Pheidole* with 45 species (30% of Mirmicinae), of which 27 species are unidentified. Other representative genera regarding the number of species were *Crematogaster* with 11 species and posteriorly *Camponotus*, *Gnamptogenys*, and

Table 1. List of ant species recorded at an Amazonian fragmented landscape, municipality of Juara, Mato Grosso state, Brazil. Twenty four ants species were sampled for the first time in Mato Grosso state* and four ant species sampled for the first time in Brazil**.

Subfamily/Species	Number of taxa and method of sample	Subfamily/Species	Number of taxa and method of sample
DORYLINAE	1 genus and 2 species	Apterostigma	3 species
Eciton	2 species	<i>Apterostigma megacephala</i> Lattke, 1999	Pitfall
<i>Eciton burchellii</i> (Westwood, 1842)	Pitfall	<i>Apterostigma urichii</i> Forel, 1893	Pitfall
<i>Eciton</i> aff. <i>burchellii</i>	Pitfall	<i>Apterostigma</i> sp.2	Pitfall and bait
DOLICHODERINAE	4 genera and 8 species	Atta	2 species
Dolichoderus	4 species	<i>Atta sexdens</i> (Linnaeus, 1758)	Pitfall
<i>Dolichoderus attelaboides</i> (Fabricius, 1775)	Pitfall and bait	<i>Atta</i> aff. <i>bisphaerica</i>	Pitfall and bait
<i>Dolichoderus bidens</i> (Linnaeus, 1758)	Pitfall	Blepharidatta	1 species
<i>Dolichoderus bispinosus</i> (Olivier, 1792)	Pitfall	<i>Blepharidatta brasiliensis</i> Wheeler, 1915	Pitfall and bait
<i>Dolichoderus imitator</i> Emery, 1894	Pitfall	Cardiocondyla	1 species
Dorymyrmex	1 species	<i>Cardiocondyla obscurior</i> Wheeler, 1929	Pitfall
<i>Dorymyrmex insanus</i> (Buckley, 1866)	Pitfall and bait	Carebara	1 species
Linepithema	2 species	<i>Carebara brevipilosa</i> Fernández, 2004	Pitfall
<i>Linepithema cerradense</i> Wild, 2007*	Pitfall and bait	Cephalotes	1 species
<i>Linepithema neotropicum</i> Wild, 2007	Bait	<i>Cephalotes atratus</i> (Linnaeus, 1758)	Pitfall and bait
Tapinoma	1 species	Crematogaster	11 species
<i>Tapinoma ramulorum</i> Emery, 1896	Bait	<i>Crematogaster brasiliensis</i> Mayr, 1878	Pitfall and bait
ECTATOMMINAE	2 genera and 12 species	<i>Crematogaster carinata</i> Mayr, 1862	Pitfall and bait
Ectatomma	4 species	<i>Crematogaster erecta</i> Mayr, 1866	Pitfall and bait
<i>Ectatomma brunneum</i> Smith, 1858	Pitfall	<i>Crematogaster evallans</i> Forel, 1907*	Pitfall
<i>Ectatomma lugens</i> Emery, 1894	Pitfall	<i>Crematogaster flavosensitiva</i> Longino, 2003*	Pitfall
<i>Ectatomma muticum</i> Mayr, 1870*	Pitfall and bait	<i>Crematogaster levior</i> Longino, 2003	Pitfall and bait
<i>Ectatomma tuberculatum</i> (Olivier, 1792)	Pitfall and bait	<i>Crematogaster limata</i> Smith, 1858	Pitfall and bait
Gnamptogenys	8 species	<i>Crematogaster nigropilosa</i> Mayr, 1870	Pitfall and bait
<i>Gnamptogenys acuminata</i> (Emery, 1896)	Pitfall	<i>Crematogaster sotosbosque</i> Longino, 2003*	Bait
<i>Gnamptogenys concinna</i> (Smith, 1858)	Pitfall	<i>Crematogaster tenuicula</i> Forel, 1904	Pitfall and bait
<i>Gnamptogenys horni</i> (Santschi, 1929)	Pitfall	<i>Crematogaster</i> sp.1	Pitfall
<i>Gnamptogenys mina</i> (Brown, 1956)*	Pitfall	Cyphomyrmex	4 species
<i>Gnamptogenys moelleri</i> (Forel, 1912)	Pitfall and bait	<i>Cyphomyrmex laevigatus</i> Weber, 1938	Pitfall and bait
<i>Gnamptogenys relictata</i> (Mann, 1916)	Pitfall	<i>Cyphomyrmex vorticis</i> Weber, 1940*	Pitfall
<i>Gnamptogenys vriesi</i> Brandão & Lattke, 1990	Pitfall	<i>Cyphomyrmex</i> aff. <i>minutus</i>	Pitfall
<i>Gnamptogenys</i> aff. <i>lanei</i>	Pitfall	<i>Cyphomyrmex</i> aff. <i>rimosus</i>	Pitfall
FORMICINAE	4 genera and 19 species	Megalomyrmex	1 species
Brachymyrmex	2 species	<i>Megalomyrmex</i> sp.1	Pitfall and bait
<i>Brachymyrmex</i> sp.1	Pitfall and bait	Mycetophylax	1 species
<i>Brachymyrmex</i> sp.2	Bait	<i>Mycetophylax</i> sp.1	Pitfall and bait
Camponotus	8 species	Myoceporus	1 species
<i>Camponotus atriceps</i> (Smith, 1858)	Pitfall	<i>Myoceporus smithii</i> (Forel, 1893)	Pitfall
<i>Camponotus femoratus</i> (Fabricius, 1804)	Pitfall and bait	Nesomyrmex	1 species
<i>Camponotus leydigii</i> Forel, 1886	Pitfall and bait	<i>Nesomyrmex</i> sp.1	Pitfall
<i>Camponotus novogranadensis</i> Mayr, 1870	Pitfall and bait	Ochetomyrmex	1 species
<i>Camponotus planatus</i> Roger, 1863	Pitfall and bait	<i>Ochetomyrmex neopolitus</i> Fernández, 2003	Pitfall and bait
<i>Camponotus substitutus</i> Emery, 1894	Pitfall and bait	Octostruma	1 species
<i>Camponotus</i> sp.1	Pitfall	<i>Octostruma balzani</i> (Emery, 1894)	Pitfall
<i>Camponotus</i> sp.2	Pitfall	Pheidole	45 species
Gigantiops	1 species	<i>Pheidole biconstricta</i> Mayr, 1870	Pitfall and bait
<i>Gigantiops destructor</i> (Fabricius, 1804)	Pitfall	<i>Pheidole bufo</i> Wilson, 2003	Pitfall and bait
Nylanderia	8 species	<i>Pheidole cataractae</i> Wheeler, 1916*	Pitfall and bait
<i>Nylanderia fulva</i> (Mayr, 1862)	Pitfall and bait	<i>Pheidole coffeicola</i> Borgmeier, 1934*	Pitfall
<i>Nylanderia steinheili</i> (Forel, 1893)	Pitfall and bait	<i>Pheidole deima</i> Wilson, 2003*	Pitfall
<i>Nylanderia</i> aff. <i>caeciliae</i>	Pitfall	<i>Pheidole germani</i> Emery, 1896	Bait
<i>Nylanderia</i> sp.1	Bait	<i>Pheidole leonina</i> Wilson, 2003*	Pitfall
<i>Nylanderia</i> sp.2	Pitfall and bait	<i>Pheidole lovejoyi</i> Wilson, 2003*	Pitfall
<i>Nylanderia</i> sp.3	Pitfall	<i>Pheidole microps</i> Wilson, 2003**	Pitfall
<i>Nylanderia</i> sp.6	Pitfall	<i>Pheidole oxyops</i> Forel, 1908	Pitfall
<i>Nylanderia</i> sp.7	Pitfall and bait	<i>Pheidole paraensis</i> Wilson, 2003*	Pitfall
MYRMICINAE	21 genera and 90 species	<i>Pheidole scolioceps</i> Wilson, 2003*	Bait
Acromyrmex	1 species	<i>Pheidole sculptior</i> Forel, 1893**	Bait
<i>Acromyrmex</i> sp.1	Pitfall	<i>Pheidole sensitiva</i> Borgmeier, 1959*	Pitfall and bait

Subfamily/Species	Number of taxa and method of sample	Subfamily/Species	Number of taxa and method of sample
<i>Pheidole strigosa</i> Wilson, 2003*	Pitfall	<i>Strumigenys zeteki</i> (Brown, 1959)*	Pitfall
<i>Pheidole triconstricta</i> Forel, 1886	Pitfall and bait	Trachymyrmex	4 species
<i>Pheidole vallifica</i> Forel, 1901*	Pitfall	<i>Trachymyrmex</i> sp.1	Pitfall and bait
<i>Pheidole vorax</i> (Fabricius, 1804)	Pitfall	<i>Trachymyrmex</i> sp.3	Pitfall
<i>Pheidole</i> sp.1	Pitfall and bait	<i>Trachymyrmex</i> sp.4	Pitfall
<i>Pheidole</i> sp.2	Pitfall	<i>Trachymyrmex</i> sp.5	Pitfall
<i>Pheidole</i> sp.3	Pitfall	Wasmannia	1 species
<i>Pheidole</i> sp.4	Pitfall and bait	<i>Wasmannia auropunctata</i> (Roger, 1863)	Pitfall and bait
<i>Pheidole</i> sp.5	Bait	PARAPONERINAE	1 genus and 1 species
<i>Pheidole</i> sp.6	Pitfall	Paraponera	1 species
<i>Pheidole</i> sp.7	Pitfall	<i>Paraponera clavata</i> (Fabricius, 1775)	Pitfall and bait
<i>Pheidole</i> sp.8	Bait	PONERINAE	9 genera and 16 species
<i>Pheidole</i> sp.9	Pitfall	Anochetus	1 species
<i>Pheidole</i> sp.10	Pitfall	<i>Anochetus targionii</i> Emery, 1894	Pitfall
<i>Pheidole</i> sp.11	Pitfall	Dinoponera	1 species
<i>Pheidole</i> sp.12	Pitfall	<i>Dinoponera mutica</i> Emery, 1901	Pitfall
<i>Pheidole</i> sp.13	Pitfall	Hypoponera	1 species
<i>Pheidole</i> sp.14	Pitfall	<i>Hypoponera</i> sp.3	Pitfall
<i>Pheidole</i> sp.15	Pitfall	Leptogenys	1 species
<i>Pheidole</i> sp.16	Pitfall	<i>Leptogenys</i> aff. <i>gaigei</i>	Pitfall
<i>Pheidole</i> sp.17	Pitfall	Mayaponera	1 species
<i>Pheidole</i> sp.18	Pitfall	<i>Mayaponera constricta</i> (Mayr, 1884)	Pitfall and bait
<i>Pheidole</i> sp.19	Pitfall	Neoponera	5 species
<i>Pheidole</i> sp.20	Pitfall	<i>Neoponera apicalis</i> (Latreille, 1802)	Pitfall and bait
<i>Pheidole</i> sp.21	Pitfall	<i>Neoponera magnifica</i> (Borgmeier, 1929)*	Pitfall
<i>Pheidole</i> sp.22	Pitfall	<i>Neoponera veranae</i> Forel, 1922	Pitfall
<i>Pheidole</i> sp.23	Bait	<i>Neoponera villosa</i> (Fabricius, 1804)	Pitfall and bait
<i>Pheidole</i> sp.24	Pitfall	<i>Neoponera commutata</i> (Roger, 1860)	Pitfall and bait
<i>Pheidole</i> sp.25	Pitfall	Odontomachus	3 species
<i>Pheidole</i> sp.26	Pitfall	<i>Odontomachus chelifer</i> (Latreille, 1802)	Pitfall
<i>Pheidole</i> sp.27	Bait	<i>Odontomachus haematodus</i> (Linnaeus, 1758)	Pitfall and bait
Sericomyrmex	2 species	<i>Odontomachus meinerti</i> Forel, 1905	Pitfall
<i>Sericomyrmex saussurei</i> Emery, 1894	Pitfall and bait	Pachycondyla	2 species
<i>Sericomyrmex</i> sp.3	Pitfall and bait	<i>Pachycondyla crassinoda</i> (Latreille, 1802)	Pitfall and bait
Solenopsis	5 species	<i>Pachycondyla harpax</i> (Fabricius, 1804)	Pitfall and bait
<i>Solenopsis invicta</i> Buren, 1972	Pitfall and bait	Simopelta	1 species
<i>Solenopsis</i> sp.1	Pitfall and bait	<i>Simopelta jeckylli</i> (Mann, 1916)	Pitfall
<i>Solenopsis</i> sp.2	Pitfall	PSEUDOMYRMEX	1 genera and 3 species
<i>Solenopsis</i> sp.4	Pitfall and bait	Pseudomyrmex	3 species
<i>Solenopsis</i> sp.7	Pitfall	<i>Pseudomyrmex gracilis</i> (Fabricius, 1804)	Pitfall and bait
Strumigenys	2 species	<i>Pseudomyrmex peruvianus</i> (Wheeler, 1925)**	Pitfall and bait
<i>Strumigenys denticulata</i> Mayr, 1887	Pitfall	<i>Pseudomyrmex tenuis</i> (Fabricius, 1804)	Pitfall and bait

Nylanderia with eight species each. In contrast, 51% of the genera sampled were represented by only one species.

Of these 151 sampled ant species, 23 species were collected for the first time in Mato Grosso state. Of these 23 species, three species were sampled for the first time in Brazil (Table 1). The subfamily with the largest number of species sampled for the first time in the locality was Myrmicinae, with 17 new records, 12 of which were only of the *Pheidole* genus. In relation to sampling methods, of these 151 ant species, 83 species were sampled exclusively in pitfall (55%), twelve species using baits (8%) and 56 with both methods (37%). As regards the 28 species that are new records, 16 species were sampled exclusively with pitfall and four only in baits and eight ant species in both methods.

DISCUSSION

Our results expand the current knowledge about ant species in the state of Mato Grosso, focusing in the region of Juara – in the Cerrado-Amazon transition zone. In the Neotropics, the ecotonal zones are present in many landscapes and can influence in different ways, such as faunal movement, flow of energy and nutrients, population dynamics, species interactions and changes in vegetation structure (Spector & Ayzama, 2003). In addition, the areas of transition in terrestrial ecosystems can present high species diversity and may be revealing indicators of the consequences of global climate changes (Zhu *et al.*, 2011, Malanson *et al.*, 2017).

Despite the importance of these areas for biodiversity little is known about the ant fauna in these formations

since 23 species of one inventory in an ecotone area are recorded for the first time in Mato Grosso. This number is very representative considering that it represents 15% of the sampled ant species. Including these species, three species had not been sampled so far in Brazil, which were *Pheidole microps* Wilson, 2003, *Pheidole sculptior* Forel, 1893 and *Pseudomyrmex peruvianus* (Wheeler, 1925). Among these species that were sampled for the first time in the State of Mato Grosso, 12 species were of the genus *Pheidole* (41.4%). This genus represents the second largest among ants, with 1.004 known species (Bolton, 2018) (7% of all Formicidae diversity) and the largest for the Neotropical region with over 600 species (AntWiki, 2018), which represents more than 14% of all known species for the same region. No other biogeographical region has such *Pheidole* species, apart from the Afrotropical and Indo-Australian regions which have just over 150 species (AntWiki, 2018). Due to this large number of species, it is expected that most of the work involving fauna inventory lacks identifications for this genus. This results in a disjunctive distribution of *Pheidole* species, mainly in the southern Neotropical and consequently presenting an impressive amount of new records (12 only for the present paper). In addition to the richness, *Pheidole* lacks an efficient method of identification, since the most recent dichotomous key (Wilson, 2003) was designed only for major workers, who are relatively little sampled in passive methods (pitfall and Winkler) and the correct association with the minor workers is extremely difficult.

At the same time, the genus has an interactive key developed on the Lucid platform by *Pheidole* Working group and was updated by Longino (2009). However, this key is not appropriate for finding an exact identification but is restricted to a list of names that needs to be consulted in the descriptions and images available. The lack of studies involving the *Pheidole* taxonomy for the New World has been added to these problems, with the most recent and comprehensive publications being those of Wilson (2003) for the New World, Longino (2009) focused on Central America, and a few new species described posteriorly (e.g., *Pheidole protaxi* Oliveira & Lacau, 2015 in Oliveira *et al.*, 2015). The necessity of studies focused on *Pheidole* for these regions has already been pointed out by Longino (2009) and is one of the limits regarding our knowledge for the genus.

Nevertheless, although not being a new record for Mato Grosso state, some species sampled are rarely collected, with several gaps in the distribution. *Dorymyrmex insanus* (Buckley, 1866) has records from the northern United States (Wheeler & Wheeler, 1988) to Paraguay (Brandão, 1991; Fernández & Sendoya, 2004) with several gaps in the Neotropic. However, its real distribution is unknown, since the last revisions of *Dorymyrmex* are sectorized and almost absent with focus on Neotropical species (Johnson, 1989; Snelling, 1995; Cuzzo & Guerrero, 2011). For this reason, a complete review of the group focusing on tropical species is necessary and can greatly clarify and broaden the distribution of many species.

Of the 151 species sampled, 83 species were sampled exclusively in pitfall (54.97%), 12 species using baits

(7.95%) and 56 with both methods (37.09%). Although bait is an attractive method, pitfall sampled more species. Ryder-Wilkie *et al.* (2010) also found this pattern comparing several methods of collecting ants in the Peruvian Amazon. This pattern can be explained by some factors. First, the attractive baits remain in the field for one hour and then the attracted ants are collected, while the pitfall, although not attracting, intercepts the ants that are foraging on the ground. In addition, ants are known for their aggressiveness and territoriality (Hölldobler, 1979; Vicente *et al.*, 2014; Dejean *et al.*, 2015), and by colonizing a resource, prevent other ants from accessing it by controlling the diversity of species in the bait while in the pitfall there is no such intervention of dominant species.

In summary, our work lists the ant diversity in a poorly known Meridional Amazon region, contributing to the knowledge of the Amazonia-Cerrado transition biomes. This work extends the distribution of 23 species for Mato Grosso state. Nevertheless, more intensive sampling at diverse locations in the region using different methods of sampling is necessary to get a more comprehensive idea about ant fauna.

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