



## RESEARCH ARTICLE - ANTS

## Influence of the Vegetation Mosaic on Ant (Formicidae: Hymenoptera) Distributions in the Northern Brazilian Pantanal

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### Article History

#### Edited by

Edilberto Giannotti, UNESP, Brazil

Received 17 September 2014

Initial acceptance 12 February 2015

Final acceptance 11 March 2015

#### Keywords

Cerrado, Semi-deciduous forest, Wetlands.

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### Abstract

We examined how vegetation mosaic influences distribution of the edaphic ant (Formicidae) community in the northern part of the Pantanal in Cáceres, State of Mato Grosso, Brazil. Plant formations (hereafter habitats) that characterize this area include several savanna types, such as: Cerrado *sensu stricto*, Cerradão, Semi-deciduous forest, Termite savanna, Open fields and Cerrado field/carandazal. Pitfall traps were placed in ten 250 m transects each one separated by 1 km, within an area of 2 x 5 km (following RAPELD methodology). Five traps at intervals of 50 m were placed along each transect, in September and December 2008. Forty-four ant species were collected. Leaf litter predicted ant presence and influenced species occurrence in the different habitats. Pantanal habitats are very different structurally from one to another, which has have resulted in areas with very specific ant assemblages. The understanding of the ant community structure in these areas is fundamental to floodplain management.

### Introduction

Floodplains, especially the Brazilian Pantanal, are characterized by the controlling influence of flood pulses and vegetation, which have a major impact on the population dynamics of species, thereby influencing community structure (Junk et al., 1989; Junk, 1997). Another defining factor in the Pantanal of the state of Mato Grosso, Brazil is its landscape heterogeneity, which comprises a mosaic of forest, cerrado, grasslands and monodominant clusters of trees (Por, 1995; Silva et al., 2000). Together, in association with flood pulses, influence animal diversity, especially invertebrates (Brown, 1970).

Plant formation and landscape diversity in this ecosystem result from many climatic changes that occurred throughout geological formation (Jimenez-Rueda et al., 1998), which was also influenced by seasonal flooding (Junk et al., 1989; Junk & Nunes-

da-Cunha, 2005) with input from adjacent phytogeographic provinces (Adámoli, 1982; Silva et al., 2000; Alho & Gonçalves, 2005; Junk et al., 2006). This landscape diversity also helps the Pantanal resist stressful conditions such as drought, floods and large fires (Nunes-da-Cunha et al., 2011).

Ant (Formicidae) population dynamics are likely to be influenced by a variety of factors, including food resource availability, nest sites, competition and climate (Kaspari, 2000). Behavioral diversity also structures these communities, and organization is influenced by the distribution of unexploited resources and strategies used to obtain these resources (Fowler et al., 1991). These behavioral differences are a consequence of the variety of available niches, which increase with vegetation diversity and complexity (Hölldobler & Wilson, 1990; Tews et al., 2004).

Ants are an important component of terrestrial invertebrate communities in the Pantanal because they



participate in most ecological processes and have complex social behaviors and a variety of strategies for survival (Adis et al., 2001; Battirola et al., 2005; Castilho et al., 2005; Santos et al., 2008; Silva et al., 2013; Soares et al., 2013). In an attempt to associate habitat complexity with the role played by ants in tropical ecosystems of the Pantanal, we tested the interaction between the vegetation mosaic and the distribution and richness of the edaphic ant community in the Pantanal in Brazil.

## Materials and Methods

### Study area

Ants were studied on the ranch Baía de Pedra, in Cáceres, state of Mato Grosso, Brazil (16°28'49"S 58°08'26"W). This area is in the Pantanal sub-region of Cáceres (Silva et al., 2000), and comprises six plant formations (hereafter habitats) belonging to the Cerrado biome (Brazilian savanna): Cerrado *sensu stricto* (SS), Cerradão (C), Semi-deciduous forest (SDF), Termite savanna (TS), Open field (OF) and Cerrado field/carandazal (CC) (e. g. Nunes-da-Cunha et al., 2011).

### Methods

Samples were taken twice during the dry period, once in September and once in December 2008. For this, 10 transects were established, each 250 m in length, and with at least 1 km minimum distance between them. Transects were established in a 2x5 km grid following RAPELD protocol (Magnusson et al., 2005). Transects followed the topography to maintain a constant elevation (flooding regime) but independent of other natural habitat variation. This design provides a method to independent sample species distribution and abundance in each site. Each sampling point was characterized by a 250 m transect with five pitfall traps placed 50 m apart. Traps were on the field for five days when all samples were collected, for a total of 50 traps each, as well in September as in December.

We also sampled leaf litter in ten 25 x 25 cm quadrants next to the pitfall traps. Leaf litter was placed in paper bags and dried until a constant weight was reached. Temperature and relative humidity were measured with a digital thermohygrometer at ground level next to all traps. Individual ants were identified according (Bolton, 2003) and nomenclature following Bolton's catalog (Antweb, accessed 2014). Reference collections were deposited in the Laboratory of Ecology and Arthropod Taxonomy (LETA) of the Federal University of Mato Grosso Bioscience Institute and the Mirmecology Laboratory Collection of the Cacau Research Center (CPDC), CEPEC-CEPLAC, Ilhéus, Bahia, under the reference number #5574.

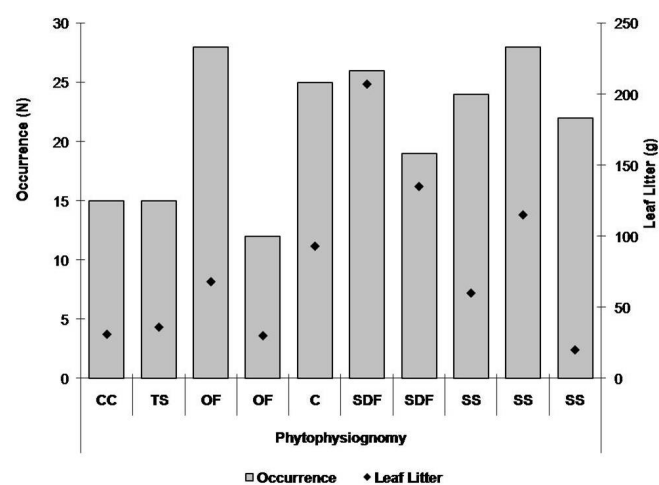
### Data analysis

Community distribution patterns were determined in each habitat type, by non-metric multidimensional scaling (NMDS).

We used presence/absence in the data matrix, and similarity was estimated using the Jaccard index. We associated the ant community (dependent variable) with leaf litter, temperature and humidity (independent variables) using multivariate multiple regressions. Significance level was established at 0.05, and we used the programs PAST (Hammer et al., 2001) and Systat 11 (Wilkinson, 2004) to carry out the analyses.

## Results

The ant community comprised 44 species (Fig 1, Table 1), with the greatest species richness in the Cerrado *sensu stricto* and Open field (28 spp.), followed by Semi-deciduous forest (26 spp.). While species richness was similar, individual species varied in each habitat. Six species were exclusive to the Open field and five exclusive to the Cerrado *sensu stricto*.



**Fig 1.** Ant presence and leaf litter mass of each phytophysiognomy in the Pantanal of Cáceres, Mato Grosso, Brazil. CC - Cerrado field/carandazal; TS - Termite savanna; OF - Open field; C - Cerradão; SDF Semi-deciduous forest; SS - Cerrado *stricto sensu*.

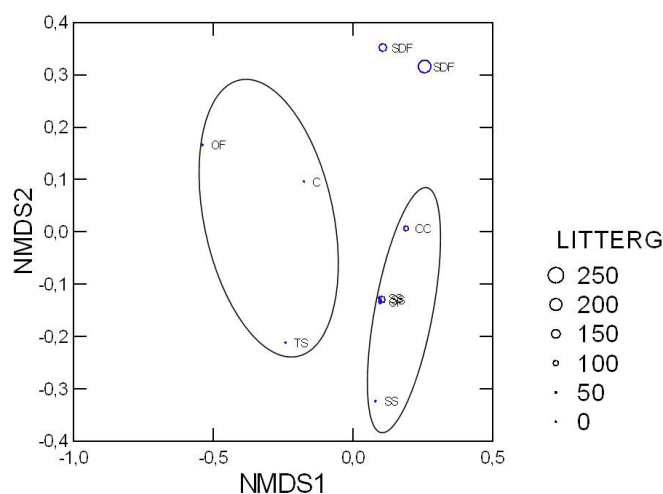
In the ant fauna, we noticed that *Gracilidris pombero* Wild and Cuezco was restricted to Cerrado field/carandazal and Open field while *Dinoponera mutica* (Emery) was restricted to Semi-deciduous forest. NMDS found two axes that explained 84% of the variation in the data (stress = 0.147). Sampling locations formed three groups defined by the quantity of leaf litter in each sampling unit. The first group had dense vegetation (Semi-deciduous forest), which thus have a greater amount of leaf litter. The second group was Cerradão, Cerrado *stricto sensu*, and Open field, and the third was formed by Cerrado field/carandazal, Termite savanna and Open field (Fig 2). The amount of leaf litter (g) was the best predictor of ant occurrence in this vegetation mosaic (multivariate regression,  $F_{2,5} = 10.847$ ,  $P = 0.003$ ), and ant presence was independent of both humidity ( $F_{2,5} = 3.884$ ,  $P = 0.098$ ) and temperature ( $F_{2,5} = 3.224$ ,  $P = 0.120$ ).

**Table 1.** Ant presence and richness (S) from pitfall traps in the Pantanal of Cáceres, Mato Grosso, Brazil. \*CC - Cerrado field/carandazal; TS – Termite savanna; OF - Open field; C - Cerradão; SDF Semi-deciduous forest; SS - Cerrado *stricto sensu*.

Taxa	Phytophysiognomy										Sum
	*CC	TM	CF	CF	C	SDF	SDF	SS	SS	SS	
<b>Myrmicinae</b>											
<i>Acromyrmex rugosus</i> (Smith, F. 1858)	-	-	-	-	1	-	-	1	1	-	3
<i>Atta sexdens</i> (Linnaeus, 1758)	-	-	1	-	1	-	-	1	1	1	5
<i>Cardiocondyla obscurior</i> Wheeler, 1929	-	-	-	-	-	-	-	-	1	-	1
<i>Cephalotes persimplex</i> De Andrade, 1999	-	-	-	-	-	1	-	-	-	-	1
<i>Cephalotes pusillus</i> (Klug, 1824)	1	-	1	-	1	-	-	-	-	-	3
<i>Crematogaster brasiliensis</i> Mayr, 1878	1	-	1	-	-	1	1	1	1	1	7
<i>Crematogaster victima</i> Smith, F. 1858	-	-	-	-	-	-	-	1	1	-	2
<i>Cyphomyrmex major</i> Forel, 1901	-	-	-	-	1	-	-	-	-	-	1
<i>Cyphomyrmex transversus</i> Emery, 1894	-	-	1	-	1	-	-	1	1	1	5
<i>Mycocepurus goeldii</i> (Forel, 1893)	-	-	-	-	1	1	1	-	-	1	4
<i>Ochetomyrmex neopolitus</i> Fernández, 2003	-	1	1	-	1	1	1	1	1	1	8
<i>Pheidole prox. cursor</i>	-	-	1	-	1	1	-	-	1	1	5
<i>Pheidole</i> sp.1 grupo <i>fallax</i>	-	1	1	-	1	1	1	1	1	1	8
<i>Pheidole subarmata</i> Mayr, 1884	-	1	1	1	-	-	1	1	1	1	7
<i>Pogonomyrmex naegelii</i> Forel, 1886	-	-	1	-	-	-	-	1	-	1	3
<i>Sericomyrmex</i> sp.1	-	-	1	-	1	1	1	1	-	-	5
<i>Solenopsis</i> sp.2	1	1	1	1	1	1	1	1	1	1	10
<i>Solenopsis</i> sp. complexo <i>tridens sensu</i> Trager, 1991	1	1	1	1	1	1	-	1	1	1	9
<i>Solenopsis invicta</i> Buren, 1972	-	-	1	-	-	-	-	-	1	1	3
<i>Solenopsis globularia</i> (Smith, F. 1858)	1	1	1	1	1	-	-	1	1	1	8
<i>Strumigenys denticulata</i> Mayr, 1887	-	1	-	-	-	1	1	-	-	-	3
<i>Wasmannia auropunctata</i> (Roger, 1863)	1	1	-	1	1	1	1	1	1	1	9
<i>Xenomyrmex</i> sp.1	-	-	-	-	-	1	-	-	-	-	1
<b>Dolichoderinae</b>											
<i>Dorymyrmex brunneus</i> Forel, 1908	1	1	1	-	1	-	-	1	1	1	7
<i>Forelius pusillus</i> Santschi, 1922	1	-	1	1	-	1	1	1	1	-	7
<i>Gracilidris pombero</i> Wild & Cuzzo, 2006	1	-	1	-	-	-	-	-	-	1	3
<i>Tapinoma melanocephalum</i> (Fabricius, 1793)	-	1	1	-	-	-	-	1	1	1	5
<b>Formicinae</b>											
<i>Brachymyrmex</i> sp.1	-	-	1	-	1	-	1	1	1	-	5
<i>Brachymyrmex heeri</i> Forel, 1874	-	-	1	-	1	1	1	1	1	-	6
<i>Brachymyrmex patagonicus</i> Mayr, 1868	-	-	-	1	1	-	-	1	1	1	5
<i>Camponotus melanoticus</i> Emery, 1894	1	1	1	1	-	1	1	1	1	-	8
<i>Camponotus novogranadensis</i> Mayr, 1870	-	1	-	1	-	1	-	-	-	-	3
<i>Nylanderia</i> sp.1	1	1	1	1	1	1	1	1	1	1	10
<i>Nylanderia</i> sp.2	-	-	-	-	-	1	-	-	-	-	1
<i>Nylanderia fulva</i> (Mayr, 1862)	-	-	1	-	-	1	-	-	1	-	3
<b>Ectatomminae</b>											
<i>Ectatomma brunneum</i> Smith, F. 1858	1	-	1	-	1	1	1	1	1	-	7
<i>Ectatomma permagnum</i> Forel, 1908	1	-	1	1	1	1	1	-	-	-	6
<i>Gnamptogenys acuminata</i> (Emery, 1896)	-	-	-	1	-	-	1	-	-	-	2

**Table 1.** Ant presence and richness (S) from pitfall traps in the Pantanal of Cáceres, Mato Grosso, Brazil. \*CC - Cerrado field/carandazal; TS – Termite savanna; OF - Open field; C - Cerradão; SDF Semi-deciduous forest; SS - Cerrado *stricto sensu*. (Continuation)

Taxa	Phytophysiognomy										
	*CC	TM	CF	CF	C	SDF	SDF	SS	SS	SS	Sum
<b>Ponerinae</b>											
<i>Dinoponera mutica</i> Emery, 1901	-	-	-	-	1	1	-	-	-	-	2
<i>Odontomachus bauri</i> Emery, 1892	1	1	1	-	1	-	-	-	1	1	6
<i>Odontomachus haematodus</i> (Linnaeus, 1758)	-	-	-	-	-	1	-	-	-	-	1
<i>Pachycondyla apicalis</i> (Latreille, 1802)	-	-	-	-	1	1	1	-	1	1	5
<b>Pseudomyrmecinae</b>											
<i>Pseudomyrmex termitarius</i> Smith, F. 1855	1	1	1	-	1	1	-	1	1	1	8
<b>Ecitoninae</b>											
<i>Labidus praedator</i> (Smith, F. 1858)	-	-	1	-	-	1	1	-	-	-	3
Total number of occurrence	15	15	28	12	25	26	19	24	28	22	144
Leaf litter (g)	31	36	68	30	93	207	135	60	115	20	
Temperature (°C)	33	28	35	34	33	31	31	21	23	30	
Relative Humidity (%)	40	50	54	40	50	46	42	41	40	51	

**Fig 2.** Ordination (NMDS) of the ant community (presence and absence) obtained by pitfall traps in the Pantanal of Cáceres, Mato Grosso, Brazil. CC - Cerrado field/carandazal; TS – Termite savanna; OF - Open field; C - Cerradão; SDF Semi-deciduous forest; SS - Cerrado *stricto sensu*.

## Discussion

Species richness was clearly a consequence of habitat complexity, as observed too in other studies, such as in different successional stages (Leal & Lopes, 1992), vegetation types (Leal, 2002), vegetation complexity (Hölldobler & Wilson, 1990; Corrêa et al., 2006) and plant density and richness (Leal, 2003). Ant communities respond to changes in plant composition between different habitats (Morrison, 1998; Gotelli & Ellison, 2002). Variation in ant diversity is influenced by environmental characteristics, and greater complexity leads to greater species diversity (Matos et al., 1994; Oliveira et al., 1995). Soares et al. (2003) found a greater number of ant species in native forest than in montane savanna (Campo rupestre), which reinforces

the idea that ant diversity is affected by vegetation structure. This relationship is direct (Andow, 1991) since more complex vegetation leads to a more diverse ant community due to the greater support capacity.

Habitat types may determine species composition of a region (Vasconcelos & Vilhena, 2006). Studies show that leaf litter can predict species richness in different plant formations and habitats (Matos et al., 1994; Carvalho & Vasconcelos, 2002; Leal, 2003). Differences between composition and structure of the ant community are probably a consequence of resource and niche distribution and foraging strategies in each (Fowler et al., 1991; Kaspari, 2000). Leaf litter thickness might be important because less litter implies reduced food abundance as well as less shelter and material for nest construction (Hölldobler & Wilson, 1990).

Variation in the occurrence of ant communities among the vegetation types is explained by the positive relationship between species richness and heterogeneous environmental conditions (Cerdá et al., 1997; Santos et al., 2008). Locations with greater variety and availability of resources support a greater number of species than poorer habitats due to greater resource sharing (Lassau & Hochulli, 2004; Cramer & Willig, 2005).

Ant species richness in this study is similar to other studies in the Pantanal (Ribas & Schoederer, 2007; Marques et al., 2010; Marques et al., 2011; Silva et al., 2013; Soares et al., 2013). Wilson (1987) was the first to show that periodically flooded Peruvian Amazon forests had more species than dry forests. In the Amazon, species that are associated with soil and leaf litter are more affected by natural and periodic disturbances than those that use other forest strata (Majer & Delabie, 1994). Similar situation was observed in cocoa plantations inserted in places formerly occupied by gallery forest and irregularly flooded in the Brazilian state of Bahia (Delabie et al., 2007).

Ant species richness in the Pantanal is also less than that in other ecosystems (for example: Delabie et al., 2000; Silva & Silvestre, 2004, Santos et al., 2006; Leal et al., 2012). Low richness in the Pantanal of Mato Grosso may be due to periodic flooding and the resulting effect of the flood pulse on Pantanal biota (Junk et al., 1989; 2006). Habitat disturbances significantly affect species diversity and abundance (Vasconcelos, 1998) since strong climatic variation in the Pantanal limits local diversity (Lange et al., 2008).

*Gracilidris pombero* is found in a variety of open environments (Wild & Cuzzo, 2006) including cerrado pastures with *Copernicia alba* Morong ex. Morong & Britton (Arecaceae). On the other hand, *D. mutica* is usually found in forests. Biological and ecological aspects of this genus have received increasing attention during the last 20 years due to its very large size, its notable reproductive system and its wide occurrence in the Atlantic Forest, Caatinga, Cerrado and Amazon (for example: Monnin & Peeters, 1998; Peixoto et al., 2010; Lenhard et al., 2013).

High structural variation of Pantanal habitats and the effects on ant communities have resulted in areas with specific characteristics, and learning more about these environments is fundamental to floodplain management and conservation. Leaf litter was most influential for the distribution pattern of the edaphic ant community in this vegetation mosaic, and it was thus considered a predictor of this community among the different plant formations studied. The different occurrence in these plant formations and low diversity could be related to forage characteristics and habitat preference of ant species in this ecosystem.

### Acknowledgments

We thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES / MEC) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for a Ph.D. grant. Further financial and logistic support came from the Programa de Pós-Graduação em Ecologia e Conservação da Biodiversidade at the Instituto de Biociências of the Universidade Federal de Mato Grosso (UFMT), the Centro de Pesquisas do Pantanal (CPP), the Programa de Apoio a Núcleos de Excelência - PRONEX/FAPEMAT/CNPq, and the Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU).

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