View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Directory of Open Access Journals

Check List the journal of biodiversity data

LISTS OF SPECIES

Check List 11(1): 1545, January 2015 doi: http://dx.doi.org/10.15560/11.1.1545
ISSN 1809-127X © 2015 Check List and Authors

Termite diversity in the Abobral region of the Pantanal wetland complex, Brazil

Hélida Ferreira da Cunha[1*], **Tiago Fernandes Carrijo**[2], **Alfredo Raul Abot**[3] and **Carolina da Silva Barbosa**[3]

1 Universidade Estadual de Goiás, Unidade Universitária de Ciências Exatas e Tecnológicas (UnUCET), BR 153, 3105, Fazenda Barreiro do Meio, CEP 75132-903, Anápolis, GO, Brazil
2 Museu de Zoologia da Universidade de São Paulo (MZUSP), Avenida Nazaré, 481, Ipiranga, CEP 04263-000, São Paulo, SP, Brazil
3 Universidade Estadual do Mato Grosso do Sul, Unidade Universitária de Aquidauana, Rodovia Aquidauana, km 12, CEP 79200-000, Aquidauana, MS, Brazil
* Corresponding author. E-mail: cunhahf@ueg.br

Abstract: This is the first termite survey using standard protocols in the Abobral region of the Pantanal complex of South America. Abobral, which is primarily composed of four physiognomies: 1) *campo*, annually flooded grassland; 2) *capão*, which are islands of semi-deciduous forests; 3) *carandazal*, annually flooded vegetation composed of a native palm; and 4) *paratudal*, annually flooded savanna vegetation. Ten species of termites were sampled in the *capões*, three in the grasslands, two in the *paratudal* and no species in the *carandazal*. The diversity of termites in the Abobral Pantanal is concentrated in the *capões*, which stay above water level during the flood season. In the others physiognomies of the Abobral, the termite fauna is poor. The species composition of termites of the Abobral Pantanal seems to be more related to the Cerrado and Chaco faunas than to the Amazonia and Atlantic Forest faunas.

Key words: flooded grasslands, Isoptera, Neotropical region

INTRODUCTION

Termites are social insects that are classified as ecosystem engineers due to the important role they play in ecosystems, such as contributing to the organic matter decomposition, soil formation and aeration, carbon and nitrogen biogeochemical cycles, and nutrient cycling (Jones *et al*. 1994; Higashi and Abe 1997; Lavelle *et al*. 1997). These insects are among the most abundant arthropods of tropical soil ecosystems (Black and Okwakol 1997; Davies *et al*. 1999; Jouquet *et al*. 2011) and represent 10% of the animal biomass in the tropics (Bignell 2006).

The Pantanal is a seasonally flooded complex in the center of South America, and its fauna and flora are influenced by all of the nearby phytogeographic regions: Amazon Forest, Cerrado, Chaco and Atlantic Forest (Alho 2005). The flood dynamics are linked to the rain season, which normally occurs from October to March (Cadavid-Garcia 1984), and to the plain's regional topography (Alvarenga *et al*. 1984). Almost 60% of the soils in the Pantanal are hydromorphic, with low drainage and a tendency for flooding and with discontinuous portions of clay and sand (Orioli *et al*. 1982).

The Pantanal complex is normally subdivided into 11 regions according to the relief and flood pattern (Silva and Abdon 1998; Alho 2005). The Abobral region is composed of different physiognomies, mostly periodically flooded grasslands (native pastures for cattle), with highlands or *capões* (the plural of *capão*), which are islands of semi-deciduous forest that remain above water level during the flood season (Allem and Valls 1987). The flooded grasslands are one of the first regions to flood during the rainy season and are composed of the floodplains that are common to the Abobral, Miranda and Negro Rivers (Cunha *et al*. 1986).

The termite fauna of the Pantanal is poorly known (Constantino and Acioli 2006), and the few studies published (e.g. Polatto and Alves Jr. 2009; Plaza *et al*. 2014) do not use standard protocols for comparisons with adjacent environments such as the Cerrado, Chaco or Amazonia. However, these studies did not have the principal objective of evaluating termite richness. The aims of this study were to compare the termite fauna from different physiognomies in the Abobral region of the Pantanal complex, to provide a first check list for the species of this singular environment. The study areas were characterized based on the physical-chemical properties of the soil.

MATERIALS AND METHODS

Study site

This study was conducted in the Abobral region of the Pantanal complex, west of Mato Grosso do Sul, Brazil (Figure 1). The weather is tropical sub-humid Aw, with 1,100 mm of annual precipitation and an average temperature of 26°C (Cadavid-Garcia 1984). The following physiognomies can be found in the Abobral region (Figure 1): (a) "*Campo*", flooded grasslands, lowland areas with grass and sedges; (b) "*Capões*", also called mounds and "*murundus*", are islands between grasslands with semi-deciduous forests and 8–20 m high canopies, that stay above water level during the flood season; (c) "*Carandazal*" formations with native palms ("*carandá*", *Copernicia alba* Morong.) that are 8–20 m high in periodically flooded areas; and (d) "*Paratudal*", savanna formations in flooded areas near rivers with a dominance of the "*paratudo*" tree (*Tabebuia aurea* (Manso) B. & H.) and 5–16 m high canopies. The sampling was performed in five areas of four physiognomies: A1 (*Campo*) (19°30′39″ S, 057°02′32″ W); A2 (*Carandazal*) (19°15′15″ S,

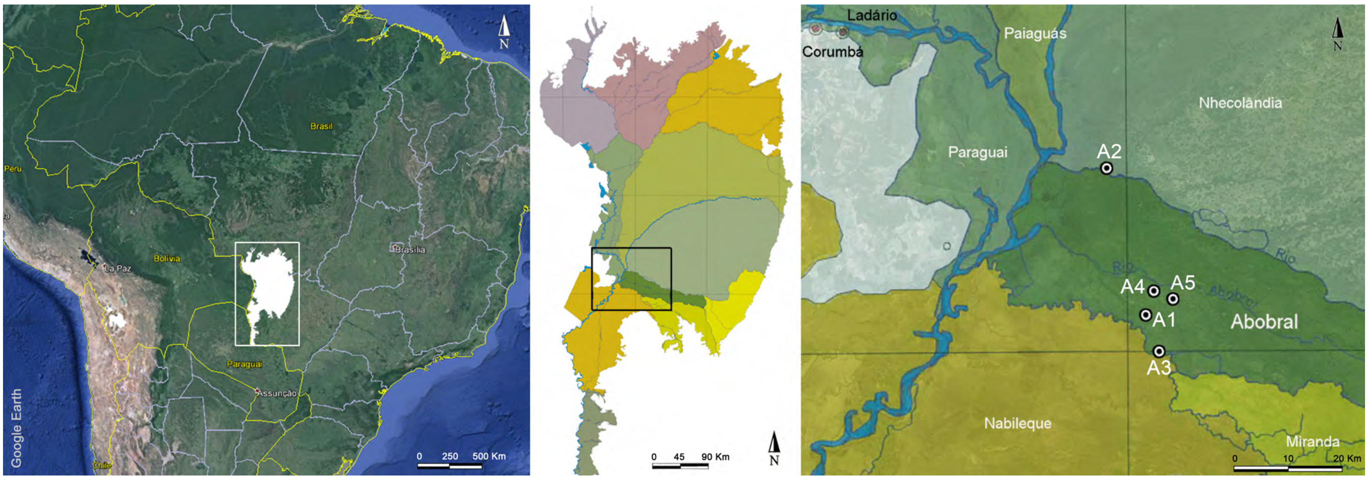

Figure 1. Localization of the study areas in the Abobral region of the Pantanal, Mato Grosso do Sul, Brazil.

057°06′36″ W); A3 (*Paratudal*) (19°34′12″ S, 057°01′12″ W); A4 (*Capão*) (19°28′08″ S, 057°01′41″ W); and A5 (*Capão*) (19°28′56″ S, 056°59′35″ W).

Termite sampling

The sampling was performed in July 2012. In each area, the termites were sampled during 1 hour/collector in 10 plots of 5 × 2 m, 10 m distant from each other. Termites were sought in all possible places inside the plots, including in nests, galleries, wood, leaf litter, and soil and under cattle dung. Samples from all colonies were identified using the appropriate literature and/or comparison with the Termitological Collections of the Museu de Zoologia of the Universidade de São Paulo (MZUSP) and of the Laboratório de Pesquisa Ecológica e Educação Científica of the Universidade Estadual de Goiás (Lab-PEEC/UEG). The collections had Sisbio Authorization number 15976-1 (13/05/2008). Voucher specimens from 2987 to 3030 were deposited in the collection of Lab-PEEC/ UEG, Goiás, Brazil.

According to field observations and literature information (Mathews 1977; Gontijo and Domingos 1991; De Souza and Brown, 1994), the species were classified in four feeding groups: xylophagous (wood feeder species), humivorous (species that feed on humus and organic matter on soil), grass/ litter feeders (species that forage on surface and feed on litter and/ or grass), and intermediate (species that feed of organic matter in high decomposed state or do not fit within any of the other groups).

Soil sampling

In each of the five areas, one soil sample of 25 cm² and 30 cm in depth were collected, preserving the soil profile to ensure that the quantity of soil to be analyzed is the same both on the surface and 30 cm depth. At each point, the surface vegetation was removed as well as stones and other materials that would not be part of the analysis. The sampling sites were located away from nests, termite mounds, fences and carriers, in order to avoid: changes in the chemical and physical composition of soil caused by insect bioturbation; contamination by feces and urine of cattle over the carrier. Soil samples were labeled and sent for physical-chemical analysis to Laboratório de Análises de Solo e Consultoria Ltda. de Campo Grande, MS. Soil samples were analyzed to determine pH in $CaCl_2$, organic matter content, available P by the *Mehlich-1* method, exchangeable Al, H, K, Ca and Mg, exchangeable acidity and fraction of sand, clay and silt. With the above parameters, was possible to infer, the sum of bases (sum of Ca, Mg e K), base saturation (CEC proportion that is occupied by bases) and cation exchange capacity (the quantity of cations—Al, H, Ca, Mg e K—remain in the soil) at pH 7.0.

Data Analysis

The sampling effort was evaluated using a species accumulation curve, constructed using the observed richness and number of samples for each study area. The termite richness was estimated by Jackknife, a nonparametric method that estimates the richness based on the incidence. The estimated richness is obtained by the sum of the observed richness and of the parameter calculated from the number of species that occurs in one (Jack1) or two (Jack2) samples (Magurran 2004). It is calculated using the software EstimateS version 7.0 (Colwell 2004), with 50 randomizations without replacement.

RESULTS

In the four physiognomies of the Abobral region, 13 species of termites belonging to the following families and subfamilies were sampled: Rhinotermitidae (1); Termitidae, Apicotermitinae (4), Nasutitermitinae (3), Syntermitinae (3) and Termitinae (2) (Table 1). The total observed richness (13 ± 1.36) corresponded to 82% of the expected richness predicted by the Jackknife1 estimator (15.94 ± 1.66) and to 77% by the Jackknife2 estimator (16.94 ± 0.68) (Figure 2). The areas with higher species richness are: *Capões* (A4 and A5, with 10 species each), *Campo* (A1, 3 species) and *Paratudal* (A3, 2 species). No species were found in the *Carandazal* (A2), and from the total of 50 plots, 29 had no termites (Table 1). A high diversity and similarity of species were found in *Capão*: eight species in common between A4 and A5 and nine species unique to this physiognomy were sampled (see Table 1). The observed richness relative to the expected richness predicted by Jackknife2 estimator, corresponded to 37% to A1 and A3, 68% to A4 and 72% to A5 (Table 1). More than 50% of the species have underground nests, in the soil, and nearly the same percentage is xylophagous (Table 1).

Table 1. Termite species from the Abobral region in the Pantanal complex, Mato Grosso do Sul, Brazil: A1 *Campo*; A2 *Carandazal*; A3 *Paratudal*; A4 and A5 *Capões*.

Species	A1	A2	A3	A4	A5	Nest	Feeding group
Rhinotermitidae							
Heterotermes longiceps (Snyder, 1924)				2	5	Underground	Xylophagous
Termitidae							
Apicotermitinae							
Anoplotermes sp.1				2		Underground	Humivorous
Anoplotermes sp.2				4	6	Underground	Humivorous
Aparatermes sp.	1					Underground	Humivorous
Ruptitermes sp.				1		Sample	Grass/litter feeders
Nasutitermitinae							
Diversitermes diversimilis (Silvestri, 1901)	1				2	Sample	Grass/litter feeders
Nasutitermes corniger (Motschulsky, 1855)				1	2	Arboreal	Xylophagous
Nasutitermes ephratae (Holmgren, 1910)	1		1	7	2	Arboreal	Xylophagous
Syntermitinae							
Labiotermes laticephalus (Silvestri, 1901)				4	1	Underground	Humivorous
Procornitermes triacifer (Silvestri, 1901)				1	1	Underground	Grass/litter feeders
Rhynchotermes nasutissimus (Silvestri, 1901)				2	1	Underground	Grass/litter feeders
Termitinae							
Microcerotermes strunckii (Soerensen, 1884)			1	1	2	Arboreal	Xylophagous
Termes bolivianus (Snyder, 1926)					1	?	Intermediate
Empty plots	8	10	8	2	1		
Abundance (number of encounters)	3	0	2	25	23		
Richness	3	0	2	10	10		
Richness estimated by Jackknife1	5.7 ± 1.92	0	3.8 ± 1.2	13.6 ± 1.98	13.6 ± 1.98		
Richness estimated by Jackknife2	8.1 ± 2.17	0	5.4 ± 1.11	14.66 ± 2.07	13.95 ± 2.39		

The physical and chemical parameters of soil for each study areas are presented in Table 2. The soil of the five areas has sandy texture with more than 70% sand. A2, A3, A4 and A5 have eutrophic soil, with more than 50% base saturation, indicates soils with high fertility. A1 have dystrophic soil, which indicates soils with medium fertility. A1, A3 and A4 have acidic soil, while A2 and A5 have alkaline soil. A5 has the highest CEC and content of organic matter, while A2 has the lowest CEC and content of organic matter. Comparing the two *Capões*, the soil of A5 has more organic matter than that of A4.

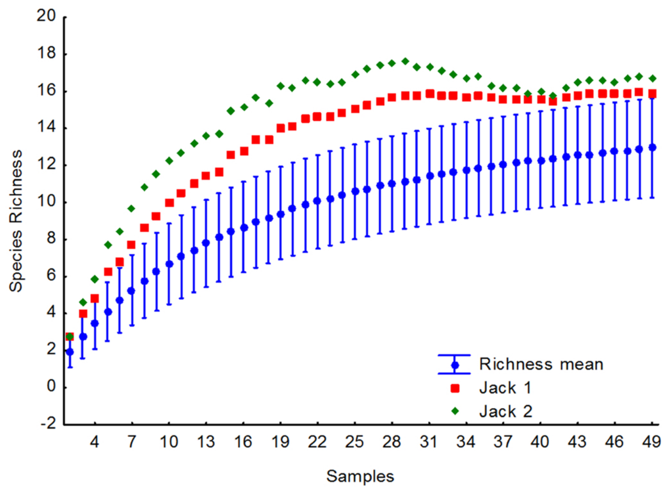

Figure 2. Number of termite species collected in 21 plots relative to the number of species predicted by the Jackknife1 and the Jackknife2 estimator in the Abobral region, Pantanal complex, Mato Grosso do Sul, Brazil. Lines are the 95% Confidence Intervals to Lower and Upper Bounds of the observed richness.

Table 2. Chemical and physical properties of soil samples from five areas in the Abobral region, in the Pantanal complex, Mato Grosso do Sul, Brazil.

	A1	A2	A3	A4	A5
pH (CaCl^2)	4.78	7.20	4.74	5.27	7.68
Organic Matter (g/dm^3)	11.37	3.87	26.94	23.10	62.89
Total CEC (cmol/dm^3)	4.08	1.25	9.53	6.75	20.21
Base saturation (%)	49.75	100	61.59	69.63	100
Sand (g/kg)	770	730	700	800	670
Silt (g/kg)	90	130	150	100	160
Clay (g/kg)	140	140	150	100	170

DISCUSSION

This is the first termite survey in the Abobral region of the Pantanal complex. The observed richness was equivalent to 77% of the total richness estimated for the entire region by the Jackknife2 estimator, the most conservative one. In each physiognomy, the observed richness was 40% to 70% of the estimated richness (see Table 1, except for the *Carandazal*, where no species were recorded). Whereas that were sampled 10 plots in each area, 70% of the total richness can be considered a relatively well sampled area. Other termite surveys had similar completeness using Jackknife estimator in other biomes, but with higher sampling efforts (e.g. Reis and Cancello 2007). *Nasutitermes ephratae* was the only species recorded in all four study physiognomies; this species is xylophagous and builds cartons nests, and has a wide distribution, going until to Panama, in Central America (Thorne 1980).

No species were found in the *Carandazal*, which is dominated by palm trees in hydromorphic soil, whose physicochemical analysis revealed eutrophic soil, alkaline pH, little organic matter and a low cation exchange capacity (CEC) (see Table 2). In *Paratudal*, only species that build arboreal nests were found (*Nasutitermes ephratae* and *Microcerotermes strunckii*). The absence of termites that build nests in the ground or underground can be because this area is located on the banks of the Miranda River, and suffers frequent flooding, which results in a very acidic soil and a low organic matter content (see Table 2).

The Pantanal fauna is considered to be influenced by all surrounding biomes (Alho 2005); however, the termite fauna seems to be more related to the Cerrado and Chaco. Excluding the species of *Nasutitermes* and *Microcerotermes*, which have wide distributions and occur in many biomes, most of the species found in the Abobral region located in the Pantanal complex, can also be found in the Cerrado and Chaco. This is the case for the species *Labiotermes laticephalus*, *Rhynchotermes nasutissimus* and *Procornitermes triacifer* (Roisin and Leponce 2004; Constantino *et al*. 2006). Additionally, the species *Heterotermes longiceps* and *Diversitermes diversimilis* occur in the Cerrado and Chaco, but are also distributed across the Atlantic Forest region (Constantino 2000; Cancello *et al.* 2014).

Studying the inquiline fauna of *Cornitermes silvestrii*, Plaza *et al*. (2014) found a different termite fauna in the Pantanal region of Cáceres, north of the Pantanal complex. In the Abobral region, we did not find any epigeal nest, but in the Cáceres region we found three species that can build epigeal nest (*C. silvestrii*, *C. bequaerti* and *Silvestritermes euamignathus*).

Based on the highest number of species in *capões*, we conclude that the diversity of termites in the Abobral Pantanal is concentrated in that physiognomy, which normally stay above the water level during the flood season. Additionally, the termite species composition of the Abobral Pantanal seems to be more related to the Cerrado and Chaco fauna, while different regions of the Pantanal have a completely different termite fauna. Similar studies should be performed in other regions of the Pantanal to forge a better understanding of the diversity pattern of the complex as a whole.

ACKNOWLEDGMENTS

The authors were supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) HFC grant #475484/2011-8 and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) TFC postdoctoral scholarship #2013/03767-0.

LITERATURE CITED

Alho, C.J.R. 2005. The Pantanal; pp. 203–271, in: L.H. Fraser and P.A. Keddy (org.). *The World's Largest Wetlands—Ecology and Conservation.* New York, USA: Cambridge University Press.

Allem, A.C. and J.F. Valls. 1987. *Recursos forrageiros nativos do Pantanal mato-grossense*. Brasília, Anais EMBRAPA/ CENARGEN. Documentos, 8.

Alvarenga, S.M., A.E. Brasil, R. Pinheiro and H.J.H. Kux. 1984. *Estudo geomorfológico aplicado à Bacia do Alto Paraguai e Pantanais Mato-grossense*. Projeto RADAMBRASIL. Boletim Técnico. Série Geomorfologia.

Bignell, D.E. 2006. Termites as soil engineers and soil processors; pp. 183–220, in: H. König and A. Varma (eds.). *Intestinal Microorganisms of Soil Invertebrates*. Berlin: Springer.

Black, H.I.J. and M.J.N. Okwakol. 1997. Agricultural intensification, soil biodiversity and agrosystem function in the tropics: the role of termites. *Applied Soil Ecology* 6: 37–53 (doi: 10.1016/S0929-1393(96)00153-9).

Cadavid-Garcia, E.A. 1984. *O clima no Pantanal Mato Grossense*. Corumbá, EMBRAPA/UEPAE de Corumbá. 42p. (EMBRAPA. UEPAE de Corumbá. Circular Técnica, 14).

Cancello, E.M., R.R. Silva, A. Vasconcellos, Y.T. Reis and L.M. Oliveira. 2014. Latitudinal Variation in Termite Species Richness and Abundance along the Brazilian Atlantic Forest Hotspot. *Biotropica* 46(4): 441–450 (doi: 10.1111/btp.12120).

Constantino, R., A.N.S. Acioli, K. Schmidt, C. Cuezzo, S.H.C. Carvalho and A. Vasconcellos. 2006. A taxonomic revision of the Neotropical termite genera *Labiotermes* Holmgren and *Paracornitermes* Emerson (Isoptera: Termitidae: Nasutitermitinae). *Zootaxa* 1340: 1–44 (http://www.mapress.com/zootaxa/list/2006/2006-10.html#Zootaxa 1340).

Constantino, R. and A.N.S. Acioli. 2006. Termite diversity in Brazil (Insecta: Isoptera); p.117–128 in F. Moreira, J.O. Siqueira and L. Brussaard (ed.). *Soil Biodiversity in Amazonian and Other Brazilian Ecosystems*. Wallingford, UK: CAB International.

Constantino, R. 2000. Key to the soldiers of South American Heterotermes with a new species from Brazil (Isoptera: Rhinotermitidae). *Insect Systematics & Evolution* 31: 463–472 (doi: 10.1163/187631200X00499).

Cunha, N.G., A. Pott and A.R. Gonçalves. 1986. *Solos calcimórficos da sub-região do Abobral, Pantanal mato-grossense*. Corumbá, EMBRAPA, CPAC.

Colwell, R.K. 2004. EstimateS: Statistical estimation of species richness and shared species from samples. Version 7. Persistent URL: http://purl.oclc.org/estimates.

Davies, R.G., P. Eggleton, L. Dibog, J.H. Lawton, D.E. Bignell, A. Brauman, C. Hartmann, L. Nunes, J. Holt and C. Rouland. 1999. Successional response of a tropical forest termite assemblage to experimental habitat perturbation. *Journal of Applied Ecology* 36: 1–18 (doi: 10.1046/j.1365-2664.1999.00450.x).

De Souza, O. and W.L. Brown. 1994. Effects of habitat fragmentation on Amazonian termite communities. *Journal of Tropical Ecology* 10: 197–206 (doi: 10.1017/S0266467400007847).

Gontijo, T.A. and Domingos, D.J. 1991. Guild distribution of some termites from cerrado vegetation in southeast Brazil. *Journal of Tropical Ecology* (7): 523–529. (doi: 10.1017/S0266467400005897).

Higashi, M. and T. Abe. 1997. Global diversification of termites driven by the evolution of symbiosis and sociality; pp. 83–112, in: T. Abe, S.A. Levin and M. Higashi (eds.). *Biodiversity—An Ecological Perspective*. New York: Springer Verlag.

Jones, C.G., J.H. Lawton and M. Shachak. 1994. Organisms as ecosystem engineers. *Oikos* 69: 373–386 (doi: 10.1007/978-1-4612-4018-1_14).

Jouquet, P., T.Saran, C. Choosai, C. Hartmann and D. Bignell. 2011. Influence of termites on ecosystem functioning. Ecosystem services provided by termites. *European Journal of Soil Biology* 47: 215–222 (doi: 10.1016/j.ejsobi.2011.05.005).

Lavelle, P., D. Bignell, M. Lepage, V. Wolters, P. Roger, P. Ineson, O.W. Heal and S. Dhillion. 1997. Soil function in a changing world: the role of invertebrate ecosystem engineers. *European Journal of Soil Biology* 33: 159–193.

Magurran, A.E. 2004. *Ecological Diversity and Its Measurement*. Princeton, NJ: Princeton University Press. 179 pp.

Mathews, A.G.A. 1977. *Studies on termites from the Mato Grosso State, Brazil*. Rio de Janeiro: Academia Brasileira de Ciências, p. 267.

Orioli, A.L., Z.P. Amaral Filho and A.B. Oliveira. 1982. Pedologia: Levantamento exploratório de solos; pp. 225–328, in: Departamento Nacional da Produção Mineral. Projeto RADAMBRASIL. Levantamento de recursos naturais. *Folha SE.21. Corumbá e parte da Folha SE.20.*: geologia, geomorfologia, pedologia, vegetação e uso potencial da terra. Rio de Janeiro. (Levantamento dos Recursos Naturais, 27).

Plaza, T.G.D., T.F. Carrijo and E.M. Cancello. 2014. Nest plasticity of *Cornitermes silvestrii* (Isoptera, Termitidae, Syntermitinae) in response to flood pulse in the Pantanal, Mato Grosso, Brazil.

Revista Brasileira de Entomologia 58 (1): 66–70 (doi: 10.1590/S0085-56262014000100011).

Polatto, L.P. and V.V. Alves-Junior. 2009. Distribuição e densidade de *Nasutitermes* sp. (Isoptera: Termitidae) em Mata Ribeirinha do Rio Miranda, Pantanal Sul-Matogrossense, Brasil. *EntomoBrasilis* 2(1): 27–30 (http://www.periodico.ebras.bio.br/ojs/index.php/ebras/article/view/38).

Reis, Y. and E.M. Cancello. 2007. Riqueza de cupins (Insecta, Isoptera) em áreas de Mata Atlântica primária e secundária do sudeste da Bahia. *Iheringia Série Zoologia* 97(3): 229–234 (doi: 10.1590/S0073-47212007000300001).

Roisin, Y. and M. Leponce. 2004. Characterizing termite assemblages in fragmented forests: a test case in the Argentinian Chaco. *Austral Ecology* 29: 637–646 (doi: 10.1111/j.1442-9993.2004.01403.x).

Silva, J.S.V. and M.M. Abdon. 1998. Delimitação do Pantanal brasileiro e suas sub-regiões. *Pesquisa Agropecuaria Brasileira* 33: 1703–1711 (http://seer.sct.embrapa.br/index.php/pab/article/view/5050).

Thorne, B.L. 1980. Differences in nest architecture between the Neotropical arboreal termites, *Nasutitermes corniger* and *Nasutitermes ephratae* (Isoptera: Termitidae). *Psyche* 87: 235–244 (http://psyche.entclub.org/87/87-235.html).

Author's contribution statement: All authors designed the project, collected data and reviewed the text. ARA and CSB made the soil collection and sent for analysis. HFC and TFC wrote the text and made the data analysis.

Received: June 2014
Accepted: November 2014
Editorial responsibility: Regiane Saturnino