academicJournals

Vol. 10(49), pp. 4449-4454, 3 December, 2015
DOI: 10.5897/AJAR2015.9521
Article Number: 4E11A3056275
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Ant diversity in agro ecosystems and secondary forest

Albéryca Stephany de J. C. Ramos[1]*, Raimunda Nonata S. de Lemos[1], Alirya Magda S. do Vale[1], Michela C. Batista[1], Aldenise A. Moreira[2], Ana Y. Harada[3] and Mário L. R. Mesquita[1]

[1]Maranhão State University, Brazil.
[2]Bahia Southwest State University, Brazil.
[3]Emilio Goeldi Museum at Pará State, Brazil.

Received 19 January, 2015; Accepted 15 October, 2015

The knowledge of ant diversity in an area can provide important information to set up management and conservation planning. This study aimed to identify the ants colonizing cultivated areas comparing their composition, abundance and diversity with the myrmecofauna from a non-managed area. The research was carried out at the Farm School at the Maranhão State University in São Luis, Northeastern Brazil from August, 2011 to July, 2012 in three environments (citrus orchard, agroforestry system and secondary forest), using pitfall traps. Ants were collected every two weeks, totaling 24 collections, from August, 2011 to July, 2012. We identified 21 species, with predominance of the sub family Myrmicinae, the genera *Pheidole* and the species *Pheidole obscurithorax* Naves, 1985. The study of ant abundance, composition, richness and similarity, showed higher diversity in the agroforestry system.

Key words: Formicidae, inventory, myrmecofauna, biodiversity.

INTRODUCTION

The indiscriminate use of natural resources is causing harm to ecosystems worldwide (Santos et al., 2006). However, biodiversity has been identified as a crucial factor for the operation and stability of ecosystems (Hooper et al., 2005).

One way to assess environmental quality associated with areas under cultivation to detect and monitor changes in biodiversity, is the study of species that behave as environmental degradation bioindicators.Their high diversity and sensitivity to changes in the biological and physical environments, highlights the ants (Santos et al., 2006).

The Formicidea (Insecta: Hymenoptera: Formicidae) are related with many important land environment processes acting as herbivores, pollinators, seed dispersers and predators, being important pests in urban and agrosilvicultural areas. In addition, ants are recognized as potential indicators of ecosystem environmental quality (Freitas et al., 2006), since they work in all levels of the food chain (Folgarait, 1998) playing a key role in ecosystems maintenance.

The ant diversity surveys portray a temporary and permanent situation of the evaluated environments which are frequently associated with agricultural activities. It is

*Corresponding author. E-mail: rlemos@cca.uema.br, Tel:(+55) 98 9972 9504.

assumed that differences observed among studied areas resulting from farming practices, may affect ant community due to changes in microclimate conditions, food supply and species nesting areas. The objective of this research was to compare abundance, diversity, richness, composition and similarity of ant communities that colonize areas under cultivation (Citrus orchard and Agroforestry system) with a non-cultivated area (Secondary forest).

MATERIALS AND METHODS

This research was carried out at the Farm School of the Maranhão State University at São Luis, in three sites:Citrus orchard (02° 58' 75" S and 44° 20' 79" W), Agroforest system (02° 58' 35" S and 44° 20' 81" W), and Secondary forest (02°58' 88" S and 44° 20' 88" W).

The Citrus orchard was planted in 2003, in anarea of 0.5 ha where the following species are grown: Tahiti lime (*Citrus latifolia* Tan.), Natal Folha Murcha orange (*Camellia sinensis* L. Obs.), Tanjaroa tangerine (*Camellia reticulate* Blanco), Rugoso-do-Maranhão lemon (*Citrus* sp.) and Galego lemon (*Citrus aurantifolia* Swing.), all grafted over Cravo lemon (*Citrus limonia* Osb.). Plant spacing is 6 x 6 m. The Rugoso-do-Maranhão lemon and Tanjaroa tangerine are local selections collected in Maranhão State, northeastern Brazil.

The Agroforestry system was planted in 2004 in an area of 600 m². Its main crop is cupuaçu *Theobroma grandiflorum* Willd ex Spreng). There are four clones of grafted cupuaçu: Manacapuru, Codajás, Coari and Belém at 5 x 6 m spacing intercropped with dry land Açaí (*Euterpe oleracea* Mart.) at 2.5 x 6 m spacing, to provide definitive shading to the main crop and also to fruit production. Additionally, *Inga edulis* Mart. was planted just beside Açaí, at 1.25 x 6 m spacing to provide temporary shading for cupuaçu and to serve as source of biomass for the agroforest system. The secondary forest fragment assessed in this study is known as Rosa Mochel Forest Reserve, with an area of eight hectares and more than 40 years old, whose vegetation is described as Ombrophillous Mixed Forest. Nine pitfall traps were placed in each area, totaling 27 by collection which were distributed in a transect (3x3) spaced by 10m. Every 15 days the traps were placed in the field and recovered after 48 h. Therefore, 24 collections were done in the period from August 2011 to July 2012. The traps consisted of 400 ml plastic cups, containing a (9:1) water and neutral detergent solution. They were duly numbered and buried in the soil, keeping the flatness of the cup edge with the soil surface and respecting border effects. A cover made with plastic plates and wire was assembled and placed over each trap to protect from the rain.

The collected material was identified at the Entomology Laboratory from the Maranhão State University at São Luis, by means of a Stemi DV4 stereomicroscope. Identification at species level was done at the Ant Taxonomy and Systematics Laboratory at the Emílio Goeldi Museum at Para State (EGMPS), based on external morphology, by comparison with other species from the EGMPS using taxonomic keys available in the literature.The collected material was deposited in the Entomological Collection from the Maranhão State University and in the Invertebrate Collection from the EGMPS.

The myrmecofauna abundance was recorded based on the species absolute frequencies from each sample. The species saturation curves based on ant abundance were computed for each studied area by means of the Mao Tau function in the estimates 8 program (Colwell, 2006).The Jaccard index was used to analyze variation in the species composition among the studied areas. This index is very useful to analyze species presence and absence data since species composition among the studied areas is assessed with equal weights. It is computed as $J = a / (a + b + c)$, where a is the number of species in common to both areas b and c are the number of species represented exclusively in each area. The Jaccard index intervals were, for $J = 0.0$ (no species to be divided in two collections) and for $J = 1.0$ (identical composition from two collections) (Chao et al., 2005).

The Shannon-Wiener index was computed by the formula: $H' = -\sum_1^S (pi \cdot \ln pi)$, where pi: frequency of each species (the proportion of the species related to the total number of the species found in the survey) for i ranging from 1 to S (number of species). The Simpson index by: $\lambda = \sum_1^S pi^2$, and Pielou equitativity by: $J = \frac{H'}{H\,max.}$. The indexes were computed by means of the software BioDiversity Pro.

RESULTS AND DISCUSSION

A total of 21 species of ants were identified with predominance of the subfamily Myrmicinae, the genera *Pheidole* and the species *Pheidole obscurithorax* Naves, 1985 (Table 1). The subfamily Myrmicinae had the highest number of species, (n = 10), followed by Formicinae (n = 8), Ponerinae, Ectatomminae and Ecitoninae (n = 1, each) (Table 1). Myrmicinae, the most abundant subfamily in this study, is also dominant in many Brazilian ecosystems in number of genera and species (Albuquerque and Diehl, 2009).

The genus *Camponotus* had the highest species richness (n = 5), followed by *Pheidole* (n = 3), *Acromyrmex*, *Brachymyrmex* and *Crematogaster* (n = 2, each), *Labidus*, *Ectatomma*, *Mycocepurus*, *Paratrechina*, *Solenopsis, Trachymyrmex* and *Pachycondyla* (n = 1, each) (Table 1). The genus *Camponotus* is represented by the carpenter ants are important ecological components of most environments where they act as predators, scavengers (necrophagous) and food for other animals (Hansen and Klotz, 2005). They are also tolerant to moisture and temperature range of variation (Tavares et al., 2008).

The most abundant species was *P. obscurithorax* Naves, 1985 followed by *Solenopsis tridens* Forel, 1911 and *Camponotus brettesi* Latreille, 1809 (Table 1). Ants from the genera *Pheidole* are most common in the Neotropical region, where they are associated with different plant communities. They are predominant in all terrestrial ecosystems in species diversity, geographical distribution and abundance, since they show wide tolerance to environmental conditions (Corrêa et al., 2006). All species were found in all three areas except *Trachymyrmex* nr. JTL-004 which was not found in the

Table 1. Abundance of ant species (Formicidae) collected in agroforest system, secondary forest and citrus orchard areas in São Luís municipality, Maranhão State, northeastern Brazil in 2011/2012.

Subfamilies and species	Citrus orchard	Secondary forest	Agroforest system
Ecitoninae			
Labidus coecus (Latreille, 1802)	9* (94)**	4 (10)	11 (41)
Ectatomminae			
Ectatomma brunneum Smith, 1858	97 (839)	22 (35)	131 (670)
Formicinae			
Brachymyrmex nr. patagonicus Mayr, 1868	14 (30)	4 (4)	12 (26)
Brachymyrmex obscurior Forel, 1893	43 (102)	10 (16)	15 (30)
Camponotus brettesi Forel, 1899	37 (126)	37 (75)	104 (315)
Camponotus coloratus Forel, 1904	4 (4)	3 (4)	6 (8)
Camponotus JTL-036 Longino ms.	4 (8)	4 (5)	13 (16)
Camponotus nr. coruscus (Smith, 1862)	26 (75)	39 (60)	66 (103)
Camponotus nr. JTL-044 Longino ms.	15 (25)	11 (13)	38 (85)
Paratrechina nr. longicornis (currens) (Latreille, 1802)	15 (23)	13 (45)	19 (40)
Myrmicinae			
Acromyrmex coronatus (Fabricius, 1804)	16 (26)	7 (10)	10 (20)
Acromyrmex landolti (Forel, 1885)	9 (47)	6 (7)	9 (13)
Crematogaster evallans Forel, 1907	54 (121)	16 (28)	65 (211)
Crematogaster nr. abstinens Forel, 1899	32 (69)	17 (67)	21 (59)
Mycocepurus smithii (Forel, 1893)	3 (7)	4 (12)	4 (6)
Pheidole coracina Wilson, 2003	23 (95)	7 (38)	24 (38)
Pheidole scapulata Santschi, 1923	15 (22)	2 (4)	17 (17)
Pheidole obscurithorax Naves, 1985	155 (973)	117 (475)	171 (906)
Solenopsis tridens (Forel, 1893)	44 (255)	77 (1337)	65 (1029)
Trachymyrmex nr. JTL-004 Longino ms.	11 (13)	0	10 (20)
Ponerinae			
Pachycondyla crassinoda (Latreille, 1802)	27 (46)	132 (921)	27 (82)
Numbers ants	653 (3002)	532 (3166)	838 (3735)
Shannon-Wiener diversity	1.107	0.995	1.124
Simpson diversity	0.106	0.145	0.106
Pielou equitativity	0.894	0.855	0.894

*Absolute frequencies in the samples of species.** Total number of individuals.

Secondary forest (Table1). Most species from the genera *Trachymyrmex* are of small size. They forage in a conspicual way on the soil, opportunistically collecting a wide variety of items from the symbiotic fungus substrate, including animal faeces and dried plant parts. Occasionally, they feed on live plant parts (Mayhê-Nunes and Brandão, 2007).

The only army-ant found in this study was *Labidus coecus* Latreille, 1809 which was found in all studied areas (Table 1). Ants belonging to the genera *Labidus* are characteristically invaders and extremely aggressive attacking soil fauna (Hölldobler and Wilson, 1990). Occurrence of this species in this study may be explained by its well known nomadic behavior.

The highest values for H' and J' indexes were recorded in Agroforest system (H'=1.12; J'= 0.89) and citrus orchard (H'=1.11; J'= 0.89), and the lowest values for such parameters were recorded in Secondary forest (H'= 0.99; J'= 0.25), where Simpson index (λ=0.14) reached the highest value (Table 1). Therefore, the Agroforestry

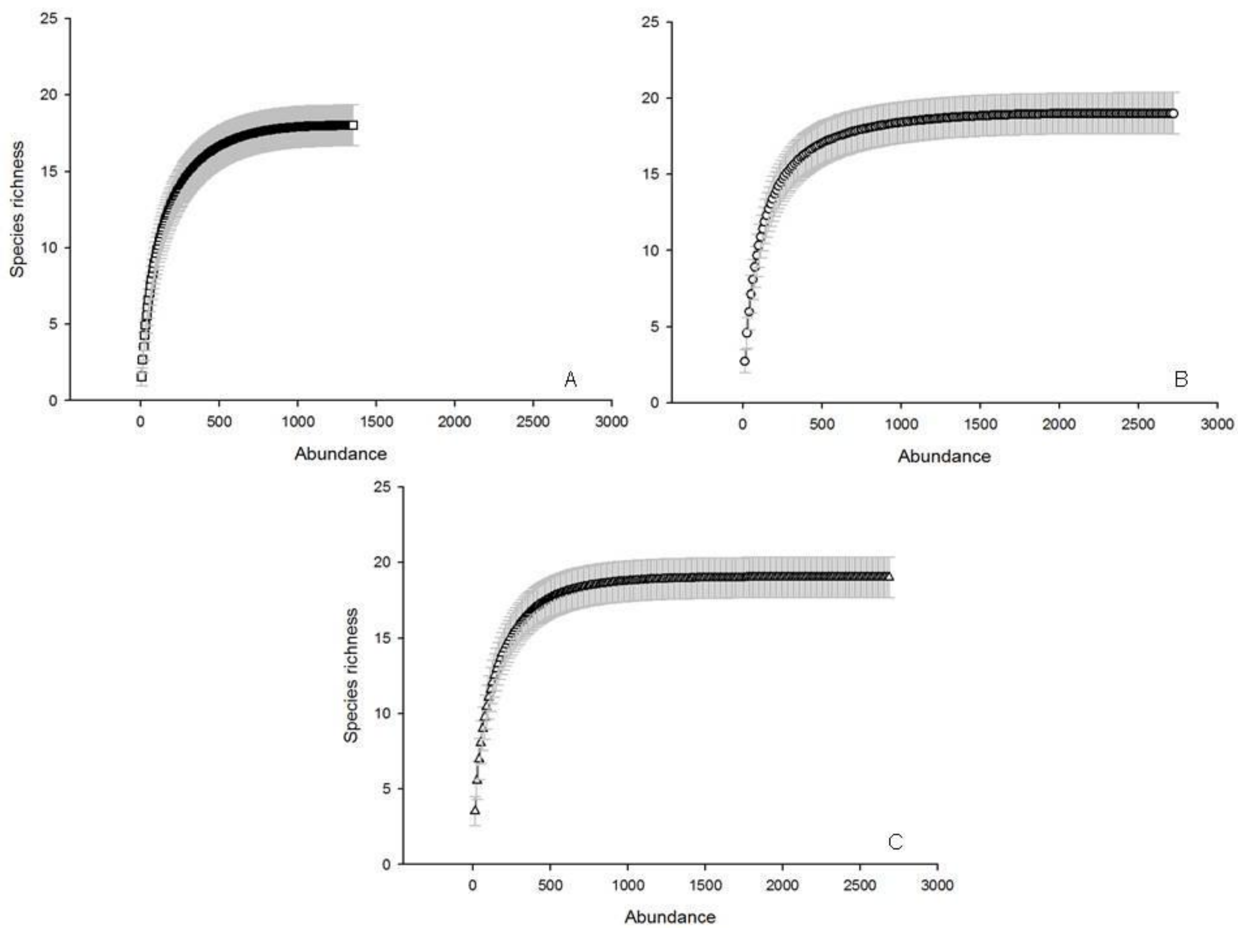

Figure 1. Saturation curves standardized by ant species number generated by the Mao Tau estimator in function of the species abundance in A: Secondary forest, B: Citrus orchard and C: Agroforestry system. The error bars show the standard deviation.

system was considered the most diverse among the studied areas. Agroforestry systems can be suitable habitats for ant communities, but management is also important since the forest ants suffer with canopy cover reduction and associated microclimate modifications (Bos et al., 2007).

The species saturation curves demonstrated that ant species richness increased reaching the asymptote, indicating that the sample effort and sample sizes were appropriate. They also showed that species richness were similar in all the studied areas (Figure 1). It was expected that the Secondary forest would be different from the other treatments due to its natural high niche diversity and plant species richness, and therefore, higher ant species diversity (Leal et al., 2012).

However, this did not happen probably due to anthropogenic perturbance and to its area size. According to Báldi (2008) small and more homogeneous areas often harbor a lower number of species than large and heterogeneous areas. The Jaccard index showed a high level of similarity of species composition among the studied areas.The Citrus orchard and Agroforestry system had higher number of and similar species with a similarity higher than the secondary forest compared with the two agroecosystems (Figure 2). The effects of habitat fragmentation, as well as anthropogenic effects on microclimate and vegetation enable ant adaptation to colonize other agroecosystems (Leal et al., 2012). It is suggested that this could be occurring within the Rosa Mochel Reserve where many ant species migrate from the near forest fragment to the orchards, searching for resources for their survival. This study quotes the species *S. tridens* and *P. obscurithorax* which were most frequent in the Secondary Forest fragment and also showed high frequency values in the Citrus orchard and Agroforest system. A very strong anthropogenic activity including

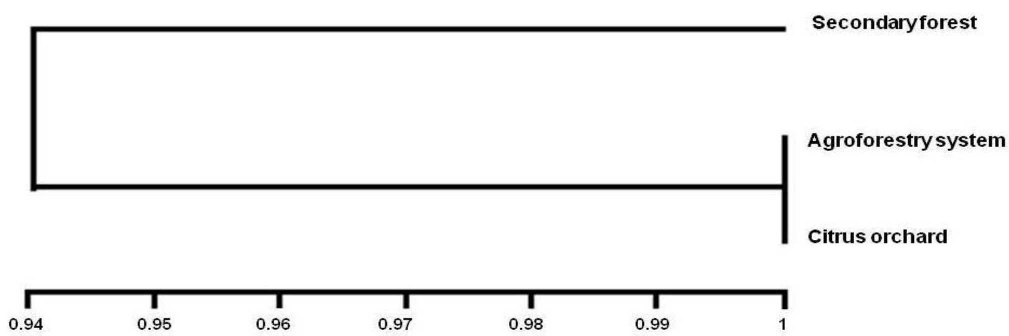

Figure 2. Ant fauna similarity dendogram (Jaccard Index) in Agroforestry system, Secondary forest and citrus orchard areas in São Luís municipality, northeastern Brazil, 2011/2012.

deforestation, presence of tracks in the woods and waste deposits were observed in the Secondary forest when compared with the other agroecosystems. This was reflected in the low ant diversity found in this area, as well as in the absence of the species *Trachymyrmex nr.* JTL-004, which was found in the other agroecosystems and is sensitive to disturbance (Longino, 2007). Also the few records of army ants which are known to suffer population reduction and even local extinction as a result of the forest fragmentation process (Freitas et al., 2006) reflect this. The high abundance values of the species *Paratrechina* nr. *longicornis* (currens)and *S. Tridens* in this area confirm the hypothesis of high disturbance since these species are related to areas that were subjected to alterations (Fernández, 2003). However, even with the finding of intense environmental disturbance one can only recommend preservation of the Rosa Mochel forest reserve which is considered as a natural treasure for the region.

Conclusion

The myrmecofauna observed in the three studied areas is composed basically by the same species, except for *Trachymyrmex* nr. JTL-004 which was not found in the Secondary forest. The subfamily Myrmicinae, the genus *Pheidole* and the species *P. obscurithorax* are the most abundant. The species richness is similar in all the studied areas. The agroforestry system and the citrus orchard are quite similar, indicating a similar composition between these two environments. The Agroforestry system showed the highest ant species diversity.

Conflict of Interests

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

To The Emilio Goeldi Museum at Pará State scientists for helping on ant species identification. To National Council for Scientific and Technological Development – CNPq for granting a scholarship of scientific initiation to the first author.

REFERENCES

Albuquerque EZ, Diehl E (2009). Análise faunística das formigas epígeas (Hymenoptera: Formicidae) em campo nativo no Planalto das Araucárias, Rio Grande do Sul. Rev. Bras. Entomol. 53:398-403.

Báldi A (2008). Habitat heterogeneity overrides the species–area relationship. J. Biogeogr. 35:675-681.

Bos MM, Steffan-Dewenter I, Tscharntke T (2007).The contribution of cacao agroforests to the conservation of lower canopy ant and beetle diversity in Indonesia. Biodivers. Conserv. 16:2429-2444.

Chao A, Chazdon RL, Colwell RK, Shen TJ (2005). A new statistical approach for assessing compositional similarity based on incidence and abundance data. Ecol. Lett. 8:148-159.

Colwell RK (2006). EstimatesS: Statistical estimation of species richness and shared species from samples. Version 8. Available at: http://viceroy.eeb. uconn.edu/estimatesS

Corrêa MM, Fernandes WD, Leal IR (2006). Diversidade de formigas epigéicas (Hymenoptera: Formicidae) em capões do Pantanal Sul Matogrossense: relações entre riqueza de espécies e complexidade estrutural da área. Neotrop. Entomol. 35:724-730.

Fernández F (2003). Subfamília Formicidae, In: F. Fernández (ed.). Introducción a las hormigas de la región Neotropical. Bogotá, Colômbia, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. pp. 299-306.

Folgarait PJ (1998). Ant biodiversity and its relationship to ecosystem functioning: a review. Biodivers. Conserv. 7:1221-1244.

Freitas AVL, Leal IR, Uehara-Prado M, Ianuzzi L (2006). Insetos como indicadores de conservação da paisagem. In: Rocha CDF, Bergallo HG, Van Sluys M, Alves MAS (eds.). Biologia da Conservação: Essências. São Carlos: Rima Editora. pp. 357-384.

Hansen LD, Klotz JH, (2005). Carpenter ants of the United States and Canada. New York: Ithaca: Cornell University Press. Extension Bulletin 0818.

Hooper DU, Chapin FS, Ewel JJ, Inchausti P, Lavorel S, Lawton JT, Lodge DM, Loreau M, Naeem S, Schmid B, Setälã H, Symstad AJ, Vandermeer J, Wardle DA (2005). Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecol. Monogr. 75:3-35.

Hölldobler B, Wilson EO (1990).The ants.Cambridge: Harvard University Press. P 732.

Leal IR, Filgueiras BKC, Gomes JP, Iannuzzi L, Andersen AN (2012). Effects of habitat fragmentation on ant richness and functional composition in Brazilian Atlantic forest. Biodivers. Conserv. 21:1687-1701.

Longino JT (2007). A taxonomic review of the genus *Azteca* in Costa Rica and a global revision of the aurita group. Zootaxa 1491:1-63.

Mayhé-Nunes AJ, Brandão CRF (2007). Revisionary studies on the attine ant genus *Trachymyrmex* Forel. Part 3: The Jamaicensis group (Hymenoptera: Formicidae). Zootaxa 1444:1-21.

Santos MS, Louzada JNC, Zanetti R, Delabie JHC, Nascimento IC (2006). Riqueza de formigas (Hymenoptera, Formicidae) da serapilheira em fragmentos de floresta semidecídua da Mata Atlântica na região do Alto do Rio Grande, MG, Brasil. Iheringia, Sér. Zool. 96:95-101.

Tavares AA, Bispo PC, Zanzini AC (2008). Efeito do turno de coleta sobre comunidades de formigas epigéicas (Hymenoptera: Formicidae) em áreas de *Eucalyptus cloeziana* e de cerrado. Neotrop. Entomol. 37:126-130.