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Ant Diversity in a Sugarcane Culture without the Use of Straw Burning in Southeast, São Paulo, Brazil

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Abstract: Problem statement: One of the current requirements of agroecosystem management is the maintenance of biodiversity. Manual sugarcane harvesting with the previous burning of straw has been gradually replaced by mechanical harvesting in Brazil. However, the diversity of Formicidae, which can be a natural pest controller, has not been studied in this new system yet. **Approach:** This study was carried out to assess the diversity of ants in an exclusively mechanically harvested sugarcane culture based on the hypothesis that species richness and abundance will increase with the deposition of straw in this culture system. Ants were sampled using pitfall traps in six sugarcane cultivars during three consecutive harvest cycles. **Results:** A total of 8,139 ants, distributed in 39 species, were collected. Richness, abundance and diversity differed between harvest cycles, especially in the first cycle, when the soil did not have any straw and in the two last cycles and the straw layer was about 10-15 cm thick. The communities found in the second and third cycles were similar and the maintenance of straw in the culture contributed to a greater species diversity, particularly of generalist predaceous taxa, which may contribute to the natural control of pests. **Conclusion:** The diversity of ants increased with straw deposition, including of taxa that may be beneficial to the sugarcane culture. However, new studies of the predatory and competition relations in this agroecosystem are necessary.

Key words: *Saccharum officinarum*, community, richness, abundance, taxa, predators

INTRODUCTION

Saccharum officinarum L. is a grass native of Southeast Asia. Its culture area of 7 million ha makes Brazil its largest producer and the second largest producer of ethanol in the world (CONAB, 2009; Institute of Agro-industrial Development, 1998; UNICA, 2009).

Presently, ethanol is used as an alternative vehicle fuel in Brazil and the interest of the external market has grown (Corbi and Trivinho-Strixino, 2008). The high productivity, quality and competitiveness of sugarcane cultures require planning and technological changes, besides maintenance of the socio-economical development, rational exploitation and the preservation of the environment. To this end and due to the innumerous negative effects on the environment, especially on insects, manual harvesting and burning have been gradually replaced by mechanical harvesting (Araujo *et al*., 2005).

Despite the low richness of ants in culture areas (Adams *et al*., 1981; Risch and Carroll, 1982) they play an important role in these ecosystems, including as biological indicators of edaphic conditions (Lobry de Bruyn 1999; Morris *et al*., 1999; Peck *et al*., 1998; Philpott and Armbrecht, 2006; Philpott *et al*., 2008; Santos *et al*. 2007) and as pest controllers (Fernandes *et al*., 1994; Ibarra-Núnez *et al*., 2001). In soil, they contribute to

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water infiltration, aeration (Agosti *et al*., 2000; Hölldobler and Wilson, 1990; 1995), mineralization (Gunadi and Verhoef, 1993) and they stimulate the action of bacteria that contribute to increase soil fertility (Petal *et al*., 1977).

Based on the ecological importance of Formicidae and the fact that agrosystem management is fundamental for the preservation and maintenance of biodiversity (Dias *et al*., 2008), this study aimed to study their biodiversity in sugarcane cultures with exclusively mechanical harvesting and test the hypothesis that maintenance of straw in the culture increases the number of species and specimens of ants.

MATERIALS AND METHODS

Area of study: This study was performed in the municipality of Paraguaçu Paulista (22°24' 46"S; 50°34' 33"W) in six sugarcane culture areas grown with cultivar SP81-3250. Each sampling site was prepared before the implementation of the sugarcane culture by conventional techniques, surface soil revolving and fertilization at plantation. Management routines and harvest procedures were used during the experimental phase.

Ant sampling: Ants were collected from May 2005 to August 2008, a period corresponding to three harvest cycles of a commercial culture. During the 1st cycle (I), the soil surface did not have any straw, in the 2nd cycle (II), it had a layer of approximately 10 cm and in the 3rd cycle (III), the layer was about 15 cm thick. A 1 ha parcel was chosen in each area for the placement of six pitfall traps measuring 8 cm high and 9 cm in diameter, each containing 500 mL water plus 25 g of salt and two drops of neutral detergent. The traps were places 30 m away from each other. The sampling sites were the same in the three sampling periods and the traps were left in the field for 7 days. The collected ants were preserved in 70% alcohol.

The material was initially identified by genera and morphospecies. The species were identified by comparison with the collection of the Zoology Museum of the University of São Paulo and the pertinent literature. Classification was performed according to Bolton *et al*. (2006) and voucher specimens were deposited at the University of Mogi das Cruzes (SP).

Data analysis: For the data analysis, richness was defined as the number of species and abundance, as the number of collected individuals per culture cycle. The relative frequency of occurrence was determined based on the total number of records of each species in each cycle using presence/absence data. Shannon's indexes of biodiversity and evenness were calculated with software Biodap (Thomas, 2000). The hypothesis that ant richness and abundance are related to the maintenance of straw in the culture was tested using the Kruskal-Wallis and the Dunn test (Ayres *et al*., 2007). A matrix with the sum of the records of all species in each of the cycles was used to plot a dissimilarity dendogram based on the Bray-Curtis distance index (Legendre and Legendre, 1998) using software R. The sample effort was analyzed using species accumulation curves. The richness estimation curves were plotted with EstimatesS version 8.0 (Colwell, 2007).

RESULTS

A total of 39 ant species were collected (8,139 specimens), nine (266 workers) in cycle I, 23 (2,808 workers) in cycle II and 21 (5,065 workers) in cycle III. The accumulation curves did not reach the asymptote level (Fig. 1), indicating that the sampling effort was not sufficient to represent the communities in each cycle. The estimated number of species was 23.58 in cycle I, 33.94 in cycle II and 35.58 in cycle III.

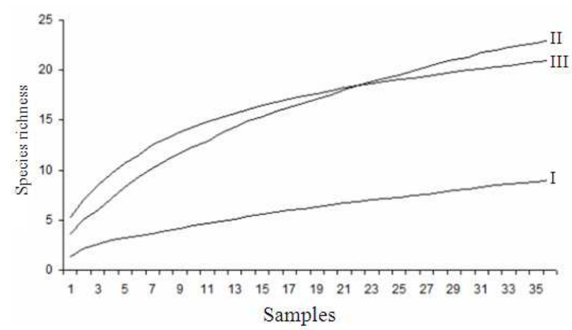

Fig. 1: Curves of accumulation of species for three sugarcane harvest cycles

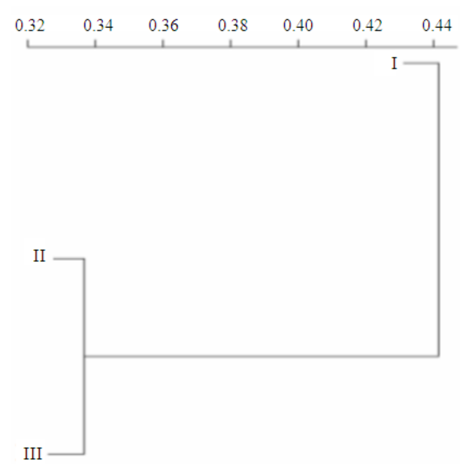

Fig. 2: Dendogram of ant communities sampled during three sugarcane harvest cycles based on the bray-curtis dissimilarity index

Table 1: Relative Frequencies of Occurrence (RFO%) and Abundance (RFA%) of the species collected during three sugarcane harvest cycles

	Cycles					
	I (%)		II (%)		III (%)	
Taxa	RFO	RFA	RFO	RFA	RFO	RFA
Dolichoderinae						
Dorymyrmex sp.1	45.28	69.17	28.35	48.43	17.91	36.76
Linepithema iniquum (Mayr)	-	-	0.79	0.04	-	-
Ectatomminae						
Ectatomma tuberculatum (Olivier, 1791)	-	-	1.57	0.07	0.05	0.02
Gnamptogenys striatula (Mayr, 1883)	-	-	-	-	1.49	0.06
Formicinae						
Brachymyrmex incisus (Forel, 1912)	1.89	1.13	7.87	2.28	15.42	6.44
Camponotus rufipes (Fabricius, 1775)	-	-	-	-	1.49	0.06
Camponotus sp.4	-	-	-	-	1.49	0.06
Camponotus sp.8	-	-	0.79	0.04	-	-
Camponotus sp.11	-	-	3.15	1.39	-	-
Myrmicinae						
Acromyrmex niger (Fr. Smith, 1858)	-	-	3.15	0.21	-	-
Apterostigma sp.2	-	-	-	-	3.98	0.61
Atta sexdens (Linnaeus, 1758)	-	-	2.36	1.78	-	-
Mycocepurus sp.1	-	-	-	-	0.50	0.04
Trachymyrmex urichi (Forel, 1893)	1.89	0.38	0.79	0.39	-	-
Crematogaster (*Orthocrema*)	-	-	0.79	0.04	-	-
Crematogaster sp.5	1.89	1.50	-	-	-	-
Crematogaster sp.7	-	-	-	-	3.48	0.53
Pheidole sp.2	-	-	-	-	0.50	0.04
Pheidole sp.4	-	-	4.72	1.28	11.44	3.36
Pheidole sp.6	-	-	-	-	2.49	0.14
Pheidole sp.20	-	-	1.57	0.68	-	-
Pheidole sp.21	-	-	-	-	0.50	0.02
Pheidole sp.22	1.89	0.75	-	-	2.99	1.95
Pheidole sp.27	-	-	2.36	0.89	-	-
Pheidole sp.28	-	-	-	-	0.50	0.02
Pheidole sp.34	-	-	-	-	7.46	1.13
Pheidole sp.35	37.74	25.19	28.35	38.75	17.91	47.92
Pheidole sp.45	-	-	0.79	0.11	2.49	0.49
Solenopsis saevissima (Smith)	-	-	-	-	1.49	0.06
Solenopsis (*Diplorhoptrum*) sp.2	-	-	0.79	2.10	-	-
Strumigenys elongata (Roger, 1863)	-	-	0.79	2.10	-	-
Ponerinae						
Anochetus sp.2	-	-	-	-	5.47	0.30
Hypoponera sp.2	-	-	0.79	0.04	-	-
Hypoponera sp.4	1.89	0.38	-	-	-	-
Odontomachus affinis (Guerin, 1845)	-	-	2.36	0.11	0.50	0.02
Odontomachus meinerti (Forel, 1905)	5.28	1.13	0.79	0.04	-	-
Odontomachus chelifer (Latreille, 1802)	1.89	0.38	1.57	0.14	-	-
Pachycondyla striata (Fr. Smith, 1858)	-	-	4.72	1.14	-	-
Pachycondyla harpax (Fabricius, 1804)	-	-	0.79	0.04	-	-
Richness per cycle	9.000		23.000		21.000	
Abundance per cycle	266.000		2.808		5.065	
Total richness	39.000					
Total abundance	8.139					
Diversity index	1.340		2.260		2.450	
Evenness	0.610		0.720		0.800	

Richness was significantly different between cycles (Kruskal-Wallis = 57.6203, df = 2, $p<0.05$, I X II: Z = 6.4963, $p<0.05$ and I X III: Z = 6.6487, $p<0.05$). A similar result was observed for abundance (Kruskal-Wallis = 10.4116, df = 2, $p<0.05$; I X II: Z = 6.4963, $p<0.05$ and I X III: Z = 2.8043, $p<0.05$). The diversity index was significantly different between cycles (Kruskal-Wallis = 8.8570, df = 2, $p<0.05$; I X III: Z = 2.8118, $p<0.05$), the evenness values indicate that the species that composed the ant communities in cycles II and III have similar representations (Table 1). These values corroborate the Bray-Curtis distance index (Fig. 2).

Myrmicinae was the richest subfamily (22 species), followed by Ponerinae (8 species) and Formicinae (5 species). In the three cycles, the most frequent and abundant species were the same, *Dorymyrmex* sp.1 and *Pheidole* sp. 35 (Table 1) and most of the species that were sampled were generalists.

DISCUSSION

Mulching in extensive sugarcane culture may contribute to the action of decomposers that increase the availability of resources in the environment by actively recycling several organic compounds (Gonzalez and Seastedt, 2000), such as sugars, amino acids, waxes, phenols, lignins and acids (Shinitzer, 1991), thus allowing the coexistence of a greater number of species in the same habitat. The presence of straw affords greater richness, abundance and diversity to the ant community in relation to the culture without mulching, or even when compared to the culture with manual harvest and straw burning (Rossi and Fowler, 2004).

However, no significant difference was observed in richness, abundance and diversity after mulching, even with the accumulation of organic matter between cycles. In tropical forest areas, the amount of litter influences species richness, as ants find more food resources and nesting places and a microclimate more favorable to their requirements (Andersen, 1983; Armbrech *et al*., 2004; Campos *et al*., 2003; Carvalho and Vasconcelos, 1999; Kaspari and Weiser, 2000; Philpot and Foster, 2005). More recent studies acknowledge that the base of the trophic in the litter are fungi, bacteria and chemical elements and all are particularly important to increase the diversity of the ant fauna (Kaspari *et al*., 2008; Mcglyn and Salinas, 2007; Mcglyn *et al*., 2009). Thus, the resources produced by these interactions in the straw layer between Cycles II and III probably become available in a similar way.

In cycle I, most of the species are generalist and can exploit a large variety of environmental resources (Brown, 2000). In the subsequent cycles, besides generalist species, there are also some fungus-growing species, such as *Apterostigma* and *Mycocepurus,* which use insect feces, dead insects and cellulosic material as substrates (Hölldobler and Wilson, 1995) and also cryptic and specialized predaceous species, such as *Hypoponera*, *Odontomachus*, *Ectatomma*, *Gnamptogenys*, *Anochetus*, *Pachycondyla and Strumigenys* (Delabie *et al*., 2000), which often are absent in disturbed environments (Underwood and Fisher, 2006).

In comparison to generalist taxa, *Pheidole* is richer between harvest cycles. This genus is important for the control of several agroecosystem pests, as it can predate on eggs and immature stages of other insects (Fernandes *et al*., 1994; Rossi and Fowler, 2000; Way and Khoo, 1992). In contrast, the frequency, occurrence and abundance of *Odontomachus* and *Dorymyrmex* decreased between cycles and those of *Brachymyrmex incisus* Forel, 1912, *Pheidole* sp.35 and *Solenopsis saevissima* F. Smith increased. The presence of straw probably did not favor the survival of some species due to abiotic changes in the environment, or even due to the presence of competitive taxa, as is the case with *Solenopsis* (Delabie and Fowler, 1995) and *Pheidole* (Fowler *et al*., 1993). As an example, *Dorymyrmex* is negatively associated with *Pheidole* and *Brachymyrmex* (Kamura *et al*., 2007) in urban areas. The same may happen in the studied agroecosystem. One of the aggravating factors of this association may be the long term increase in *Diatraea saccharalis* (Fabr.), a major sugarcane pest (Beuzelin *et al*., 2009; Pinheiro *et al*., 2008), as *Dorymyrmex* is one of its predators (Rossi and Fowler, 2004).

In general, straw enables the presence of generalist predaceous taxa that may contribute to the natural biological control (Fernandes *et al*., 1994; Risch and Carroll, 1982), such as *Ectatomma*, which predates about 89.9% of the pests, including leaf-cutting ants, in coffee culture (Ibarra-Núnez *et al*., 2001) or *Crematogaster*, *Pheidole* and *Solenopsis*, in sugarcane culture (Rossi and Fowler, 2004).

CONCLUSION

The analyzed ecological variables had a lower magnitude in the first sugarcane cycle, when the soil had no cover. The presence of generalist taxa that predate on several culture pests was also noticeable in the second and third cycles. However, as mechanical harvesting is a recent management practice, studies that demonstrate the diversity of the agroecosystem as a whole and the possible competition and predation relations between the communities are necessary to better evaluate the possible benefits of mulching on the soil for the culture.

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