



RESEARCH ARTICLE - WASPS

Diversity and Structure of Social Wasps Community (Hymenoptera: Vespidae, Polistinae) in Neotropical Dry Forest

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Abstract

Social wasps are potential predators of agricultural pest species. The objective of this study was to conduct a survey of the community of social wasps (Polistinae species) that inhabit the neotropical dry forest named Caatinga of Paraíba, Northeast of South America (Brazil), and to compare the richness and abundance of wasps located in areas of Caatinga with those inhabiting areas of organic intercropping farming. The present study sampled 10 Polistinae species distributed in six genera. Two new species were registered for the state. The comparison between the community of social wasps of the Caatinga showed that there was not statistical difference in the richness and abundance between the natural vegetation and organic intercropping. This means that agroecosystem attracted community of Polistinae, promoting the maintenance of social wasps in anthropic environment and possibly favoring biological control.

Introduction

The several Brazilian ecosystems have different characteristics resulting in specificity in certain animal groups, including wasps. In this context, stands out the tropical dry forests of Northeastern Brazilian semi-arid region, which is characterized by technical criteria as a region with the average annual rainfall of less than 800 mm, irregularly distributed in space and time, and the risk of increased drought in 60% (Brazil, 2007). Northeastern Brazil is composed by 90% of semi-arid climate, where Neotropical dry forests are found in areas with very specific characteristics called Caatinga (Brazil, 2007). This biome is characterized by tropical dry forest with an increase on resource supply in the rainy periods (Pereira Filho et al., 2013).

The Caatinga biodiversity is considered to be the lowest when compared to other areas of Brazil (see Ducke, 1907). Lewinsohn (2000) emphasized the importance of surveys on the biodiversity for this biome. Brandão et al. (2000)

revealed the lack of studies on invertebrates for the Northeast region. Recent studies in the Caatinga have showed that the fauna and flora were underrated and also revealed important adaptations of its organisms to the irregular rainfall (Leal et al., 2005). In addition, the knowledge of its diversity is very important to understanding the environmental changes caused by human activities or by natural factors, including climate changes (Lawton et al., 1998). The Caatinga is considered a very important biome in the discovery of new species and new records, once it is understudied and has a long history of deforestation and fragmentation, mainly by human activities (Guérnard, 2014).

Social wasps surveys in Brazilian tropical dry forests were made mainly in the Bahia state, which is responsible for the majority of Polistinae diversity found in the semi-arid region (Aguir & Santos, 2007; Santos et al., 2007; Santos et al., 2009; Andena & Carpenter, 2014). In Paraíba state no surveys of social wasps were carried out. The diversity of this group is known only by studies of associated entomofauna



and floral visitors. Only nine species of Polistinae were recorded for Paraiba (Andena & Carpenter, 2014). The aim of this study was to accomplish a survey of the Polistinae species in the Paraiba dry forest, and compare the richness, abundance and composition between the natural vegetation and intercropping on organic farms.

Material and Methods

Study area

This study was carried out from 2013 to 2015, in the cities of Sumé (7° 40' 18" S, 36° 52' 54" W) and Prata (7° 41' 27" S, 37° 4' 48" W), both located in the Western Cariri of Paraiba, one of driest regions of the Brazil, in the northeast of South America. At these areas low mechanization and intercropping on organic farms are established. The region is predominantly agricultural and goat breeding with patches of tropical dry forest, characterizing the Caatinga biome. The rainy season occurs mainly between January to July (rainfall season), representing 78% of total annual precipitation (Sena et al., 2012).

Methodology of survey

The sample and transportation of specimens were authorized and certified by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). Social wasps were sampled through attractive pet bottle trap and active search, guided by three transects of 100 meters length, 20 meters away one of the other. These transects were repeated in the farm areas as well as in the Caatinga area.

The wasps were captured through 60 traps (30 in each area), containing passion fruit juice concentrate and neutral detergent, distributed 10 per transect, distant from each other by 10 meters. These traps were exposed in the environment for five days per sample.

The active search was performed with hand net, in fixed periods of 20 minutes, walking close to the transects with attractive traps. The perpendicular distance of search on the track was limited to two meters on each side of the transects.

Social wasps specimens captured were placed in plastic pots containing 70% alcohol. In addition to the field survey, it was analyzed a material captured by EMBRAPA COTTON in Caatinga vegetation and intercrops areas, at Sumé city. EMBRAPA data were sampled in 2011 using Malaise traps.

Data analyses

The Relative Frequency and Constancy values were calculated from the data obtained for wasps species and abundance. The frequencies were determined by the proportion of individuals of a species on total of individuals of the sample, showed as a percentage. Constancy was calculated from the percentage of samples in which one

particular species was present. The species were classified by their constancy, being CONSTANT (C) as present in over 50% of the samples; ACCESSORY (AA) as present in 25-50% of the samples; accidental (AL) as present at less than 25% of the samples. Analyses were performed in the EXCEL program.

The data was submitted to normality Shapiro-Wilk test (R-program). Analysis of the communities of wasps was performed in EstimateS (Version 9.1.0), in which the Shannon Wiener indices and Richness Estimators (Chao 1) were obtained. The Rarefaction Curve was built in EXCEL. The data of abundance and richness were used to check whether the Caatinga and Intercrop areas differ statistically. For this, the Wilcoxon test and Levene (R-program) were used.

Species identification

The sampled material was identified with the support of taxonomic keys, comparison with material deposited in the Entomological Collection of the State University of Feira de Santana, and by the specialist Dr. Sergio Andena, from this institution. The specimens were deposited in the Entomological collection of Department of Systematics and Ecology/UFPB.

Results and Discussion

Social Wasps from Cariri, Paraiba, Brazil

The survey resulted in 341 specimens of social wasps, from ten species in six genera (Table 1). The richness found was similar to that shown in the study of Santos et al., (2006) and Aguiar and Santos (2007) in the Caatinga of Bahia state. These authors reported, respectively, 12 and 13 species of social wasps as flower visitors. Nevertheless, Santos et al., (2009) registered a richness of 17 species in a survey of nests in Caatinga and Agricultural systems. However, the highest number of species was recorded in the rainy season, while in the dry season only 13 species were found.

The study recorded two new species of social wasps to Paraiba state: *Polistes simillimus* and *Mischocyttarus cearensis*, being also the first record of Mischocyttarini tribe (Elisei et al., 2015). These two species had been reported to Caatinga, and found in other studies realized on Northeastern Brazil states (Santos et al., 2007; Melo et al., 2015). Andena and Carpenter (2014) registered only nine species of social wasps in Paraiba state, being the addition of those two new species a significant increase on the diversity of Polistinae.

The present study was carried out in a historic drought period (Table 2). Thus, richness may have been affected by this weather phenomenon, reducing diversity of social wasps, once they are influenced by environmental variations (Richter, 2000). This is so because with the decrease of nutrients, associated with reduced rainfall, also occurs a decline in search activity for resources (Jeanne, 1991; Resende et al., 2001; Lima & Prezoto 2003; Elisei et al., 2005; Ribeiro Jr et

Table 1. Abundance (N), Relative Frequency (F), Constancy value (C) and Constancy Category (C = Constant; AA = Accessory; AL = Accidental) Richness (S) and Shannon Diversity Index (H'), for social wasps collected in the cities of Sumé and Prata, Paraíba state.

Species	N	F (%)	C%	CONST
<i>Brachygastra lecheguana</i>	35	10.26	21.88	AL
<i>Polybia ignobilis</i>	69	20.23	68.75	C
<i>Polybia sericea</i>	43	12.61	12.50	AL
<i>Polybia occidentalis</i>	112	32.84	75.00	C
<i>Polybia sp. grupo occidentalis</i>	20	5.87	25.00	AA
<i>Protopolybia exigua</i>	21	6.16	28.13	AA
<i>Polistes canadensis</i>	34	9.97	34.38	AA
<i>Polistes simillimus</i>	1	0.29	3.13	AL
<i>Mischocyttarus cearensis</i>	3	0.88	9.38	AL
<i>Protonectarina sylveira</i>	3	0.88	9.38	AL
Total (N)	341			
Richness (S)	10			
Diversity (H')	1.85			

al., 2006; Elisei et al., 2013). Santos et al., (2009) and Souza et al., (2012) verified that the number of nests diminished with decreasing rainfall during the two seasons (dry and wet). On this way, rainfall is a very important factor on the Polistinae community dynamic.

Data analysis revealed that the sample effort recorded most of the species present in the areas ($S = 10$; Chao 1 = 10). The rarefaction curve almost reached the asymptote, fact that can be explained by needed more intensive surveys in region and by rare species captured (Figure 1). When compared with other biomes, the Caatinga has a reduced diversity of social wasps. Diniz and Kitayama (1994) identified 30 species in Chapada dos Guimarães (savannah), Mato Grosso state. Silva et al. (2011) reported 31 species of social wasps in savannah, Maranhão state. Rodrigues and Machado (1982)

Table 2. Average annual Pluviosity for Sumé and Prata. Average observed and expected precipitation measured in millimeters* (mm). *Data: Executive Agency for Water Management in the State of Paraíba.

	Sumé			
	Observed (mm)	Expected (mm)	Deficit (mm)	Deficit (%)
2012	27	559.3	-532.3	-95.2
2013	254.4	559.3	-304.9	-54.5
2014	726.1	559.3	166.8	29.8
2015	220.4	559.3	-338.9	-60.6
	Prata			
2012	152.8	745.6	-592.8	-79.5
2013	445.7	745.6	-299.9	-40.2
2014	603.9	745.6	-141.7	-19
2015	317.6	745.6	-428	-57.4

found 33 species in the São Paulo state, in areas of savannah, eucalyptus and secondary forest. Tanaka Junior and Noll (2011) collected 29 species in semideciduous seasonal forest fragments in São Paulo state. Marques et al., (1993) recorded 20 species for Atlantic Forest. In the Pará state, Silva and Silveira (2009) found 65 species and in other areas of the Amazon forests, as in Roraima (Raw, 1992; 46 species) and Rondônia (Raw, 1998; 36 species), the number of species was much higher than recorded in this present study and other Brazilian ecosystems.

The species with the highest abundance was *Polybia occidentalis* ($n = 112$, $F = 32.84\%$), followed by *Polybia ignobilis* ($n = 69$, $F = 20.23\%$) (Table 1). Melo et al., (2015) reported these species also had the major abundance and constancy in the Caatinga, Bahia state. Other similar studies showed *P. occidentalis* and *P. ignobilis* as abundant and constant in tropical dry forests of Brazil (Aguiar & Santos

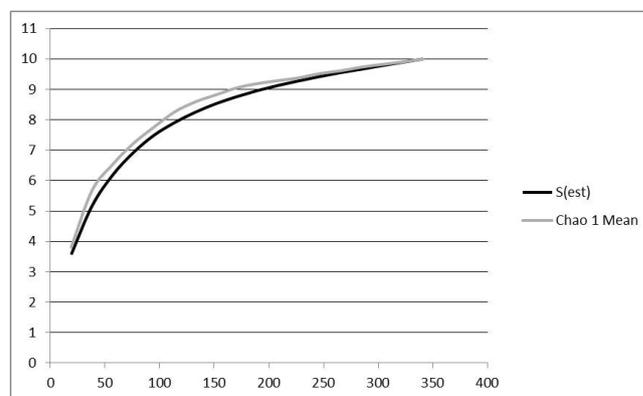


Fig 1. Rarefaction curve of social wasp species collected in the Caatinga, Paraíba state, Brazil (S = observed diversity, Chao 1 = estimated diversity).

2007; Santos et al., 2006; Santos et al., 2007).

Polybia genus comprised 72% of the trapped samples (Figure 2). This value may be related with the swarm founding behavior of this genus, which guaranteed the more success in foundation (Jeanne, 1991). Another characteristic is that the nests of *Polybia* have a protective envelope, creating a better micro climate for the colony members inside (Richard & Richard, 1951). In addition, this genus has been reported as having a high storage capacity of protein resources and carbohydrates (Ihering, 1896; Machado, 1984), which confers resistance to periods of environmental stress, such as the long drought period in the semi-arid (Jeanne, 1991).

Polistes canadensis was considered accessory, and was found in 38% of the samples. The studies conducted in Caatinga by Santos (2006), Silva-Pereira and Santos (2007), Santos et al. (2007) and Santos et al. (2009) showed the same species with high abundance and significant constancy. The *Polistes* genus is characterized by building nests without protective envelope. This absence may result in lower internal control of the nests in relation to the environmental variables (Jeanne, 1991). In the period of the present study occurred a

deficit in rainfall of 50% below historical averages (AESAs, 2016). The decrease in water supply and, as a result, the fall in the supply of nutrients, may have resulted in the decline of this group in the study area. This means that, because of sensitivity to environmental variations, social wasps can be used as bioindicators of environment quality. Souza et al. (2010) verified preference by some species to different environmental and appoint someone's as bioindicators.

Polistes simillimus had the lowest constancy in samples, because just one specimen was captured. *Mischocyttarus cearensis*, *Polybia sericea*, *Protonectarina sylveira* and *Brachygastra lecheguana* were considered accidental species (Table 1). However, in other research also conducted in areas of Caatinga, some of these wasps were classified as accessory or constant, as *B. lecheguana*, *P. sericea* and *P. sylveira* by Santos et al. (2006); *M. cearensis* and *P. simillimus* by Melo et al. (2015). The lack of previous surveys in the region affects discussions, for example a possible reduction on the wasps populations.

Santos et al. (2009) reported a higher number of active colonies of social wasps in the wet period of the year in the Caatinga. Polistinae populations are strongly influenced by environment, and those euriécias are most resistant to unfavorable changes than estenoécias (Souza, 2010). The present research can strengthen the influence of drought on the dynamics of the captured Polistinae community in Caatinga, resulting in a reduced abundance of certain populations. The predictions indicate that global warming will result in an intensification of drought extremes in the Brazilian Northeast (Marengo, 2006). Thus, surveys of different groups in the region are very important to determine the loss of biodiversity

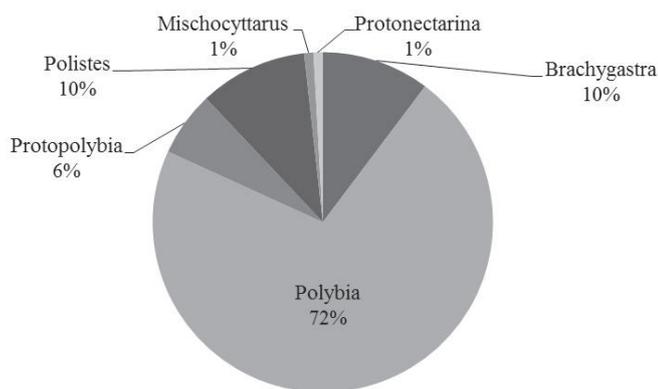


Fig 2. Abundance of social wasps genera captured in semi-arid, municipalities of Sumé and Prata, Paraíba state, Brazil.

due this phenomenon (Lawton et al., 1998).

Comparative analysis of social wasps communities in Caatinga and organic intercropping

There was no statistical difference of richness between the Caatinga vegetations and intercropping areas (Wp-value = 0.2994) (Figure 3, Table 3). Intercropping areas showed a higher number of individuals although there was no significant

difference between the abundances in the analyzed areas (Wp-value = 0.4663) (Figure 3, Table 3). In addition, the Levene Homogeneity Test revealed that Caatinga and intercrop showed homocedasticity (Lp-value = 0.6562), confirming the similarity between abundances.

The results of this study were similar to those registered in Santos et al. (2009). These authors verified no significant differences among richness of Polistinae in Caatinga and crop areas (cowpea, corn and beans). However, they found a greater number of social wasp nests founded in crop area, which can explain the high abundance in the cultivated area reported in the present study.

It is known that heterogeneous environments, with higher diversity of plants, tend to have an elevate number of niches and, thus, to promote the highest number of coexisting species (Latham & Ricklefs, 1993; Bragança et al., 1998). The Caatinga is an environment more heterogeneous than monoculture crops. However, the plantation in the study areas is done with consortia of different types of vegetables (mainly: beans, corn, cotton, peanuts and sesame). Thus, the intercropping may exercise more attraction to individuals than the natural environment area. Altieri et al. (2003) highlighted the importance of biodiversity in plantations, especially in areas where it applies the Integrated Pest Management, once biodiversity favors the maintenance of

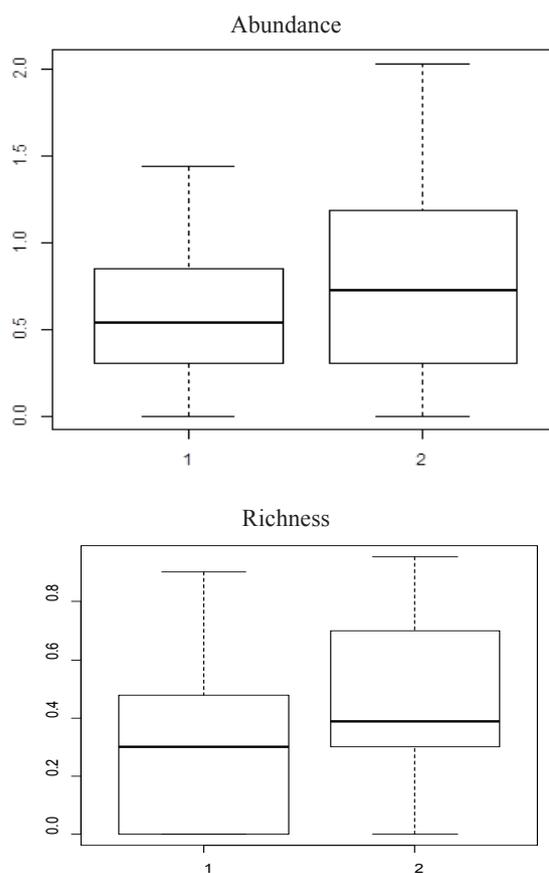


Fig 3. Abundance and Richness of social wasps captured in Caatinga (1) and Intercropping (2), in the cities of Sumé and Prata, Paraíba state, Brazil.

natural enemy species of pests.

The most abundant species was *P. occidentalis*, both in intercropping and in the Caatinga, and was classified as constant in the two study areas (Table 3). This species has been reported as floral visitor and predator of caterpillar, exerting an important role in crop production (Gravena, 1983; Gobbi et al., 1984; Resende et al., 2001; Santos et al.,

2006; Nadia et al., 2007).

Surveys registered lower diversity of social wasps in monocultures when compared to natural vegetation (Santos, 1996; Souza et al., 2011; Silva et al., 2013.). Hence, our results suggest that intercropping may have an important role in the maintaining of community Polistinae in Paraiba Caatinga. Social wasps are natural enemies of pest species, thus it is important to favor their populations in environments with

Table 3. Abundance (N), Relative Frequency (F), Constance (C) and Category of Constancy (CONST; C => 50%; AA = 25% - 50%; AL = <25%), Richness (S) and Shannon diversity index (H') of social wasps collected in the Caatinga and Intercropping, Sumé and Prata cities, Paraíba state, Brazil.

Species	Caatinga				Intercropping			
	N	F (%)	C%	CONST	N	F (%)	C%	CONST
<i>Brachygastra lecheguana</i>	6	5.41	11.11	AL	29	12.61	35.7	AA
<i>Polybia ignobilis</i>	24	21.62	55.56	C	45	19.57	85.7	C
<i>Polybia sericea</i>	8	7.21	11.11	AL	35	15.22	14.3	AL
<i>Polybia occidentalis</i>	39	35.14	77.78	C	73	31.74	71.4	C
<i>Polybia sp. grupo occidentalis</i>	8	7.21	16.67	AL	12	5.22	35.7	AA
<i>Protopolybia exigua</i>	8	7.21	27.78	AA	13	5.65	28.6	AA
<i>Polistes canadensis</i>	16	14.41	38.89	AA	18	7.83	28.6	AA
<i>Polistes simillimus</i>	0	0.00	0.00	-	1	0.43	7.1	AL
<i>Mischocyttarus cearensis</i>	1	0.90	5.56	AL	2	0.87	14.3	AL
<i>Protonectarina sylveira</i>	1	0.90	5.56	AL	2	0.87	14.3	AL
Total (N)	111				230			
Richness (S)	9				10			
Diversity (H')	1.76				1.85			

organic agriculture (Parra et al., 2002).

Conclusion

Caatinga has a neglected knowledge of its biodiversity, and requires more detailed studies about various groups, including social wasps. The data increased the number of Polistinae species registered for the Paraíba state. In addition, the comparison between the social wasps community of the natural environment (Caatinga) and intercropping, reinforced the importance of diversity in crops, favoring the maintenance of the natural enemy species.

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