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RESEARCH ARTICLE - WASPS

Social Wasps in Exotic Forest Planting and Atlantic Rainforest in the Neotropical Region

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Abstract
Social wasps play an important role in communities, whether in natural or agricultural ecosystems, performing pollination and/or predation on other organisms, especially caterpillars, which reveals their potential for biological control. We register species of predatory wasps found in a eucalypt reforested area compared with a native rainforest. Five species of social wasps were found: *Agelaia myrmecophila* (Ducke), *Mischocyttarus punctatus* (Ducke), *Polistes carnifex* (Fabricius), *Polybia liliacea* (Fabricius), and *Polybia striata* (Fabricius), with higher numbers in the eucalypt monoculture than in the Atlantic rainforest, suggesting no negative impact of the monoculture on the population of that natural enemies.

Introduction

The Brazilian fauna is composed of 22 genera of 304 species of registered social wasps, of which 104 occur exclusively in Brazilian territory (Silveira et al., 2016). Three tribes occur in Brazil: Mischocyttarini (*Mischocyttarus*), Polistini (*Polistes*) and Epiponini (Carpenter & Marques 2001; CTFB, 2017). These wasps have high predation potential and are important in population regulation of pest insects (Richards, 1978; Richter, 2000; Brügger et al., 2019a; Prezoto et al., 2019). Social insects forage for food resources (proteins, carbohydrates) material for building nests (plant fibers and clay), and water (Richter, 2000; Brügger et al., 2019b). Environmental factors such as humidity, sunlight, and temperature regulate these activities (Kovac et al., 2018). Brazil has a large insect fauna and wasp diversity is poorly known, so new records may contribute to the understanding of species diversity and richness in an area (De Souza et al., 2017; Brügger et al., 2019b; Somavilla et al., 2019).

Eucalyptus trees play an important role in the Brazilian economy. Because they are locally abundant, this type of biomass is used as an energy source in agribusiness (Lenz et al., 2019), but its monoculture can favor the occurrence of pests such as defoliator caterpillars, which must be controlled to reduce their damage (Masson et al., 2017; Munique et al., 2018; Zanuncio et al., 2018).

The collection and identification of social wasps in a given region provide information for studies on the ecology of these organisms and their interactions with the environment (Silveira et al., 2002). Therefore, the objective was to record the occurrence of social wasps in an area with *Eucalyptus* and Atlantic Forest.

Materials and Methods

Social wasps were collected from May 2008 to March 2009 in an area of 117.07 ha with four-year hybrid *Eucalyptus* (*Eucalyptus grandis* x *Eucalyptus urograndis*) and in 35.05 ha of secondary Atlantic Forest in the municipality of Dionísio, Minas Gerais; Brazil (19º 48 'S 42º 45' W and 315 m elevation). The distance between the areas was 953 meters.

PET bottle traps with three 2.5 cm diameter side openings adapted to 200 ml plastic pots containing baits (sardines or honey) were used to capture wasps (Fig 1). Thirty traps were used in the eucalyptus plantation or Atlantic Forest, being 15 with fish and 15 with honey, spaced every 50 m, 1.60 m high and verified every 24 hours for 5 days, every month for 12 months.

Species frequency was calculated with the equation F = / ΣS1.100 / ΣS2, where S1 = total number of species and S2 = total number of wasps collected.

Fig 1. Trap used for wasp capture (Silva-Filho, 2008).

Results

Five species, 827 and 351 individuals of social wasps, *Agelaia myrmecophila* (Ducke) (559 and 224), *Polybia striata* (Fabricius) (111 and 54), *Polistes carnifex carnifex* (Fabricius) (99 and 43), *Polybia liliacea* (Fabricius) (42 and 22) and, *Mischocyttarus punctatus* (Ducke) (16 and 08) were collected in the areas of *Eucalyptus* or Atlantic forest respectively (Table 1).

The number of individuals of *A. myrmecophila* (F = 59.68, p <0.001), *M. punctatus* (F = 6.32, *p* = 0.003), *P. carnifex carnifex* (F = 9.47, *p* = 0.001), *P. liliacea* (F = 7.34, *p* = 0.0038) and *P. striata* (F = 10.57, *p* <0.0001) were significantly different between Atlantic forest (F = 35.87, *p* <0 .0001) and the areas of *Eucalyptus* (F = 65.91, *p* <0.001). The average of all wasp species was higher in *Eucalyptus* than in the Atlantic Forest, and those of *A. myrmecophila* higher and *M. punctatus* lower in both environments (Fig 2).

Table 1. Social wasps sampled in eucalypt and Atlantic rainforest from May 2008 to March 2009 in the municipality of Dionísio, Minas Gerais State, Brazil.

Species	Atlantic rainforest		Eucalypt	
	number	frequency (%)	number	frequency (%)
Agelaia myrmecophila	224	63.8	559	67.6
Polybia striata	54	15.4	111	13.4
Polistes carnifex carnifex	43	12.2	99	12.0
Polybia liliacea	22	6.3	42	5.1
Mischoyttarus punctatus	8	2.3	16	1.9
Total	351		827	

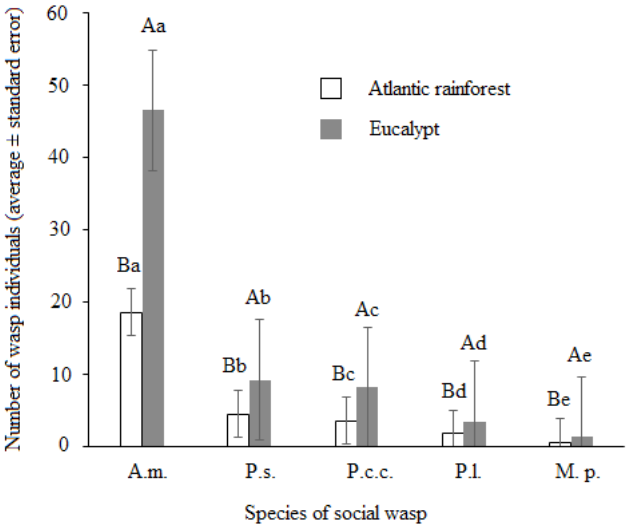

Fig 2. Number of wasp individuals (average ± standard error) of the social wasps *Agelaia myrmecophila* (A.m.), *Mischocyttarus punctatus* (M.p.), *Polistes carnifex carnifex* (P.c.c.), *Polybia liliacea* (P.l.) and *Polybia striata* (P.s.) (Hymenoptera: Vespidae: Polistinae) captured with traps from May 2008 to March 2009 in eucalypts reforested and native Atlantic rainforest areas. Municipality of Dionísio, Minas Gerais State, Brazil. Bars with the same letters (comparison within a species between two environments) and the same small letters (comparison within a species within an environment) Tukey's test (*p*> 0.05).

Discussion

The largest number wasp individuals in the *Eucalyptus* area in relation to the Atlantic Forest is due to the abundance of prey in this area, which may be present in trees or in the understory (Kato, 1996; De Souza et al., 2011). *Eucalyptus* monoculture has defoliating caterpillars (Zanuncio et al., 2018),

favoring the wasps due to pest insect outbreaks (Elisei et al., 2010). However, the use of only attractive traps, may have influenced the result, since in environments with less food availability (*Eucalyptus*) (De Souza et al., 2011) it may have captured more social wasps in relation to an environment rich in food (Atlantic forest) (Brügger et al.,2019b). In addition, the higher light intensity in *Eucalyptus* monoculture than in the Atlantic Forest may have contributed to the number of wasp individuals, as these insects use marked clues or points for short or long-distance orientation in relation to their nests (Steinmetz & Schmolz, 2004; Warrant et al., 2006; Mandal, 2018; Silva-Filho et al., 2020). Daytime insects can make navigation errors in low sunlight conditions (Spiewok & Schmolz, 2005). In social wasps it is common for the colonies' foundations to be in forest areas due to their cryptic aspect, using monoculture only as a foraging site (Jeanne, 1975). The maintenance of Atlantic forest areas is important because among the management strategies that can favor the performance of biological control agents, there is the preservation of areas of refuge (Van Driesche & Bellows, 1996; Menezes et al., 2017). In Brazil, some studies have evaluated the effects of fragments of native forest on natural enemies, in crops such as: Eucalyptus (*Eucalyptus* spp.) (Murta et al., 2008), corn (*Zea mays* L.) (Sousa et al., 2011) and sugar cane (*Saccharum officinarum* L.) (Demite et al., 2015; Duarte et al., 2015).

The lower number of individuals of both *A. multipicta* and *M. punctatus* in both environments was expected because *Agelaia* has the largest colony size among wasps (Zuchi et al., 1995; Noll et al., 1997; London & Jeanne, 2000). The colonies of *Agelaia* and *Polybia* are founded by swarms, consequently with larger numbers of individuals than that of independent foundation such as *Polistes* or *Mischocyttarus* (Wenzel, 1998).

The higher number and frequency of social wasps in the *Eucalyptus* compared to the Atlantic Forest demonstrates the importance of maintaining refugee areas for biological control, as it can positively influence the diversity of social wasps in monoculture. However, the use of only the attractive trap methodology, may underestimate the results, due to differences in food supply in the areas, so we recommend the consortium between the active search methodologies and the attractive traps.

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