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Visitation of Social Wasps in Arabica Coffee Crop (*Coffea arabica* L.) Intercropped with Different Tree Species

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Abstract

Brazil stands out for its coffee plantations for which the 2015 harvest yielded a revenue of over 600 million dollars. Its production is closely related to biotic and abiotic factors, and insect pests are noted for reducing this production. However, those insects are highly influenced by biological control agents such as predator wasps. This study aimed to survey the wasps visiting intercropping coffee cultivation with different tree species. Four plots of coffee intercropped with different tree species and coffee in full sun (control) were sampled for comparison. Tree species were: Teak (*Tectona grandis* L.f), Australian redcedar (*Toona ciliata* M. Roem.), Mangium (*Acacia mangium* Willd.) and Avocado (*Persea americana* Mill.). Six hundred and thirty-nine individuals of social wasps were collected, with 20 species and 7 genera, and an overall diversity index of 1.14. The plot with Avocado had the highest Shannon diversity index (H') 1.23 and the lowest dominance according to the Index Berger-Paker (DPB) 0.54.

Introduction

Brazil stands currently as the world's largest coffee producer, having a coffee park of over 2.2 million hectares with a revenue of over 600 million dollars in 2015 (Martins, 2008; CONAB, 2016). The crop yield is closely related to the rainfall in the producing regions and several biotic factors, among which we can mention the insect pests that cause huge yield losses (Reis & Souza, 2002).

A lot of phytophagous insects cause damage to coffee plantations. Two stand out as primary pests: the coffee leaf miner *Leucoptera coffeella* (Guérin-Mèneville, 1842) (Lepidoptera: Lyonetiidae) and the coffee berry borer *Hypothenemus hampei* (Ferrari, 1867) (Coleoptera: Curculionidae, Scolytinae), which cause large losses because of the injury they inflict (Gallo et al., 2002; Reis & Souza, 2002). The leaf miner is a small whitish moth with nocturnal habits, whose caterpillars cause damage to the leaf parenchyma. The coffee berry borer is a tiny beetle, sleek black, which penetrates the fruit and the larvae destroy partially or totally the seed (Reis et al., 2002).

The most common form of control of coffee pests is the conventional method, with large and frequent applications of chemicals to control, especially against the miner and the coffee berry borer, the main pests of the crop. The application of such products directly and indirectly affects the natural enemies, causing great loss of their diversity in the fields. In contrast, the diversification of farm agroecosystem contributes to an increase in the diversity of natural enemies (Root, 1973; Altieri & Letourneau, 1982; Altieri et al., 2003) due to several factors, such as alternative food supply for adults (e.g. nectar, pollen and sugary substances), and suitable microclimate, and the presence of preys and alternative hosts (Root, 1973; Andow, 1991). In coffee plantations, several species of predator wasps benefit from this diversification (Fernandes, 2013) and the presence of trees promotes greater predation of leaf miners (*Leucoptera coffeella*) by these wasps (Hymenoptera: Vespidae) (Amaral et al., 2010).

Wasps are social insects belonging to Order Hymenoptera, family Vespidae, and subfamilies Stenogastrinae, Polistinae and Vespidae (Carpenter, 1993; Carpenter & Marques, 2001).

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Wasps of Polistinae subfamily are the only ones that occur in Brazil, belonging to three tribes, Polistini, Mischocyttarini and Epiponini, with 23 genera and 319 species (Carpenter & Marques, 2001). These wasps forages, mainly, in hot periods of the day (Picanço et al., 2010), to find water, nectar, pollen, material for construction of nests and prey for their larvae (Lima & Prezoto, 2003), being the main source of protein of social wasps in their first stages of development (Evans & West-Eberhard, 1970).

The main preys of social wasps (around 90%) are insects from the order Lepidoptera. It also preys on insects of the orders Diptera, Hemiptera and Hymenoptera (Gobbi & Machado, 1986; Prezoto et al., 2005; Bichara-Filho et al., 2009). Several species of social wasps have been reported as effective predators of the coffee pests, such as *Agelaia pallipes* (Olivier, 1972), *Brachygastra lecheguana* (Latreille, 1824), *Polistes* sp., *Polybia ignobilis* (Haliday, 1836), *Polybia occidentalis* (Olivier, 1791), *Polybia scutellaris* (White, 1841), *Polybia sericea* (Olivier, 1971), *Protonectarina sylveirae* (De Saussure, 1854) and *Synoeca surinama cyanea* (Fabricius, 1775) (Parra et al., 1977; Reis & Souza, 2002; Perioto et al., 2011) accounting for approximately 70% of control in coffee plantations (Reis & Souza, 2002).

Thus, this study aimed to evaluate the influence of different tree species in the diversity of social wasps that visit coffee plantation (*Coffea arabica* L.).

Material and Methods

This study was conducted at Fazenda da Lagoa, Km 642 on the BR 381, located in Santo Antônio do Amparo municipality, Minas Gerais, Brazil (20 ° 91'S / 44 ° 85'W / 1100m) in Arabica coffee (*Coffea arabica* L.) Catuaí 99 variety, in a two-year-old stand with spacing of 3.40m x 0.65m, conducted in the conventional cultivation system with total control of weeds, leaving the culture always in bare ground. Four intercropping coffee plots were used with different tree species and coffee in full sun (control) for comparison (Fig 1). Tree species were: Teak (*Tectona grandis* L.f), Australian redcedar (*Toona ciliata* M. Roem.), Mangium (*Acacia mangium* Willd.) and Avocado (*Persea americana* Mill.).

Wasp sampling was carried out monthly from November/2014 to October/2015 using two types of traps: oval yellow plastic traps, Moericke type adapted, with 20 cm in greater diameter and 10 cm in the least, suspended 50 cm from the ground, attached to a bamboo stick, and filled in halfway with a saline solution of 10% NaCl and 5 drops of detergent. The second type was an attractive trap, consisting of a PET bottle with a capacity of 2 litres, containing three triangular holes with 2 cm edges, approximately 5 cm from the bottom of the bottle (Souza & Prezoto, 2006). These were hung on a bamboo stake at 1.10 m from the ground, containing 200 ml of passion fruit juice (*Passiflora edulis* f. *flavicarpa* Deg. - Passifloraceae) as attractant, made with 1 kg of fruit pulp, 1 L of water and 150 g sugar. Six attractive traps and 18 Moerick adapted yellow trap were used for each treatment. Three Moerick composed a sample and both traps were left in the field for 48 hours.

The insects collected were mounted on entomological pins for later identification with the aid of entomological keys (Richards, 1978). Diversity was calculated using Shannon index (H') and the dominance with the Berger-Parker index (DPB) through Past® program, also the comparative analysis of means (R Development Core Team, 2015).

Results and Discussion

Six hundred and thirty-nine subjects of social wasps were collected, with 20 species and 7 genera, with an overall diversity index of 1.14 (Table 1). This diversity index was low due to the high dominance of *Agelaia vicina* De Saussure

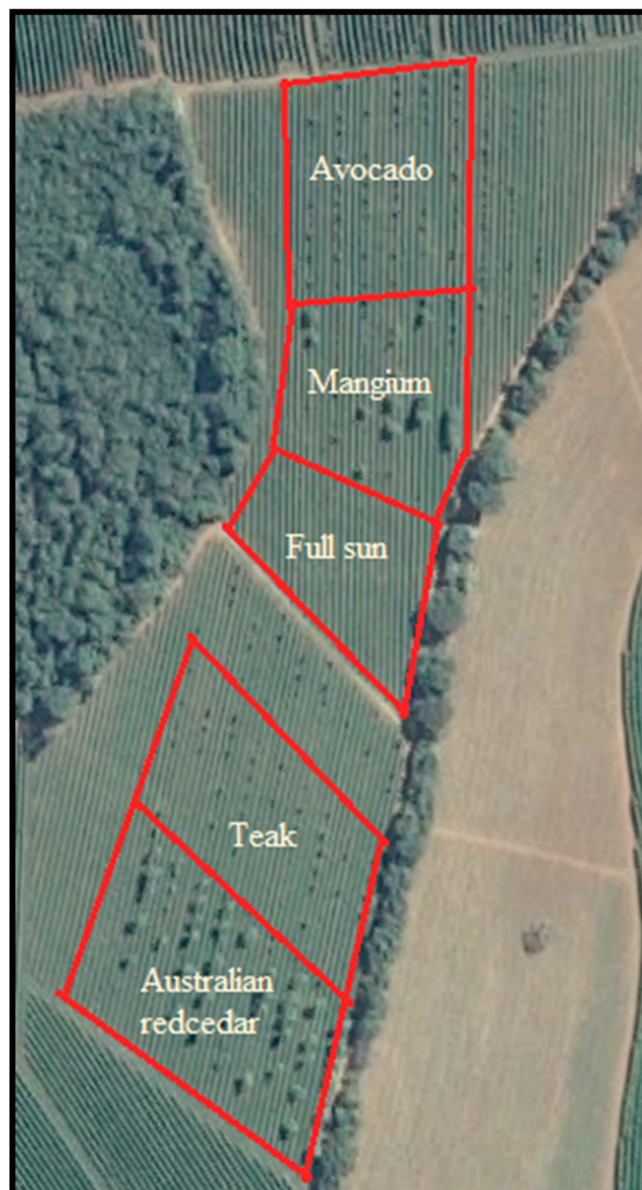

Fig 1. Aerial image of the sample area with separation of plots. Santo Antônio do Amparo, MG.

(1854). This dominance is explained because some species of the genus *Agelaia* (Lepeletier, 1836) can build colonies with population estimated at up to one million adults (Zucchi et al., 1995), what means higher foraging capacity by a greater number of wasps and increase of the chances of capturing individuals of this group (Hunt et al., 2001). The high abundance of this genus was also reported in different ecosystems in Brazil (Gomes & Noll, 2009; Arab et al., 2010; Jacques et al., 2012; Jacques et al., 2015; Gradinete & Noll, 2013; Locher et al., 2014).

Among the 20 species collected, the species *Brachygastra lecheguana* (Latreille, 1824), *Polybia ignobilis* (Haliday, 1836), *Polybia occidentalis* (Olivier, 1791), *Polybia sericea* (Olivier, 1971) and *Protonectarina sylveirae* (De Saussure, 1854) have already been reported as effective predators of coffee pests (Parra et al., 1977; Reis & Souza, 2002; Perioto et al., 2011). Even in low population levels, these predators contribute for the decrease of pests, lowering infestation peaks (DeBach, 1951).

There was also the collection of two species of *Polistes*, a genus that is associated with decreased damage caused by pests in different crops such as cotton (Kirkton, 1970), tobacco (Lawson et al., 1961), cabbage (Gould & Jeanne, 1984) and coffee (Gravena, 1983), showing the importance of this genus for the study of biological control of pests. The introduction of wasps colonies of this genus in tobacco plantation reduced in 68% the damage caused by the caterpillar *Protoparce sexta* (Johan) (Rabb & Lawson, 1957). A single colony of *Polistes* can prey on around 2,000 caterpillars of *Pieris rapae* L., a kale pest, during its development cycle (Morimoto, 1961). For instance, (Prezoto & Machado, 1999b) observed a reduction of 77.16% in the incidence of *Spodoptera frugiperda* in corn plantations with the utilization of *Polistes simillimus* Zikan, 1951.

The species richness (S) (Table 2) between the treatments was very similar, what can be explained by the proximity of the treatments, because the shorter the distance between the sampling areas, the greater the probability of finding out a faunistic similarity (Souza et al., 2015). Moreover, there is also the fact that these insects have the habit of nesting in one place and forage in another (Pereira & Santos, 2006).

The avocado treatment had the higher Shannon Index (H´) and the lowest Berger-Parker Index (Dpb) (Table 2). The avocado trees were the most leafy and with a more closed canopy, which can justify this greater diversity index, because a better structured vegetation provides more substrate for nesting (Santos & Gobbi, 1998; Cruz et al., 2006), glycidic resources (Santos & Gobbi, 1998; Pereira & Santos, 2006), material for nest building (Marques & Carvalho, 1993), hunting area (Santos & Gobbi, 1998) and weather protection (Altieri et al., 2003). Furthermore, avocado trees were the only ones that bloomed during the experiment period, possibly attracting a higher diversity of wasps, because the adults feed on nectar (Melo et al., 2011).

Table 1. Total richness, diversity and dominance of species of social wasps collected in Arabica coffee (*Coffea arabica* L.).

Species	Traps	
	Nº of Individuals	Frequency (%)
Agelaia multipicta (Haliday, 1836)	17	2,66%
Agelaia vicina de Saussure, 1854	486	76,06%
Apoica pallens (Fabricius, 1804)	10	1,56%
Brachygastra lecheguana (Latreille, 1824)	1	0,16%
Parachartergus fraternus (Griboldo, 1892)	1	0,16%
Polistes ferreri (Saussure, 1853)	2	0,31%
Polistes versicolor (Olivier, 1971)	15	2,35%
Polybia bifasciata Saussure, 1854	4	0,63%
Polybia chrysothorax (Lichtenstein, 1796)	2	0,31%
Polybia diguetana (Buysson, 1905)	10	1,56%
Polybia fastidiosuscula (Saussure, 1854)	39	6,10%
Polybia ignobilis (Haliday, 1836)	17	2,66%
Polybia jurinei Saussure, 1854	2	0,31%
Polybia occidentalis (Olivier, 1971)	5	0,78%
Polybia platycephala (Richards, 1978)	5	0,78%
Polybia punctata du Buysson, 1907	1	0,16%
Polybia sericea (Olivier, 1971)	1	0,16%
Polybia sp1	5	0,78%
Polybia sp2	7	1,10%
Protonectarina sylveirae (Saussure, 1854)	9	1,41%
Total of Individuals	639	
Specie Richness (S`)	20	
Shannon-Wiener Index (H`)	1,14	
Berger-Parker Index (Dpb)	0,76	

The diversification of coffee plantations with avocado threes contribute positively to diversity of social wasp's species, and thus possibly contribute to a better control and stability of the plantation.

Table 2. Richness, diversity and dominance of species of social wasps collected in Arabica coffee (*Coffea arabica* L.) in different treatments. Avoc = Avocado; Mang = Mangium; Aust = Australian redcedar; Teak = Teak; Full S = Full Sun.

	Treatments				
Species	Avoc.	Mang.	Aust.	Teak	Full S.
Agelaia multipicta (Haliday, 1836)	2	1	1	2	11
Agelaia vicina de Saussure, 1854	63	103	103	75	142
Apoica pallens (Fabricius, 1804)	4	5	0	1	0
Brachygastra lecheguana (Latreille, 1824)	1	0	0	0	0
Parachartergus fraternus (Griboldo, 1892)	1	0	0	0	0
Polistes ferreri (Saussure, 1853)	0	1	0	0	1
Polistes versicolor (Olivier, 1971)	7	3	1	0	4
Polybia bifasciata Saussure, 1854	0	2	0	1	1
Polybia chrysothorax (Lichtenstein, 1796)	0	1	0	0	1
Polybia diguetana (Buysson, 1905)	4	4	1	1	0
Polybia fastidiosuscula (Saussure, 1854)	13	11	6	4	5
Polybia ignobilis (Haliday, 1836)	7	1	2	1	6
Polybia jurinei Saussure, 1854	0	0	1	0	1
Polybia occidentalis (Olivier, 1971)	1	2	1	1	0
Polybia platycephala (Richards, 1978)	1	4	0	0	0
Polybia punctata du Buysson, 1907	0	0	0	1	0
Polybia sericea (Olivier, 1971)	0	0	1	0	0
Polybia sp1	0	0	0	2	3
Polybia sp2	3	0	1	1	2
Protonectarina sylveirae (Saussure, 1854)	5	0	4	0	0
Total of Individuals	112	138	122	90	177
Specie Richnesse (S`)	13	12	11	11	11
Shannon-Wiener Index (H`)	1,23a	1,04b	0,93b	0,94b	1b
Berger-Parker Index (Dpb)	0,54b	0,74a	0,83a	0,79a	0,8a

Rows with different letters differ between them by Scott-Knott test at 5% of significance.

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