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Can season and intercropping Conilon coffee favor predatory ant species?

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ABSTRACT

Conilon coffee (*Coffea canephora* Pierre ex A. Froehner) is an important crop in Brazil, and this culture is widely grown in Espírito Santo State. Intercropping this species has been adopted for better use, profitability, and sustainability of the cultivated area. Intercropping provides higher shading and may favor edaphic fauna that plays an important ecological function in the soil. Ants are part of the edaphic meso - and macrofauna, considered ecosystem engineers and actively participate in pest predation. The goal of the study was to evaluate predatory ant richness in Conilon coffee in monoculture and intercropped with teak or Australian cedar. Furthermore, the influence of these crops on the richness of predator ant communities in the dry (winter) and rainy (summer) seasons was analyzed. The study was conducted in the municipality of Sooretama, northern Espírito Santo State (Brazil) using pitfall soil traps. Ant communities were analyzed with their distribution in trophic guilds. The richness of predatory ants (predatory and generalist omnivore predatory ant species) was studied in Conilon coffee in monoculture and intercropped with teak (*Tectona grandis* L.f.) and with Australian cedar (*Toona ciliata* M. Roemer), in the dry (winter) and wet (summer) seasons. A total of 49 ant species were collected, 29 predatory and 15 generalist omnivore predatory ant species were identified, and 16 ant species were recorded for the first time in Espírito Santo State. Conilon coffee cropping systems did not affect the richness of predatory or generalist omnivore predatory ant species, however, summer favored the occurrence of total predatory ants (generalist omnivore + predators); intercropping Conilon coffee did not favor predatory ants. The presence of predatory species is important for natural pest control, consequently improving crop sustainability. However, new research must be done to evaluate other Conilon coffee intercropping for a longer period.

Key words: Biological control; *Coffea canephora*; Edaphic fauna; *Toona ciliata*; *Tectona grandis*.

1 INTRODUCTION

Coffee production has great economic importance for many countries, and Brazil is currently the largest world producer of this crop (Food and Agriculture Organization of the United Nations - FAOSTAT, 2022; International Coffee Organization - ICO, 2022). Arabica coffee (*Coffea arabica* L.) and Robusta (Conilon) coffee (*Coffea canephora* Pierre ex A. Froehner) are widely cultivated in different edaphoclimatic Brazilian regions. Its cultivation area covers 17 Brazilian states, with an emphasis on Espírito Santo, where fourteen municipalities classified as major coffee producers have been recognized (Venâncio et al., 2023). Coffee growing in Espírito Santo has played an important economic role since the 19th century (Magalhães; Delamerlina, 2013); this Brazilian state has been responsible for around 70% of the country's *Coffea canephora* production and is currently the largest Brazilian producer and exporter of Conilon coffee (Ferrão et al., 2019; Partelli; Espindula, 2019; Companhia Nacional de Abastecimento - CONAB, 2022). Sooretama is the municipality that presented the largest production of Conilon coffee in this Brazilian state in 2018, with numbers that exceeded 28.7 thousand tons, being classified as the third largest producer of Conilon coffee in the country (Salvador; Pianca, 2022).

Intercropping of some coffee species with teak (*Tectona grandis* L.f.) and Australian cedar (*Toona ciliata* M. Roemer) has become an alternative as it improves the use of the cultivated areas (Sales et al., 2013; DaMatta et al., 2019). This practice allows shading provide improve the stability of coffee production by controlling the amount of water that reaches the soil and the persistence of biological control agents (Guimarães et al., 2016; DaMatta et al., 2019). Furthermore, it generates microclimates in the litter, favoring many groups of edaphic invertebrates that act directly in nutrient cycling, improving soil physical and chemical conditions, and improving sustainable cultivation systems (Lima et al., 2010; De Muner et al., 2019).

Ants are important components of edaphic communities and represent one of the most abundant populations in coffee systems (Teixeira; Silva; Mendonça, 2014; Guimarães et al., 2016; Sales; Baldiand; Queiroz, 2018). These insects have been used as bioindicators as they are sensitive to environmental changes, abundant and present in disturbed or undisturbed habitats (Brown-Junior, 2000; Philpott et al., 2010; Ribas et al., 2012; Rodríguez-de-León et al., 2019).

Brazilian biomes present a highly variable extension of rainy and dry periods (Ab'Sáber, 2012; Coutinho, 2016). Climatic seasonality can affect ant activity and diversity (Rabello et al., 2015; Costa et al., 2018; Lasmar et al., 2021; Queiroz et al., 2022). The rainy season has high humidity and temperature and is recommended in biomes with marked climatic seasonality, such as Caatinga, Cerrado, and Pantanal; Amazon Forest and coastal Atlantic Forest, that have low seasonality, ants can be sampled abundantly throughout the year (Levings, 1983; Kaspari, 2000).

The study of ants can be based on trophic guilds, providing predictive information concerning communities facing disturbances (Leal et al., 2010; Wike et al., 2010). This is a valuable tool to enable comparisons among environments in different conditions (Macedo; Berti; Delabie, 2011). Ants are also important generalist predators in natural and agricultural environments, including agroforestry coffee systems (Schmitz; Hamback; Beckerman, 2000). Some species attack pests such as the coffee berry borer *Hypothenemus hampei* (Ferrari) (Curculionidae: Scolytinae), an important pest in coffee plantations (Philpott; Armbrecht, 2006; Fornazier; Martins; Pratissoli, 2015; Fornazier et al., 2019), and herbivores introduced in coffee plantations (Philpott; Perfecto; Vandermeer, 2014). Natural control of the coffee berry borer by ants is particularly important because chemical insecticides do not always show the desired efficiency (Fornazier et al., 2019; Krohling et al., 2021).

This study was carried out aiming to evaluate predatory ant richness in Conilon coffee in monoculture and intercropped with teak or Australian cedar, as the separation of guilds simplifies the community of organisms and can facilitate the understanding of ecological patterns (Farias; Jaksic, 2006). In ant species, guilds reflect the function of the species (Silva; Brandão, 2010). Thus, this grouping can facilitate understanding ant communities in different types of crops. Moreover, the influence of these crops was analyzed on the richness of predatory ants in the dry (winter) and wet (summer) seasons. In this case, the hypothesis that predatory ants are richer in intercropping systems in the wet season was tested. This hypothesis stems from the fact that predatory ants guild are more stable in systems with greater plant diversity when compared to monocultures and that ants are positively influenced by humidity (Kaspari, 1996).

2 MATERIAL AND METHODS

The sampled areas were in the same farm in the municipality of Sooretama, in the northern Espírito Santo State, Brazil (19°09'08" S, 40°06'16" W, 72 m altitude) (Figure 1). According to the Köppen classification, the region has an Awi-type climate, characterized as hot and humid, with a rainy season in summer and a dry season in winter, with an average annual precipitation of 1,200 mm and an average temperature of 25° C. The soil was a dystrophic-yellow Argisol (Santos et al., 2018).

The three Conilon coffee cropping systems evaluated were: i) coffee monoculture (c); ii) intercropping coffee with teak (c + t), and iii) intercropping coffee with Australian cedar (c + ac) (Table 1). Agricultural practices such as sprinkler irrigation, mineral fertilization with macro-and micronutrients were used every year according to technical recommendations, and periodic pruning of coffee and the side branches of the two intercropped species. Aiming to standardize the treats used in the three coffee crop systems, weeds were controlled by mowing and annually using the herbicide Roundup®; coffee pest management was carried out using Verdadero® in soil drench application at the beginning of November as usual practices used on the farm (Fonseca et al., 2019; Prezotti et al., 2019; Silva; Reis, 2019; Ventura; Costa; Lima, 2019).

One hectare was delimited within each of the three cropping systems. Each area was divided into three linear transects randomly selected. The distance between each transect was 16 m. In each transect, eight pitfall traps were placed in the soil, in the coffee line, every 8 meters, totaling 24 traps. In each area, two collection expeditions were carried out in February, in the summer (wet), and July, in the winter (dry) of 2011. The pitfall traps remained buried with the opening at the same level as the soil surface. They were closed until the collection and remained in the field for 48 hours. The pitfall traps were made with one-liter plastic pots, with 14 cm in top opening diameter, and filled with 500 mL of water, five drops of detergent, and 200 mL of 4% formaldehyde (Moreira; Huising; Bignell, 2010; Teixeira; Silva; Mendonça, 2014).

The collected material was separated into distinct taxonomic groups in the Laboratory of the Experimental Unit of Agroecological Animal Production (UEPA) of the Experimental Farm of Linhares - Capixaba Institute for Research, Technical Assistance, and Rural Extension (INCAPER), in the municipality of Linhares, Espírito Santo State. The ant species were stored in plastic tubes with 70% alcohol (ethanol), and sent to Alto Tietê Mirmecology Laboratory (LAMAT) of the University of Mogi das Cruzes, in Mogi das Cruzes, São Paulo State where samples were sorted into subfamilies and genera following Baccaro et al. (2015), and then up to species and morphospecies according to Suguituru et al. (2015) and Souza-Campana et al. (2020) by Dr. Maria Santina de Castro Morini. Voucher specimens were deposited in the Silvia Sayuri Suguituru Reference Collection, at LAMAT.

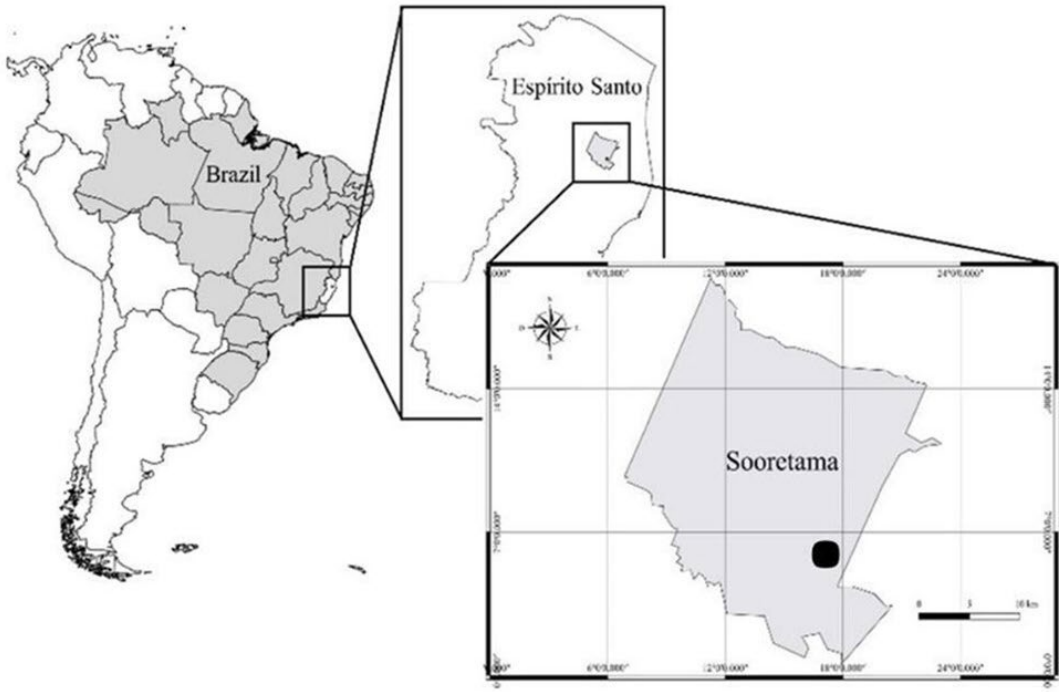


Figure 1: The geographic location of the sampled area in the municipality of Sooretama, Espírito Santo State, Brazil.

Table 1: Description of Conilon coffee cropping systems in the municipality of Sooretama, Espírito Santo State, Brazil.

Conilon coffee cropping systems	Description
Coffee monoculture	Five years old coffee crop, 3 x 2 m spacing coffee trees, totaling 10 ha of cultivated area.
Coffee + teak	Ten years-old coffee crop, 3 x 2 m spacing coffee crop; 6 x 8 m spacing teak trees, totaling 20 ha of cultivated area.
Coffee + cedar	Eight years-old coffee crop, 3 x 2 m spacing; 15 x 9 m spacing Australian cedar trees, totaling 20 ha of cultivated area.

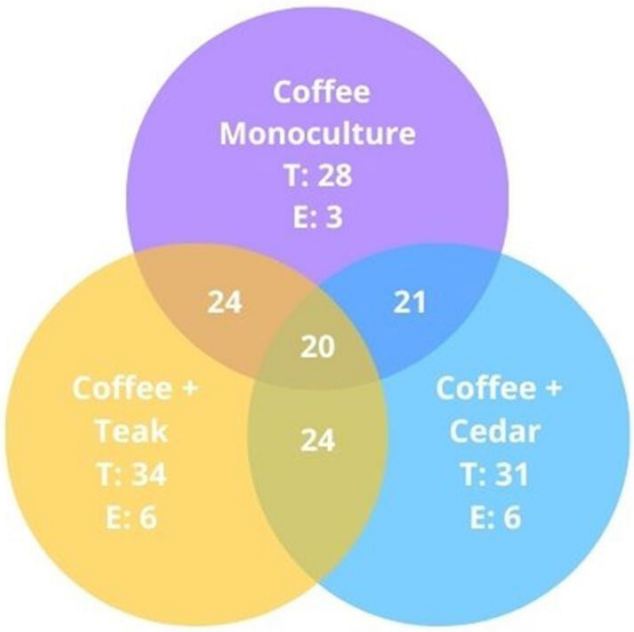


Figure 2: Venn diagram with the total (T), exclusive (E), and common number of the predatory ant species (predatory + omnivore generalist) among the three different Conilon coffee cropping systems. Municipality of Sooretama, Espírito Santo State, Brazil.

The species collected were divided into trophic guilds (predators, generalist omnivores, fungivores, and granivores), according to Weiser and Kaspari (2006) and Brandão, Silva and Delabie (2009). The ant species classified by Brandão, Silva and Delabie (2009) as Epigeic Generalist Predators and Arboreal Generalist Predators, even though classified as Omnivores by Weiser and Kaspari (2006), were maintained in the trophic guild predator. Omnivore ant species are considered generalist omnivore predators. The species *Dorymyrmex brunneus* Forel was considered a predator based on the study of Rossi and Fowler (2004).

Shannon-Wiener diversity (H') and Pielou equitability (J') were calculated using Past software version 3.22 (Hammer; Harper; Ryan, 2001). The similarity of communities among planting types was calculated by the Jaccard index (J), and data normality was assessed by the Lilliefors test. The software Past version 3.22 and Bioestat version 5.0 (Ayres et al., 2007) were used. Venn diagram was used to group the total, exclusive, and common number of predatory ant species (predatory + generalist omnivore) among the three different Conilon coffee cropping systems used.

The richness of predatory and generalist omnivore ants among the studied systems and seasons was compared using the t-test ($p<0.05$), and data normality was assessed by the Lilliefors test, using the R program (R Core Team 2021).

3 RESULTS

A total of 1,973 specimens of ants were collected, belonging to seven subfamilies, 24 genera, 49 species/morphospecies, and four trophic guilds associated with the three Conilon coffee cropping systems studied. Sixteen of these species are recorded for the first time in Espírito Santo State (Table 2).

Table 2: Taxonomic list containing the species of ants grouped by Formicidae subfamilies in the three Conilon coffee cropping systems, municipality of Sooretama, Espírito Santo State, Brazil.

Taxa	Trophic guilds[1]	Coffee monoculture	Coffee + teak	Coffee + cedar
DOLICHODERINAE				
Dorymyrmex brunneus Forel, 1908*	Predator	36	28	241
Linepithema micans (Forel, 1908)	Generalist omnivore	-	1	2
Linepithema neotropicum Wild, 2007	Generalist omnivore	-	-	1
Tapinoma melanocephalum (Fabricius, 1793)	Generalist omnivore	29	31	27
DORYLINAE				
Labidus praedator (Smith, 1858)	Predator	-	1	-
ECTATOMMINAE				
Ectatomma brunneum Smith, 1858	Predator	86	59	62
Ectatomma edentatum Roger, 1863	Predator	13	7	6
Ectatomma tuberculatum (Olivier, 1792)	Predator	-	7	2
Gnamptogenys sulcata (Smith, 1858)*	Predator	1	-	-
FORMICINAE				
Brachymyrmex patagonicus Mayr, 1868*	Generalist omnivore	139	79	13
Camponotus atriceps (Smith, 1858)	Generalist omnivore	1	1	-
Camponotus blandus (Smith, 1858)	Generalist omnivore	14	25	-
Camponotus lespesii Forel, 1886*	Generalist omnivore	-	1	-
Camponotus leydigi Forel, 1886	Generalist omnivore	-	2	-
Camponotus novogranadensis Mayr, 1870*	Generalist omnivore	3	18	15
Nylanderia fulva (Mayr, 1862)*	Generalist omnivore	41	23	9
MYRMICINAE				
Acromyrmex diasi Gonçalves, 1983*	Fungivore	-	1	-
Atta sexdens (Linnaeus, 1758)	Fungivore	41	10	14
Cardiocondyla wroughtonii (Forel, 1890)*	Generalist omnivore	9	5	98
Crematogaster sp.9	Generalist omnivore	-	3	1
Cyphomyrmex minutus Mayr, 1862*	Fungivore	3	7	4

Continue...

Table 2: Continuation.

Taxa	Trophic guilds[1]	Coffee monoculture	Coffee + teak	Coffee + cedar
Monomorium floricola (Jerdon, 1851)	Generalist omnivore	2	-	-
Monomorium pharaonis (Linnaeus, 1758)	Generalist omnivore	-	-	1
Mycetophylax sp.1	Fungivore	1	-	-
Pheidole flavens Roger, 1863*	Predator	1	7	11
Pheidole megacephala (Fabricius, 1793)*	Predator	2	2	1
Pheidole obscurithorax Naves, 1985*	Predator	1	4	-
Pheidole oxyops Forel, 1908*	Predator	6	44	4
Pheidole radoszkowskii Mayr, 1884	Predator	3	7	9
Pheidole subarmata Mayr, 1884*	Predator	24	24	10
Pheidole triconstricta Forel, 1886*	Predator	25	35	38
Pheidole sp.24	Predator	24	12	19
Pheidole sp.36	Predator	24	10	8
Pheidole sp.39	Predator	-	2	-
Pheidole sp.42	Predator	4	2	7
Pheidole aff. sp.42	Predator	-	-	1
Pogonomyrmex naegelii Emery, 1878	Granivore	33	3	5
Solenopsis saevissima (Smith, 1855)*	Predator	70	5	52
Solenopsis sp.2	Predator	-	1	13
Tetramorium simillimum (Smith, 1851)	Generalist omnivore	-	-	24
PONERINAE				
Anochetus neglectus Emery, 1894*	Predator	4	2	3
Odontomachus chelifer (Latreille, 1802)	Predator	61	37	41
Pachycondyla harpax (Fabricius, 1804)	Predator	4	7	-
Pachycondyla striata Smith, 1858	Predator	-	1	-
Pachycondyla sp.1	Predator	6	-	-
PSEUDOMYRMECINAE	Predator			
Pseudomyrmex schuppi (Forel, 1901)	Predator	-	2	-
Pseudomyrmex termitarius (Smith, 1855)	Predator	-	-	1
Pseudomyrmex sp.3	Predator	-	-	1
Pseudomyrmex aff. sp.3	Predator	1	-	1
Total richness	Richness (Total)	32	38	34
	Fungivore	3	3	2
	Granivore	1	1	1
	Generalist omnivore	8	11	10
	Predator	20	23	21

[1]Trophic guild: Fungivore (feed on fungi), Granivore (feed on seeds and grains), Generalist omnivore (generalist ants, eat everything, plant, and animal foods, including insects), Predator (food of animal origin, including insects); *New records for Espírito Santo State, Brazil.

No differences were found among the ants' diversity (coffee monoculture: H'=2.891; coffee + teak: H'=2.991; coffee + cedar: H'=2.547), and richness (H'=1.7696; gl=2) among the different Conilon coffee cropping systems studied. The distribution of ant species was homogeneous in all cropping systems studied, and J' ranging from 0.7055 to 0.8268.

The lowest number of exclusive species (3), which occurred only in one of the coffee crop systems, was recorded in Conilon coffee monoculture, followed by the intercropped crops (coffee + teak = 6 and coffee + cedar = 6). Despite this, the coffee + teak showed the highest number of ant predatory species (predatory + omnivore generalist) (34) than coffee + cedar

cropping, and coffee monoculture systems (31 and 28) (Figure 2). The occurrence of ants showed greater similarity between coffee monoculture and coffee + teak growing system (J=64%).

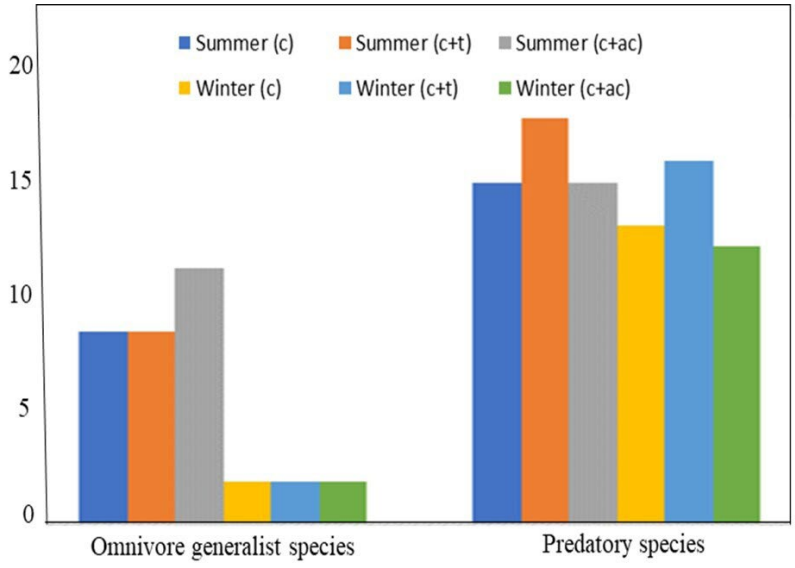
Four trophic guilds were found, with predatory ant species (Figure 3). The mean of the total predator ants (predator + generalist omnivore predators) did not differ among the Conilon coffee cropping system studied. However, the richness of predatory ants was only different in coffee monoculture and coffee + teak cropping systems in summer. In winter, coffee + teak differed from coffee monoculture in richness. No other difference was observed when comparing the other coffee cropping systems in summer and in winter. The highest number of species and specimens of predatory ants in all cropping systems was observed in summer, the wet season (Table 3).

The richness of the generalist omnivore predator group of predatory ants was ever higher in the three evaluated systems in summer than in all evaluated systems when compared to the winter season. The richness of the predator ant population differed only in the coffee monoculture, being higher in the summer; no differences in richness in the two other studied systems (coffee + teak, and coffee + cedar) were found when comparing summer and winter (Table 4).

All the characteristics contribute to the prevalence of the occurrence of the largest population of ants in the summer. The two groups formed by the dispersion of seasons and cropping systems regarding the variables evaluated (Figure 4) were according to the season, with group A formed by the systems of cultivation in the summer (reddish color) and group B formed by the systems of cultivation in winter (greenish color). The components absorbed 89.76% of the variability of the original variables, 76.15% for CP1, and 13.63% for CP2. These results confirm those expressed in Tables 3 and 4.

4 DISCUSSION

In this study, we compared the ant communities in Conilon coffee cultivation systems: monoculture, intercropping with teak, or with Australian cedar. Our hypothesis was corroborated when the greater number of predatory species in the rainy season (summer) was recorded. Humidity is a limiting factor for ants (Kaspari, 1996), which also influences other groups of edaphic macrofauna (Oliveira et al., 2020), which are potential prey for predatory ants. Our results also showed a difference in the occurrence of predatory ants between Conilon coffee (monoculture) and coffee intercropped with teak, both in summer and winter. Lepage et al. (1986) found that the presence of substances of phenolic origin, such as those released by cedar, with fungicidal and insecticidal properties, can influence negative predatory ants. Thus, studies that investigate the influence of Australian cedar and its compounds on ants, particularly predators, become necessary, because these ant species are sensitive to disturbances and loss of essential resources (Andersen, 1995). Additionally, sixteen new records of ant species in Espírito Santo State contribute to the knowledge of the geographic distribution of ants in the Atlantic Forest biome; this Brazilian biome has the second highest diversity of described ant species, and above all to the biodiversity of ants in Espírito Santo state (Feitosa et al., 2022; Schmidt et al., 2022; Silva et al., 2022; AntWeb, 2023; Vicente; Souza; Prado, 2023).



*coffee monoculture (c); coffee with teak (c + t); coffee with Australian cedar (c + ac)

Figure 3: Total ant species richness per trophic guild in the three Conilon coffee crop systems in winter and summer in Sooretama, Espírito Santo State, Brazil.

Table 3: Means of the richness of total predator ants (predator + generalist omnivore predators) in the summer (wet) and winter (dry) seasons, in three Conilon coffee cropping systems.

Season	Conilon coffee cropping systems		
	Coffee monoculture	Coffee + teak	Coffee + cedar
Summer (wet)	1.8039A	1.8088A	-
	1.8039A	-	1.8966A
	-	1.8088A	1.8966A
Winter (dry)	1.1322B	1.4107A	-
	1.1322A	-	1.3086A
	-	1.4107A	1.3086A
Year	1.4681A	1.6098A	-
	1.4681A	-	1.5995A
	-	1.6098A	1.5995A

[1]Means followed by the same horizontal capital letter do not differ from each other by the t test ($p>0.05$).

Season	Coffee monoculture	Coffee + teak	Coffee + cedar
Summer (wet)	1.8039a	1.8088a	1.8966a
Winter (dry)	1.1322b	1.4107b	1.3086b

[1]Means followed by the same vertical capital letter do not differ from each other by the t test ($p<0.05$).

Intercropping of Conilon coffee with Australian cedar is likely to show few resources (food sources and nesting sites), where less sensitive omnivorous ants, that exploit a wide variety of environmental resources (Brown-Junior, 2000), can predominate, and recolonize the disturbed habitat more quickly than predatory ants (Philpott; Foster, 2005; Campos; Schoereder; Sperber, 2007). Predatory ant species were the richest guild in all the three Conilon coffee cropping systems evaluated. These crops are likely to provide ideal resources for the greater richness of ant species from this guild. Plant residues from coffee, teak, and cedar plants probably made food and organic matter available in the soil, which increased the diversity of organisms that are resources for predatory species (Crepaldi et al., 2014; Góes et al., 2021).

Ants are important generalist predators in many natural and agricultural systems and help to prevent herbivores from damaging plants including coffee agroecosystems (Schmitz; Hamback; Beckerman, 2000; Philpott; Armbrecht, 2006; Gonthier et al., 2013). Since a diverse community of ant species can improve the overall function of predation in coffee agroecosystems (Hooper et al., 2005), it can be important for the control of invertebrate pests; as the richer of predatory ants, the greater the natural control they provide (Armbrecht; Perfecto, 2003). This fact contributes to the reduction of herbivore populations, and may increase plant yield (Cardinale et al., 2003).

Table 4: Means of richness of the number of generalist omnivore and predatory ants occurred in the summer (wet) and winter (dry) seasons, in three Conilon coffee cropping systems.

Season	Generalist omnivore			Predators		
	Conilon coffee cropping systems			Conilon coffee cropping systems		
	Coffee monoculture	Coffee + teak	Coffee + cedar	Coffee monoculture	Coffee + teak	Coffee + cedar
Summer (wet)	1.8860a	1.7950a	1.6975a	2.1684a	1.6811a	2.4416a
Winter (dry)	0.7361b	0.7469b	0.9854b	1.3273b	1.7330a	1.5213a

[1]Means followed by the same vertical lowercase letter do not differ from each other by the t-test ($p>0.05$).

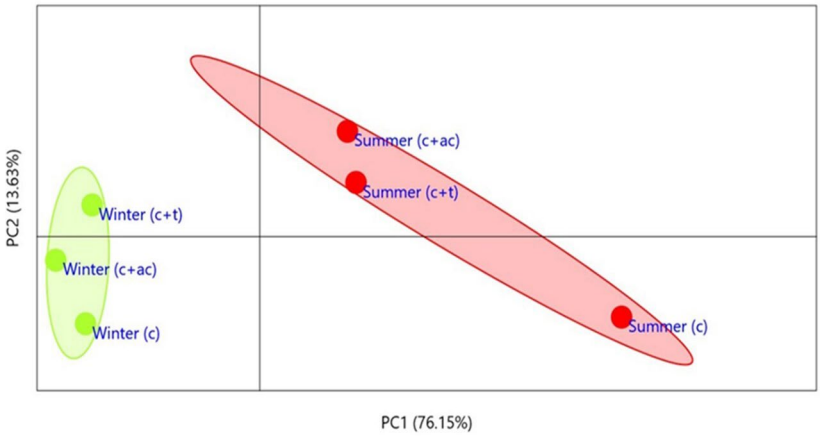


Figure 4: Dispersion of seasons and Conilon coffee crop systems concerning the variables evaluated.

*Richness (R); coffee monoculture (c); intercropping coffee with teak (c + t); intercropping coffee with Australian cedar (c + ac)

Conilon coffee has been referred to as a potential crop due to the rapid development of pest population since the areas where this coffee species has been cultivated have temperature and relative humidity that benefits pests such as scale insects and the coffee berry borer (CBB). This is a pest that causes high economic damage to coffee plantations worldwide, not only in Brazil (Fornazier; Martins; Pratissoli, 2015; Fornazier et al., 2019).

Some diverse ant genera have been associated with coffee mainly to the CBB control such as *Azteca*, *Brachymyrmex*, *Crematogaster*, *Dolichoderus*, *Paratrechina*, *Pheidole*, *Prenolepis*, *Pseudomyrmex*, *Solenopsis*, *Tapinoma*, *Technomyrmex*, *Wasmannia* (Pardee; Philpott, 2011; Onishi et al., 2017; Morris et al., 2018). Some ant species that are small enough to enter CBB galleries as *Crematogaster crinosa* Mayr and *Solenopsis picea* Emery have great potential to biocontrol attacking CBB larvae inside coffee fruits (Gallego-Ropero; Armbrecht, 2005; Constantino-Chuaire et al., 2022). *Ectatomma brunneum* Smith was the ant species with the highest frequency in Conilon coffee (monoculture) (86 specimens) and it was very frequent intercropped with Australian cedar (62), and teak (59 specimens). The diet of *E. brunneum* consists mainly of proteins and carbohydrates, its protein source being in general terrestrial arthropods such as termites, caterpillars, bee pupae, and other ants (Baccaro et al., 2015). Species of this genus are important for pest control in coconut and cocoa trees in Bahia State, Brazil (Conceição et al., 2009) and in Mexico (Valenzuela-González; López-Méndez; Lachaud, 1995).

Conilon coffee in monoculture and intercropped with teak showed a high frequency of *Brachymyrmex patagonicus* Mayr (139 and 77 specimens, respectively). Species of this genus can be found at different levels of management intensification in coffee plantations (Philpott; Perfecto; Vandermeer, 2006). It is noteworthy that previous research has described *Brachymyrmex* as a predator of the CBB (Bustillo; Cardenas; Posada, 2002).

Solenopsis saevissima (Smith) was very frequent in Conilon coffee in monoculture (70 specimens) and intercropped with Australian cedar (52 specimens). This species is considered the most abundant component of the ant community in non-shaded coffee systems (Perfecto; Vandermeer, 1996). Species of this genus stand out among ants as important predators of the CBB (Bustillo, Cardenas; Posada, 2002; Philpott; Armbrecht, 2006), and eggs and immatures of the sugarcane borer *Diatraea saccharalis* (Fabricius) (Lepidoptera: Crambidae) (Oliveira et al., 2012).

Intercropping Conilon coffee with teak showed a high frequency of *Pheidole oxyops* Forel (44 specimens). The ant genus *Pheidole* is the most species-rich lineage of ants in the world and one of the dominant organisms in tropical regions (Casadei-Ferreira; Economo; Feitosa, 2020). This genus, together with *Camponotus*, was the most abundant in areas of the Cerrado Biome, coexisting with other ant species (Santos; Moura, 2021). This species is a generalist ant that can display passive and active forage strategies. Moreover, this species can forage actively for a variety of food resources from plant debris to dead arthropods (Assis et al., 2021). Also, it is aggressive and dominant (Gomes; Campos; Vasconcelos, 2021), and is considered an important predator, with effectiveness in controlling pests such as the beetle *Anthonomus grandis* (Boheman) (Coleoptera: Curculionidae) in cotton trees (Fernandes et al., 1994), and the coffee berry borer (Bustillo; Cardenas; Posada, 2002). Species of this genus are also recognized as predators of eggs and immatures of *D. saccharalis* in sugarcane fields (Oliveira et al., 2012). Reports also show their predatory activity on larvae of the curculionids *Conotrachelus psidii* Marshall and *C. myrciariae* Marshall (Coleoptera: Curculionidae), and guava (*Psidium guajava* L.) and jaboticaba (*Myrciaria cauliflora* (Vell) Berg) pests (Fowler, 1989).

Intercropping Conilon coffee with Australian cedar showed a high frequency of *D. brunneus* (241 specimens) over other species. This may be because this species is well adapted to anthropic environments, being found in shaded coffee crops (Cuezzo; Guerrero, 2012). Species of this genus have been cited as predators of the sugarcane borer (Pinto; Botelho; Oliveira, 2009).

5 CONCLUSIONS

There is a great similarity among the Conilon coffee cultivation systems: monoculture, intercropping with teak, or with Australian cedar in terms of diversity, and richness of predatory and generalist omnivore predatory ant species. Conilon coffee cropping systems did not affect the richness of predatory, or generalist omnivore predatory ant species, however, summer (wet season) favors the occurrence of total predatory ants (generalist omnivore + predators). Intercropping Conilon coffee does not favor predatory ants. However, new research must be done to evaluate other Conilon coffee intercropping for a longer period.

6 AUTHORS' CONTRIBUTIONS

Conceptual Idea: Martins, D.S.; Teixeira, A.F.R.; Fornazier, M.J., Methodology design: Teixeira, A.F.R.; Fornazier, M.J.; Guarçoni, R.C; Martins, D.S.; Morini, M.S.C., Data collection: Teixeira, A.F.R.; Magalhães, F.S.; Souza-Campana, D.R.; Data analysis and interpretation: Guarçoni, R.C; Morini, M.S.C.; Souza-Campana, D.R.; Abonizio-Santos, D.B.; Magalhães, F.S.; Fornazier, M.J.; Martins, D.S., and Writing and editing: Fornazier, M.J.; Martins, D.S.; Morini, M.S.C.

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