JÚLIA JANTSCH FERLA

INTERCROPPED PLANTS AS A RESERVOIR OF PREDATORY MITES IN COFFEE CROP WITH A DESCRIPTION OF A NEW SPECIES

Dissertação apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Entomologia, para obtenção do título de *Magister Scientiae*.

Orientador: Angelo Pallini Filho

Coorientadores: André Lage Perez
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RESUMO

FERLA, Júlia Jantsch, M.Sc., Universidade Federal de Viçosa, agosto de 2021. **Plantas consorciadas como reservatório de ácaros predadores na cultura do café, com a descrição de uma nova espécie.** Orientador: Angelo Pallini Filho. Coorientadores: André Lage Perez, Gustavo Júnior de Araújo, Madelaine Venzon e Noeli Juarez Ferla.

A taxonomia descreve e identifica táxons, de modo a permitir que uma ampla diversidade de pesquisas seja desenvolvida com base na utilização de informações taxonômicas para arquitetar estratégias de manejo de pragas. O cultivo de café no Brasil se configura como um setor de grande importância econômica para o país, além de consistir em um dos exemplos de uso da identificação de organismos associados. Atualmente o Brasil é o maior produtor de café e o sistema convencional desse cultivo é feito a partir da monocultura com baixa diversificação de plantas e do uso de insumos químicos para o controle de pragas. Os químicos utilizados afetam não somente a praga alvo, diversos artrópodes e patógenos, mas também outros organismos benéficos que desempenham importantes papéis na manutenção do ecossistema, já que estes são fornecedores de serviços ecossistêmicos, como a polinização e o controle biológico. Assim, o controle biológico conservativo pode ser usado como uma estratégia alternativa ao uso de agroquímicos quando se objetiva controlar pragas nos agroecossistemas. O uso de práticas desse controle pode ser feito com uma variedade de estratégias integradas, que utilizam os serviços ecológicos da biodiversidade local. Uma das estratégias que pode ser empregada é o plantio de espécies vegetais que fornecem abrigo e alimento alternativo, como pólen e néctar, a ácaros predadores. Esse sistema resulta no aumento da biodiversidade no agroecossistema e pode permitir que um controle estável de pragas seja alcançado. Eu estudei a comunidade de ácaros sob a perspectiva taxonômica existente em um sistema de café consorciado intercalado em uma faixa lateral com plantas que fornecem pólen e néctar para a comunidade de artrópodes. Meu objetivo foi avaliar se as comunidades de ácaros fitófagos e predadores presentes nos cafeeiros sofrem modificações conforme se aumenta a distância das Espécies de Plantas Consorciadas (EPC). Eu também investiguei se existe alteração na composição das espécies de ácaros predadores e fitófagos nas EPC e avaliei o papel que essas plantas desempenham como estratégia de controle biológico conservativo. Além disso, eu descrevi de uma nova espécie de Tydeidae coletada em folhas de café e *Inga*. O estudo foi realizado na Fazenda Experimental da EPAMIG, em Patrocínio – MG. Os ácaros foram coletados nas EPC e em café, em diferentes distâncias em um transecto de 16 metros (4, 8, 12 e 16 metros). Para realizar a descrição da nova espécie, a identificação foi feita através de chaves dicotômicas e microscópio óptico com contraste de fases e os desenhos foram feitos com o programa Adobe Illustrator®. Nesse trabalho, eu demonstrei que as EPC avaliadas não modificam a comunidade de predadores e fitófagos ao longo de um gradiente de distância. Apesar disso, estas abrigam ácaros herbívoros, que não são pragas do café e que podem ser presas alternativas para aumentar a população de predadores e, portanto, auxiliar no controle biológico de ácaros pragas no cultivo de café.

Palavras-chave: Controle biológico conservativo. Diversificação do agroecossistema. Serviços ecossistêmicos. Tydeidae. Taxonomia.

ABSTRACT

FERLA, Júlia Jantsch, M.Sc., Universidade Federal de Viçosa, August, 2021. **Intercropped plants as a reservoir of predatory mites in coffee crop with a description of a new species.** Adviser: Angelo Pallini Filho. Co-advisers: André Lage Perez, Gustavo Júnior de Araújo, Madelaine Venzon and Noeli Juarez Ferla.

Taxonomy describes and identifies species allowing different investigation to be developed from it, becoming possible to use taxonomic information in order to build strategies for pest management. This is the case of coffee crops in Brazil, which are of great importance to the country's economy. Currently, Brazil is the world main coffee exporter and the conventional system production consists in a monoculture with low plant diversification that uses chemical inputs to control pests. This system not only affects the target pest species, different arthropods and pathogens but also many other beneficial species that can play important roles in maintaining the ecosystem due to the services they provide, such as pollination and biological control. Hence, the conservation biological control can be an alternative to pesticides while controlling insect and mite pests in agroecosystems. The use of conservation biological control practices could be done with a variety of integrated strategies using ecological services from the local biodiversity. One strategy is using plants that provide shelter and alternative food to predatory mites, such as nectar and pollen, increasing biodiversity in agroecosystems in order to reach a sustainable control of pests. I studied the mite community from a taxonomic perspective in a coffee system intercropped interspersed on a side strip with plants that provided nectar and pollen for the arthropod community. My aim was to evaluate if the communities of predators and phytophagous mites present on coffee crops changed if their distance from the selected Intercropped Plants Species (IPS) increased. I also investigated the composition of predatory and phytophagous mite species on the IPS and assessed the role of these plants as a conservative biological control strategy. Finally, I described a new Tydeidae species sampled on coffee and *Inga* plants. The study was carried out at the EPAMIG Experimental Farm, in Patrocínio county, Minas Gerais state. To do so, the mites were recorded on IPS and in different distances on coffee transects of 16 m (4, 8, 12 and 16 meters) extending from IPS. Morphological identification of the new tydeid species was made with a microscope with phase contrast and dichotomous key and drawings were made using Adobe Illustrator® program. I show that the IPS do not modify the community of predators and phytophagous mites in coffee along the distance, but they harbor herbivorous mites that are not pests on coffee. Those mites can be an alternative prey to increase the population of predators on these plants, assisting in the biological control of mite pests in the coffee crops.

Keywords: Conservative biological control. Agroecosystem diversification. Ecosystem service. Tydeidae. Taxonomy.

SUMÁRIO

GENERAL INTRODUCTION

Taxonomy describes and identifies taxons allowing different investigation to be developed from it. So, it is important to create dichotomous key or other strategies to disseminate and facilitate identification of species, which will facilitate studies on a broad range of research from basic ecology to more applied field as biological control (Moraes 1987). Once a species is identified, it is possible making taxonomic comparison of populations, identifying herbivorous pest and their natural enemies (Moraes 1987). Furthermore, when investigating arthropod communities much can be used from the taxonomic information in order to build strategies to manage pests and this is the case of coffee crops in Brazil that have great importance to the country's economy (Pallini 1991; Spongoski et al. 2005; Mineiro et al. 2006a; Marchetti 2007; da Silva et al. 2020; Conab 2021).

Currently, Brazil is the main producer and the largest exporter in the world and the species most cultivated in the country is *Coffea arabica* L. (Rubiaceae) (Conab 2021). The covered area is 1.75 million hectares, from which Minas Gerais State has the largest cultivated area (1.22 million hectares). This corresponds to 71.7% of the area occupied with this plant species nationwide, followed by Espírito Santo, São Paulo and Bahia (Conab 2021). In general, Minas Gerais is divided into three main coffee producer regions: South of the State, Zona da Mata (reminiscent of Atlantic Forest area) and Alto Paranaíba (Cerrado biome) (Conab 2021). The Cerrado biome in this state is characterized by mechanized coffee production (Conab 2020) and Zona da Mata and South of Minas Gerais has predominantly family farming production (Coelho 2005).

This crop suffers from diseases and pests that can cause economic yield loss (Le Pelley 1973; Pallini 1991; Souza et al. 1998; Spongoski et al. 2005). Some of the most important insects that cause economic losses and are serious pests in coffee agroecosystems are the coffee leaf miner *Leucoptera coffeella* (Guérin-Mèneville) (Lepidoptera: Lyonetiidae) and the coffee berry borer *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae: Scolytinae) (Le Pelley 1973; Souza et al. 1998). Apart from insets, there are phytophagous mites that cause economic damages such as *Oligonychus ilicis* (McGregor) (Tetranychidae) that causes defoliation, premature leaf drop and reduction in plant photosynthesis (Reis 2005; Reis and Souza 1986) and *Polyphagotarsonemus latus* (Banks) (Tarsonemidae) that damages the leaves, curling it downward (Amaral 1951; Chagas 1973; Flechtmann 1967; Jeppson et al. 1975; Matiello 1987; Peña and Bullock 1994).

There are also some species of the genus *Brevipalpus*, that despite being of great economic importance on coffee culture, also represent economically damage to other cultures in the world (Childers and Rodrigues 2011; Nunes et al. 2018; Mineiro and Sato 2019). They can transmit viruses to many plant species and acting as vectors of the Coffee ringspot virus (Chagas et al. 2003; Childers et al. 2003; Kitajima et al. 2003; Nunes et al. 2018; Mineiro and Sato 2019). The taxonomy of this group is complex (Beard et al. 2015) and *Brevipalus phoenicis* (Geijskes) comprises several cryptic species (Beard et al. 2013; Navia et al. 2013; Beard et al. 2015). Beard et al (2015) reorganized this group dividing one species (*B. phoenicis*) into a complex of species. Before this organization, *B. phoenicis* was recorded on coffee and after this revision there are records of *B. yothersi* and *B. papayensis* from this crop and both can transmit Coffee ringspot virus (Spongoski et al. 2005; Mineiro et al. 2006a; Mineiro et al. 2006b; Marchetti 2007; Mineiro et al. 2008; Mineiro et al. 2009; Nunes et al. 2018; Mineiro and Sato 2019). The family of predatory mites commonly found on coffee plants in Brazil are Phytoseiidae, Ascidae, Cheyletidae, among others (Pallini 1991; Spongoski et al. 2005; Marchetti 2007). Some species of this families such as Phytoseiidae are associated and feed on phytophagous mites including some of this pest families, other arthropods and also on pollen and nectar (McMurtry and Croft 1997; Croft et al. 2004; McMurtry et al 2013)

Conventional coffee system is based on monoculture with low plant diversity and the use of agrochemicals to control pests (Thrupp 1990; Cardoso et al. 2001). There are side effects in applying pesticides such as pest resistance and resurgence and the residues remaining in the field and on the fruits, that impacts biodiversity, environment and the human life (Thrupp 1990; Perfecto et al. 1996; Perfecto and Vandermeer 2008; Khan et al. 2009; Pedlowski et al. 2012; Morris et al. 2013; Sales et al. 2013; Avelino et al. 2018; Aparecido et al. 2020). Nonetheless, there are some alternatives to conventional practices in order to control pests in the crop being one of them the conservative biological control, which is the enhancement of the natural enemies present in the agroecosystem (Letourneau et al. 2011; Ratnadass et al. 2012; Tixier 2018). To do so, a strategy is to attract and maintain the natural enemies in the system increasing diversity of plants that provide food and shelter for them (Rezende et al. 2014, 2021; Rosado et al. 2021).

Some farmers have already adopted the coffee crop intercropped system with native and exotic plant species to biome in Brazil (Souza et al. 2010). This intercrop favors to food security and production, in addition to low cost beneficial in the agroecosystem (Souza et al. 2010). In the studied system, to increase the diversity, some endemic plants from Brazil were planted intercropped with coffee as *Senna macranthera* (Dc. ex collad.) H.S. Irwin & Barnaby, *Inga edulis* Mart and *Varronia curassavica* Jacq. (Cordiaceae). *Senna macranthera* and *I. edulis* are trees with extrafloral nectaries (Koptur 1994; Melo et al. 2010) and *Varronia curassavica* is an aromatic perennial shrub that provides pollen during the whole year (Brandão et al. 2015). Together in the system, they can be a good strategy for conservative biological control by providing alternative food to natural enemies. Furthermore, there are some studies associating *S. macranthera* and *Inga* spp. with coffee crops. However, they involve mainly insects but not mites (Cardoso et al. 2001; Teodoro et al. 2009; Souza et al 2010; Rezende et al. 2014,2021).

Thus, given the importance of increasing biodiversity in agroecosystems in order to reach a sustainable control of pests, the general objective of this work was to evaluate the mite community in a coffee system intercropped with plants that provide nectar and pollen to the arthropods. To do so, in the first chapter I sampled and identified the mites in this system to evaluate if the communities of predators and phytophagous mites present on coffee crops changed if their distance from the selected intercropped plants increased. Additionally, I assessed the composition of predacious and phytophagous species on these selected intercropped plants to investigate if they are reservoir of beneficial or detrimental mites for the coffee crop.

In the second chapter, I described a new species of Tydeidae based on specimens collected on both *C. arabica* and *I. edulis*, named *Tydeus mineirensis* **sp. nov.** as a tribute for the first Tydeidae species described from Minas Gerais state. Additionally, given the importance of properly identification and to facilitate future studies involving tydeids in coffee, I provided a dichotomous key of Tydeoidea reported from coffee crops in the states of Minas Gerais and São Paulo, Brazil.

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Chapter 1

Intercropped plants as a reservoir of predatory mites in coffee crop

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Abstract

Conservation biological control of pest mites can be an alternative to pesticides in agroecosystems. The use of conservation biological control practices could be done with a variety of integrated strategies using the local biodiversity. Pollen and extrafloral nectar are important food source to some mites, making the intercropping systems with plants that provide this diet a suitable strategy to attract natural enemies of pests. We investigate if the communities of predators and phytophagous mites on coffee crops change along a distance gradient from selected Intercropped Plants Species (IPS) that provide nectar and pollen: *Inga edulis* Mart., *Senna macranthera* (Dc. ex collad.) H.S. Irwin & Barnaby and *Varronia curassavica* Jacq. We also assessed the composition of these mites on IPS. To do so, we recorded the mites species on coffee along transects of 16 m extending from the IPS and we sampled the mites on IPS. The community of predators and phytophagous mites on coffee was not modified by the distance from IPS, but IPS harbor several mite species of mites. Furthermore, it was found that the composition of predators and phytophagous mites among the IPS was different. The

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findings suggest that the intercropped plants with coffee can attract and serve as a reservoir of predatory mites.

Keywords: Conservative biological control, Agroecosystem diversification, Ecosystem service, Phytophagous mites.

Introduction

Brazil is the main coffee producer and the largest exporter in the world, and the species most cultivated in the country is *Coffea arabica* L. (Rubiaceae) (Conab 2021). Minas Gerais is the state with the largest crop area, corresponding to 71.7% of the area occupied with this species nationwide (Conab 2021). Pests and diseases occurring in this culture can cause economic yield and quality losses (Avelino et al. 2018). The most frequent strategy in controlling them is the use of chemical inputs, such as: fungicides, insecticides and acaricides (Spongoski et al. 2005; Aparecido et al. 2020). However, the impact of these agrochemicals does not only affect the target pest species, but also many others that can play important roles in maintaining the ecosystem due to the services they provide, such as pollinators and natural enemies (Tasei 2002; Desneux et al. 2007; Giglio et al. 2017). In addition to the impact on biodiversity, the continued use of this practice also affects the quality of human life, as ecosystem services are lost, increasing the costs of food production (Perfecto et al. 1996; Perfecto and Vandermeer 2008; Khan et al. 2009; Pedlowski et al. 2012; Sales et al. 2013).

Conservation biological control is the enhancement of natural enemies populations in the agro-ecosystem and can be an alternative to conventional practices to control pests in the crop (Letourneau et al. 2011; Ratnadass et al. 2012; Tixier 2018). This management could be done with a variety of integrated strategies using the local biodiversity (Zehnder et al. 2007; Venzon et al. 2011). In management strategies, such as the intercropped systems, which aim to reduce the pest population throughout the increasing of natural enemy presence, it is important that introduced plants are effective in attracting and favors enemy target but not pests in crops (Venzon and Sujii 2009; Begg et al. 2017). Extrafloral nectar and pollen are important sources of energy that can attract natural enemies, such as insects and mites and also pollinators (i.e. wasps, ants, mites, bees, chrysopids), making the intercropping systems a suitable strategy of conservative biological control in crops, such as coffee (Pemberton and Vandenberg 1993; van Rijn and Tanigoshi 1999; Wäckers et al. 2005; Rezende et al. 2014, 2021; Botti et al. 2021; Martins et al. 2021; Rosado et al. 2021).

Some predatory mites, such as phytoseiid from the genus *Amblyseius, Euseius, Neoseiulus*, *Galendromus* and *Iphiseiodes* for instance, can feed on phytophagous mites or some plant sources as pollen and nectar (McMurtry and Croft 1997; Croft 2004; McMurtry et al. 2013). There are some studies with predatory mites associated with extrafloral nectar (Pemberton 1993; Pemberton and Vandenberg 1993; Van Rijn and Tanigoshi 1999), pollen (McMurtry 1977; Villanueva and Childers 2004; Rodríguez-Cruz et al. 2013) and spontaneous plants intercropped with the main crop (Rosado et al. 2021). However, little is known about the effect of intercropped plants with nectaries and pollen on herbivores and predatory mites in coffee crops (Teodoro et al. 2009; Peixoto et al. 2017; Rosado et al. 2021).

Coffee crops dwell mites with different food habits, such as predators, fungivores, micophagous, phytophagous and other species that does not have a well-known food source reported (Pallini 1991; Reis et al. 2000; Spongoski et al. 2005; Marchetti 2007; Mineiro et al. 2008). Some of the most common predatory mites found on these plants are from the families Phytoseiidae, Ascidae, Stigmaeidae, Cunaxidae, Cheyletidae and Anystidae (Pallini 1991; Spongoski et al. 2005; Mineiro et al. 2006a; Marchetti 2007; Mineiro et al. 2008; Mineiro et al. 2009; Silva et al. 2010; Berton et al. 2019), being phytoseiid mites one of the most known and studied (McMurtry and Croft 1997). The phytophagous mites most economically important in this culture are *Oligonychus ilicis* (McGregor) (Tetranychidae), causing significant economic losses due to defoliation, premature leaf drop and reduction in plant photosynthesis (Reis and Souza 1986; Reis 2005) and *Brevipalus phoenicis* (Geijskes) (Tenuipalpidae), that can transmit Coffee Ringspot Virus, causing defoliation of the plants (Chagas 1973; Reis and Zacarias 2007). This species used to comprise several cryptic species (Navia et al. 2013; Beard et al. 2015a). Beard et al. (2015a) divided it into a species complex of eight species. So, before this division, *B. phoenicis* were recorded on this crop, and after this there are records of *B. yothersi* Baker and *B. papayensis* Baker, and both species belong to *B. phoenicis* species complex and can transmit Coffee ringspot virus (Spongoski et al. 2005; Mineiro et al. 2006a, 2006b; Marchetti 2007; Mineiro et al.

2008, 2009; Nunes et al. 2018; Mineiro and Sato, 2019). Additionally, *Polyphagotarsonemus latus* (Banks) (Tarsonemidae) is also a pest on coffee, that damages the leaves, curling it downward (Amaral 1951; Flechtmann 1967; Chagas 1973; Jeppson et al. 1975; Matiello 1987; Peña and Bullock 1994).

Increasing plant diversity enhances the coffee productivity and the soil quality, attracts natural enemies and levels up predation and parasitism in this agroecosystem (Rezende et al. 2014; de Souza et al. 2017; Androcioli et al. 2018; Rezende et al. 2021). Therefore, our aim in this work was to evaluate if the communities of predators and phytophagous mites present on coffee crops change if their distance from the selected intercropped plants increase. For this, we used an established coffee system intercropped with providing nectar and pollen plants and evaluated whether the insertion of each intercropped plant modifies the abundance, richness and composition of predators and phytophagous mites. Our hypothesis is that coffee plants closer to the intercropped plants will have more predators, and consequently, less herbivores. Additionally, we evaluated the composition and species of predatory and phytophagous mites these plants can host to assess the role of these plants as a conservative biological control strategy.

Material and methods

Study area

The experiment was carried out at the EPAMIG Experimental Farm, in Patrocínio county (18°59'52.0"S 46°58'59.8"W), Minas Gerais state, Brazil, in Cerrado biome. The region is located at the mesoregion of Triângulo Mineiro and Alto Paranaíba (IBGE 2010). The sample area was characterized by a diversified system (1080 m^2), with 3 replicas in random blocks on 3 different places at the farm, away from at least 200m from each other. The diversified system is surrounded by two lines of three Intercropped Plant Species (IPS): two *Inga edulis* Mart. (Fabaceae) trees, one *Senna macranthera* (Dc. ex collad.) H.S. Irwin & Barnaby (Fabaceae) tree and six shrubs of *Varronia curassavica* Jacq. (Cordiaceae) in each line (Figure 1). *Inga edulis* and *S. macranthera* have extrafloral nectaries and *V. curassavica* produces flowers during the whole year (Koptur 1994; Melo et al. 2010; Brandão et al. 2015). No pesticides were applied in the study area. Fertilization was made with chemical fertilizers and the spontaneous plant growth was controlled by a brush cutter.

Data collection

Coffee plants were sampled along the lines of coffee plantation by detaching four leaves distally from the third leaf pair of two different branches. Two branches in the middle third of each bush facing both sides of the coffee lines were sampled (adapted Souza et al. 1998). There was a total of four plants, every 4 meters in a coffee line (4; 8; 12 and 16 m), with 16m extending from each IPS (Figure 1). One line in front of each IPS was sampled. It was a total of 192 leaves/area, totaling 576 leaves. As it was a huge amount of material and the mite species repeated itself, the fourth and fifth sampling were made the same way but instead of four leaves per plant, just 25% of the material were sampled, which means one leaf per plant. It was a total of 48 leaves/area, totaling 144 leaves (adapted Pallini 1991). To sample the IPS, five leaves of each plant species were detached randomly per line, with 10 leaves per plant species/area, totaling 90 leaves. The material was collected from June/2020 to Feb/2021, summing up 5 samplings in dry and rainy seasons.

The samples were placed separately in paper bags and kept at low temperature with Gelo-X® inside a cooler box until arrive to the laboratory of Acarology at the Department of Entomology from the Federal University of Viçosa, Viçosa, where it was kept in a refrigerator at approximately 10°C for a period up to 10 days. The material was examined with a stereoscopic microscope and all mites were mounted on glass slides in Hoyer's medium for identification (Krantz and Walter 2009). Morphological identification was made with a microscope with phase contrast and dichotomous key (André 1980; Baker and Tuttle 1994; Chant and McMurtry 1994, 2007; Beard et al. 2015a, 2015b, 2015c; Fan et al. 2016; Paktinat-Saeij et al. 2016).

To maintain a pattern, as the collections of coffee plants were made with different amounts of leaves, 25% of each slide from first to third collections was identified. To do so, the cover slide was divided into four identical quadrants, each one corresponding to 25% of the slide. The identified quadrant was raffled. If in the raffled quadrant there were no mites, the identified was the anterior one. In the fourth and fifth collections all the slide were identified.

To analyze abundance, females, male and immature mites were included but to richness, only females were included. When assessing Eriophyoidea mites, some individuals were mounted on microscope slides with modified Berlese's medium (Amrine and Manson 1996) for morphotyping and some individuals were preserved in

70% ethanol for posterior identification. To measure the abundance, all Eriophyoidea were counted in the first sample. To the second up to the fifth sample we did the mean number of mites per leaf. Hence, all individuals of the same morphospecies were counted in a 1 cm^2 quadrant in the abaxial surface of each leaf, in the region near to petiole and midrib. The leaves were measured and the number of specimens per leaf was estimated. Only to this superfamily, all specimens were included in richness.

All specimens were deposited in the mite reference collection of the Laboratory of Acarology in the Department of Entomology at Federal University of Viçosa, state of Minas Gerais, Brazil.

Statistical analyses

We used Generalized linear models (GLM) to test if the insertion of plants modifies the abundance of different groups of mites along the coffee line in front of the IPS. Since we had counting data, our model was fitted the family error Poisson. When we detected overdispersion in the residuals of the model, the Negative Binomial error was used. To determine the best-model we used Akaike Information Criterion corrected (AICc) comparing Akaike Information Criterion corrected (AICc) values, the difference in AICc between the model and the model with the smallest AICc (ΔAICc) and weights of each model (AICcWt) for values of the following sub-models: (1) Model 1: response variable ~ family * distance * plant; (2) Model 2: response variable ~ family * distance + plant; (3) Model 3: response variable ~ family + distance * plant; (4) Model: response variable ~ family + distance + plant, (5) Null model: response variable ~ 1. We obtained the best-model selecting that one with the lowest AICc throughout the function aictab from "AICcmodavg package" version 3.2-1 (Mazerolle 2020). To compare the differences in abundance and richness among families we performed a post-hoc analysis using the glht function from "multcomp package" version 1.4-17 (Hothorn et al. 2021). To test the variation in composition of predatory and phytophagous mites over distance and among plants, we used Permutational analysis of multivariate dispersions (PERMDISP) and Permutational multivariate analysis of variance (PERMANOVA) using the function betadisper and adonis, respectively, both from package 'vegan' version 2.4-2 (Oksanen et al. 2017). When we found differences in composition among treatments, we performed pairwise comparison using pairwise adonis function with Bonferroni correction (Arbizu 2019). All analyses were performed in R version 3.5.1 (R Core Team 2018)

Results

Abundance and richness on coffee and IPS

In total, we collected 8259 specimens belonging to 8 families and 28 species. Of the 28 species, 16 were predators (2 Iolinidae, 12 Phytoseiidae and 2 Stigmaeidae) and 12 were phytophagous (4 Eriophyidae, 1 Diptilomiopidae, 1 Tarsonemidae, 1 Tenuipalpidae and 5 Tetranychidae). On coffee, Tenuipalpidae was the most abundant family (n= 656) but only one species was reported, followed by Tetranychidae (n=96) with 2 species and Phytoseiidae (n=67) with 4 species. On IPS, Eriophyidae was the most abundant family (n= 6252) with 4 species, followed by Tenuipalpidae (n=257) with 1 species and Phytoseiidae (n=282) with 11 species (Table 1, Table 2).

Diversity and composition on coffee crops

The best model that described the mite abundance was *families* + *distance* + *plant* (AICc= 698.14; and AICcWt = 0.84) (Tab. S1). We found statistical differences in Family abundance (X^2 = 626.83, df = 4, p > 0.001). No difference was found to distance (X^2 = 5.80, df = 3, p = 0.12) and plant (X^2 = 1.13, df = 2, p = 0.56, R^2=0.59).

In the coffee system studied, Tenuipalpidae was the most abundant family and Stigmaeidae was the least one. We also found differences in Stigmaeidae vs. Iolinidae, Phytoseiidae, Tenuipalpidae and Tetranychidae, as well to Tenuipalpidae vs. Iolinidae, Phytoseiidae and Tetranychidae, and Tetranychidae vs. Iolinidae (Figure 2, Table 3).

The best model that described the mite richness was *families* + *distance* + *plant* (AICc= 331.16; and AICcWt = 1.00) (Tab. S1). We found statistical differences in Family richness (X^2 = 39.537, df = 4, p > 0.001). No difference was found to distance (X^2 =0.899, df = 3, p = 0.82) and plant (X^2 =0.14, df = 2, p = 0.93, R^2=0.39).

The richness was similar in all families, but it differs from Stigmaeidae vs. Iolinidae, Phytoseiidae, Tenuipalpidae and Tetranychidae (Figure 3, Table 4).

We did not find variation in composition between mite communities along distance in coffee plants (PERMDISP: F = 0.07 p = 0.93; PERMANOVA; R^2 = 0.12, p = 0.63; Figure 4). But the composition of phytophagous on IPS was different (PERMDISP: F= 0.21, p =0.80; PERMANOVA: R^2 = 0.22, p < 0.05, Figure 5A). *Inga edulis* was different from *S. macranthera* (R^2 =0.32, p < 0.05) and *V. curassavica* (R^2

=0.32, $P<0.05$), but we did not find difference between *V. curassavica* and *S. macranthera* (R^2= 0.09, p = 0.36).

The composition of predators on IPS was also different (PERMDISP: F= 0.18, p =0.83; PERMANOVA: R^2 = 0.33, $p < 0.001$, Figure 5B). *Inga edulis* were different from *V. curassavica* (R^2 =0.32, $P<0.05$) and *S. macranthera* (R^2 =0.32, $P<0.05$), but *V. curassavica* and *S. macranthera* was not different (R^2 =0.09, P=0.37).

The predatory mite species commons in all IPS were *Pseudopronematulus nadirae* Silva, Da-Costa & Ferla, *Euseius citrifolius* (Denmark & Muma), *E. concordis* (Chant), *E. sibelius* (De Leon), *Typhlodromalus aripo* DeLeon and *Agistemus floridanus* Gonzalez. In general, *I. edulis* houses more predator species than the other IPS, with *Amblyseius* sp., *E. alatus* DeLeon, *Iphiseiodes zuluagai* Denmark & Muma and *Agistemus brasiliensis* Matioli, Ueckermann & Oliveira occurring only on this plant species. *Varronia curassavica* have only one exclusive species (*Neoseiulus tunus* (De Leon)) and *S. macranthera* did not have any exclusive species.

Brevipalpus yothersi and *Atrichoproctus uncinatus* Flechtmann were the only phytophagous mite species common in all IPS. Eriophyidae sp1., *O. ilicis* and *Tetranychus* sp. are the species exclusive of *I. edulis.* Eriophyidae sp2 and sp3, Diptilomiopidae sp. and *P. latus* were the species that occurs only on *V. curassavica* and *Aculus* sp. and *Mononychellus planki* (McGregor) are the only two species exclusive from *S. macranthera.* The number of Eriophyidae on *I. edulis* is high (4885), despite having only one species, while *V. curassavica* and *S. macranthera* have different species, and in a much lower number. It is important to notice that despite being a pest on coffee, *P. latus* only occurs on *V. curassavica* with no records on coffee.

Discussion

The data presented here shows that the plants intercropped are a reservoir of natural enemies as it harbors several species of predators. However, it does not modify the community of predators and phytophagous mites in coffee plants along the distance.

Diversified coffee production systems attract predators, mostly wasps and parasitoids, increases biological control, improves soil quality and decreases the spontaneous plants (Silva et al. 2013; Rezende et al. 2014; De Souza et al. 2017; Peixoto et al. 2017; Androcioli et al. 2018; Rezende et al. 2021; Rosado et al. 2021). Studies with *Inga* spp. demonstrate the positive effects of this plant intercropped with coffee increasing natural control of coffee berry borers and coffee leaf miners, important coffee pests, by attracting wasps and parasitoids due to the provision of nectar and consequently enhancing the coffee production (Rezende et al. 2014, 2021). So, in this work we can see that not just *I. edulis* so as *V. curassavica* and *S. macranthera* houses predators. All predatory mites found on coffee were also found on IPS (except for *A.* aff *impressus* that have only one individual) meaning that coffee predators are benefiting from IPS, but what is the exactly source of attraction and benefits are not clear. Besides providing additional food sources such as pollen and nectar, the intercropped plants also can provide shelter, favorable microclimate and a habitat where preys are present (Landis et al. 2000).

The composition of phytophagous and predaceous mites were different in *I. edulis* and similar in *V. curassavica* and *S. macranthera*. *Inga* plants harbored much more predators than other IPS and did not harbored *P. latus* and just few *O. ilicis* (n=1), two herbivore pests of economic impact on coffee crops. *Senna macranthera* doesn't host any of these pest species and also harbors some predators. This is an important finding because these plants have the potential of harboring different natural enemies and do not attract these coffee pest species.

The natural enemies found in this work belong to the families Stigmaeidae, Iolinidae and Phytoseiidae, being the last one with the most number of species. Most of the species found here are known as feeding and reproducing on a wide range of prey and in the case of Phytoseiidae, pollen and nectar can constitute an important part of their diet (Hessein and Perring 1988; Thistlewood et al. 1996; McMurtry and Croft 1997; Abou-Awad et al. 1999; Horn et al. 2011; McMurtry et al. 2013; Van de Velde et al. 2021). This is an important predatory family, extensively studied and used for biological control of pests (Gerson et al. 2003). Species of the genus *Amblyseius, Neoseiulus*, *Galendromus* and *Typhlodromalus* have records of feeding on pollen, Eriophyidae, Tarsonemidae, Tetranychidae, Tydeoidea and other families (McMurtry and Croft 1997; McMurtry et al. 2013). Besides that, *Euseius* and *Iphiseiodes* are pollen feeding generalists that prey on a range of mite families, being *B. phoenicis* one of them (McMurtry et al. 2013; Reis et al. 1998; Reis et al. 2003; Yamamoto and Gravena 1996). At the time of studies cited above, the *B. phoenicis* were not divided into a species complex yet (Beard et al. 2015a) and all the species of these complex were called just *B. phoenicis,* so we cannot know for sure which species of these complex this works refers. Additionally, *I. zuluagai* can feed on sugary substances, being able to be reared on a range of alternative food sources (Yamamoto and Gravena 1996; Albuquerque and Moraes 2008).

The feeding habits of Tydeoidea are diverse (André and Fain 2000) and Iolinidae are associated with several phytophagous species, preying Eriophyidae, Tenuipalpidae and Tetranychidae (Hessein and Perring 1988; Abou-Awad et al. 1999; Horn et al. 2011; Van de Velde et al. 2021). Other mites that feed on Eriophyoidea are Stigmaeidae, which also can feed on Tetranychidae (White 1976; Thistlewood et al. 1996). In this work there were a great amount of Eriophyidae and other phytophagous species belonging to Diptilomiopidae, Tenuipalpidae, Tarsonemidae and Tetranychidae. Knowing that the pests on coffee vary in quantity during the year, probably the phytophagous on IPS can be preyed and serve as alternative food by the predators recorded here, mainly when the pests on coffee are in low population (Pallini 1991; Reis and Zacarias 2007; Franco et al. 2008). Besides, the IPS stimulate diversity of natural enemies of other insect pests in this crop (Landis et al. 2005; Rezende et al. 2014, 2021).

Thus, these results suggest that IPS attract predator and herbivore mites that are not pests on coffee. These herbivores could be an alternative prey to increase the population of predators on these plants that could later migrate to coffee plants and control their pest mites. Once this happens, it could enhance conservation biological control in the area. Understanding how the dynamics of predators and prey in this system would facilitate management practices and favor the establishment of a sustainable pest mite control on coffee crops.

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Table 1: Abundances of mite species recorded on the cited plants between June 2020 and February 2021: ***Vc*** *Varronia curassavica*, ***Sm*** *Senna macranthera*, ***Ie*** *Inga edulis*, ***Ca1*** *Coffea arabica* line 1, ***Ca2*** *C. arabica* line 2, ***Ca3*** *C. arabica* line 3 and ***Ca4*** *C. arabica* line 4.

	Mite family	**Mite species**	**Plant species**						
			Vc	***Sm***	***Ie***	***Ca1***	***Ca2***	***Ca3***	***Ca4***
Phytophagous	Eriophyidae	*Aculus* sp.		1200					
	Eriophyidae	Eriophyidae sp1			4885				
	Eriophyidae	Eriophyidae sp2	70						
	Eriophyidae	Eriophyidae sp3	97						
	Diptilomiopidae	Diptilomiopidae sp.	18						
	Tarsonemidae	*Polyphagotarsonemus latus* (Banks)	65						
	Tenuipalpidae	*Brevipalpus yothersi* Baker	15	144	77	95	152	110	100
	Tetranychidae	*Atrichoproctus uncinatus* Flechtmann	12	7	12				
	Tetranychidae	*Mononychellus planki* (McGregor)		3					
	Tetranychidae	*Oligonychus coffeae* (Nietner)				7	4	12	4
	Tetranychidae	*Oligonychus ilicis* (McGregor)			1	1	1	4	2
	Tetranychidae	*Tetranychus* sp.			2				
Predators	Iolinidae	*Pseudopronematulus nadirae* Silva, Da-Costa & Ferla	41	61	1	5	7	10	4
	Iolinidae	*Pausia* sp.	5	7					

Phytoseiidae	*Amblyseius* aff. *chiapensis*	1		2				
Phytoseiidae	*Amblyseius* aff *impressus*				1			
Phytoseiidae	*Amblyseius* sp.			1				
Phytoseiidae	*Euseius alatus* DeLeon			4				
Phytoseiidae	*Euseius citrifolius* (Denmark & Muma)	5	6	7	4	2	2	1
Phytoseiidae	*Euseius concordis* (Chant)	1	1	11	4	5	3	3
Phytoseiidae	*Euseius sibelius* (De Leon)	1	6	1				
Phytoseiidae	*Iphiseiodes zuluagai* Denmark & Muma			32			2	2
Phytoseiidae	*Galendromus annectens* (De Leon)		4	2				
Phytoseiidae	*Neoseiulus tunus* (De Leon)	6						
Phytoseiidae	*Typhlodromalus aripo* DeLeon	4	4	1				
Phytoseiidae	*Typhlodromips mangleae* De Leon		1	4				
Stigmaeidae	*Agistemus floridanus* Gonzalez	38	13	78	1		1	1
Stigmaeidae	*Agistemus brasiliensis* Matioli, Ueckermann & Oliveira			2				

Table 2: Abundances of mite families recorded on the cited plants between June 2020 and February 2021: ***Vc*** *Varronia curassavica*, ***Sm*** *Senna macranthera*, ***Ie*** *Inga edulis,* ***Ca1*** *Coffea arabica* line 1*,* ***Ca2*** *C. arabica* line 2*,* ***Ca3*** *C. arabica* line 3 and ***Ca4*** *C. arabica* line 4**.**

	Mite family	**Plant species**						
		Vc	***Sm***	***Ie***	***Ca1***	***Ca2***	***Ca3***	***Ca4***
	Eriophyidae	167	1200	4885				
Phytophagous	Diptilomiopidae	18						
	Tarsonemidae	108						
	Tenuipalpidae	15	158	84	130	208	171	147
	Tetranychidae	19	14	18	16	14	27	39
	Iolinidae	85	134	2	8	12	20	11
Predators	Phytoseiidae	37	53	192	16	15	15	21
	Stigmaeidae	48	20	129	1		1	1

Table 3: Tukey contrasts between the abundance of different mite families recorded in coffee plants between June 2020 and February 2021

	Estimate	Std. Error	z value	Pr (>|z|)
Phytoseiidae - Iolinidae	0.2481	0.2155	1.151	0.7560
Stigmaeidae - Iolinidae	-2.8655	0.6038	-4.746	<0.001
Tenuipalpidae - Iolinidae	2.5244	0.1820	13.868	<0.001
Tetranychidae - Iolinidae	0.5989	0.2051	2.920	0.0242
Stigmaeida - Phytoseiidae	-3.1136	0.6003	-5.186	<0.001
Tenuipalpidae - Phytoseiidae	2.2763	0.1702	13.377	<0.001
Tetranychidae - Phytoseiidae	0.3508	0.1947	1.802	0.3406
Tenuipalpidae - Stigmaeidae	5.3899	0.5892	9.148	<0.001
Tetranychidae - Stigmaeidae	3.4644	0.5967	5.806	<0.001
Tetranychidae -Tenuipalpidae	-1.9255	0.1567	-12.286	<0.001

Table 4: Tukey contrasts between the richness of different mite families recorded in coffee plants between June 2020 and February 2021

	Estimate	Std. Error	z value	Pr (>|z|)
Phytoseiidae - Iolinidae	0.39087	0.26998	1.448	0.57553
Stigmaeidae - Iolinidae	-2.03688	0.61374	-3.319	0.00697
Tenuipalpidae - Iolinidae	0.44802	0.26694	1.678	0.42518
Tetranychidae - Iolinidae	0.26570	0.27715	0.959	0.86363
Stigmaeida - Phytoseiidae	-2.42775	0.60217	-4.032	<0.001
Tenuipalpidae- Phytoseiidae	0.05716	0.23914	0.239	0.99921
Tetranychidae - Phytoseiidae	-0.12516	0.25049	-0.500	0.98619
Tenuipalpidae - Stigmaeidae	2.48491	0.60081	4.136	<0.001
Tetranychidae - Stigmaeidae	2.30259	0.60542	3.803	0.00110
Tetranychidae - Tenuipalpidae	-0.18232	0.24721	-0.738	0.94310

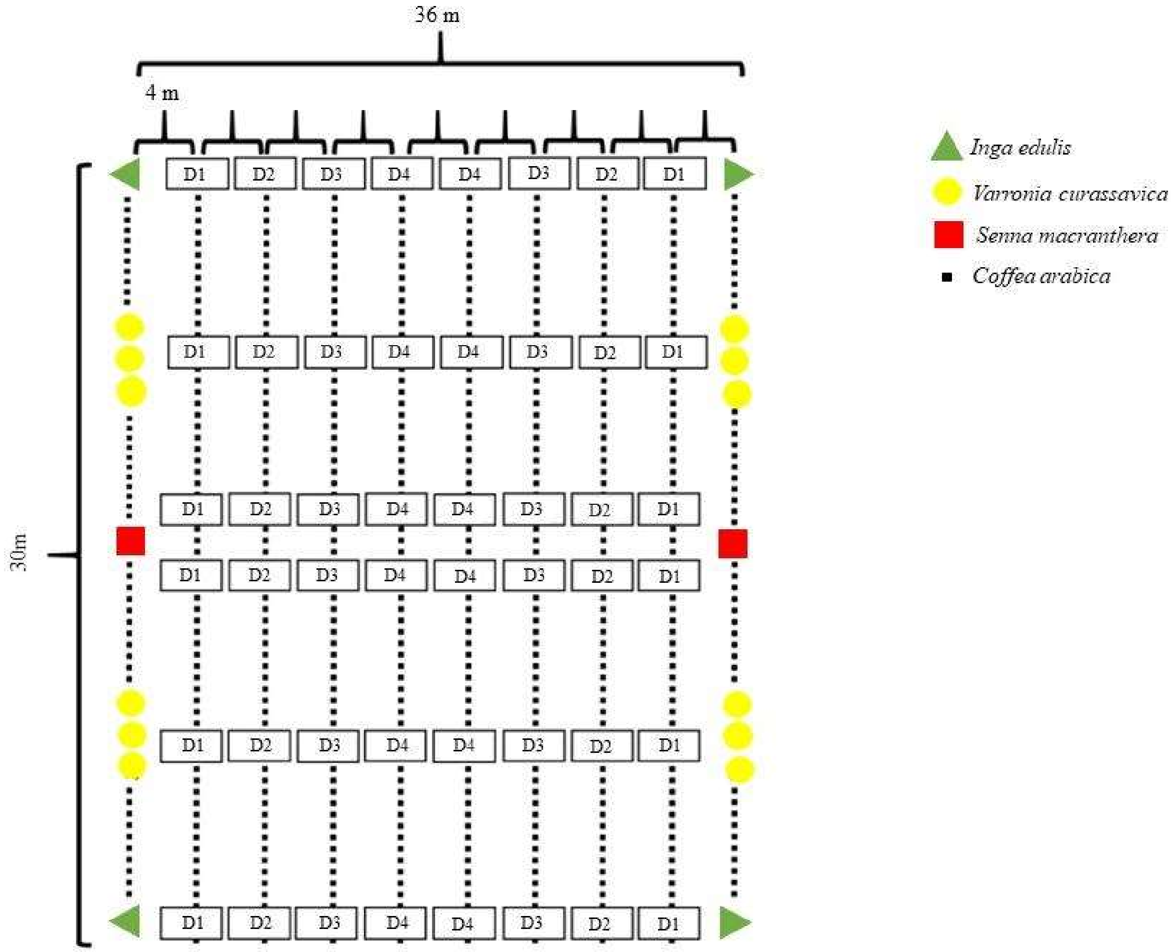

Figure 1: Adapted Botti 2021. Diversify Coffee system (1080 m²). Black points represent coffee plants, yellow circles represent *Varronia curassavica*, red squares represent *Senna macranthera* and green triangles represent *Inga edulis*. D1, D2, D3 and D4 represent the coffee plants sampled in their respective distances from IPS: D1 represents distance 1 from IPS (4 m); D2 represents distance 2 from IPS (8 m); D3 represents distance 3 from IPS (12 m) and D4 represent distance 4 from IPS (16 m).

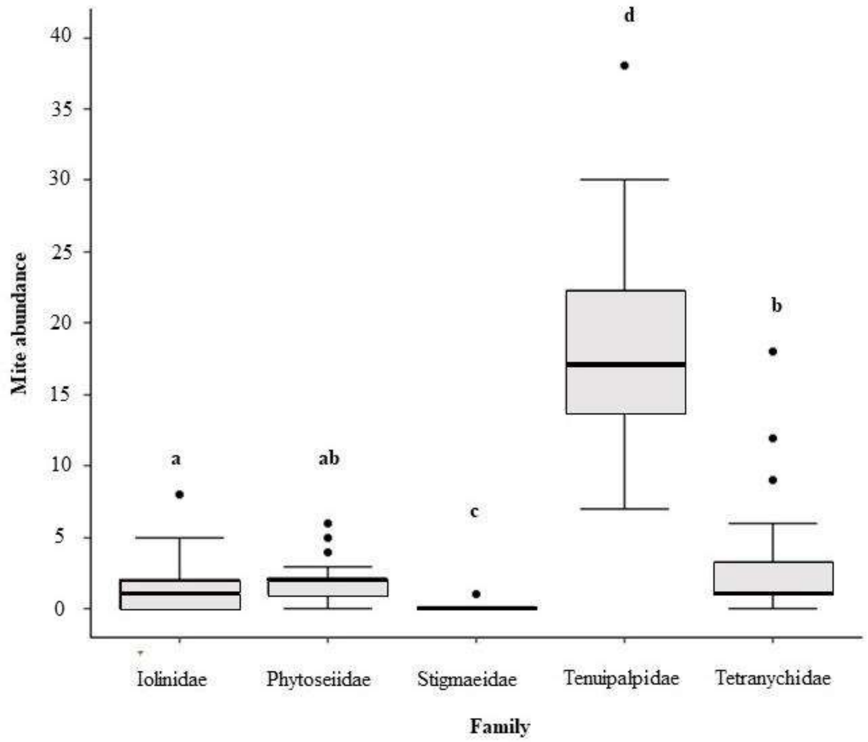

Figure 2: Abundance of mites in the coffee system. The thicker line indicates the medians. Boxes represent 25 to 75 percent of the data distribution and black spots are outliers. Different letters correspond to significant differences between treatments.

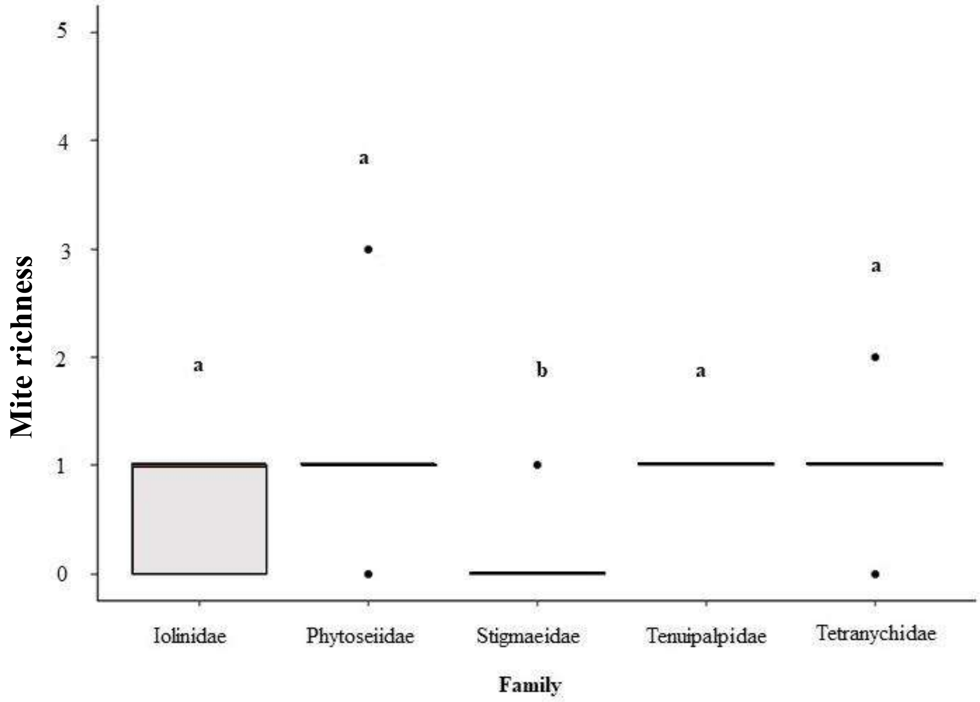

Figure 3: Richness of mites in the coffee system. The thicker line indicates the medians. Boxes represent 25 to 75 percent of the data distribution and black spots are outliers. Different letters correspond to significant differences between treatments.

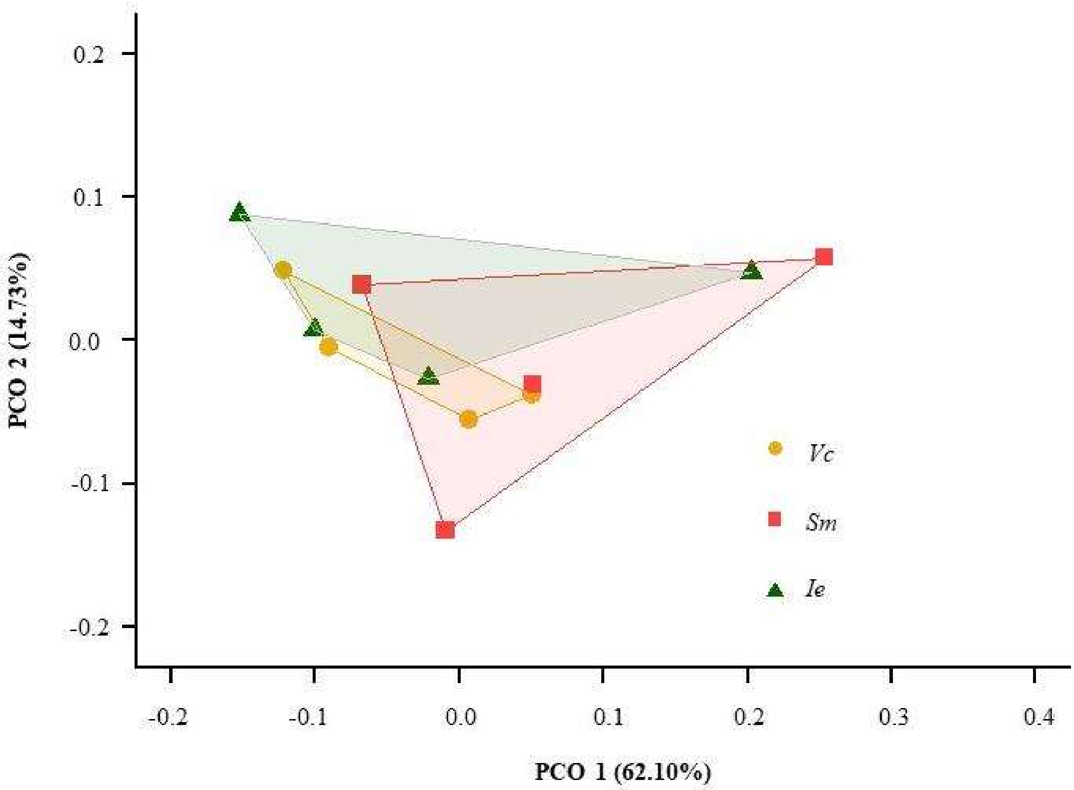

Figure 4: Principal coordinate analysis (PCO) plot based on Bray–Curtis dissimilarity index from samples of predator and phytophagous composition in coffee plants. Yellow circles represent *Varronia curassavica* (*Vc*), red squares represent *Senna macranthera* (*Sm*) and green triangles represent *Inga edulis* (*Ie*).

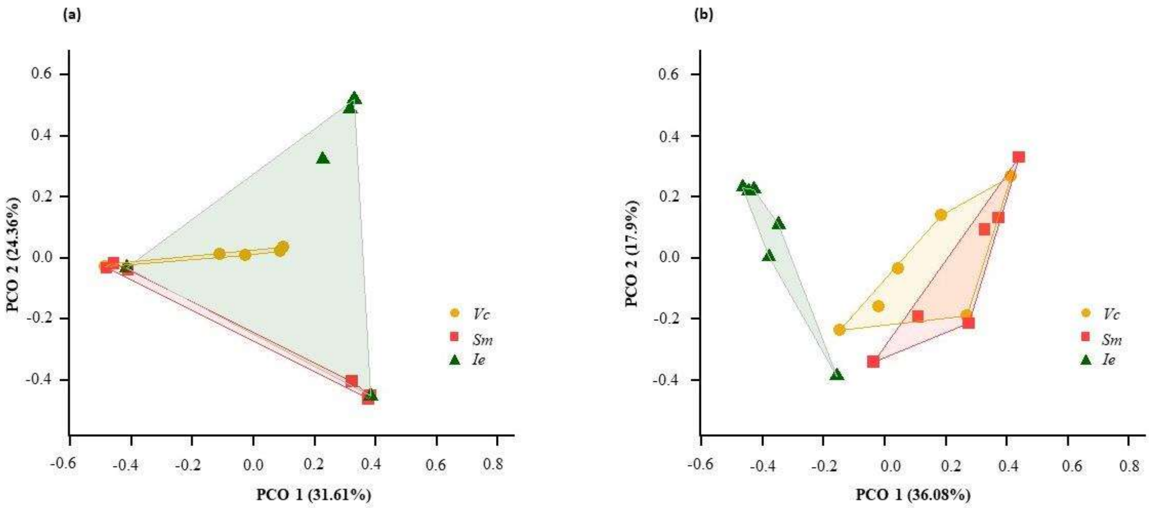

Figure 5: Principal coordinate analysis (PCO) plot based on Bray–Curtis dissimilarity index from samples of predator and phytophagous composition between IPS. Composition of phytophagous (a) and predators (b) from IPS. Yellow circles represent *Varronia curassavica* (*Vc*), red squares represent *Senna macranthera* (*Sm*) and green triangles represent *Inga edulis* (*Ie*).

Table S1: Comparison of response models to the mite abundance and richness. AICc is Akaike Information Criterion corrected; ΔAICc is the difference in AICc between the model and the model with the smallest AICc; AICcWt is the model weight according to ΔAICc.

Richness	AICc	ΔAICc	AICcWt
model 4	331,16	0,00	1,00
model 2	343,51	12,35	0,00
null model	352,46	21,30	0,00
model 3	357,19	26,03	0,00
model 1	475,45	144,29	0,00
Abundance	AICc	ΔAICc	AICcWt
model 4	698,14	0,00	0,84
model 2	701,47	3,33	0,16
model 3	711,50	13,36	0,00
model 1	798,81	100,67	0,00
null model	910,01	211,87	0,00

Chapter 2

New tydeid mite (Acari: Prostigmata) associated to coffee and inga plants

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Abstract
A new species of Tydeidae (Acari: Prostigmata) is herein described and illustrated. It was collected from *Coffea arabica* L. (Rubiaceae) and *Inga edulis* Mart. (Fabaceae) plants from Cerrado biome in the state of Minas Gerais, Brazil. It has been named *Tydeus mineirensis* **sp. nov.**. A dichotomous key of Tydeoidea recorded on coffee crops in the states of São Paulo and Minas Gerais is provided.

Keywords: Cerrado biome*, Coffea arabica*, *Inga edulis*, mite, *Tydeus*.

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2 Chapter formatted in the norms of Acarologia

Introduction

Brazil is the largest world coffee producer and exporter, being Minas Gerais the state with the largest cultivated area in the country. The main species cultivated is arabica coffee (*Coffea arabica* L.) (Conab 2021). In attempt to diversify coffee crops, leguminous trees of the genus *Inga* Miller (Fabaceae) are used by coffee farmers in some Brazilian regions (Cardoso *et al.* 2001; Grossman 2003; Souza *et al.* 2010). Besides providing shade and wood, and fixing nitrogen, these trees possess extrafloral nectaries that benefit natural enemies of coffee pests, thereby decreasing pest damage (Rezende *et al.* 2014, 2021).

Coffee crops harbor several mite species, and some of them belong to the Tydeidae family (Pallini 1991; Mineiro *et al.* 2001; Spongoski *et al.* 2005; Mineiro *et al.* 2006a, 2006b; Marchetti 2007; Mineiro *et al.* 2008, 2009, 2010; Berton *et al.* 2019; Mineiro *et al.* 2019). The superfamily Tydeoidea was reorganized by André & Fain (2000) and comprises four families: Iolinidae, Ereynetidae, Edbakerrelidae and Tydeidae. Only Edbakerrelidae was not recorded in the Brazilian coffee crops. Tydeidae is the commonest Tydeoidea family found in this crop (Pallini 1991; Mineiro *et al.* 2001; Spongoski *et al.* 2005; Mineiro *et al.* 2006a, 2006b; Marchetti 2007; Mineiro *et al.* 2008, 2009, 2010; Berton *et al.* 2019; Mineiro *et al.* 2019).

The genus *Tydeus* comprises 49 species, but only two of them are described from Brazil: *Tydeus riopardensis* Silva, Cunha & Ferla and *T. manoi* Silva, Rocha & Ferla from the state of Rio Grande do Sul (Silva *et al.* 2016). The aim of this work was to describe a new species of Tydeidae, from the state of Minas Gerais, based on specimens collected on both *C. arabica* and *I. edulis* and to provide a dichotomous key of Tydeoidea reported from coffee crops in the states of Minas Gerais and São Paulo, Brazil.

Material and Methods

Samples of *C. arabica* and *I. edulis* leaves were collected from the EPAMIG Experimental Farm, in Patrocínio county (18°59'52.0"S 46°58'59.8"W), Minas Gerais, Brazil, in the Cerrado biome, during 2020 - 2021. *Inga edulis* was intercropped with *C. arabica*, and it possesses extrafloral nectaries, which provide alternative food to the natural enemies of coffee pests and enhances conservation biological control on the crop (Rezende *et al.* 2014; 2021). All collected leaves were placed in plastic bags, kept in a styrofoam box with Gelox® at low temperature and taken to the Laboratory of Acarology, at the Department of Entomology of Federal University of Viçosa (UFV), Viçosa, Brazil. The mites were mounted on slide glasses under a stereomicroscope in Hoyer's medium (Krantz and Walter 2009).

The identification of Tydeoidea mites was done with a phase contrast microscope and based on dichotomous keys (André 1980; Kaźmierski 1998; Silva *et al.* 2016). Drawings were made using Adobe illustrator® program. The nomenclature of idiosomal chaetotaxy follows Kaźmierski (1989, 1998) and leg chaetotaxy follows André (1981). All measurements are in micrometers (µm) and the measurements are those of the holotype followed by the range of the paratypes in parentheses. Number of setae on leg segments are from tarsi to trochanter.

The dichotomous key was made with the species of Tydeoidea sampled and those already reported on coffee plants (*C. arabica* and *C. canephora* Pierre) from the states of Minas Gerais and São Paulo (Pallini 1991; Mineiro *et al.* 2001; Spongoski *et al.* 2005; Mineiro *et al.* 2006a, 2006b; Marchetti, 2007; Mineiro *et al.* 2008, 2009, 2010; Berton *et al.* 2019; Mineiro *et al.* 2019).

Results

Systematic

Family **Tydeidae** Kramer 1877
Subfamily **Tydeinae** Kramer sensu André 1980
Genus *Tydeus* (Koch 1835)

Tydeus mineirensis Ferla & Pallini **sp. nov.**
(Figures 1 - 5)

General diagnosis

All dorsal setae, except for *ro*, *la* and *bo*, are short and spatulated. Ventral setae are slender and smooth. Dorsal ornamentation is striated, type *Tydeus*. Some specimens with and others without longitudinal striae between *ro*, *la* and *bo*. Setae *d* are bifurcated. Some seta on legs I-IV are smooth and some serrated. Empodium with two hooks.

Description. Adult female (n=7)

Dorsum (Figure 1) - Dorsum with 13 pairs of setae (*ro*, *la*, *bo*, *ex*, *c1*, *c2*, *d*, *e*, *f1*, *f2*, *h1*, *h2* and *ps1*). Dorsal shield (excluding gnathosoma) 280 (268 - 300), width 203 (200 - 210). Setae *ps1* is located dorsally. Dorsum of idiosoma faintly striated. Dorsal setae are short and spatulate, except for *ro* and *la*, that are slightly serrated and *bo* is smooth. Striation U-shaped between setae *c1* and *d1*, transverse to diagonal posterior to setae *d1*. There is a variation in this species, some specimens have a suture between the propodosoma and the hysterosoma and some of them do not.

Lengths of dorsal setae: *ro* 15 (13 - 15), *la* 15 (13 - 15), *bo* 33 (33 - 35), *ex* 15 (10 - 15), *c1* 13 (10 - 13), *c2* 10 (10 - 13), *d* 15 (10 - 15), *e* 13 (10 - 15), *f1* 15 (13 - 15), *f2* 13 (10 - 15), *h1* 13 (13 - 15) and *h2* 15. *Distances between dorsal setae: ro-ro* 30 (23 - 33), *la-la* 88 (88 - 128), *bo-bo* 60 (58 - 68), *ex-ex* 138 (53 - 70) *c1-c1* 48 (48 - 55), *c2-c2* 175 (170 - 210), *d1-d1* 33 (33 - 38), *e1-e1* 90 (88 - 100), *f1-f1* 23 (23 - 28), *f2-f2* 58 (55 - 65), *h1-h1* 23 (20 - 25), *h2-h2* 50 (38 - 50), *ro-la* 33 (30 - 40), *c1-d1* 50 (48 - 53), *d1-e1* 40 (23 - 40), *e1-f1* 43 (38 - 43), *f1-f2* 15 (13 - 18) and *h1-h2* 13(13 - 15).

Venter (Figure 2) - All venter striated (Coxa I, III and IV with reticulations). All ventral setae are slender and smooth. Anogenital area with five pairs of genital setae, four pairs of aggenital and one pair of pseudoanal setae. Genital striation pattern extended. Shape of *cg* organ elliptical. Epimeral formula: 2-1-3-1.

Measurements of setae: *pt* 13 (10 - 15), *mtα* 13(10 - 15) and *mtβ* 13 (10 - 13). Four pairs of aggenital setae (*ag1*, *ag2*, *ag3* and *ag4*) and one pair of pseudanal setae (*ps2*). Setal lengths: *ag1* 10 (5 - 10), *ag2* 10 (5 - 10), *ag3* 13 (5 - 13), *ag4* 8 (8 - 13), *g1* 5 (5 - 8), *g2* 5 (4 - 8), *g3* 6 (5 - 6), *g4* 5 (5 - 6), *g5* 7 (5 - 10) and *ps2* 7 (7 - 13).

Gnathosoma (Figure 3). Length 48 (43 - 53), width 57 (50 - 58). Gnathosoma visible from above. Setal lengths: *sc1* 14 (8 - 14), *sc2* 9 (9 - 18). Palp (from genus to tarsus) 44 (38 - 60) long, setation 5(+1ω)-2-2 (Figure 4), setae *d* distally bifurcated. Palp tarsus with eupathidium *ρζ* 44 (43 - 45) semilunar distally. Palptarsus significantly longer than cheliceral digits. Cheliceral stilettos 14 (13 - 15) long.

Legs. (Figure 5A-D) - Leg setae are smooth, except for some seta that are serrated: two dorsal setae from genu I, two ventral from genu II and one dorsal from genu III and IV each, two on tibia IV and one dorsal on femur I. Tarsi I-IV with two claws and hairy empodium but empodial hooks (*om*) are absent. Some leg segments with ventral reticulations. Chaetotaxy of legs I–IV (tarsus to trochanter): I: 8(+1ω)-3(+1κ)-3-3-1 (Figure 5A); II: 6(+1ω)-2-2-2-0 (Figure 5B); III: 5-2-1-1-1 (Figure 5C) and; IV: 5-2-1-1-0 Figure 5D). Length of leg (from trochanter to tarsi): I 133 (123 - 155), leg II 113 (88 - 113), leg III 130 (103 - 130) and leg IV 143 (123 - 143).
Length of tarsus + apotele I 44 (43 - 45) and 10 (10 - 13) width, length of solenidion *ωI* 5 (4 - 5), length of seta *ft'* 20 (11 - 20), *ft''* 13 (11 - 21), length of seta *k* 3 (1–3), length of *ωII* 3 (2 - 3).

Male. Unknown.

Differential diagnosis

The new species is similar to *T. munsteri* Meyer & Ryke, *T. nieuwkerkeni* André, *T. taiwanensis* (Baker) and *T. costensis* Baker. However, it differs from the number of genital setae: *T. munsteri* presents 4 setae, the others species 6 and *Tydeus mineirensis* **sp. nov.** 5 setae.

The dorsal setae of *T. munsteri* is similar to *Tydeus mineirensis* **sp. nov.**, while the dorsal setae of *T. nieuwkerkeni* is characterized by three pairs of short and spatulated setae. *Tydeus taiwanensis* has some dorsal setae slightly spatulated and others broadly and *T. costensis* has dorsal body setae slender and slightly serrated. Besides these characteristics, *T. taiwanensis*, *T. costensis* and *T. munsteri* have *bo* not exceeding the base of the next arrow (*c1*), while *bo* of the new species exceed the base of *c1*.

Etymology

The species name is a tribute for the first Tydeidae described for state of Minas Gerais.

Type material

Female holotype and 6 female paratypes.

Patrocínio, Minas Gerais, Brazil, (18°59'52.0"S 46°58'59.8"W), collected by Ferla J. J. from Jun. 2020 to Feb. 2021. Holotype and three paratype are deposited in the collection of the Acarology and Entomology Department, Escola Superior de Agricultura "Luiz de Queiroz", University of São Paulo (ESALQ/USP), Piracicaba, São Paulo State, Brazil. There are one paratype deposited at Laboratory of Acarology, Department of Entomology, Federal University of Viçosa (UFV), Viçosa, Minas Gerais state, Brazil and two paratypes deposited at the Museu de Ciências Naturais (ZAUMCN), Universidade do Vale do Taquari - Univates, Lajeado, Rio Grande do Sul state, Brazil.

Dichotomous key of Tydeoidea mites on Coffee plants (*C. arabica* and *C. canephora*) to São Paulo and Minas Gerais state, Brazil (based partially on André 1980; André and Fain 2000; Baker 1965; Kaźmierski 1998; Silva *et al.* 2016)

1. With posterior bothridia on the opisthosoma……………………………………………..………..…......Ereynetidae
- Without posterior bothridia on the opisthosoma……………………………………………….…………..……..……..2

2.Pretarsus of leg I present and normal …..Tydeidae…………………..……………………………………………...………....3
- Pretarsus of leg I with vestigial claws or with no claws…..Iolinidae…..6

3. Genu II with one or two seta; double or triple eupathidia at the end of the palptarsus…..Tydeinae……………..……………………………………..……....4
- No setae on genu II; triple eupathidia at the end of the palptarsus…..Pretydeinae…..Trochanter II with seta……...……………………………………………...…….……...*Pretydeus* André

4. Femur III with two setae…..*Lorryia sensu* André…..Dorsal idiosomal setae nude; reticulate areas are divided into Ac2, A(c1), Ac2, Ae1, A(d1), and Ae1 ……………………………………………………..……..*Lorryia formosa* Cooreman
- Femur III with one seta . . . . ….…... 5

5. Femur II with three setae………………….……..…....……..*Pseudolorryia* Kaźmierski
- Femur II with two setae…..*Tydeus* Koch….. Genital with 5 setae (*g1-g5*); dorsal setae spatulated, except for *ro*, *la* and *bo* ……………………………………………………..……..*Tydeus mineirensis* **sp. nov.**

6. Setae *la* reduced or absent…..*Parapronematus* Baker…..Femur III and IV with forked setae ………………………………….…..….....*Parapronematus acaciae* Baker
-Setae *la* present and normal…………………………..…………………...……………………..……………..7

7. Tarsus I with 8 setae; femur IV divided…..*Pseudopronematulus* Fan & Li…..Tarsus IV with five setae and tarsus II with six setae…………………….……....*Pseudopronematulus nadirae* Silva, Da-Costa & Ferla
-Tarso I with 8 setae; femur IV entire……..………..…..…………………..…………………………………......…......8

8. Tarsus III and IV with 6 setae; four pairs of aggenital setae ……………………………………..……..…..………….....*Homeopronematus* André
-Tarsus III with 6 setae and tarsus IV with 5 setae; three pairs of aggenital setae …………………………………………….…………………....*Metapronematus* André

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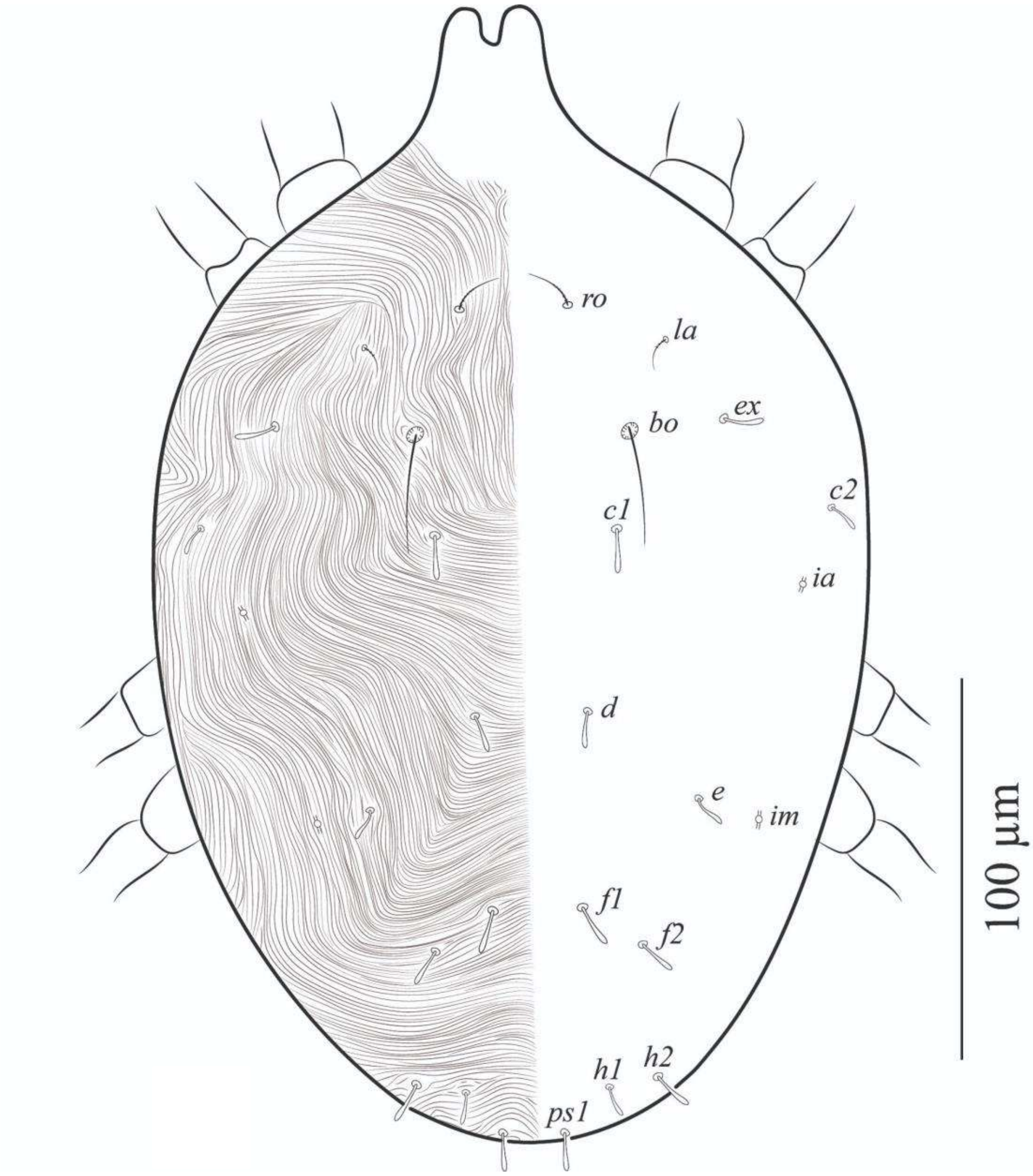

Figure 1: *Tydeus mineirensis* **sp. nov.** Female. Idiosoma in dorsal view.

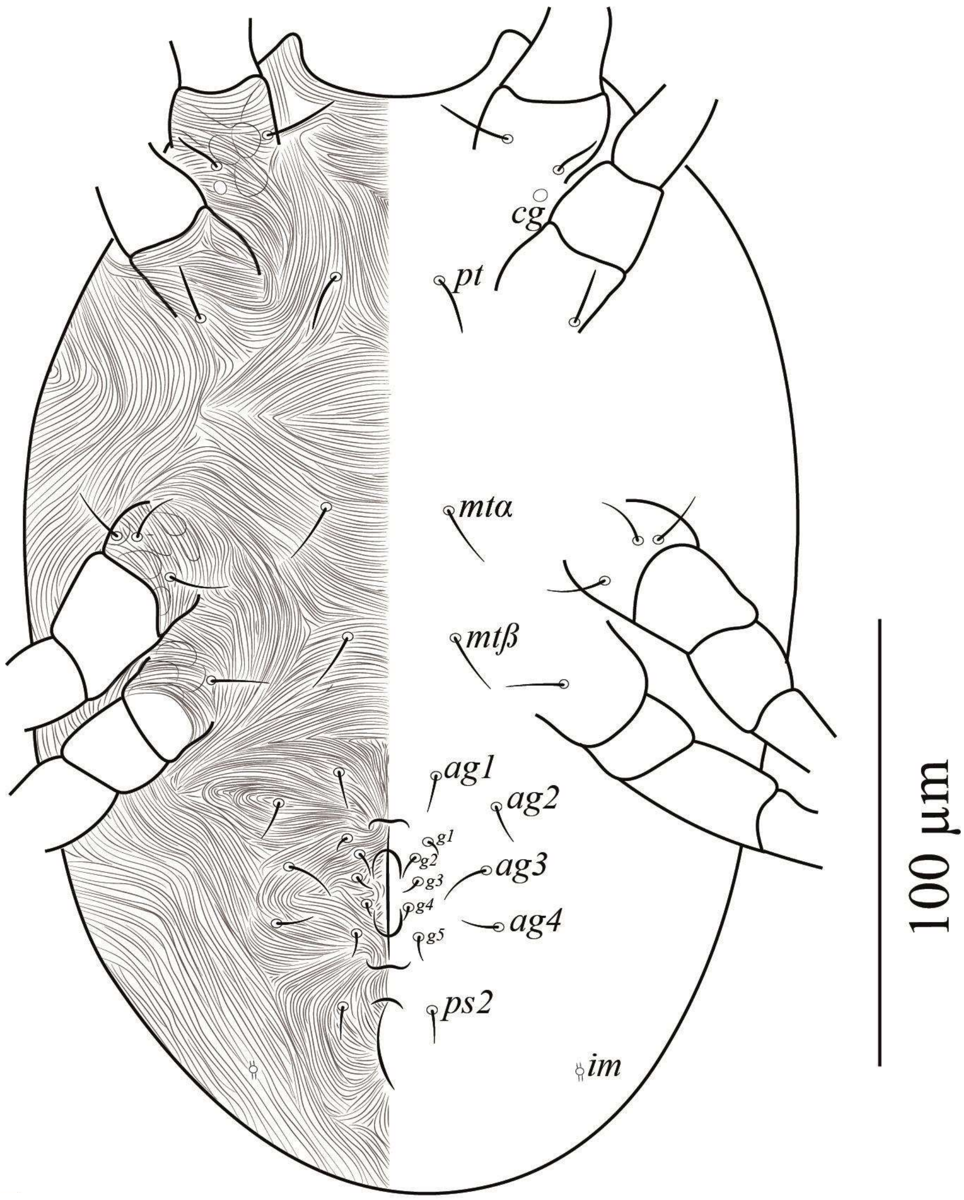

Figure 2: *Tydeus mineirensis* **sp. nov.** Female. In ventral view.

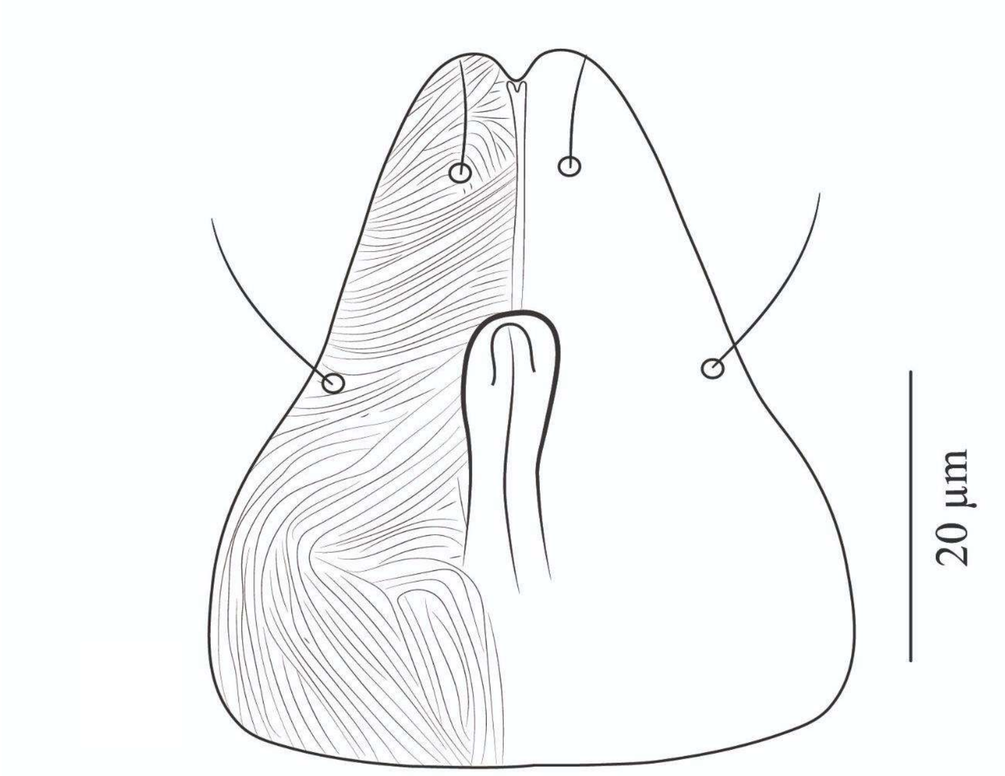

Figure 3: *Tydeus mineirensis* **sp. nov.** Female**.** Gnathosoma in ventral view**.**

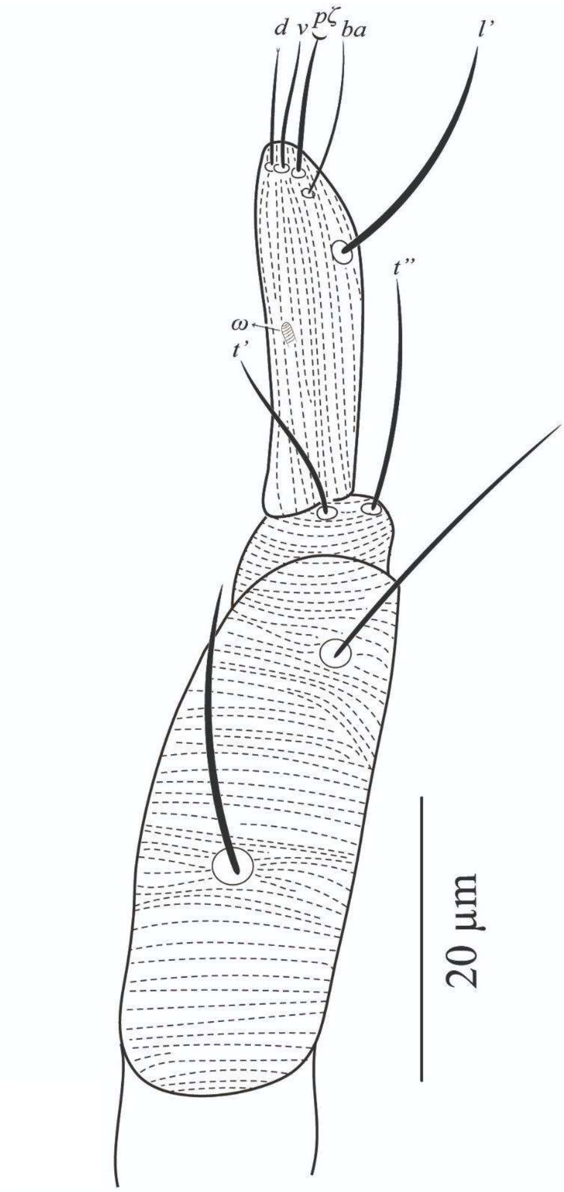

Figure 4: *Tydeus mineirensis* **sp. nov.** Female. Palptarsus.

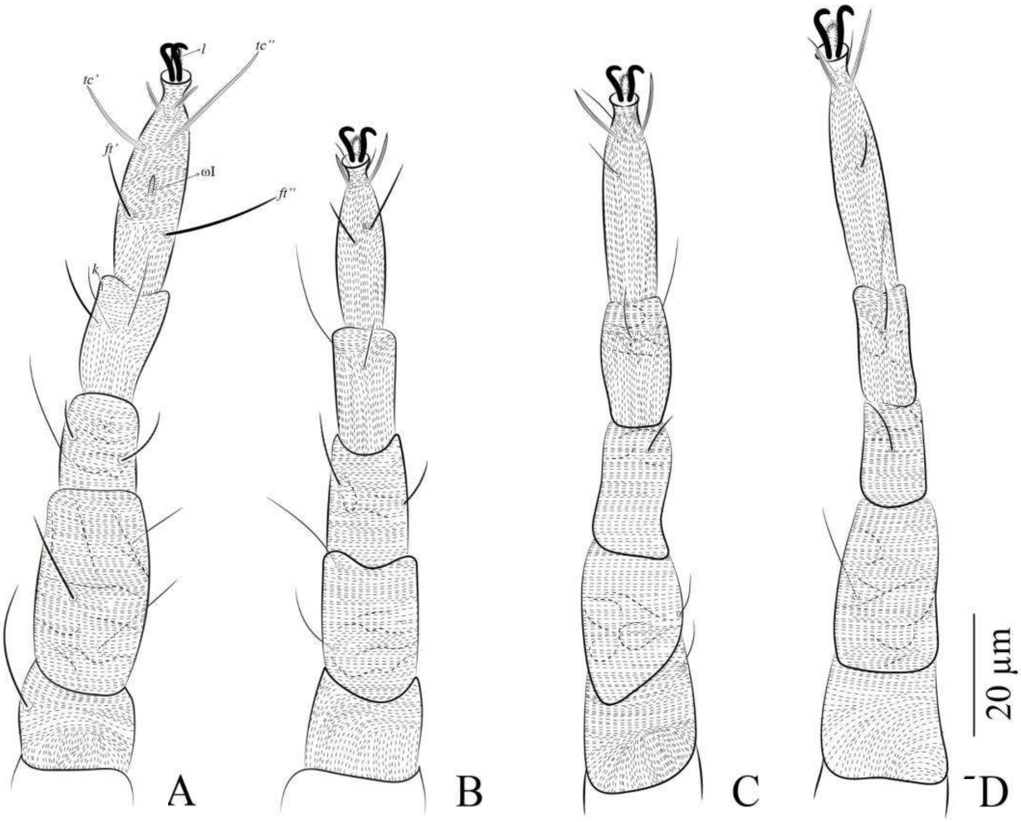

Figure 5: *Tydeus mineirensis* **sp. nov.** Female. A - Leg I; B - Leg II; C - Leg III; D - Leg IV; (From trochanter to tarsi).

GENERAL CONCLUSIONS

Our main conclusions provide evidence that the abundance and richness of predatory and phytophagous mites families are different in coffee intercropped with plants that provides alternative food, but their composition is not. Furthermore, the communities of these mites do not change if their distance from the IPS increases.

The composition of phytophagous and predatory mites is different in IPS. It is similar between *S. macranthera* and *V. curassavica* and different from *I. edulis*. These 3 plant species are a reservoir of natural enemies of predatory mites and harbor herbivorous mites that are not pests on coffee and they can serve as alternative prey to predators in the crop.

Finally, we described a new mite species named *Tydeus mineirensis* **sp. nov.** recorded on coffee and *I. edulis* plants and it is the first Tydeidae described for Minas Gerais state.