Diversity of insects associated with two common plants in the Brazilian Cerrado: Responses of two guilds of herbivores to bottom-up and top-down forces

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Abstract. The Trophic Cascade Theory has been used to explain the organization of herbivorous insect communities in tropical ecosystems. In addition, the insect community associated with a species of plant can also be determined by the geographical distribution and taxonomic isolation of the plant. In this study, the following predictions about the number of herbivores associated with particular host plants were tested: (i) plant species belonging to large taxonomic groups with broad geographical distributions have a higher number, (ii) the abundance of ants negatively affects herbivore insect diversity, (iii) local plant diversity positively affects chewing herbivore diversity and (iv) local abundance of a specific host plant positively affects the diversity of sucking herbivores. The samples of insect herbivores were collected from 32 plants (16 plants of *Erythroxylum suberosum* and 16 of *Qualea parviflora*) by beating. A total of 71 ants (13 species) and 158 herbivorous insects (90 species) were collected from these two species of plants. The richness and abundance of the insect herbivores collected from *E. suberosum* differed from those collected from *Q. parviflora*. The abundance of ants negatively affected the diversity of sucking insects associated with *E. suberosum*. In addition, the interaction between the variables total plant richness per plot and ant abundance affected the diversity of chewing insects associated with *E. suberosum*. The density of *Q. parviflora* per plot affected the diversity of associated sucking insects. In addition, the interaction of the variables abundance of ants and abundance of *Q. parviflora* influenced the diversity of chewing insects. Our results indicate that there is no predominance of bottom-up or top-down forces in the organization of herbivorous insect communities in this area of tropical savanna, but the roles of these forces on insect communities are guild-dependent.

INTRODUCTION

The Trophic Cascade Theory predicts that every trophic level is directly affected by the upper and lower trophic levels (Paine, 1980; Carpenter et al., 1985). This theory is used to explain the organization of communities of insect herbivores in ecosystems (Del-Claro, 2004; Abdala-Roberts et al., 2010; Scherber et al., 2010; Moon & Silva, 2013). Many studies indicate that communities of insect herbivores are shaped by a top-down interaction (e.g. predation and parasitism) with the third trophic level (e.g. Vega et al., 2012; Hoog & Daane, 2015) and by bottom-up effects, such as chemical and physical plant defenses (e.g. Richards et al., 2015), plant architecture (e.g. Lázaro-González, 2017) and vegetation heterogeneity (e.g. Moon & Silva, 2013; Lin et al., 2015). In addition, recent studies have also shown that communities of insect herbivores can

also be shaped by the interactions that occur at the same trophic level (Kaplan & Denno, 2007; Cornelissen et al., 2013).

Vegetation heterogeneity (i.e. richness and abundance of plants) is considered to be a good predictor of the local diversity of insect herbivores, especially in tropical terrestrial ecosystems (Araújo et al., 2013; Leal et al., 2015; Nascimento et al., 2015). In general, the number of insect species is directly related to local vegetation heterogeneity (Root, 1973; McCoy et al., 1991; Scherber et al., 2010; Lin et al., 2015), but the lack of a relation (Coelho et al., 2017) or a negative relation between these variables have also been documented (Neves et al., 2012). In addition, the geographical distribution (Costa et al., 2011) and taxonomic isolation (Grandez-Rios et al., 2015) of a species of plant can affect the insect community associated with a plant.

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In general, species of plants that have a broad geographical distribution and belong to large genus or family have a greater diversity of herbivorous insects (Southwood, 1960; Grandez-Rios et al., 2015; Coelho et al., 2017).

Generalist predators can have a big effect on the organization of communities of insect herbivores in many different habitats (Dyer & Letourneau, 1999; Del-Claro, 2004; Rosumek et al., 2009). Ants are dominant invertebrate predators in tropical and subtropical terrestrial ecosystems (Brady et al., 2014) and interact with a variety of animal and plant taxa (Del-Claro et al., 1996). For example, many species of ants that feed on extrafloral nectary or honeydew exuded by homopterans reduce herbivory by driving off herbivores or eating insect herbivores (Fagundes et al., 2005). In contrast, it is also possible that ants increase the numbers of some Homoptera by moving them to particular plants (Del-Claro, 2004; Neves et al., 2011). Therefore, ants are important elements of the third trophic level and are able to shape the community of insect herbivores on plants (Davidson et al., 2003; Heil & McKey, 2003; Ribas et al., 2003; Fagundes et al., 2005; Rosumek et al., 2009). In addition, some studies also show that different insect food guilds respond differently to vegetation heterogeneity or third trophic level pressure (Grimbacher & Stork, 2007; Neves et al., 2013; Leal et al., 2015).

In general, the sucking herbivore guild is considered more specialized in the use of food resources than the chewing herbivore guild (Neves et al., 2010, 2013; Forister et al., 2015) and sucking insects generally spend more time feeding on plants than chewing herbivores (Novotny et al., 2003; Ribeiro, 2003; Mody & Linsenmair, 2004). In addition, the occurrence of specialist herbivores on a specific plant must be more dependent on the attributes of this plant because these herbivores have finer mechanisms for locating and feeding on plants (Ribeiro, 2003; Neves et al., 2011). On the other hand, habitats with high plant diversity should have a greater diversity of generalist insects (Novotny et al., 2002, 2006; Ricklefs & Marquis, 2012). In this case, we expect that the diversity of chewing herbivores on a particular plant is more dependent on local plant species diversity whereas sucking insects are more affected by attributes of their host plant.

The Cerrado (Brazilian savannah) is the second biggest Brazilian biome and one of the global biodiversity hotspots (Myers et al., 2000; Silva & Bates, 2002; Strassburg et al., 2017). Its biodiversity is one of the most diverse on this planet and no other savannah in the world has such species, shapes and functional richness (Fernandes et al., 2016). Recent estimates indicate that in the Cerrado biome there is approximately 13,140 species of plants, but its invertebrate fauna is not very well know (Fernandes, 2016). Invertebrates are of fundamental importance for the processes that structure terrestrial ecosystems (Wilson, 1987; Weisser & Siemann, 2004; Prather et al., 2013), which accounts for the growing number of studies on invertebrate communities and the use of this data for the formulation and testing of different hypothesis.

In this study we compare the herbivore insect diversity associated with two species of plants common in the Cerrado and evaluate the responses of two guilds of insect herbivores associated with these plants to generalist predators and vegetation heterogeneity. Specifically we tested the following prediction: (i) plant species belonging to large taxonomic groups with a broad geographical distribution have a higher number of associated herbivores (ii) the abundance of ants negatively affects the richness and abundance of herbivorous insects on plants (iii) the local plant richness positively affects the chewing herbivore diversity associated with a host species and (iv) the local abundance of a particular host plant positively affects the associated diversity of sucking herbivores.

MATERIAL AND METHODS

Study site

This study was carried out in a protected area (–17.215, –44.414 UTM) of approximately 98 hectares located in the municipality of Jequitaí, northern Minas Gerais, Brazil. The dominant vegetation in the study area is the regenerating "sensu stricto" cerrado. Physiognomically, the area is in the transition zone between the Cerrado and Caatinga biomes (Costa et al., 2016) and has a semiarid climate with well defined dry and wet seasons. The average annual temperature is 23°C and precipitation is approximately 1000 mm/year, with the rain falling mostly from November to January (INMET, 2016).

Plants studied

The two species of plants used to test the proposed hypotheses occur sympatrically in the study area, and are similar in size and leaf phenology. *Qualea parviflora* Mart. (Vochysiaceae) is a deciduous species of Cerrado shrub-tree that can attain 2–8 m in height and remains leafless until the end of the dry season (Sajo & Rudall, 2002). *Q. parviflora* is the second most common woody species in the Cerrado (Ratter et al., 2003). The *Qualea* genus is comprised of approximately 60 species, with a geographic distribution ranging from Central America to the state of Santa Catarina in Brazil, and is widely distributed in the Cerrado (Shimizu, 2009). *Erythroxylum suberosum* A. St.-Hil. (Erythroxylaceae) is a shrub or small tree that can be up to six meters in height. There are four genera in the Erythroxylaceae, but only *Erythroxylum* occurs in Brazil, especially in the Caatinga and Cerrado Biomes (Plowman & Hensold, 2004). In the study area, leaf flushing of *E. suberosum* shrubs occurs in October–November and coincides with the first rains.

Data collection

During random walks in the study area, specific spots were located where at least one individual of *Erythroxylum suberosum* (Erythroxylaceae) and *Qualea parviflora* (Vochysiaceae) co-occurred within a distance of 10 m of one another. Later, a plot of 100 m² (10 m × 10 m) was demarcated around each location. A total of 16 plots, at distances from each other of at least 50 m, were delimited in the study area. Initially, all the plants with DBH (Diameter at Breast Height measured at 1.30 m from the soil) of 10 cm or greater were marked with metallic plates and had their DBH and height measured. Representative samples from these plants were collected for identification based on comparison with botanic collections, herbariums and by consulting specialists. By doing so, the richness and abundance of the plants in each plot were determined (see Table S1) and used as a measure of environmental heterogeneity. All species that were collected are now

in the basic reference collection of the Rio Jequitaí Consorce – Jequitaí Project.

In each plot, one individual of *Erythroxylum suberosum* and one individual of *Qualea parviflora* with DBHs of 10 cm or greater were arbitrarily chosen, totaling 32 plants for insect sampling. The herbivorous insects and ants were collected by beating and using an entomological umbrella to collect the dislodged insects (Neves et al., 2013). Three branches of similar size and shape of each plant were each beaten 10 times and the dislodged insects collected in the entomological umbrella. This was done in the morning from 8 h to 12 h, in February, April and June 2016, that is, the beginning, middle and end of the wet season and when both species of plants have leaves. The sampled insects were properly conditioned in individual plastic containers and transported to the Laboratory of Conservation Biology where they were screened and identified. The insects collected were identified to family level using taxonomic keys and separated into morphospecies (see Leal et al., 2015). Then the herbivores were grouped into two guilds (sucking or chewing) according to their feeding habits (Neves et al., 2014).

Data analysis

In order to determine if the richness and abundance of insect herbivores on *Erythroxylum suberosum* and *Qualea parviflora* differed, Generalized Linear Mixed Models (GLMM's) were used. For this, the richness or abundance of the insect herbivores was used as responses variables and plant species as explanatory variables, assuming a Poisson distribution of data and treating the plot as a random factor. Finally, the significance of the models was tested by comparing original models with a null model using a chi-squared test. All statistical analyses were done using the lmer package in R software (R Development Core Team, 2015).

Multivariate analyses were used to test differences in the composition of the herbivorous insects on the two host plants. Firstly, samples were ordered using Non-metric Multidimensional Scaling (nMDS). For that, a matrix of the abundance of the species of herbivorous insects was constructed and the Euclidean distance index was used as dissimilarity metric. Then, a non-parametric permutation procedure (ANOSIM) was applied, using the Euclidean distance index with 5000 permutations, to test the significance of the groups formed in the nMDS (Hammer et al., 2001). The values of P and r were obtained and the similarity patterns between species of insect herbivores on the plants studied were determined. The analyses were developed using the software PAST (Hammer et al., 2001). Before these analyses, the abundance data of the insect herbivores were log-transformed.

In order to verify if the richness and the abundance of sucking or chewing insect herbivores associated with each plant were influenced by the local richness of plants (i.e. richness of plant species per plot), the abundance of the species of plants studied (i.e. *E. suberosum* or *Q. parviflora*) and abundance of ants on these plants, different Generalized Linear Models with the proper error distribution were created. Thus, eight different models were constructed using the richness or the abundance of sucking and chewing herbivorous insects as response variables. The abundance of ants per sampled plant, the richness of plant species per plot, the abundance of the focal plant species in the plot and the interactions among these variables were the explanatory variables. We tested the models using a chi-squared test based on the Poisson distribution as they contained count data. To control for the effect of the entry sequence of variables used in the models, we use a stepwise model selection analysis in the package MuMIn for R (Bartón, 2015). In this analysis, the selection of the most parsimonious model is based on the values of the Akaike Information Criterion (AIC). Finally, we submitted the most parsimonious model

to an analysis of residues to test for the adequacy of the model to meet statistical assumptions. The analyses were made using R software (R Development Core Team, 2015).

RESULTS

General patterns

In this study, 71 individuals belonging to 12 species of ants were collected from *Erythroxylum suberosum* and *Qualea parviflora*. The most abundant species of ants were *Crematogaster victim* Smith and *Camponotus blandus* Smith, which made up, respectively, 36.62% and 18.31% of the total abundance of ants. The most frequent species were *Camponotus blandus* and *Crematogaster victim*, occurring respectively on 37.5% and 25% of the plants sampled (Table S2).

A total of 157 insect herbivores belonging to 29 families and 90 species were collected from *E. suberosum* and *Q. parviflora* (Table S3). Of this total, 117 were sucking and 40 chewing insects. Among the sucking herbivores, Cicadelidae and Tingidae were the richest in species and most abundant, while for the chewing insects the Chrysomelidae and Lepismatidae were the richest in species and most abundant.

The richness (Chisq = 16.175; P < 0.001) and abundance (Chisq = 8.293; P = 0.004) of the insect herbivores collected from *E. suberosum* differed from that recorded on *Q. parviflora*. The species richness and abundance were, respectively, 83% and 85% higher on *Q. parviflora* (Fig. 1). The species composition of insect herbivores also differed on the two plant species (Fig. 2, Stress = 0.153; ANOSIM: r = 0.068, P = 0.007), suggesting a substitution of insect species between host plants. However, this result should be viewed with caution because there is an overlap in the points representing the insect communities on the two plants.

Insect herbivores associated with *Erythroxylum suberosum*

The abundance of ants affected the richness and abundance of sucking insects (Table 1). In fact, the plants of
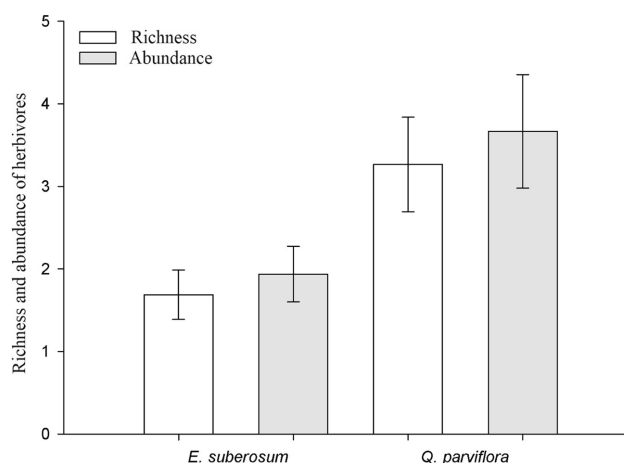

Fig. 1. Average richness and abundance of herbivorous insects collected from *Erythroxylum suberosum* and *Qualea parviflora* in an area of Cerrado in Brazil.
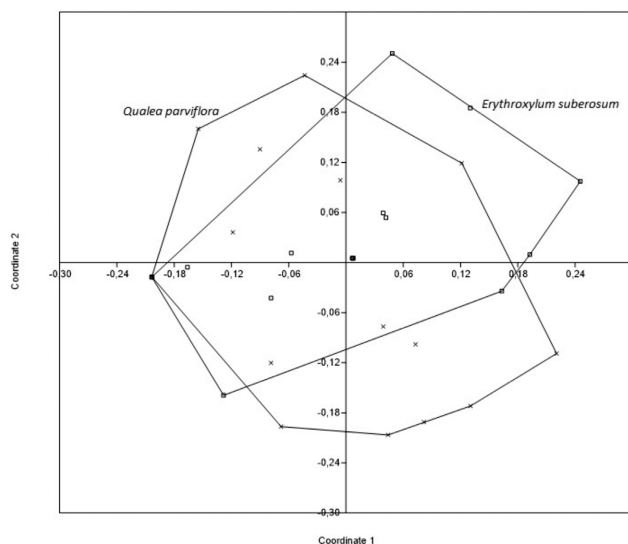
Fig. 2. Non-Metric MultiDimensional Scaling (nMDS) showing the ordination of insect herbivores collected from *Erytroxylum suberosum* and *Qualea parviflora* plants in an area of Cerrado in Brazil.

E. suberosum with the greatest abundance of ants had the greatest richness (Fig. 3A) and abundance (Fig. 3B) of sucking insects. The numbers of chewing insects recorded are not affected by plant richness and ant abundance alone. However, the interaction between the variables plant richness and ant abundance affected the richness and abundance of chewing insects (Table 1). Thus, plants of *E. suberosum* with a low abundance of ants that were located in plots with the greatest plant richness had the greatest richness (Fig. 4A) and abundance (Fig. 4B) of chewing insects.

Insect herbivores associated with *Qualea parviflora*

The density of *Q. parviflora* in each plot positively affected the richness (Table 2, Fig. 5A) and the abundance (Table 2, Fig. 5B) of sucking insects associated with this plant. Moreover, the interaction between the variables abundance of ants and abundance of *Q. parviflora* per plot affected the richness and abundance of chewing insect herbivores (Table 2). Again, it is important salient that the explanatory variables (focal plant abundance and ant abundance) alone had no significant effects on chewing insects. The interaction term showed that plants of *Q. parviflora* with low numbers of ants that were in plots where there were few of these plants had the greatest richness (Fig. 6A) and abundance (Fig. 6B) of chewing insects.
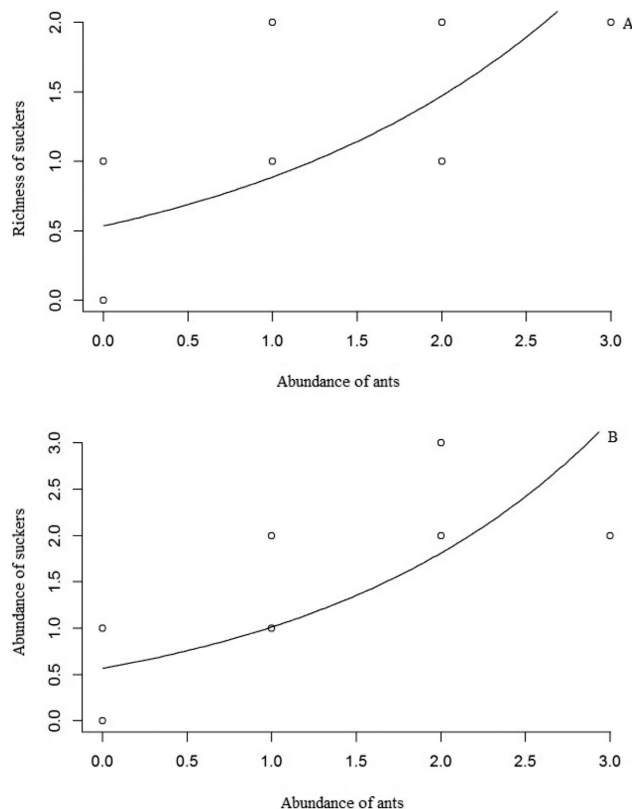

Fig. 3. The relationship between ant abundance and richness (A) and abundance (B) of sucking herbivorous insects associated with *Erythroxylum suberosum* in an area of Cerrado in Brazil.

DISCUSSION

In the tropics, insect herbivore communities are characterized by a high richness and low abundance of each species (Price, 1994; Fagundes & Fernandes, 2011). Recent studies also demonstrate a low population density and frequency of free-living herbivorous insects associated with a specific host plant (Fagundes & Fernandes, 2011; Neves et al., 2012). This pattern is probably associated with the greater plant diversity and greater herbivore specificity in tropical environments (Dyer et al., 2007). The results of this study corroborate this general pattern of high richness and low abundance of insect herbivores. In addition, the difference in the composition of herbivorous insect communities recorded on *Erythroxylum suberosum* and *Qualea parviflora* (but see observation in results) indicate that each species of plant has a specific fauna of insect herbivores,

Table 1. Minimum adequate models showing the effects of the explanatory variables (total richness of plant species per plot and abundance of ants associated with *Erythroxylum suberosum*) on the richness and abundance of the herbivorous insects collected from *E. suberosum*.

| Response variables	Explanatory variables	Deviance	Df	Resid. dev.	F	P
Richness of sucking insects	Abundance of ants	3.9186	12	8.0988	3.9186	0.0477
Abundance of sucking insects	Abundance of ants	6.2007	12	8.7088	6.2007	0.0127
Richness of chewing insects	Abundance of ants	3.1280	13	16.392	3.1280	0.0769
	Richness of plants	0.0940	12	16.297	0.0940	0.7586
	Richness of plants: Abundance of ants	4.1662	11	12.131	4.1662	0.0412
Abundance of chewing insects	Abundance of ants	3.1346	13	21.719	3.1346	0.0766
	Richness of plants	0.4529	12	21.266	0.4529	0.5009
	Richness of plants: Abundance of ants	4.7466	11	16.520	4.7466	0.0244
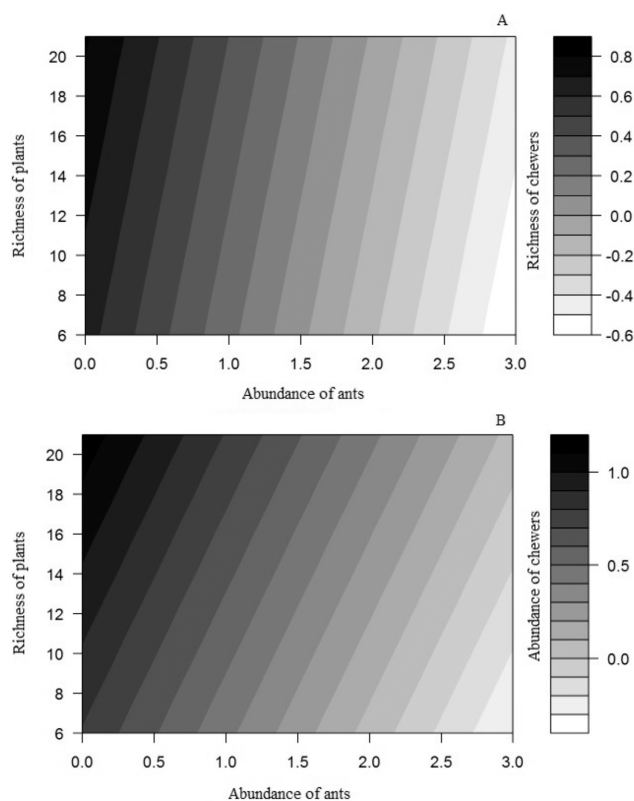
Fig. 4. The effects of the interaction between abundance of ants collected on *Erythroxylum suberosum* and plant species richness per plot on the richness (A) and abundance (B) of chewing herbivorous insects associated with *E. suberosum* in an area of Cerrado in Brazil.

Fig. 5. The relationship between the abundance of *Qualea parviflora* per plot and the richness (A) and abundance (B) of sucking herbivorous insects collected from *Q. parviflora* in an area of Cerrado in Brazil.

which is reflected in the high β diversity between plant species. Thus, one can expect that a high plant diversity associated with differences in the insect composition recorded on different species of plants generates the pattern of low density of herbivores per plant and high total diversity.

The composition of the insect herbivore families recorded in this study also corroborates the general pattern of insect diversity described for other tropical regions. Commonly, Chrysomelidae, Cicadelidae and Curculionidae are considered to be important herbivorous insects (Basset, 2001; Neves et al., 2011). Since these families are among the most abundant in tropical environments (Campos et al., 2006; Costa et al., 2011) it is not surprising that we recorded them in this study.
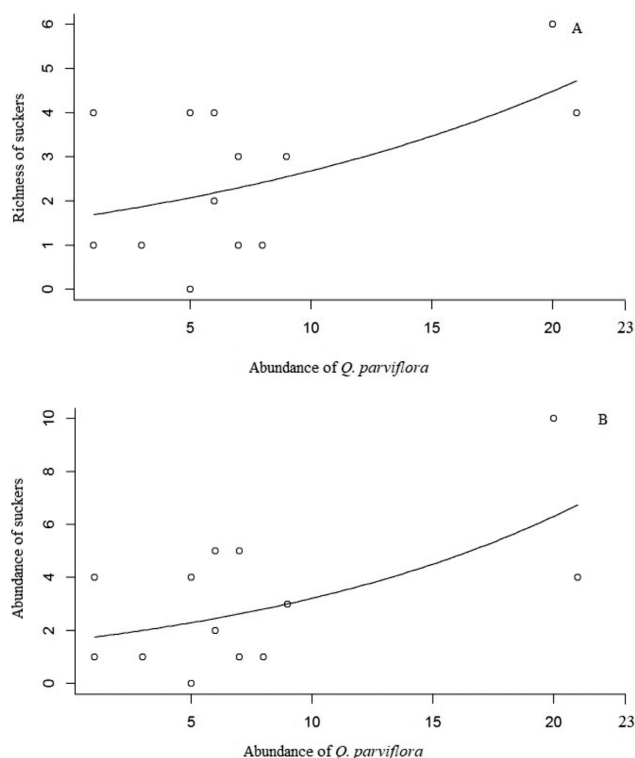
The richness and abundance of insect herbivores were higher on *Q. parviflora* than on *E. suberosum*. There are six tropical genera in the family Vochysiaceae (Souza, 2014), whereas in the family Erythroxylaceae there is only the genus *Erythroxylym* in the neotropical region (Plowman & Hensold, 2004). Furthermore, *Q. parviflora* is considered to be the second most common woody species in the Brazilian Cerrado (Ratter et al., 2003). In this study, *Q. parviflora* made up 22.46% of all the plants present in the plots sampled, while *E. suberosum* represented 9.11% (Appendix 1). Therefore, the greater diversity of herbivores recorded on *Q. parviflora* can be explained by both the hypothesis of taxonomic isolation (Owen & Whiteway, 1980) and of geographical area (Southwood, 1960). These hypotheses predict, respectively, that plant species belonging to large taxonomic groups and with a broad geographical distribution have a greater diversity of associated herbivores.

Table 2. Minimum adequate models showing the effects of the explanatory variables (abundance of *Qualea parviflora* per plot and abundance of ants collected from *Q. parviflora*) on the richness and abundance of herbivorous insects associated with *Q. parviflora*.

| Response variables	Explanatory variables	Deviance	Df	Resid. dev.	F	P
Richness of sucking insects	Abund. of *Q. parviflora*	3.8793	12	13.799	3.8793	0.0488
Abundance of sucking insects	Abund. of *Q. parviflora*	8.4839	12	20.108	8.4839	0.0036
Richness of chewing insects	Abund. of ants	0.6882	12	15.938	0.6882	0.4067
	Abund. of *Q. parviflora*	0.1400	11	15.798	0.1400	0.7082
	Richness of plants	1.5020	10	14.296	1.5020	0.2202
	Abund. of ants: Abund. of *Q. parviflora*	8.6220	9	5.674	8.6220	0.0033
Abundance of chewing insects	Abund. of ants	1.2100	12	17.269	1.2100	0.2713
	Abund. of *Q. parviflora*	0.3650	11	16.897	0.3650	0.5433
	Richness of plants	1.2230	10	15.673	1.2230	0.2687
	Abund. of ants: Abund. of *Q. parviflora*	8.0390	9	7.634	8.0390	0.0040
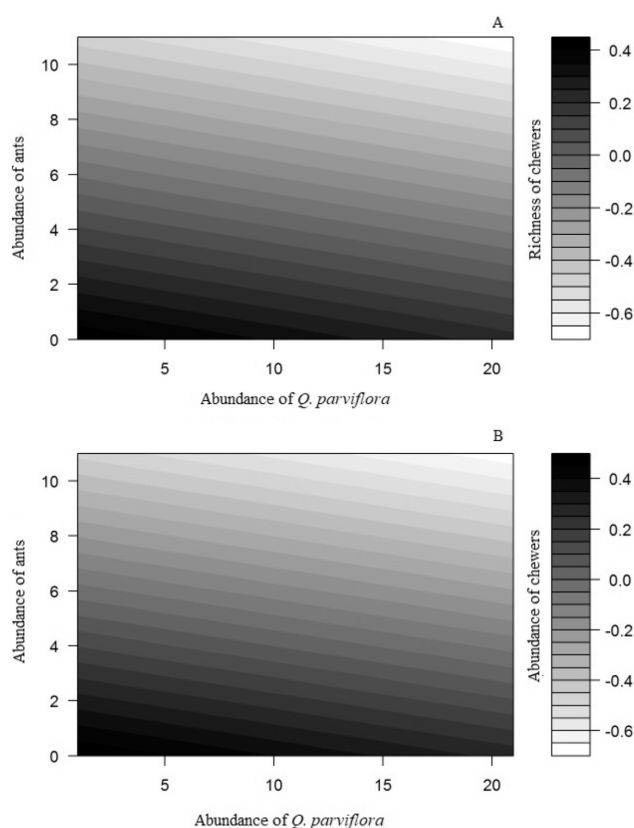
Fig. 6. The effects of the interaction between the abundance of *Qualea parviflora* per plot and abundance of ants on the richness (A) and abundance (B) of chewing herbivorous insects collected from *Q. parviflora* in an area of Cerrado in Brazil.

Contrary to our initial hypothesis, the abundance and the richness of sucking insects associated with *E. suberosum* was positively associated with the abundance of ants. The interaction between ants and herbivores is very variable (Bronstein, 1998; Fraser et al., 2001; Michelangeli, 2003). For example, there is a greater abundance of ants on plants infested with Homoptera that secrete honeydew, but these ants can also prey on or deter other herbivorous insect that feed on the same plant (Del-Claro, 2004; Rosumek et al., 2009). Our results indicate that 11% of the insect herbivores that were collected from *E. suberosum* belong to families that include species that produce honeydew (Aphididae, Thyreocoridae and Cicadelidae). Therefore, these herbivores might attract ants to plants and account for the positive relationship between sucking insect diversity and abundance of ants recorded on *E. suberosum*.

Our results also indicate that the richness and abundance of chewing herbivores were lower on plants of *E. suberosum* with few ants located in plots with a greater diversity of plants. The negative effect of ants on the abundance of chewing insects is a relatively common phenomenon (eg. Gibb, 2003; Cross, 2016; Styrsky & Eubanks, 2007). In addition, a positive relationship between plant diversity and the diversity of generalist insect herbivores is also documented (Ricklefs & Marquis, 2012). In this context, it is reasonable to expect that the probability of finding a generalist insect herbivore in a plot increases with increasing plant richness per plot. Therefore, it is possible to find a

large number of chewing insects on plants of *E. suberosum* with few ants located in plots with a high plant richness.

The richness and abundance of sucking insects associated with *Qualea parviflora* were affected only by the abundance of the host plant. Some studies show that the diversity of herbivorous specialists is positively associated with the abundance of the host plant (Blanche & Ludwig, 2001; Cuevas-Reyes et al., 2004; Araújo et al., 2013). The resource concentration hypothesis (Root, 1973) has been used to account for this pattern. According to this hypothesis, herbivore specialists locate big patches of resource more easily and remain in these patches for a longer because the resource is more abundant (Souza & Fagundes, 2017). Thus, individuals of *Q. parviflora* located in plots where this plant is abundant should have greater diversity of sucking herbivores, as observed in this study.

Similar to what was observed on *E. suberosum*, the richness and abundance of chewing insects associated with *Q. parviflora* are affected by the interaction between top-down and bottom-up forces. In fact, the richness and abundance of chewing insects was higher on plants of *Q. parviflora* with low numbers of ants and located in plots where the abundance of this plant is low. Again, generalist predators seem to play a negative role in the diversity of chewing herbivores on this plant. In addition, the negative response of chewing insect diversity to the abundance of the host plant could be associated with the high density of the plant. In this case, the local pool of herbivores could be partitioned between the two plants studied, resulting in the negative relationship between the numbers of herbivores per plants and abundance of each plant (see also, Otway et al., 2005; Souza & Fagundes, 2017). However, it is important that only the combination of these explanatory variables (i.e. abundances of ant and *Q. parviflora* plants) affected the richness and abundance of chewing herbivores on plants of *Q. parviflora*.

Finally, this study indicates that the diversity of insect herbivores on the two host plants differ. Moreover, the variation in the composition of herbivorous insects recorded indicates a substitution of herbivorous insect among host plants and can help explain the high diversity of insect herbivores in the tropics. Our results also indicate that top-down and bottom-up forces can act jointly to shape the organization of insect herbivore communities. For example, the effect of generalist predators on the diversity of chewing herbivores associated with the host plants *Q. parviflora* and *E. suberosum* is dependent on interactions between the abundance of these plants and total plant richness, respectively. In addition, the effect of ants on herbivorous insects can be guild-dependent. In fact, the guild of generalist herbivores was negatively affected by ants, while the top-down effect on the sucking insect guild were less consistent and dependent on the trophobosis between homopterans and ants.

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Table S1. Abundance (number of individual per species) and frequency (percent of plots that each plant species occur) of plant species sampled in a Cerrado area of Brazil.

Family	Species	Abundance	Frequency
Anacardiaceae	*Astronium fraxinifolium* Schott	15	0.31
Annonaceae	*Annona dioica* A. Saint-Hilaire	1	0.06
Apocynaceae	*Aspidosperma tomentosum* Martius	16	0.41
Apocynaceae	*Himatanthus obovatus* (Müll. Arg.) Woodson	1	0.06
Asteraceae	*Eremanthus* sp.	1	0.06
Bignoniaceae	*Handroanthus ochraceus* (Cham.) Mattos	2	0.12
Caryocaraceae	*Caryocar brasiliense* A. Saint-Hilaire	4	0.25
Calophyllaceae	*Kielmeyera coriacea* Martius	1	0.06
Connaraceae	*Connarus suberosus* Planch.	2	0.12
Dilenaceae	*Curatella americana* Linnaeus	17	0.31
Dilenaceae	*Davila elliptica* A. Saint-Hilaire	6	0.19
Erythroxylaceae	*Erythroxylum suberosum* A. Saint-Hilaire	43	1.00
Leguminosae	*Acosmium dasycarpum* (Vogel) Yakovlev	39	0.69
Leguminosae	*Acosmium subelegans* (Mohlenbr.) Yakovlev	2	0.06
Leguminosae	*Copaifera oblongiolia* Martius	1	0.06
Leguminosae	*Dimorphandra mollis* Bentham	8	0.19
Leguminosae	*Dipteryx alata* Voguel	1	0.06
Leguminosae	*Enterolobium gummiferum* (Mart.) J.F. Macbr.	2	0.12
Leguminosae	*Hymenaea courbaril* Linnaeus	10	0.31
Leguminosae	*Hymenaea stigonocarpa* Hayne	3	0.06
Leguminosae	*Machaerium acutifolium* Vogel	5	0.12
Leguminosae	*Machaerium opacum* Vogel	1	0.06
Leguminosae	*Plathymenia reticulata* Bentham	46	0.62
Leguminosae	*Sclerolobium aureum* (Tul.) Baill.	2	0.12
Leguminosae	*Smartzia* sp.	1	0.06
Leguminosae	*Stryphnodendron adstringens* (Mart.) Coville	2	0.12
Lythraceae	*Lafoensia pacari* A. Saint-Hilaire	5	0.12
Malpighiaceae	*Byrsonima crassifolia* (L.) Kunth	9	0.56
Malpighiaceae	*Heteropterys byrsonimifolia* A. Juss.	6	0.19
Malvaceae	*Eriotheca pubescens* (Mart. & Zucc.) Schott & Endler	8	0.37
Myrtaceae	*Eugenia dysenterica* de Candolle	40	0.56
Myrtaceae	*Myrciaria floribunda* (H. West ex Willd.) O. Berg	3	0.06
Nictaginaceae	*Guapira* sp.	7	0.37
Opiliaceae	*Agonandra brasiliensis* Miers ex Bentham	1	0.06
Polygonaceae	*Coccoloba* sp.	6	0.37
Proteaceae	*Roupala montana* Aubl.	4	0.12
Sapindaceae	*Magonia pubescens* A. Saint-Hilaire	8	0.25
Sapotaceae	*Pouteria ramiflora* (Mart.) Radlk.	1	0.06
Sapotaceae	*Pouteria torta* (Mart.) Radlk.	2	0.12
Simaroubaceae	*Simarouba versicolor* A. Saint-Hilaire.	2	0.06
Vochysiaceae	*Callisthene fasciculata* Martius	9	0.19
Vochysiaceae	*Callisthene major* Martius	11	0.19
Vochysiaceae	*Qualea grandiflora* Martius	8	0.19
Vochysiaceae	*Qualea parviflora* Martius	106	1.00
Vochysiaceae	*Salvertia convallariodora* A. Saint-Hilaire	3	0.19
Vochysiaceae	*Vochysia elliptica* Martius	1	0.06
Total		472	

Table S2. Relative abundance and frequency of ant species collected from *Erythroxylum suberosum* and *Qualea parviflora* in a Cerrado area of Brazil.

Subfamily	Species	Abundance	Frequency
Dolichoderinae	*Azteca* sp.	1.41	6.25
Formicinae	*Brachymyrmex admotus* Mayr	16.90	18.75
	Camponotus blandus (Smith) Forel	18.31	37.50
	Camponotus novogranadensis Mayr	4.22	12.50
	Camponotus sp.	1.41	6.25
Pseudomyrmecinae	*Pseudomyrmex gracilis* Fabricius	2.82	12.50
	Pseudomyrmex simplex Smith	1.41	6.25
	Pseudomyrmex termitaria Smith	1.41	6.25
Myrmicinae	*Cephalotes pusillus* Klug	11.27	18.75
	Crematogaster erecta Mayr	2.82	12.50
	Crematogaster victim Smith	36.62	25.00
	Pheidole diligens	1.41	6.25

Table S3. Richness and abundance (numbers in parenthesis) of sucking and chewing insects herbivorous collected from two host plant *Erythroxylum suberosum* and *Qualea parviflora* in each spots (S1–S16) in a Cerrado area of Brazil.

Guild	Taxa	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	Total
Sucking	Aphididae		1(2)															1(2)
	Cecidomyidae	1(1)																1(1)
	Cicadelidae		2(2)	1(1)	3(3)	3(6)	1(1)	3(4)	3(4)	12(66)		2(2)	1(1)			1(1)		32(91)
	Derbidae														1(1)			1(1)
	Fulgoromorpha	1(1)																1(1)
	Hemiptera				1(1)	1(1)			1(1)		2(2)				1(1)		1(1)	7(7)
	Mesoveliidae															1(1)		1(1)
	Unidentify						1(1)											1(1)
	Pentatomiidae	1(1)																1(1)
	Sisyridae									1(1)								1(1)
	Thyreocoridae						1(1)											1(1)
	Tingidae	1(1)							1(4)	1(1)		1(1)		2(2)				6(9)
	Total	4(4)	3(4)	1(1)	5(5)	4(7)	2(2)	4(5)	7(11)	15(69)	2(2)	4(4)	1(1)	3(3)	2(2)	4(4)	1(1)	54(117)
Chewing	Acrididae			1(1)														1(1)
	Anobiidae														1(1)			1(1)
	Bostrichidae											1(1)						1(1)
	Bruchidae															1(1)	1(1)	2(2)
	Chrysomelidae						1(2)		1(1)							1(1)		3(4)
	Coleoptera															2(2)		2(2)
	Curculionidae			1(1)				1(1)				1(1)						3(3)
	Lepidoptera			1(1)						2(2)		1(1)		1(1)		2(2)		7(7)
	Lepismatidae	1(1)					1(3)				1(1)	1(1)		1(1)		1(2)		6(9)
	Unidentify											1(1)						1(1)
	Orthoptera			1(1)														1(1)
	Psocidae											1(1)						1(1)
	Psyllipsocidae				1(1)													1(1)
	Pteromalidae				1(1)													1(1)
	Rhysodidae								1(1)									1(1)
	Scirtidae			1(2)														1(2)
	Tettigoniidae												1(1)					1(1)
	Trigonidiidae	1(1)																1(1)
	Total	2(2)		4(5)	2(2)		1(3)	2(3)	1(1)	1(1)	2(2)	4(4)	1(1)	1(1)	1(1)	5(6)	1(1)	35(40)