Predictors of Leafhopper Abundance and Richness in a Coffee Agroecosystem in Chiapas, Mexico

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ABSTRACT Coffee agroecosystems with a vegetatively complex shade canopy contain high levels of biodiversity. However, as coffee management is intensified, diversity may be lost. Most biodiversity studies in coffee agroecosystems have examined predators and not herbivores, despite their importance as potential coffee pests and coffee disease vectors. We sampled one abundant herbivore group of leafhoppers on an organic coffee farm in Chiapas, Mexico. We sampled leafhoppers with elevated pan traps in high- and moderate-shade coffee during the dry and wet seasons of 2011. The two major objectives were to 1) compare leafhopper abundance and richness during the wet and dry seasons and 2) examine the correlations between habitat characteristics (e.g., vegetation, elevation, and presence of aggressive ants) and leafhopper richness and abundance. We collected 2,351 leafhoppers, representing eight tribes and 64 morphospecies. Leafhopper abundance was higher in the dry season than in the wet season. Likewise, leafhopper richness was higher in the dry season. Several vegetation and other habitat characteristics correlated with abundance and richness of leafhoppers. The number of *Inga* trees positively correlated with leafhopper abundance, and other significant correlates of abundance included vegetation complexity. Leafhopper richness was correlated with the number of *Inga* trees. As leafhoppers transmit important coffee diseases, understanding the specific habitat factors correlating with changes in abundance and richness may help predict future disease outbreaks.

KEY WORDS agroforest, biodiversity, Cicadellidae, intensification, management

Coffee is an essential economic resource in Latin America, and is of extreme conservation importance because coffee production areas tend to overlap with biodiversity hotspots (Philpott and Dietsch 2003). Coffee was traditionally cultivated in the understory of a native forest canopy, or under a diverse, densely planted canopy, and for this reason traditional coffee agroecosystems are effective habitats for biodiversity conservation (Perfecto et al. 1996). However, in the past several decades, farmers have increasingly intensified coffee management by reducing canopy cover and vegetation complexity and increasing agrochemical inputs all to increase yields (Perfecto et al. 1996, Moguel and Toledo 1999, Rice 1999). As a result, biodiversity is lost (Perfecto et al. 1996, Philpott et al. 2008). Traditional shaded systems, containing complex food webs with high diversity and abundance of interacting natural enemies, may provide natural or autonomous biological control of coffee pests (Vandermeer et al. 2010).To date, most studies on biodiversity within coffee agroecosystems have focused on insectivorous taxa, such as birds, bats, lizards, spiders,

and ants, because of a strong focus on understanding how loss of predators relates to pest control functions within agroecosystems (e.g., Perfecto et al. 2003, Borkhataria et al. 2006, Philpott et al. 2008, Williams-Guillén and Perfecto 2010, Marin and Perfecto 2013). Only a few studies have explicitly focused on other trophic levels, such as nectarivores (Mas and Dietsch 2003), herbivores (Rojas et al. 2001), or plants (Soto-Pinto et al. 2002, Moorhead et al. 2010). However, organisms in different trophic levels may respond quite differently to management changes in coffee agroecosystems (Philpott et al. 2004). In addition, certain species of insects within coffee agroecosystems (e.g., *Azteca sericeasur* Longino (Hymenoptera: Formicidae)) act as keystone predators, influencing a wide range of other insects, including herbivores-like scale insects (Vandermeer et al. 2010). This ant was previously referred to as *Azteca instabilis* (F. Smith), but has been reidentified as *A. sericeasur* due in part to the queens' smaller ocelli and distinct yellow and brown facial markings (J. Longino, personal communication). No work has examined the impacts of *A. sericeasur* on leafhopper communities.

One important taxon of herbivorous arthropods inhabiting coffee agroecosystems is leafhoppers. Leafhoppers (Hemiptera: Cicadellidae) are an extremely diverse and abundant arthropod group, with >11,000 described species in the world (Oman et al. 1990). Leafhoppers are herbivores that feed on vascular

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plants, including fruit trees and weeds. They have piercing mouthparts that are used to feed from phloem, xylem, or mesophyll plant tissues. Leafhopper species tend to be host-specific and are important agricultural pests in a range of crop systems (Stiling 2008). Despite their importance as pests and disease vectors (e.g., phony peach disease, plum leaf scald), few have evaluated the abundance and richness of leafhoppers in coffee or in other agroecosystems. Studies in grasslands in Hungary indicate that vegetation structure is a key factor in determining the composition of leafhopper communities (Kőrösi et al. 2012), thus agricultural intensification may strongly affect leafhoppers, and potentially the diseases they spread. Leafhoppers are relatively resilient to some forms of agricultural intensification; at least one study found that inorganic fertilizers have no impact on leafhopper abundance or species richness (Blake et al. 2011). Generalist leafhopper species have a broader host range and can adapt, and even thrive, as intensification occurs (Kőrösi et al. 2012), whereas specialist leafhopper species are most likely to be affected by intensification, such as increased use of pesticides or pruning (Trivellone et al. 2012). In coffee agroecosystems, specifically, the few studies conducted to date show that leafhopper richness increases in areas with shade trees, different leafhopper species typically dominate specific habitat types, and species distribution changes based on plant and geographic variance (Rojas et al. 2001).

In this study, we examined the abundance and richness of leafhoppers in a coffee agroecosystem in Chiapas, Mexico. The two major objectives were to 1) compare leafhopper abundance and richness during the wet and dry seasons and 2) examine the correlations between habitat characteristics (vegetation, elevation, and presence of the aggressive, dominant ant *A. sericeasur*) and leafhopper abundance and richness. We predicted that increased vegetation complexity and decreased abundance of *A. sericeasur* would lead to an increase in the abundance of leafhopper individuals and richness of species and tribes encountered.

Materials and Methods

Site Description. We worked in coffee agroecosystems surrounding the Finca Irlanda Research Station, located in Southwest Chiapas, Mexico (15° 11′ N, 90° 20′ W) between March and July 2011. The study areas consist of >280 ha of coffee located between 950 and 1,150 m elevation year (Philpott et al. 2009b). The site receives between ≈4,500–6,000 mm of rain per year, mostly during a rainy season that lasts from May through October. Most of the coffee production surrounding the field station was traditionally managed as a commercial polyculture, although recent management changes have created several different management types, varying between 40–70% canopy cover (Larsen and Philpott 2009). We concentrated our surveys in two management types. The first was a high-shade coffee (7 ha in total) that was managed as a traditional polyculture system (according to the classification system by Moguel and Toledo 1999) and had high canopy cover (≈75%), ≈41 trees, and ≈16 tree species per 0.2-ha plot. The second was a moderate-shade coffee (45 ha in total) that was managed as a mixture of commercial polyculture coffee and shade monoculture coffee (Moguel and Toledo 1999) and had relatively lower canopy cover (≈50%), ≈35 trees, and 11 tree species per hectare.

Leafhopper Sampling. We sampled leafhoppers within the two sites with elevated pan traps as described by Tuell and Issacs (2009). Each pan trap consisted of one 350-ml white bowl elevated 1 m above ground with a polyvinyl chloride tube and coupler. Each bowl contained two 5- by 1-cm rectangular slits cut halfway up the bowl, and then covered with fine mesh to allow water drainage during the wet season. During sampling dates, we filled the bowls with a salt and soap water mixture (2 kg of table salt and 80 ml of dish soap dissolved in 20 liters of water) to facilitate capture of insects. We placed pan traps in the field in groups of six at each of the 204 locations (24 in the high-shade coffee and 180 in the moderate-shade coffee). The trap locations were distributed evenly throughout the 52 ha sampled, and each pan trap location was separated by a minimum of 50 m. We collected trap contents biweekly (during the dry season) and weekly (during the wet season) between January 2011 and January 2012. We then examined leafhoppers collected over 2 wk in the dry season (14–30 March 2011), and 2 wk in the wet season (21 June to 6 July 2011). We sorted leafhoppers to tribe using 3I Interactive Keys and Taxonomic Databases (Dmitriev 2012). Once sorted to tribe, we assigned leafhoppers to morphospecies based on examination of several morphological characteristics commonly used to distinguish species (e.g., hind, femur, and setal formation; antennal placement; coloration patterns; head size and shape; and wing patterns). Voucher specimens of all leafhopper morphospecies have been deposited in the Colección de Artrópodos at El Colegio de la Frontera Sur in Tapachula, Chiapas, Mexico.

Habitat Characteristics. We sampled habitat characteristics at each of the 204 elevated pan trap locations. We recorded longitude, latitude, and elevation of each location. Then, around each group of traps, we established a 25-m radius plot within which we sampled vegetation. We counted and identified all trees, and measured the height and circumference (at 1.37 m above ground) of each tree. We measured average percentage canopy cover per plot with a convex spherical densiometer at four points at the circle center (while facing N, S, E, or W) and at 10 m from the center in each cardinal direction, then taking the mean of the eight readings. We counted the number of coffee plants within each plot. Finally, we took note of the presence or absence of *A. sericeasur* ants on each tree in the plot.

We calculated a vegetation complexity index (Mas and Dietsch 2003, Philpott et al. 2009a) to summarize the vegetation characteristics measured (i.e., tree abundance and richness, mean tree height and circumference, number of *Inga* spp. trees, canopy cover,

Table 1. Results from Moran's test for spatial autocorrelation using a spatial weights matrix

Dependent variable	Moran's I statistic standard deviate	Moran' I statistic	Expectation	Variance	P
LN Morphospecies richness	−0.2397	−0.006198	−0.004926	0.000028	0.5947
LN Tribe richness	−1.2071	−0.011332	−0.004926	0.000028	0.8863
LN Abundance	1.9183	0.005269	−0.004926	0.000028	0.02753
LN Abundance of Scarini morphospecies 1	1.7851	0.004569	−0.004926	0.000028	0.03712
LN Abundance of Cicadellini	2.0211	0.005746	−0.004926	0.000028	0.02164
LN Abundance of Empoascini	−0.3736	−0.006908	−0.004926	0.000028	0.6456
LN Abundance of Scarini	2.3556	0.007602	−0.004926	0.000028	0.009247

and coffee plant density). All variables but number of *Inga* spp. trees and coffee plant density are positively correlated with vegetation complexity. We specifically chose to examine the influence of *Inga* spp. trees because this is the most common genus at the study sites, and in general, an indicator of more intensive management. First, all raw data were converted to a scale from 0 to 1, where zero represents the least complex vegetation and 1 represents the most complex vegetation. Values for each variable in each plot (e.g., tree richness) were divided by the highest value across all plots. For coffee plants (a variable generally negatively correlated with vegetation complexity), the product was then subtracted from 1. All transformed values for a plot were summed, and divided by the total number of variables measured to yield the vegetation complexity index value for that plot.

Data Analysis. We examined several aspects of leafhopper communities. For all data analysis, each trap location was included as a replicate, thus leafhoppers from the six individual pan traps were pooled and treated together as one statistical unit. We created a species accumulation curve (for observed morphospecies richness) to examine whether a large fraction of the community was sampled in the study. We created a sample-based curve scaled to the numbers of individuals with EstimateS v. 7.5 (Colwell 2005). We considered that a large fraction of the community was sampled if the curve began to reach an asymptote. We compared the tribe richness, total morphospeices richness, total leafhopper abundance, and abundance of the most common morphospecies (Scarini morphospecies 1) with univariate analyses of variance (ANOVAs). We compared the abundance of common tribes (Empoacini, Cicadellini, and Scarini) multivariate analysis of variance, followed by univariate ANOVA where significant.

To examine the morphospecific influences of habitat characteristics on abundance, morphospecies richness, tribe richness, and on abundance of common morphospecies or tribes, we created conditional inference trees with the "party" package in R (R Development Core Team 2012). This approach allowed us to examine for relationships between a suite of predictor variables and the dependent variables (leafhopper abundance and richness). The "party" package splits the dependent variable data into groups based on the explanatory variables (De'ath and Fabricius 2000, Olden et al. 2008, Jha and Vandermeer 2010). The "party" package first examines which variable is

the best predictor of the dependent variable. A split occurs if an explanatory variable explains a significant amount of variation, and the iterative process continues until no more significant explanatory variables are encountered. We included the following variables as predictor variables: elevation, number of trees, tree species richness, number of *Inga* spp. trees, tree height, tree circumference, canopy cover, number of coffee plants, vegetation complexity index, number of trees with *A. sericeasur* ants, and percentage of trees with *A. sericeasur*). Our seven dependent variables were leafhopper abundance, morphospecies richness, tribe richness, abundance of the three most common tribes, and abundance of the single most common leafhopper morphospecies. We included only those predictor variables that were significant at $P < 0.01$ We chose a lower α to detect highly significant predictors of the dependent variables. For all data analyses, we used natural log transformed values for leafhopper abundance and richness to meet conditions of normality.

To examine whether the spatial distribution and proximity of sample plots influenced the conditional inference tree results, we tested for spatial autocorrelation in the dependent variables (Dormann et al. 2007). We examined the degree of spatial autocorrelation in the residuals of the conditional inference trees with the Moran's test for spatial autocorrelation using a spatial weights matrix (R Development Core Team 2012). For the calculation of Moran's I, we used the nearest neighbor distances as a metric, and used the permutation test option. Four of the seven variables were spatially autocorrelated (Table 1). To account for the role of space in the analysis, we reran conditional inference trees including longitude and latitude as additional explanatory variables in the models.

Results

Leafhopper Abundance and Seasonal Differences. We collected 2,351 adult leafhopper individuals. Leafhopper abundance varied from 0 to 60 individuals per trap location, from 0 to 57 in the dry season, and from 0 to 44 in the wet season. We collected leafhoppers from eight tribes (Acenopteriini, Cicadellini, Empoascini, Iassini, Marcoceratogoniini, Proconiini, Sandersellini, and Scarini). The three most common tribes, in terms of individual abundance, were Scarini, Cicadellini, and Empoascini. Scarini abundance varied from 0 to 38 individuals per trap location, Cicadellini varied from 0 to 37, and Empoascini varied from 0 to 16. The
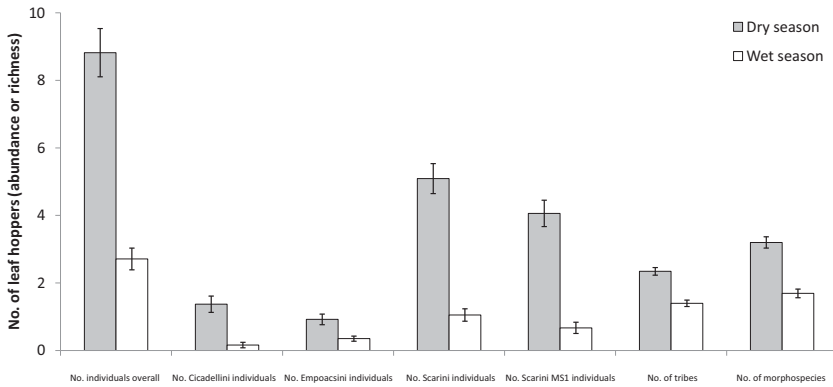
Fig. 1. Mean abundance (overall, Cicadellini, Empoascini, Scarini, and Scarini morphospecies 1) and richness (tribes and morphospecies) of leafhoppers in coffee agroecosystems during the dry and wet season. Error bars show SE.

five most common leafhopper morphospecies collected were Scarini morphospecies 1 (SM1), Iassini morphospecies 1 (IM1), Empoascini morphospecies 1 (EM1), Proconiini morphospecies 1 (PM1), and Iassini morphospecies 2 (IM2). We collected 966 individuals of SM1, representing >33% of all leafhopper individuals sampled. Leafhopper abundance varied significantly by season ($F_{7,400} = 20.265$, $P < 0.001$; Fig. 1). There were three times as many leafhoppers overall in the dry season than in the wet season ($F_{1,406} = 75.369$, $P < 0.001$; Fig. 1), and at least double the number of Cicadellini individuals ($F_{1,406} = 49.461$, $P < 0.001$; Fig. 1), Empoascini individuals ($F_{1,406} = 13.322$, $P < 0.001$; Fig. 1), and Scarini individuals ($F_{1,406} = 116.362$, $P < 0.001$; Fig. 1) in the dry season than in the wet season. There were more than four times more SM1 individuals in the dry season than in the wet season ($F_{1,406} = 117.89$, $P < 0.001$; Fig. 1).

Leafhopper Richness and Seasonal Differences. We identified 64 leafhopper morphospecies and the species accumulation curves indicate that a large fraction of the leafhopper community in this agroecosystem was sampled, as the curve approached an asymptote (Fig. 2). The tribes with the highest number of morphospecies were Proconiini (23) and Scarini (17); other tribes contained ≤10 morphospecies. Leafhopper morphospecies richness varied from 0 to 12 morphospecies per trap location with 0–11 morphospecies per trap location in the dry season and from 0 to 8 in the wet season. There were higher numbers of both leafhopper tribes (ANOVA, $F_{1,406} = 40.632$; $P < 0.001$) and leafhopper morphospecies (ANOVA, $F_{1,406} = 52.251$; $P < 0.001$) in the dry season than in the wet season (Fig. 1).

Habitat Characteristics and Leafhopper Abundance and Richness. In the 25-m radius plots, we measured a wide range of values for elevation (914–1,085 m), number of trees (16–67 trees), tree species richness (3–22 species), number of *Inga* spp. trees (6–40 trees), tree height (1.7–2.9 m), tree circumference (40.5–115.1 cm), canopy cover (14.3–100.0%), number of coffee plants (152–802 plants), vegetation complexity index (0.38–0.78), and percentage of trees with *A. sericeasur* (0–78.5%). Several habitat characteristics correlated with changes in leafhopper abundance, morphospecies richness, and tribe richness. Overall abundance of leafhoppers increased with the number of *Inga* spp. trees in plots (Fig. 3a). Leafhopper richness, at both the species and tribe level was also primarily influenced by the number of *Inga* spp. trees within plots (Fig. 3b and c). Abundance of the two most abundant tribes, Scarini and Cicadellini, both increased with more *Inga* spp. trees in plots (Fig. 4a and b). Empoascini abundance increased in plots with lower levels of canopy cover and where tree height was lower (Fig. 4c). Finally, the abundance of the most common morphospecies, SM1, was higher in plots with more *Inga* spp. trees and lower where overall vegetation complexity increased (Fig. 4d).
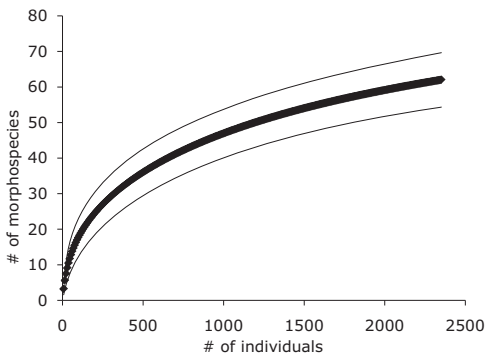
Discussion

The first objective of our study was to sample abundance and richness of leafhoppers and to determine whether leafhopper richness and abundance varies seasonally. Overall, leafhopper abundance and for the most abundant tribes and morphospecies, was higher in the dry season compared with the wet season. These
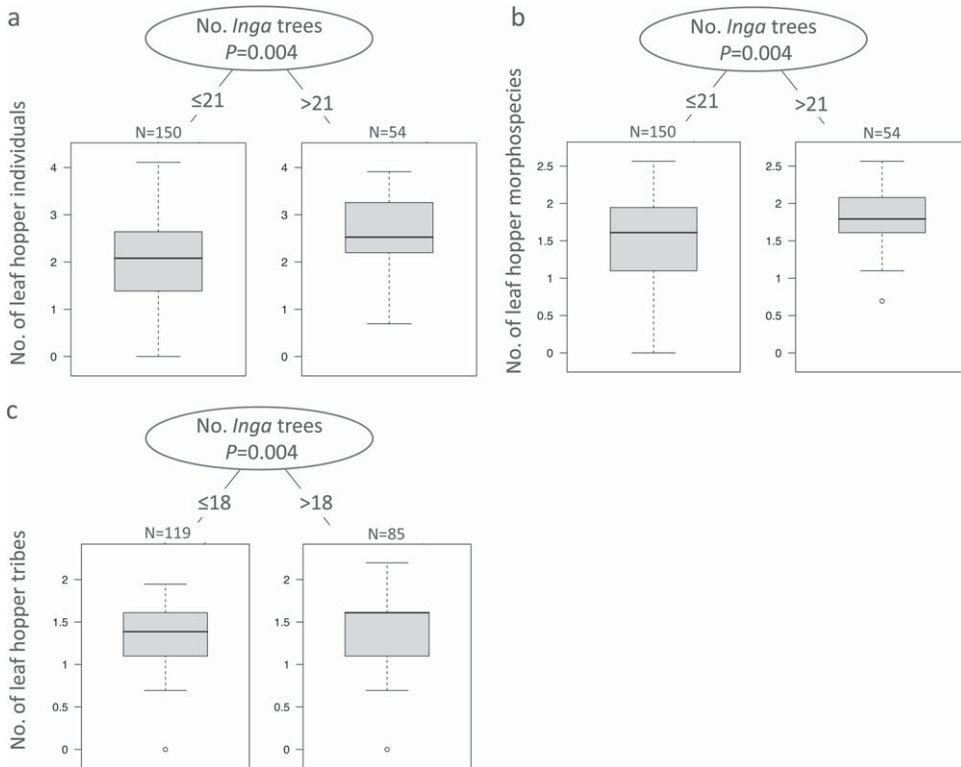

Fig. 2. Species accumulation curve for all leafhoppers sampled with elevated pan traps in a coffee agroecosystem. Error bars (95% CIs) are shown with thin lines around the observed morphospecies richness values.

Fig. 3. Conditional inference tree showing factors that correlate with (a) leafhopper abundance, (b) leafhopper morphospecies richness, and (c) leafhopper tribe richness in coffee agroecosystems. Significant predictors of leafhopper abundance are shown in circles in hierarchical ranking starting with the highest correlation to the dependent variable. *P* values indicate the significance of the relationship being tested. Numbers beneath the circles indicate thresholds over or under which data divided into significantly different values. Box plots include the inner quartiles (gray box), the median values (solid black line), and 1.5 times the inner quartiles (error bars) of leafhopper abundance associated with each string of predictor variables. Plots at each terminal node show median abundance of leafhoppers in each category and the number of pan trap locations (n) in each category.

results are in contrast to other studies that found higher leafhopper abundance in Costa Rica during the wet season (Garita-Cambronero et al. 2008) or higher leafhopper abundance at the start or end of the wet season (Wolda 1979, Ramos 2008). Second, leafhopper morphospecies and tribe richness were higher in the dry season than in the wet season. The observed differences could result from differences in regional precipitation patterns, as annual precipitation levels were higher in our study site compared with levels in the Ramos' study in Costa Rica (Ramos 2008). Our study sties receive ≈4,500 mm of rain per year, whereas the sites in Costa Rica receive ≤2960 mm of rain yearly. Furthermore, vegetation complexity was greater in our sites compared with the more conventionally managed farms used by Ramos (2008). The Costa Rican study sties contained on average 1–2 species of shade trees, whereas our sites had between 3–22 species per plot. Also notable is that Ramos (2008) found different results depending on trap type, with higher abundance in the wet season when using sticky traps and higher abundance in the dry season when using Malaise traps. Thus, trap type may have influenced our results. Ramos

(2008) only studied the subfamily Cicadellinae, which also may have contributed to differences.

The second major objective of our study was to examine for correlations between habitat characteristics, such as vegetation, elevation, and presence of the aggressive, dominant ant *A. sericeasur* on leafhopper abundance and richness. Overall leafhopper abundance, abundance of two common tribes, and abundance of the most common morphospecies all increased with the number of individuals of *Inga* spp. shade trees. Leafhopper abundance is also very high in coffee agroecosystems in Puerto Rico in areas with *Inga vera* (L.) shade trees (Marino-Cardenas et al. 2010). This is likely because leafhoppers use *I. vera* trees as a oviposition sites and as locations for nymph development (Marino-Cardenas et al. 2010). We did not find any trends between leafhopper abundance and the number of coffee plants per plot. In our study areas, each plot contained an average of 11.2 different shade tree species and an average of 36 individual trees. In these highly diversified farms, leafhoppers may thus have a more diverse range of food sources available to them. Additional vegetation factors correlated with changes in abundance of specific groups of
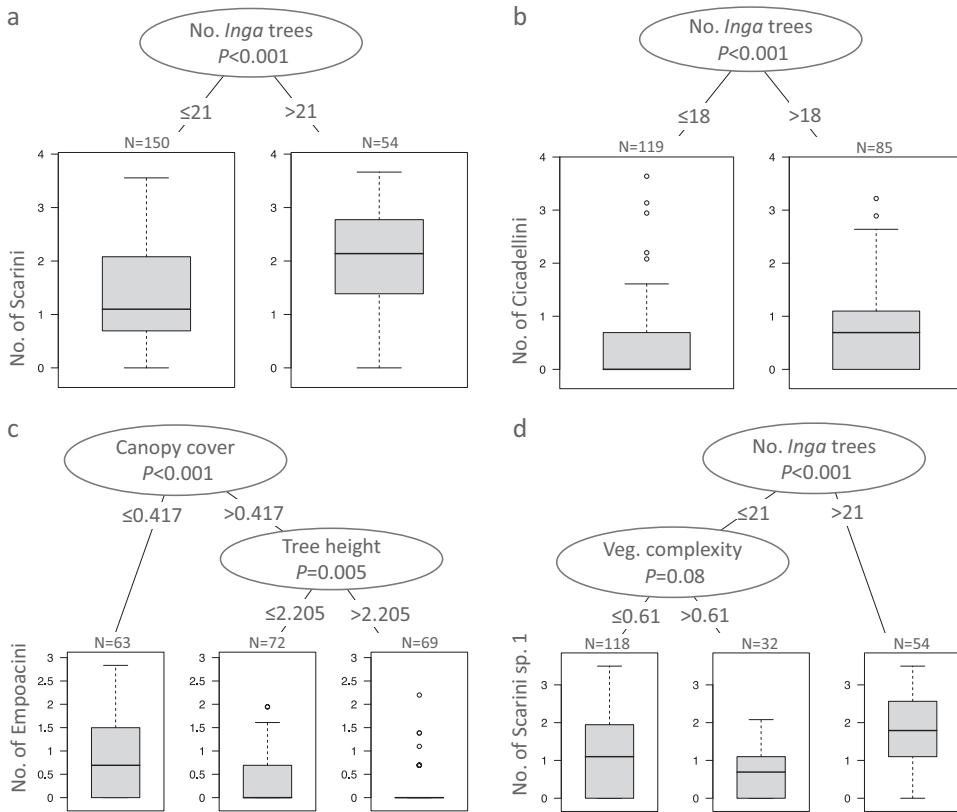
Fig. 4. Conditional inference tree showing factors that correlate with abundance of leafhoppers from the three common tribes: (a) Scarini, (b) Cicadellini, (c) Empoascini, and the most common morphospecies (d) Scarini morphospecies 1. See Fig. 3 for explanation.

leafhoppers. Empoascini abundance declined with canopy cover increases and where trees were taller. The abundance of the most common morphospecies, SM1, declined with overall vegetation complexity. Thus, leafhopper abundance was negatively influenced by factors associated with greater vegetation complexity (e.g., increased canopy cover, taller trees, and increased abundance of *Inga* spp. trees). One reason for these differences may be because increased vegetation complexity in multistrata agroforestry systems increases leafhopper parasitism, thereby lowering abundance in more complex systems (Murphy et al. 1998). In contrast, Ramos (2008) did not observe differences in abundance of leafhoppers with differences in coffee management, but did see a significant negative correlation between canopy cover (negatively associated with coffee intensification) and leafhopper abundance.

We also examined the correlations between habitat characteristics, such as vegetation, elevation, and presence of the aggressive, dominant ant *A. sericeasur* on leafhopper tribe and morphospecies richness. We found that morphospecies and tribe richness increased with higher densities of *Inga* spp. trees. *Inga* is the most abundant genus of tree at the study sites, higher density of *Inga* trees is generally associated with increased management intensity of coffee pro-

duction. Thus, our results indicate that leafhopper morphospecies and tribe richness tends to increase in more intensive coffee sites. Previous studies of leafhoppers in coffee systems show similar levels of species richness. Rojas et al. (2001) found between 60 and 88 species of leafhopper per habitat type, with a total of ≈75 species and ≈7,534 leafhopper individuals sampled in Costa Rica. However, in their study, leafhopper morphospecies richness tended to decrease in more intensive sites, with higher morphospecies richness in habitats with one (*Erythrina* spp.) or two [*Erythrina* spp. plus *Cordia alliadora* (Ruiz & Pavón)] species of shade tree compared with habitats with no shade trees, suggesting the leguminous *Erythrina* influence leafhopper communities because of high nitrogen levels (Rojas et al. 2001). In our study, both the high-shade and moderate-shade sites contain an average of at least 11.2 different species of shade trees and are likely to have far higher vegetation complexity than the shade coffee farms in Costa Rica (Philpott et al. 2008). This high number of shade tree species in both sites could explain the apparent differences in the effects of higher intensity management on leafhopper morphospecies richness in relatively complex sites in Mexico compared with relatively simple sites in Costa Rica (e.g., Philpott et al. 2008).

We expected that abundance and richness of leaf-hoppers might be affected by the abundance of *A. sericeasur* nests within the plot. *A. sericeasur* is a dominant ant species that influences the abundance and spatial patterns of many other members of the insect community, including scale insects, spiders, coccinellid beetles, and other ant species (Vandermeer et al. 2010). As an aggressive species, *A. sericeasur* is indiscriminately aggressive toward all insects. In addition, *A. sericeasur* affects patterns of diversity and abundance of other organisms by altering competitive hierarchies and by interfering with oviposition behavior (Philpott 2010, Hsieh et al. 2012). Therefore, we predicted that leafhopper abundance might decrease on plants with *A. sericeasur*. However, we did not find any effect of this ant on leafhopper richness or abundance in this study. Previous studies (Maravalhas and Morais 2009) have found *Azteca* spp. tending leafhopper nymphs for honeydew. Within the Finca Irlanda system, *A. sericeasur* is known to tend aphids and scale insects on coffee plants for honeydew. Leafhopper using *Inga* spp. as oviposition sites and for nymph development may be avoiding the aggressive *A. sericeasur* by providing sugar resources.

One important implication of increasing leafhopper abundance, especially of certain species, may be increased risk of disease spread within coffee agroecosystems. In coffee agroecosystems, some leafhopper species (*Fusigonalia lativitatta* (Fowler), *Graphocephala permagna* (Nielson & Godoy), and *Hortensia similes* (Walker), all members of the Cicadellini tribe) transmit *Xylella fastidiosa,* a bacterium that causes coffee leaf scorch and crespera diseases (Garita-Cambronero et al. 2008, Ramos 2008). These diseases cause great economic damage to farmers because the diseases cause stunted plant growth, shoot dieback, and reduced fruit yield, all resulting in high percentage of crop loss (Paradela Filho et al. 1995, Lima et al. 1998). In this study site, in particular, we did not capture any of the species that are known to be vectors. Coffee plants did not show any signs of coffee leaf scorch or crespera disease, and the disease is not known yet from the Soconusco region of Chiapas where the work took place (J. Barerra, personal communication). Although leafhoppers do not present a risk to coffee farmers in Mexico at this time, risks could emerge in the future. *X. fastidiosa* is present in Mexico as a pathogen to other crops other than coffee, especially prevalent within grape vineyards in the northern region of Mexico (Janse and Obradovic 2010). The bacterium attacks a wide range of agricultural crops, including grapes, almonds, peach, and pears (Hopkins 1989). As farmers continue intensifying production, with resulting changes in vegetation complexity, leafhopper communities may change.

In summary, this study documented that leafhopper communities in the southern part of Chiapas, Mexico, were affected by season, the number of *Inga* spp. trees, and other vegetation characteristics. Intensification of coffee farms with the intention of obtaining higher yields and higher profits has been a trend in coffee agroecosystems for the past several decades. Although these small differences observed between habitats in this farm have not yet drastically altered leafhoppers communities, certain aspects of those changes, such as decreases in canopy cover and tree height and increased relative abundance of *Inga* spp. trees due to selective cutting of other species, may have important impacts on the leafhopper community. Changes in richness and abundance of leafhoppers in coffee growing areas of Mexico could be affected more in the future with dramatic reductions in tree richness, as observed in more intensive coffee landscapes in Costa Rica.

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