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Ant diversity between two methods of coffee farming in the San Luis Valley

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Abstract

Due to herbaceous, fungal, or insectivorous pests, coffee farms are sometimes treated with chemicals throughout the year to eliminate these problems. However, this can impact beneficial insects, like predaceous ants. Using tuna and honey as bait, I captured ants on the ground of three organic and three inorganic coffee farms. I also measured the amount of ground vegetation at each site. I found a significantly higher diversity of both total and predaceous ant species on organic farms ($p < 0.001$, $p < 0.005$). The amount of ground vegetation on organic farms was also significantly higher ($p < 0.0001$).

Resumen

Debido a los insectos y los hongos, las fincas de café están a veces siendo tratadas con químicos durante todo el año por estos problemas. Sin embargo, esto puede afectar a los insectos beneficiosos, como a las hormigas que comen los malos insectos. Uso de atún y miel como carnada, capture hormigas en la tierra de tres fincas orgánicas y tres fincas que usan químicos. También, medí la cantidad de vegetación de la tierra de cada finca. Encontre una diferencia significativa de total hormigas en las fincas orgánicas ($p < 0.001$) y también una diferencia significativa de hormigas rapaz ($p < 0.005$). La vegetación en la tierra es significativa mas en las fincas orgánicas ($p < 0.0001$). La cantidad de vegetación en la tierra afecta la diversidad de especies de fincas de café. Mas estudios miran en la dieta de las hormigas, la vegetación de la tierra, y la diversidad de los malos insectos es necesario para comprender mejor esta interacción.

Introduction

In Latin America, coffee (*Coffea arabica*) is an important export crop, accounting for 44% of the area of permanent cropland (Perfect et al. 1996). In Central America approximately 750,00 ha of land are in coffee production (Perfecto et al. 1996). Like most agricultural crops, coffee is commonly treated with chemicals to avoid fungal, herbaceous, or herbivorous pests. This elimination of pests inevitably results in a loss of species diversity on coffee farms, specifically arthropods (Vober 1999). Therefore, the loss of arthropods also results in a decrease of the order Hymenoptera, which includes ants.

In the Neotropics ants have been considered to be the most important pests of crops (Hanson 1995). Among a variety of crops they have been found to be detrimental as herbivores, have mutualisms with Homopteran pests, and also interfere with harvests (Hanson 1995). For example, the morphological species Solenopsis found in this study has been described to sting fiercely, eat tips of young shoots, and protect Homoptera (Hanson 1995). Also, in Costa Rica a mealy bug that is a vector for disease in pineapple is protected by Solenopsis and Pheidole (a morphological species also found in this study) (Hanson 1995).

Despite the bad rep ants have received, species do exist that are beneficial to agricultural crops as important pest predators (Risch 1983 and Hason 1995). Ants forage on vegetation, and among their collections of food are known to include herbivores found on plants (Holldobler and Wilson 1990). In Cuba Pheidole was used to reduce populations of the sweet potato weevil (Hanson 1995), and in Mexico ants reduced the number of both arthropod individuals and species in plots of corn and squash (Holldobler and Wilson 1990). Although Solenopsis is also described as a seed predator, it is more dependent on insect prey and honeydew (Holldobler and Wilson 1990). Another morphological species found in this study, Ectatomma preys on cotton boll weevils (Hogue 1993).

Ants can also be beneficial by foraging on unwanted plants. For example, in Mexico and Central America the lowest biomass of weeds and their seeds was found where Solenopsis occurred (Holldobler and Wilson 1990). The use of herbicides, therefore, may eliminate vegetation that may sustain beneficial arthropod species.

Past studies have shown a decrease in arthropod species on coffee farms treated with pesticides (Vober 1999), but none have focused specifically on ants. This project was done in the San Luis Valley of Guanacaste, Costa Rica, to test ant species diversity and the amount of ground vegetation in coffee farms treated with pesticides (any type of anti-herbivore, weed, or fungal chemicals) versus those untreated. The foraging habits of each morphological species was also studied in literature to determine, along with the habits, which were predaceous to identify potentially beneficial ants.

Materials and Methods

The project was conducted from mid-October to mid-November, 2000 in the San Luis Valley of Puntarenas, Costa Rica. Six available coffee farms were selected; three that use no chemical treatments (organic) and three that do (inorganic). The three inorganic farms were located in Finca la Bella of San Luis Arriba, a co-op of approximately seven family farms. The farms of Señores Gilberto, Milton, and Oldemar were used. Two of the organic coffee farms were located in San Luis Arriba, and were owned by Señor Vargas and the other by Señor Camora. The third organic farm was in San Luis Abajo and was owned by Señor Ramirez.

Two farms were sampled a day, one in the morning and one in the afternoon. Trappings were alternated at each farm between morning (0800-1200 hrs) and afternoon (1300-1700 hrs). All farms were, in the end, sampled twice in the morning and twice in the afternoon. A total of three transects were completed during each sampling period, and no rows in one sampling period were repeatedly used.

A transect was begun by walking approximately ten meters between coffee rows and placing an ant trap on the ground. Each transect consisted of ten ant traps; an ant trap every ten meters. The traps were made of wax paper cut into 5 x 7.5 cm rectangles, folded, stapled, and contained small amounts of tuna and honey. Due to the short length of rows, this sometimes required entry into parallel rows of coffee to lay down ten traps, resulting in up to three rows of coffee being sampled in one transect. A total of 270 traps were used.

After lying down a transect, approximately ten minutes passed before walking along the transect and to collect traps that had the presence of one or more ants on or in the trap. Every ten minutes this was repeated until the transect was checked five times or all envelopes were collected. Each envelope was stapled in consecutive order on a notecard and its pick-up time recorded. The pick-up time was recorded as 1-5, depending on which check it was picked up. The notecard was then put in a plastic bag with alcohol to preserve the ants. All ants were identified to morphological species and given a letter. The seven morphological species were identified to sub- family and genus using the keys in Hanson and Gauld (1995) and Holldobler and Wilson (1990) and the foraging habits of each were determined using Hanson and Gauld (1995).

Ground vegetation was also sampled at each farm. A 0.5m x 0.5m grid divided into 25 (5 x 5) even squares constructed of PVC pipe and string strung through drilled holes was used. At each farm the grid was placed arbitrarily (meaning I picked a random number of paces from 10-20 between each site) on the ground at twelve different sites. Squares with vegetation protruding through them were counted and a ratio of vegetation was recorded.

Diversity values were found using a Shannon-Wiener diversity index, and a modified t-test was used to test for differences (Zar 1984). A Paired Sign Test was used to test for difference in the number of captures of the two most prominent genera over time (Zar 1984). The number of captures during each check were graphed (Fig. 2 and 3). To test difference in the number captured of the two most prominent morphological species a Chi square test was used (Ambrose and Ambrose 1995). The difference of amounts of ground vegetation between the organic and inorganic coffee farms was tested after transforming the data (arcsin) using a two-way ANOVA (Zar 1984).

Results

A total of 720 traps were used and 528 collected with ants. Among the three organic coffee farms four sub-families and seven genera were captured, and in the inorganic coffee farms three sub-families and four genera were captured (Table 1). Of these five predaceous genera (two sub-families) were captured in the organic coffee farms, and three predaceous genera (two sub-families) were captured in the inorganic coffee farms (Table 1). The ant fauna of the organic coffee farms ($H^1 = 0.4095$) was significantly more diverse than the inorganic ($H^1 = 0.2441$) (modified t-test, $p < 0.001$).

Also, the predaceous ant fauna of the organic coffee farms ($H^1 = 0.2590$) was significantly more diverse than the inorganic ($H^1 = 0.1608$) (modified t-test, $p < 0.005$).

The Paired Sign Test found no significant difference in the number of captures over time between the two farming methods for either morphological species, Pheidole or Solenopsis ($p = 0.50$ and $p = 0. 3750$, respectively). Also, there was no difference in the total number of Pheidole or Solenopsis captured (mean = .779 and 2.571 respectively, df = 1).

The ground vegetation differed significantly between the two farming methods (inorganic mean 4.111, S.D. + 4.990, Organic mean 18.750, S.D. + 7.591) (Figure 1, ANOVA, $p < 0.0001$).

Discussion

Past studies have shown that there is a positive correlation between ground vegetation diversity and arthropod diversity in coffee farms (Perfect et al. 1996). My study supports this finding with the decrease in ant diversity between the organic farms (with the greater amount of ground vegetation) and the inorganic farms (with significantly lower ground vegetation), assuming that less vegetation also means less diversity. The decrease in both vegetation and arthropods is also a decrease in the food resources of species who are omnivorous, generalized scavengers, predaceous, or forage specifically on the ground and low-growing vegetation. Six of the seven morphological species, Pheidole, Solenopsis, Amblyopone, Hypoponera, Ectatomma, and Dolichoderus found in this study have one form of the aforementioned eating habits (Hanson 1995). Therefore it is possible that the loss of vegetation has impacted the diversity of ants on the studied coffee farms.

On chemically treated farms some predaceous species may not be supported with the lack of both ground vegetation and herbivores of ground vegetation. Hanson (1995) lists Ectatomma sp., Pheidole sp., and Solenopsis sp. as specific pest predators, and each genus is represented in both organic and inorganic coffee farms (Table 1). However, Amblyopone sp. and Hypoponera sp. are described only as predaceous and were captured only in the organic farms (Longino and Hanson 1995, Table 1).

The presence of more ground vegetation and possibly herbivores in the organic coffee farms may allow a greater resource base to support higher ant diversity. Torres (1984) explains that “agricultural land ants” utilize the habitat in different ways (e.g. different diets) that allow species to coexist. However, by limiting the resources for survival through eliminating weeds along with the herbivores of those weeds may have reduced already restrained microhabitats. This may explain why three of the four genera with the fewest captures exist only in the organic coffee farms. This may also explain why, even though there are fewer genera in the inorganic coffee farms, there were not significantly more captures of the prominent genera than the organic coffee farms. Without the vegetation their levels of fitness could not be enhanced.

Longino and Hanson (1995) describe Hypoponera, Brachymyrmex, Solenopsis, and Pheidole as being common and/or variable in their habitats. This may explain the prominence of Solenopsis and Pheidole, but not the infrequency of Hypoponera and Brachymyrmex. Possibly it is because the foraging habits of Hypoponera and Brachymyrmex are more specific to predation and extrafloral nectaries, respectively (Table 1). Since Pheidole and Solenopsis have generalized foraging habits not only larger communities can be supported, but they can also be sustained by alternative resources when one is lacking. However, there being no difference in the number of captures of the two most prominent morphological species between farming methods suggests that their levels of fitness could not be enhanced.

Since Hypoponera and Brachymyrmex were captured so few times but are described as being common suggests that these two morphological species may need to be further studied. In a habitat such as an organic farm with the resources to support communities of these morphological species, why were so few caught?

It is also questionable why there was such a low frequency of Ectatomma and Dolichoderus captures since both have a very general foraging habit. Possibly it is because neither were described as common, but it would be interesting to know why two generalist species are more prominent than two others.

The morphological species Amblyopone was not described as being common and its foraging habit described as only predaceous (Table 1). Therefore it can be expected that it would be caught infrequently, and like all other species show a decrease from organic to inorganic coffee farms.

Of the two most common ant genera, the initial check on the organic farms had the higher number of captures but after this the number of captures become similar (Figures 2 and 3). This suggests that the ants may be more responsive on organic coffee farms, but the lack of significance explains that this can only be a trend. It may have been possible that the traps were placed, overall, in closer proximity to populations in organic coffee farms.

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Table 1. Number of captures of each morphological species in both organic and inorganic coffee farms, and the foraging habits of each as described in both Longino and Hanson (1995) and Hanson (1995).

Genus	Organic	Inorganic	Foraging habits
Myrmicinae			
Pheidole	199	217	Generalized scavengers, predaceous, and frequent extrafloral nectaries
Solenopsis	34	22	Generalized omnivores, scavengers, predaceous, and forage on low vegetation or ground
Formicinae			
Brachymyrmex	11	0	Extrafloral nectarines
Ponerinae			
Amblyopone	1	0	Predaceous
Hypoponera	8	0	Predaceous
Ectatomma	1	3	Forage on ground and vegetation, extrafloral nectarines, and predaceous
Dolichoderinae			
Dolichoderus	18	14	Generalized scavengers, extrafloral nectarines
total	272	256	

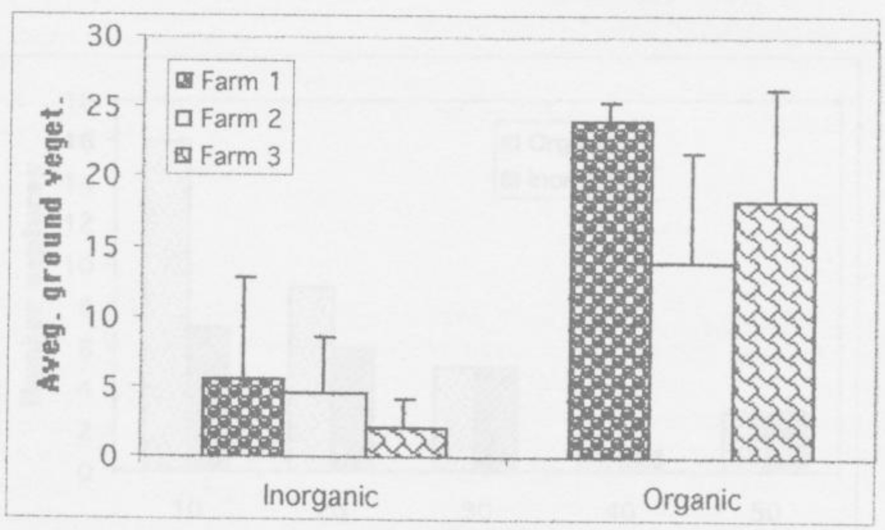

Figure 1. The average and standard deviation of ground cover vegetation for three farms of two different coffee farming methods in San Luis, Monteverde, Costa Rica.

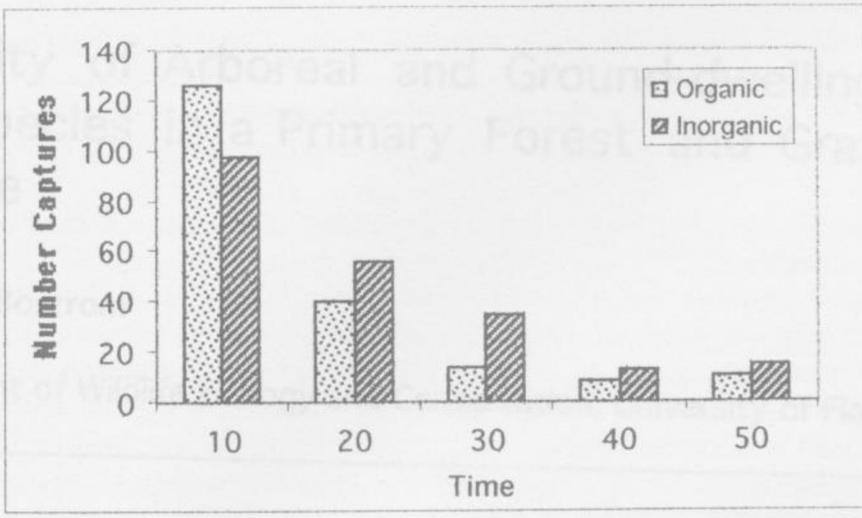

Figure 2. The number of captures of *Pheidole*after ten minute intervals on organic and inorganic coffee farms in San Luis, Monteverde, Costa Rica.

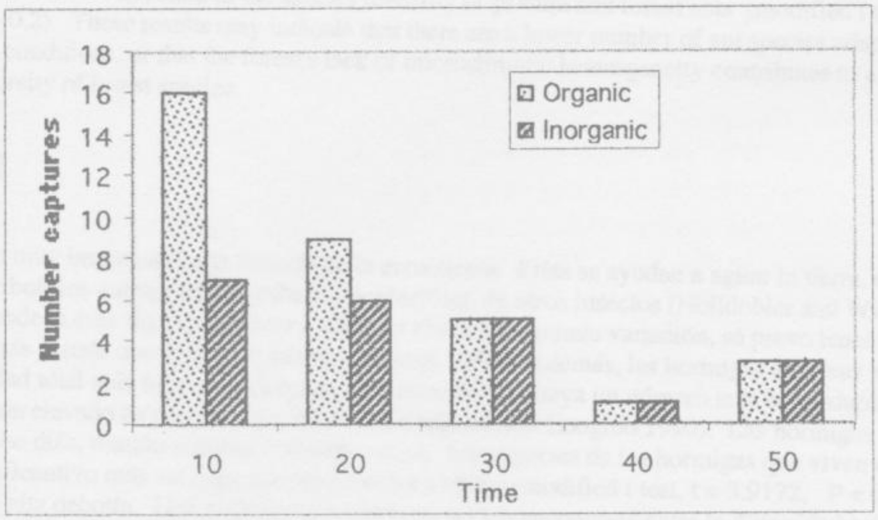

Figure 3. The number of captures of *Solenopsis* after ten minute intervals on organic and inorganic coffee farms in San Luis, Monteverde, Costa Rica.