Diversity of hoppers (Homoptera: Auchenorrhyncha) in coffee plantations with different types of shade, in Turrialba, Costa Rica

L. Rojas[1], C. Godoy[2], P. Hanson[3], C. Kleinn[4], L. Hilje[5]

Key words: Coffee, shade trees, insect diversity, Homoptera, Costa Rica

Introduction

Coffee plantations represent one of the most common agroforestry systems in Middle America and the Caribbean. Shade trees that are a part of these systems play important roles, not only from agronomic and economic standpoints (Beer et al., 1998), but also as a refuge for biodiversity, including birds and insects (Perfecto et al., 1996). Several insect groups, such as some Hymenoptera and Coleoptera, have been shown to reach high levels of diversity in traditional shaded coffee plantations (Nestel et al., 1993; Perfecto and Snelling, 1995; Perfecto and Vandermeer, 1994; Perfecto et al., 1996; 1997).

However, it is important to know if such a pattern holds for other insect groups, in order to make recommendations concerning either species conservation or pest management approaches. Therefore, a taxonomically well known insect group, such as hoppers (Homoptera: Auchenorryncha) was chosen to appraise the importance of shade trees in promoting species diversity in coffee plantations with different types of shade, including poró (*Erythrina poeppigiana*, Leguminosae) and laurel (*Cordia alliodora*, Boraginaceae), in Turrialba, Costa Rica.

Methodology

Homopteran diversity and similarity patterns were studied in three contrasting systems: unshaded coffee **(C)**, coffee-poró **(CP)**, and coffee-poró-laurel **(CPL)**. Three commercial farms, divided in four quadrats, were sampled for each type of system, on three dates, from March through October, 1997; five of them were located at CATIE (Cabiria and La Montaña), two in Pavones, one in La Suiza, and one in Verbena. Experimental plots differed in coffee variety (Caturra, Catimor, or Catuaí, of various ages), planting densities (4000-6000 plants/ha), and size (5000-8000 m^2), as well as in the type of surrounding vegetation.

Sampling included 100 coffee plants (25 consecutive plants in each of four rows, 2-3 rows apart, to prevent insect disturbance while sampling), as well as five poró or laurel trees in each quadrat, depending on the type of system; poró and laurel trees were selected so that they did not exceed 3 m in height, to allow sampling with an aerial insect net. Each coffee plant was beaten three times with the net, at different heights, in order to catch insects present in the upper, medium and lower strata, while the poró and laurel trees were beaten 15 times along the lower edge of their crown. The apical

[1] Graduate student, CATIE
[2] Instituto Nacional de Biodiversidad (INBio)
[3] Escuela de Biología, Universidad de Costa Rica
[4] Sub-unidad de Estadística, CATIE
[5] Unidad de Fitoprotección, CATIE

portion of the net was provided with a piece of fine cloth, in order to allow light penetration and easily concentrate captured insects there.

Insect samples were placed in plastic bags and taken to the laboratory, where they were killed. Specimens were separated according to morphospecies, and the numbers of individual per species were recorded. Representative specimens for each morphospecies were mounted on entomological pins for identification; species were determined by Carolina Godoy, M.Sc. (INBio). Species-abundance curves were plotted for each system, and indexes of diversity (Shannon-Wiener), dominance (Simpson), species evenness and similarity (Jaccard) were calculated for each system, plant component and plot (Krebs, 1989); in addition, similarity indexes were complemented with a cluster analysis.

Results and Discussion

A total of 10,612 specimens were caught during the study, which belonged to 131 species, in 10 families; at least three of them are undescribed species. Overall, 58% of the species and 71% of the individuals belonged to the family Cicadellidae, which was followed by Membracidae and Cercopidae.

The species-abundance curves, with an inverted J shape, had the same pattern in the three systems, and were best fitted by the logarithmic series. This is the typical curve occurring in natural communities, which shows that not all species are equally abundant; a few of them are very abundant, while the bulk of them are represented by a few individuals.

A particular species predominated in each system, as follows: *Graphocephala* sp. 1 (**C**), *Fusigonalia lativittata* (**CP**), and *Hebralebra nicaraguensis* (**CPL**). Except for *F. lativittata*, which was present in coffee regardless of the system, the other two species were barely or not represented at all in the other systems, components or plots. The five most common species for each system were *Graphocephala* sp. 1, *F. lativittata*, *Clastoptera* sp., *Graphocephala permagna*, and *Neocoelidia* sp. (**C**); *F. lativittata*, *Neocoelidia* sp., *Clastoptera* sp., Cicadellidae n.sp., and *Empoasca* sp. (**CP**); *H. nicaraguensis*, *Omegalebra* n.sp., *Empoasca* sp., *Neocoelidia* sp. and *Scaphytopius* ca. *latidens* (**CPL**).

Patterns of hopper species abundance and diversity are probably related to their ability to exploit food resources associated with foliage of coffee, poró and laurel trees, in particular ways. Indeed, members of the suborder Auchenorrhyncha vary in their food preferences and have specific morphological and physiological adaptations to feed upon either leaf phloem and mesophyll, or xylem (Backus, 1986).

Hopper species richness was higher for the **CP** system (88 species), followed by **CPL** (74) and **C** (60). Species diversity was also higher for the **CP** system (2.84), excepting in one plot (Verbena), while its values for the other two systems were very close: 2.61 (**C**) and 2.56 (**CPL**); in Verbena, poró density (270 trees/ha) was almost twice the density in the other plots (155 trees/ha). Dominance (Simpson's index) for **CPL** (0.15) was barely higher than for the other two systems (0.11), perhaps because of the unusually high numbers of *H. nicaraguensis* in laurel. The index of evenness was rather similar among systems: 0.63 (**C**), 0.62 (**CP**) and 0.59 (**CPL**).

Since the Shannon-Wiener's index accounts for both species richness and evenness (Krebs, 1989), it clearly reflected why the **CP** system was the most diverse in hopper species. Moreover, species diversity was always higher in the coffee component within each system, excepting in **CP** in

Verbena, where its value was higher in poró. This finding could be attributed not only to a higher sampling intensity in this crop (1200 net beats, as compared to 300 in both poró and laurel, for each date), but especially to species recruitment in response to planted area, that is, the concept of species-area (MacArthur and Wilson, 1967); in Turrialba, typical plant densities are 5000-6000/ha (coffee), 155/ha (poró), and 70-150/ha (laurel). In addition, species diversity in coffee itself in general increased in mixed systems, as compared to the **C** system.

The reason why species diversity was not maximum in the most complex system (**CPL**) is probably due to the fact that this type of system generally receives less external inputs, such as fertilizers. In this would be so, higher fertilizer levels in the other two systems could increase the nutritional value of coffee and coral tree foliage, thus probably favoring certain hopper species.

When examining species composition, it became clear that species similarity was higher between the **CP** and **CPL** systems (0.51), while it was very similar for the other comparisons: 0.38 (**C** and **CPL**) and 0.37 (**C** and **CP**). However, species composition did vary considerably by plant component and the geographic location of each plot, as well as by sampling date (dry or wet season). For example, within the **CP** system species similarity was highest between poró in La Montaña 2 and 3 plots, but it was lowest between them and poró in Verbena; moreover, it was high between coffee in La Montaña 3 and Verbena, but low between them and coffee in La Montaña 2. For the **CPL** system, species similarity was highest between coffee in La Montaña 1 and laurel in La Suiza, which are distant locations.

Conclusions

- The bulk of hopper species and individuals belonged to the family Cicadellidae, in the three systems studied.
- A particular species predominated in each system, as follows: *Graphocephala* sp. 1 (unshaded coffee), *Fusigonalia lativittata* (coffee-poró), and *Hebralebra nicaraguensis* (coffee-poró-laurel).
- Hopper species richness and diversity were higher for the coffee-poró system.
- Species similarity was higher between the coffee-poró and the coffee-poró-laurel systems, but it varied considerably according to plant component, geographic location of each plot, and sampling date.

References

Backus EA (1985) Anatomical and sensory mechanisms of planthopper and leafhopper feeding behavior. In: Nault LR and Rodriguez JG (eds) The leafhoppers and planthoppers. New York, Wiley. pp 163-188

Beer J, Muschler R, Kass D and Somarriba E (1998) Shade management in coffee and cacao plantations. Agroforestry Systems 38: 139-164

Krebs CJ (1989) Ecological methodology. New York, Harper & Row. 654 p

MacArthur RH and Wilson EO (1967) The theory of island biogeography. Monographs in Population Biology No 1. New Jersey, Princeton University Press. 203 p

Nestel D, Dickschen F and Altieri M (1992) Diversity patterns of soil macro-Coleoptera in Mexican shaded and unshaded coffee agroecosystems: an indication of habitat perturbation. Biodiversity and Conservation 2: 70-78

Perfecto I and Snelling R (1995) Biodiversity and the transformation of a tropical agroecosystem: Ants in coffee plantations. Ecological Applications 5(4): 1084-1097

Perfecto I and Vandermeer J (1994) Understanding biodiversity loss in agroecosystems: Reduction of ant diversity resulting from transformation of the coffee ecosystem in Costa Rica. Entomol. (Trends in Agril. Sci.) 2: 7-13

Perfecto I, Rice RA, Greenberg R and Van der Voort (1996) Shade coffee: A dissapearing refuge for biodiversity. BioScience 46(8): 598-608

Perfecto I, Vandermeer J, Hanson P and Cartìn V (1997) Arthropod biodiversity loss and the transformation of a tropical agro-ecosystem. Biodiversity and Conservation 6: 935-945