Available online at www.sciencedirect.com
ScienceDirect
Agriculture, Ecosystems and Environment 117 (2006) 218–221
Agriculture Ecosystems & Environment
www.elsevier.com/locate/agee

Short communication

# The effect of an ant-hemipteran mutualism on the coffee berry borer (*Hypothenemus hampei*) in southern Mexico

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Received 5 August 2005; received in revised form 6 April 2006; accepted 11 April 2006
Available online 5 June 2006

**Abstract**

The indirect effect of an ant-hemipteran mutualism was investigated in the coffee agroecosystem of Southern Mexico. The ant, *Azteca instabilis*, forms a mutualistic relationship with the coccid, *Coccus viridis*, on coffee plants. Through field surveys and experimental studies, the indirect effect of this mutualism on the main coffee pest in the region, *Hypothenemus hampei*, the coffee berry borer (CBB), was investigated. Results indicate a significant negative relationship between the number of coccids on a plant and the proportion of berries with damage by the CBB. Results also indicate that the effect of the ants is significant on per plant basis but not on per branch basis. Finally, a significant negative linear relationship was found between ant activity and the time it took ants to remove artificially placed borers on coffee berries. This study indicates that the mutualistic relationship between *Azteca* ants and the coccids has a positive indirect effect on the plant by reducing the numbers of the main insect pest of coffee.


*Keywords:* Integrated pest management; Coffee; Natural enemies; Pest control; Shade trees; Mutualism; Ants

## 1. Introduction

The main pest of coffee in Latin America is the coffee berry borer (CBB), *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae) a small beetle that bores into the coffee beans as they are maturing (Baker, 1999; Damon, 2000). Effects of the borer are variable but can reach epidemic proportions and cause significant economic damage (Baker, 1999). Biological control potential has been reported for parasitic wasps (Barrera et al., 1990; Damon and Valle, 2002), entomopathogens (Samuels et al., 2002; Mendez-Lopez et al., 2003; Neves and Hirose, 2005) and ants (Armbrecht, 2003; Armbrecht and Perfecto, 2003; Vélez et al., 2003; Gallego and Armbrecht, in press). This study examines a complicated interaction involving a mutualism between the ant *Azteca instabilis* (F. Smith) and the green scale *Coccus viridis* (Green), in which the ant acts as a predator on the CBB, significantly reducing its impact as a pest.

It has previously been demonstrated that the tending of various hemipterans (mainly aphids, coccids, mealybugs and treehoppers) by ants frequently has a net benefit on the host plant (Buckley, 1987; Dansa and Rocha, 1992; Oliveira and Del-Claro, 2005). In the case of *A. instabilis* and its mutualist *C. viridis*, the potential for an indirect positive effect using artificially placed larvae of *Pieris rapae* (L.) has been reported earlier (Vandermeer et al., 2002). While the ants tend coccids in large clumps concentrated on individual branches, they also patrol the rest of the plant and, in the case of an herbivore that requires some time to inflict damage, the ants are potential predators of that pest.

This study uses field surveys and experimental manipulations, to investigate whether the ant *A. instabilis* also acts as a predator on the coffee berry borer.

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doi:10.1016/j.agee.2006.04.007

## 2. Methods

### 2.1. Field survey

All *A. instabilis* nests were located in a 45 ha plot on Finca Irlanda, an organic shaded coffee farm located in southern Chiapas, Mexico (15°10′North and 92°20′West). The plot contains 10,647 shade trees (>10 cm dbh) in about 100 species, most of which seem perfectly suitable for nesting for this species of ant (nests have been found in 35 of the tree species, about what would be expected with a random allocation). Located near each of five nests that were isolated from other nests, six coffee trees were assessed for total number of coccids (*C. viridis*) (see below). The five nests were taken from widely separated areas within the 45 ha plot. Independent observers then assessed the same coffee trees, for total number of coffee berries and CBB damage. The proportion of damaged fruits per coffee plant was estimated as the number of coffee berries that had CBB (as evidenced from the entrance hole), over the total number of berries. The procedure was repeated in three areas that were isolated from any *A. instabilis* nests, again sampling areas widely separated from one another in the 45 ha plot. In the end, a total of 34 coffee plants were surveyed for total number of *C. viridis*, coffee berries and coffee berries damaged by the CBB.

An additional survey was conducted on six coffee plants (haphazardly chosen to represent a range of densities for *C. viridis*) in which the total number of coccids on each branch was directly counted, and subsequently the rate of borer attack determined for the same branches.

### 2.2. Coccid sampling and estimations

The following procedures were adapted, based on a preliminary study of 21 coffee plants for which the actual number of coccids were first determined in absolute terms and then compared with relative estimates obtained in several ways.

On a given coffee plant a quick survey was undertaken to determine whether there were any obvious concentrations of coccids or ant activities. Based on this quick survey the plant was placed into one of three categories – a 5-min category, a four-class category, or a full count category. For those plants in the 5-min category the entire plant was scanned systematically from top to bottom during a 5 min period. All coccids (larger than 2 mm in length) on leaves, stems, and berries, were counted concentrating on berries and terminal shoots where the coccids tended to concentrate. The count of total number of coccids greater than 2 mm encountered in a 5 min period is the base number. The estimated actual number was computed as, estimated number = 2.55 × base number. If, during the course of counting, more than six individual coccids were encountered on any given branch, the plant was transferred to the four-class category. For those plants in the four-class category, coccids were counted on each branch to determine which class the branch falls into: 0–6 individuals = low; 7–30 individuals = medium; 30–70 individuals = high; 70 and above = super high category. There was no need to actually count coccids unless the actual number was near the border between the categories. Normally a minute or so of counting made it evident to which class the branch belonged. To make an estimate of the final number estimate, all low branches were multiplied by 0; medium branches by 15; high branches by 46; and super extra branches by 150. Scaling numbers were determined from the initial study of 21 plants. The full count category included those plants that had no berries and fewer than 25 branches. All leaves and stems were examined and all coccids greater than 2 mm were counted. Estimating scales with this procedure and comparing the estimate to the known numbers from the preliminary study of 21 trees provides 93% efficiency in estimation ($r^2 = 0.926$).

### 2.3. Experimental methods

A coffee plant with actively foraging *A. instabilis* individuals was located near to each of the five ant nests mentioned above. A total of nine branches were chosen so as to represent a range of ant activity from high to low. On each of the branches, ant activity was assessed by watching a single point for a 5 min period and counting the number of ants passing that point, or, if ant activity was especially high, for a single minute. Then, one by one, individual borers were placed on a berry on each of the branches and the time to removal by an ant was recorded. Since it takes a borer a little more than an hour to completely burrow into a coffee berry (personal observations), the beetles were watched for a maximum of 70 min, if they persisted that long.

## 3. Results

The relationship between number of coccids and percentage of coffee berries attacked by the CBB was assessed with a simple regression, which was significant ($p = 0.014$, $r^2 = 0.18$) for a linear regression of proportion of fruits with borers versus log of number of *C. viridis* (Fig. 1). Thus the total number of coccids on a coffee plant was inversely related to the proportion of berries attacked by the CBB. Assessment on a branch-by-branch basis revealed a far weaker relationship, which, while suggestive, was not significant statistically. It appears to be protection of the coffee plant as a whole that is affected by the presence of the ant, and not strictly localized to particular branches with a high concentration of coccids, although some degree of such localization is suggested.

The results of the experimental manipulations indicated that there was a negative relationship between ant activity and the time of removal of CBB by ants (Fig. 2), with a significant regression of the log of time to removal versus the