The Effect of Ants on Nymphal Survivorship of Coccus viridis (Homoptera: Coccidae)

Honeydew, the liquid excrement produced by some homopterous insects, can provide an important source of nutrition for ants (Way 1963). And the parthenogenetic green scale, Coccus viridis (Green), has long been known to be tended by ants (Van der Goot 1916, Smith 1942, Bess 1958, Jutsum et al. 1981). Ants feeding on scale honeydew may in turn benefit their hosts (Buckley 1987 and references therein) by preventing an accumulation of honeydew that may encourage the growth of fungi harmful to the scale, or by discouraging or interfering with natural enemies of the scale. In fact, ants are associated with outbreaks of C. viridis in coffee plantations to the extent that eradication of the ants has been recommended as a method of control (Young 1982).

Although ants clearly encourage green scale infestations, the mechanism by which they do so is not certain (Bartlett 1961). Van der Goot (1916) suggested that removal of honeydew by ants improved the feeding efficiency of the scale, resulting in a twenty-fold increase in reproduction rate. Bess (1958) concluded that ants stemmed the accumulation of honeydew that would otherwise nourish growth of a sooty mold that reduces green scale survivorship and reproductive rate. Bartlett (1961), on the other hand, found that ants benefited the brown scale (C. hesperidum L.) by protecting them from natural enemies.

Our objective was to determine if the presence of ants influenced C. viridis populations in a tropical coffee plantation and, if so, was this by removal of honeydew or protection from natural enemies.

The study site was a coffee plantation at an elevation of 1 km in La Mucuy, Venezuela, state of Merida. The study took place from January 19 to 25, 1986 in the dry season; the weather was sunny and warm. The plantation was approximately one hectare in area and was overgrown with many native tree and shrub species. Coffee trees supported moderate infestations of C. viridis (no more than five adult female scales per leaf), with no trees showing weakening due to scale feeding. Adult female scales were producing crawlers at the time of the study. Two species of ants in the genera Crema togaster and Camponotus were observed tending scales on all but a very few infested leaves.

The study included ten infested coffee trees between 1 and 3.5 m in height. The scales on nine of these trees were tended by Crema togaster while those on one tree were tended by Camponotus. For each tree, we chose a contiguous pair of branchlets having a maximum of five adult female scales per leaf, and censused the scales on three to five leaves per branchlet. We selected by coin toss one branchlet of each pair for ant-exclusion: We applied a ring of sticky resin (Tanglefoot Co., Grand Rapids, Michigan, U.S.A.) to the base of this branchlet and removed existing ants. We counted initial numbers of live adult and nymphal scales on all branchlets and counted again in the mornings on four of the following six days. The mean numbers of scales per leaf on each experimental branchlet were contrasted with a Wilcoxon’s signed-ranks test (Sokal & Rohlf 1981) to determine the impact of ant exclusion on nymphal population density.

We captured adults of two species of coccinellids (Azyla elegans Gordon and Diomus sp.) for a study of the behavioral interactions between ants and these predators. Ten and 12 individuals of each respective coccinellid species were introduced one at a time to leaves tended by Crema togaster. We observed the behavior of beetles and ants for five minutes, or until the beetle vacated the leaf.

Individual ants usually remained motionless on leaves, positioned among their scale hosts, and we observed some ants feeding on the honeydew produced by the adult female scales. The sticky resin was completely effective in preventing ants from tending scales on ant-excluded branchlets as we did not find any ants on these leaves after its application. The initial mean numbers of adult female scales per leaf on ant-tended branches (2.15 ± 0.47) and ant-excluded branches (1.43 ± 0.38) were not significantly different (P < 0.29).

Figure 1 shows that the initial numbers of nymphs for the two treatments were nearly equal (P < 0.52). Significant differences in nymphal population density (P < 0.05) between the two treatments occurred after 5 days with greater numbers occurring on branchlets tended by ants. By the sixth and last
day of the study, the nymphaal scale population density of ant-tended branchlets was twice that of the ant-excluded branchlets ($P < 0.05$). At this time walking crawlers were still present on four of the ten ant-excluded branchlets and three of the ten ant-tended branchlets. None of the ant-tended branchlets showed evidence of honeydew accumulation at the end of the study while three of the ten ant-excluded branchlets had visible accumulations. There was no sign of sooty mold growth.

Four species of predators of C. viridis were observed feeding on scale nymphs during the study: a nitidulid species (Cybocephalus sp.) and three coccinellid species (Azya elegans Gordon, Diomus, and Scymnus sp.). Individuals of Azya elegans placed on an ant-tended leaf were aggressively chased from the leaf by ants eight out of ten times. Similarly, ants forced individuals of Diomus from the leaf nine out of twelve times. Ants removed beetles by chasing and biting or by twisting their abdomens toward the beetles, presumably emitting a defensive secretion. Ants attacked only when beetles approached scales that were close to the ant; beetles not chased from leaves were those that did not come into close contact with ants. In only one instance was a beetle able to feed on scales before being chased off.

Other studies have shown that different ant species tending the same homopterous host may vary in their ability to defend the host against its enemies (Bristow 1984, Takada & Hashimoto 1985). Therefore, the inclusion of data from the single Camponotus-tended tree with the Crematogaster data may be questioned. However, the effect of ant exclusion on scale survivorship was the same in this study regardless of ant species. For this reason we combined the data for analysis.

Alternative hypotheses may also explain these data. Firstly, accumulated honeydew itself might have prevented crawlers from settling on leaves. However, only three of the 10 ant-excluded branchlets showed accumulation of honeydew. Thus, this could not have been responsible for lower numbers of nymphs on the other ant-excluded branchlets. Secondly, the sticky resin applied to the ant-excluded branchlets may have had a toxic effect on mother scales, causing a reduction in the reproduction rate and, consequently, lower numbers of nymphs. At the end of the study, however, walking crawlers were present on branchlets with resin and without, suggesting that mother scales were healthy in both treatments. Thirdly, numbers of nymphs may not have increased on ant-excluded branchlets because the resin barrier also excluded walking crawlers that would be arriving from other parts of the tree. The rapid reduction in the scale population on ant-excluded branches, however, argued that differences between treatments were more likely due to a loss of nymphs in ant-excluded branchlets. The fact that the numbers of nymphs actually decreased on the ant-excluded branchlets argues against all three of these alternative hypotheses. Clearly, the differences in nymphaal survivorship are due to a disappearance of settled nymphs from the ant-excluded branchlets rather than a reduction in their birthrate or in their ability to settle on these branchlets.

Bess (1958) did not observe any aggressive interactions between ants and green scale enemies. In the
present study, however, ants clearly demonstrated aggression toward coccinellid predators. The survivorship of nymphacl scales was significantly improved in the presence of ants; after only 6 days the mean numbers of nymphacl scales on ant-excluded branchlets was reduced by 39 percent while ant-tended branchlets showed an increase of 43 percent (Fig. 1). Since the initial numbers of adult female scales per leaf were not significantly different between ant-tended and ant-excluded branchlets, and since crawlers were active on leaves in both treatments at the end of the study, these differences are most likely due to ants discouraging scale predators.

Based on our studies of nymphacl C. viridis, we concur with Bartlett (1961) that exclusion of predators by ants benefits populations of this scale. It is noteworthy, however, that coccinellid larvae were present on some trees and were completely ignored by Crematogaster, indicating that protection from enemies was not complete. The aggressive behavior of ants towards adult beetles, however, may interfere with oviposition and in this way limit the numbers of beetle larvae.

Because of the short duration of this study, it was not possible to discount the impact that honeydew accumulation might later have had on scale survivorship. Neither was it possible to examine the effect of parasitoids on the survivorship of scales. Over the course of the study, however, no parasitoids or parasitized scales were observed. Parasitism may be more important at other times of the year. Nevertheless, it was clear that ant-tending significantly reduced the activities of predators on leaves and in this way fostered an increase in the scale population. These data certainly support the practice of eliminating ants as a means of controlling green scale infestations.

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LITERATURE CITED


RESUMEN

La presencia de hormigas mejoró la sobrevivencia de las ninñas del cóccido verde Coccus viridis (Green) sobre árboles de café en una plantación tropical. Aquellas ramas en las cuales las hormigas fueron excluidas duras 6 días mediante
Host Tree Selection by the Neotropical Ant *Paraponera clavata* (Hymenoptera: Formicidae)

Colonies of the giant ponerine ant *Paraponera clavata* nest at the bases of trees throughout a wide range in Central and South America. At the La Selva Field Station of the Organization for Tropical Studies, near Puerto Viejo de Sarapiquí, Costa Rica, the ants prefer but do not limit themselves to *Pentaclethra macroloba* (Bennett & Breed 1985), a mimosaceous tree that is by far the most abundant species in the tropical moist forest of the region (Harshorn 1972). In Panama, Belk et al. (1989) found a positive association between *P. clavata* and 1 palm and 4 tree species among 76 species of trees and shrubs, 1 palm, and 2 lianas surveyed. *Pentaclethra* was not present at the Panama locality.

We asked the general question of whether the founding queens seek out *Pentaclethra macroloba* at the Costa Rican locality in preference to other tree species, or colonies subsequently emigrate to the bases of the *Pentaclethra*, or differential survivorship favors those colonies that chance to nest near *Pentaclethra*. We were inclined to the first of these three possibilities when we encountered two dealated *Paraponera* queens, apparently in the early stages of colony foundation, foraging on the lower trunks of *Pentaclethra* trees at La Selva. These occurrences, while suggestive, may be due to chance alone. In order to test the possible existence of active selection by the queens, we devised a simple olfactometer test in which one or the other of the queens was placed in a darkened 40 × 32 cm tray and allowed to choose among three 15 × 2 cm test tubes with various freshly gathered vegetable materials. Each tube contained at the bottom a one-centimeter layer of moist soil from the forest floor, on top of which was placed 3 to 5 2-cm-long strips of bark (of one tree species or another) plus 3 to 5 fragments of leaves approximately 2 cm across. One of the three tubes contained *Pentaclethra* material; each of the other two contained material collected haphazardly from other trees that grow around *Pentaclethra*. The latter control group contained one species each belonging to six families (Araliaceae, Lauraceae, Leguminosae, Melastomataceae, Nycaginaceae, and Sterculiaceae). The tubes were aligned in parallel 10 cm apart with their mouths facing the same direction. The queen was checked at hourly intervals until she was found to have entered a tube and was resting quietly in it. The *Pentaclethra* and non-*Pentaclethra* materials were put in different vials and their relative positions (left, center, or right) were changed with each replicate. The two queens were used with about equal frequency. Fresh soil, always from the same spot in the forest floor, was added to each vial with every trial.

In a total of 18 trials, each control tree species was tested at least twice in competition with *Pentaclethra*. The 2 queens chose *Pentaclethra* 13 times and 1 of the 2 competing controls 5 times. The probability that the proportion could be due to chance alone, calculated from a binomial distribution with cumulative terms for 13 and higher, is less than 0.001. The result may actually be stronger than these numbers indicate. One of the ‘mistakes’ leading to a choice of a control tube immediately followed an accident in which the queen lost part of a leg, causing visible agitation; two of the other four occurred at the end of the experimental series, when the queens had become so restless and slow to settle anywhere that we decided to end the experiment.

Three *Paraponera clavata* workers were tested together in the same way. They showed a high degree