The Green Scale, Coccus viridis (Green) (Homoptera: Coccidae), and Ants[1, 2]

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There are many specific references to the association of ants with honeydew-producing insects (Nixon, 1951; Way, 1954) and to the interference by ants with the activity of parasites and predators of many homopterous insect pests (Flanders, 1951). During the academic year 1954–55, there was an opportunity to examine a number of natural infestations of honeydew-producing coccids, fulgorids, psyllids, and aphids in Ceylon and to follow experimentally the progress of *Coccus viridis* (Green) infestations attended and unattended by ants. The primary objective was to gain information as to how this scale and some other honeydew-producing insects benefit through attendance by ants. The possible association of parasite, predator, and pathogen activity with the population density of the scale was investigated in some detail, but the data and discussion of them will be presented in a separate paper. The present paper deals with the decline in numbers of this coccid in the absence of ants, and parasite activity with and without ants present.

METHODS

During the first several weeks after the author's arrival in Ceylon in May 1954, many ant-attended honeydew-producing insects, especially mealybug infestations on cacao, were examined to determine what species appeared to be dependent on ants and the activitiy of parasites in different infestations. At that time it was planned that intensive studies would be made with mealybugs on cacao and that extensive spraying to control ants would be done in plots within the plantations. However, the anticipated investigations in the cacao plantations did not prove feasible. In August, after many localized infestations of *C. viridis* attended by different species of ants had been observed on several different host plants, it was decided to make specific studies with this species and follow the progress of colonies with and without ants present. For the more intensive studies two series of experimental plots were used;

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one with branches on a large coffee tree, *Coffea arabica* L., and the other with orange plants, *Citrus sinensis* (L.), grown in bamboo pots.

The *C. viridis* on the coffee was a natural infestation tended by a vigorous colony of the large red ant, *Oecophylla smaragdina* Fabricius. After examining the colony at frequent intervals throughout August, it was found that the infestation appeared to be healthy, that there were several hundred scales per leaf, and that parasitization of adult scales was slightly below one per cent. On September 4, fourteen infested small branches, each with a dozen or more leaves on it, were selected and tagged. On the same date the main stems of one-half of the tagged branches were first wrapped with 3 to 4 layers of wax paper, over which 3 to 4 layers of paper toweling were applied. The wrappings were then tied in place with twine, and Dieldrin was applied with a brush. All ants on the branches distal to the bands were removed by hand. The bands were re-treated in the same manner with Dieldrin one week later and again on October 1. Without further treatments the bands effectively excluded ants until March 1955, when the study was concluded.

The 25 orange plants used in these studies were obtained from a nursery on July 26 and no *C. viridis* was found on them at that time. The plants were divided into two groups and placed close together around the bases of two trees (*Thevetia peruviana* (Pers.) K. Schum.), which were about 15 feet apart in the laboratory grounds. Each of the trees was infested with *Saissetia nigra* Nietner and attended by many individuals of the ant, *Technomyrmex albipes* (F. Smith). On the following day foliage and twigs infested with *C. viridis* were attached to the orange plants with paper clips. Numerous crawlers readily settled on the plants, and when the detailed studies on the progress of *C. viridis* on these plants were begun about two months later all of the plants were heavily infested. On October 1 the plants were divided into four groups, 6 in each of three groups and 7 in the other. Two groups were left in their original sites around the bases of the two trees with ants in attendance, while the other two groups were placed about 10 feet away under similar conditions. Ants were excluded from the two groups located a few feet away from the trees by first applying Aldrin to the ground and then applying Dieldrin with a brush in a band around each pot. All ants on these plants were carefully removed by hand. The pots were re-treated with Dieldrin on November 9 when one ant was found on a plant. No additional treatment was needed during the remainder of the study, which was concluded in March 1955.

At intervals of approximately two weeks, samples of 4 to 32 coffee and orange leaves were removed from each group of the experimental branches and plants and examined under a dissecting microscope. Counts were made of the scales by instars, and the second-instar larvae and adults were dissected. The number of scales which appeared to be diseased was also recorded and notes made on the relative amount of honeydew and sooty mold present.

In addition to the above series many collections of *C. viridis* and other

coccids were made in other localities on different hosts attended by different species of ants. Usually only the adults in these collections were dissected to determine the degree of parasitization. The progress of *C. viridis* and parasitization was also followed on a large tree, *Gliricidia sepium* (Jacq.) Steud., on the laboratory grounds by periodically making spot collections of leaves from it, counting the number of adults present, and dissecting them for evidence of parasites and disease.

Results

In less than 24 hours after the attendant ants were excluded from the experimental coffee branches and orange plants infested with *C. viridis* the leaves became sticky with honeydew and took on a glistening appearance, which increased throughout the first week. Honeydew accumulated rapidly on the ant-free coffee leaves, with droplets on many scales actually larger than the scales themselves. Within a week sooty mold began to increase appreciably on the ant-free leaves; however, many scales appeared to remain healthy. In the meantime, on the leaves with ants present there was little or no accumulation of honeydew, and very little sooty mold. By the end of the second week sooty mold had become very abundant on the ant-free coffee foliage, with many scales covered with sooty mold. On the orange plants the development of honeydew and sooty mold was essentially the same as that on the coffee branches except that sooty mold developed faster on the orange plants, which was possibly due to the wetter weather in October than in September.

The scale populations, both on the coffee branches and on the orange plants, decreased and finally disappeared where ants were excluded (table 1). At the time the first samples from the coffee branches were examined on the 17th day after ants were excluded, about 35 per cent of the first- and 55 per cent of the second-instar larvae were dead on the ant-free branches, while only 10 per cent of the first- and less than 5 per cent of the second-instar larvae on the branches with ants were dead. Similar conditions prevailed two weeks later when over 50 per cent of both the first- and second-instar larvae in the samples from ant-free branches were dead, while only about 5 per cent of those on branches with ants were dead. Throughout the period of study the mortality rate among all stages was higher on the ant-free coffee branches and orange plants than on those which had ants present (table 2). Furthermore, the infestations of *C. viridis* on each of the 7 ant-free coffee branches and the 12 ant-free orange plants completely disappeared in about four months, while the ant-attended infestations were still in a healthy condition.

The possible interference of ants with parasites of the scale was followed rather closely through periodic examination and dissection of samples of adult scales. Most of the parasitization within the experimental infestations was caused by the eulophid parasite, *Aneristus ceroplastae* Howard, which attacks adult scales primarily; therefore the data presented on parasitization in

these infestations relate only to the adult stage. At first glance the percentage parasitization without ants present appeared to be higher than when ants were present (table 3). However, if parasitization is calculated on the basis of total number of scales in the samples taken from the citrus plants between October 28 and February 9 it was slightly higher (22 to 18) on the plants with ants than on the ones without ants. Furthermore, there were also more parasitized scales per leaf on the plants with ants present. On the same basis, the percentage parasitization was higher on the ant-free coffee branches (21 to 9). However, there were more parasitized scales per leaf in the samples from branches accessible to ants.

A few examples will suffice to show that in some instances parasites were quite successful in natural infestations in the presence of ants. On January 27 and 30, seventy-three adult *C. viridis* from a citrus tree about 100 yards from the laboratory were dissected, and 56 per cent of them were parasitized by an undetermined external parasite (probably a cecidomyiid, but no adults were obtained). During the next several days additional samples of the scale were obtained from a nearby coffee tree and a sapodilla tree, *Achras sapota* Mill., which were also attended by *T. albipes*. Seventeen, representing 77 per cent, of the 22 adult *C. viridis* taken from the coffee tree on February 5 and 9 were parasitized, and all of the 13 adults in the samples taken from the sapodilla tree on February 7 and 9 were parasitized. Two hundred eighty-eight, or 70

TABLE 1. Progress of *C. viridis* infestations on experimental plants with and without ants.

DATE	NUMBER LIVE SCALES PER LEAF	
	WITH ANTS PRESENT	WITH ANTS EXCLUDED[1]
	COFFEE	
9-23-54	1300	530[2]
10-10-54	1100	480
10-26-54	530	250
11-12-54	250	55
11-29-54	380	8
1-3-55	220	+[3]
2-2-55	200	0
	CITRUS	
10-2-54	160	
10-28-54	210	240
11-18-54	290	54
11-30-54	440	33
1-10-55	220	+[4]
2-9-55	27	0

[1] Only more heavily infested leaves were taken as samples; therefore, the infestations actually declined much more rapidly than these figures indicate.

[2] Ants excluded from coffee twigs on September 4 and from citrus plants on October 1.

[3] One living out of a total of 260 scales on 10 leaves.

[4] Three alive out of a total of 25 scales on 32 leaves.

per cent of the 414 second-instar *C. viridis* in these samples from the coffee tree were parasitized; and 190, or 81 per cent, of the 234 second-instar *C. viridis* in the samples from the sapodilla tree were parasitized. Individuals of *T. albipes* were numerous on both of these trees.

Discussion

The *C. viridis* infestations on the experimental coffee branches and orange plants from which ants were excluded declined rapidly during the first few weeks and disappeared completely within about four months; however, the infestations attended by ants were still thriving when the study was closed in March 1955. The decline in the ant-free infestations was actually much more rapid than indicated by the data presented in table 1, for as the scale population declined and became more spotty in distribution only more heavily infested leaves were selected as samples from the ant-free branches and plants. There was a higher percentage of the scales dead among those without ants in attendance than among those attended by ants, and this was pronounced in each developmental stage (table 2). The mortality among the ant-free scale infestations was approximately 4 times that among the ant-attended ones. The gradual rather than abrupt disappearance of the infestations on the ant-free branches and plants may be significant from a population dynamics standpoint. Unfortunately, the growth rate of individual scales with and without ants in attendance was not determined; however, Van der Goot (1916) found that ant-attended individuals developed to maturity in 65 days, while unattended individuals required 83 days.

The actual cause of death of the scales was not determined, except for those which contained parasites, parasite emergence holes, or conspicuous evidence of being infected with bacteria or fungi. Within a few hours after the ants were excluded, droplets of honeydew began to accumulate on the

TABLE 2. Summary of mortality in different stages of *C. viridis* when attended and non-attended by ants[1]

STAGE	WITH ANTS PRESENT		WITH ANTS EXCLUDED	
	No. scales in samples	Per cent dead	No. scales in samples	Per cent dead
		COFFEE		
First	9708	11	3347	45
Second	1505	19	2446	53
Adult	1012	12	506	51
		CITRUS		
First	6025	2	865	8
Second	2069	7	486	25
Adult	931	31	513	34

[1] Based on scales present at time samples were examined.

scales and foliage, and this was followed by an abundant growth of sooty mold. Both the honeydew and sooty mold might well have had an adverse effect on the scales in hindering them mechanically and otherwise upsetting their well-being. The dense growth of sooty mold appeared to interfere with crawlers in settling; and it is possible that some scales died as a result of becoming overgrown with sooty mold, as many living scales became densely covered. The indirect benefits derived in this manner from the ants could be classed as primarily sanitational. It is also possible that the dense growth of sooty mold adversely affected the nutritional qualities of the sap on which the scales fed, but this was not investigated.

During these studies no ant was seen to attack or transport a living scale; however, in several instances ants were seen transporting bits of wax from mealybugs.

Ants are known to interfere with some parasites and predators of certain coccids. However, during these studies ants were not observed molesting parasites or predators, and there was little evidence obtained to indicate that ants adversely affected the parasites of *C. viridis*. The percentage parasitized was somewhat higher in the ant-free infestations on the experimental coffee branches; but the number of parasitized scales per leaf was about the same as in the ant-attended infestations, and there was even less evidence of an adverse effect from ants on the parasites in the infestations on orange plants (table 3).

Furthermore, in several field collections of scales attended by ants, including species other than *C. viridis*, between 50 and 90 per cent of the individuals

TABLE 3. Parasitization of *C. viridis* adults with and without ants present.

DATE	WITH ANTS PRESENT			WITH ANTS EXCLUDED[1]		
	No. scales per leaf	No. scales parasitized per leaf	Per cent parasitized	No. scales per leaf	No. scales parasitized per leaf	Per cent parasitized
			COFFEE			
9-23-54	74.5	0	0	31.0	0.5	2
10-10-54	40.0	7.0	18	22.0	10.5	48
10-26-54	23.2	4.2	18	6.8	5.0	74
11-12-54	121.2	0.8	1	43.8	5.0	11
11-29-54	30.0	11.2	38	2.2	1.5	56
1-3-55	5.5	0.8	14	0		
2-2-55	14.5	1.5	10	0		
			CITRUS			
10-28-54	38.0	3.0	9	61.5	4.5	7
11-18-54	40.0	3.5	9	22.5	7.2	32
11-30-54	27.1	8.5	31	7.3	2.5	34
1-10-55	14.9	3.7	25	+[2]	+[2]	100
2-9-55	10.5	5.8	55	0		

[1] Ants excluded from coffee twigs on September 4 and from citrus plants on October 1.
[2] Only 1 scale on 32 leaves and it was parasitized.

were parasitized. In a number of instances scales were collected and dissected to determine whether parasitization was higher on the leaves than on the stems, and on leaves outside *O. smaragdina* nests than on leaves inside them. No clear-cut differences were found in either case. Parasitization in excess of 50 per cent occurred on stems which served as runways for ants attending scales on trees, and parasitization was no higher on the leaves than on the stems.

Summary

Individual colonies of the green scale, *Coccus viridis* (Green), gradually but completely disappeared in about four months after ants were excluded from them, while ant-attended colonies continued to thrive. No satisfactory answer was obtained to the question of how the scales were aided or protected by the ants. However, there was very little or no evidence obtained to indicate that the ants reduced parasite and predator attack. In several instances well over 50 per cent of the scales in ant-attended colonies were parasitized.

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