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Effect of Malathion-Bait Sprays on Biological Control of Insect Pests of Olive, Citrus, and Walnut

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The effect of malathion-bait sprays, directed against Mediterranean fruit fly (*Ceratitis capitata* [Wiedemann]), on biological control of selected non-target insects was investigated in northern California during 1982 and 1983. In Stanislaus County, 19 applications of malathion-bait spray were applied over a period of 7 months; following cessation of the spray program, increases of olive scale (*Parlatoria oleae* [Colvee]) and black scale (*Saisettia oleae* [Olivier]) on olive and of brown soft scale (*Coccus hesperidium* Linn.) and black scale on citrus were detected, compared to population levels of these scales in the adjacent unsprayed zone. The secondary outbreaks of these scales were attributed to destruction of natural enemies (chiefly parasites) by malathion. The outbreaks of black scale (citrus and olive) and brown soft scale were not apparent until 1 year after the first application of malathion-bait spray, or 5 months after the last application. Populations of cottony-cushion scale (*Icerya purchasi* Maskell), citrophilus mealybug (*Pseudococcus calceolariae* [Maskell]) and citricola scale (*Coccus pseudomagnoliarum* [Kuwana]) remained at low levels on citrus in the spray zone; no treatment effect on these species was detected. Latania scale (*Hemeberlesia lataniae* [Signoret]) on olive was apparently suppressed by the sprays. Walnut aphid (*Chromaphis juglandicola* [Kaltenbach]) in commercial walnut orchards was less abundant in the spray zone 2 months after the last application of malathion-bait; no suitable explanation for this was available. In the city of Stockton, a secondary outbreak of walnut aphid occurred in the spray zone (during the spray period) whereas an outbreak of black scale on olive was detected shortly after the spray program ended. These outbreaks were attributed to destruction of natural enemies by malathion. In general, concentrations of malathion-bait sufficient to kill most adult parasites tested were less toxic to the pest species tested. These results indicate that future (medfly) eradication programs which employ numerous sequential applications of malathion-bait spray can be expected to disrupt a substantial portion of the biological control which exists in the target zone.

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Effect of Malathion-Bait Sprays on Biological Control of Insect Pests of Olive, Citrus, and Walnut[1]

INTRODUCTION

IN THE SUMMER OF 1980, an infestation of Mediterranean fruit fly (or medfly), *Ceratitus capitata* (Wiedemann), was detected in Santa Clara County of northern California. Because this pest posed a great threat to California agriculture, an eradication program was undertaken shortly thereafter. From June to December 1980, approximately one billion sterile flies were released in the infested zone; from December 1980 to June 1981, an additional three billion flies were released, coupled with fruit stripping and ground spraying (Scribner 1982). However, by July 1981, it was clear that, for whatever reason, the medfly infestation was not eradicated. At this time, a massive program involving aerial application of malathion-bait spray was initiated.

Unfortunately, the California medfly infestation was not restricted to Santa Clara County and adjacent urban areas. In August 1981, a medfly infestation was verified near the town of Westley (Stanislaus County) in the San Joaquin Valley. An eradication program commenced shortly thereafter. In this case, the spray zone received 19 treatments of malathion-bait spray from August 15, 1981 to March 13, 1982. In July 1982, a medfly was captured in a trap in the city of Stockton (San Joaquin County). Following this find, the immediate area surrounding the site received eight treatments of malathion-bait spray from June 25 to August 12, 1982. In all of these treatments, the dosage was 2.4 fluid ounces of 91 percent malathion (in 9.6 fluid ounces of Staley's Protein Bait) per acre.

Malathion-bait sprays had been used to eradicate previous medfly infestations in Florida and Texas (Hagen et al. 1981; Steiner et al. 1961). However, during these efforts, there were apparently no thorough studies on the effect of the sprays on nontarget insects, especially predaceous and parasitic arthropods. After the 1956 medfly eradication in Florida, Steiner et al. (1961) noted that "no authentic cases of injury to... beneficial insects... were ever found." However, this should not be taken as evidence of the ecological safety of malathion-bait sprays because no experimental (or other) data were presented by these authors relative to the issue at hand. Indeed, Barnes and Ortega (1959) documented secondary outbreaks of spider mites in California walnut orchards following application of malathion-bait sprays for control of walnut husk fly (*Rhagoletis completa* Cress.). In California, the medfly eradication programs in Stanislaus County and Stockton provided a good opportunity to gather some experimental evidence on this question. Therefore, in the spring of 1982 we initiated field studies in these areas. Our primary mission was to assess the impact (if any) of malathion-bait sprays on insect pests known to be under some degree of biological control. Because of this, we were essentially restricted to pests of olive, citrus, and walnut. The results of these and related investigations are presented herein.

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MATERIALS AND METHODS

The field investigations described below were subject to two major constraints. First, our experimental design was contingent upon the nature of the medfly eradication zone, for example, size, shape, pest-natural enemy systems available. In such a case, the investigator is essentially given an experimental design and asked to make the best of it. In this regard, our general plan was to sample throughout the spray zone and in the adjacent (surrounding) unsprayed zone. A map of each spray zone is given in figure 1. Second, the funds for the research were not made available until after most of the malathion-bait sprays were already applied in Stanislaus County. In this case, all samples were taken after the spraying ended (fig. 2). In Stockton, the spraying commenced before we were able to obtain pretreatment samples. Thus, no pretreatment counts of pest-enemy levels are available for either spray zone. However, as will be shown later, these constraints did not preclude the gathering of a large data base from which some meaningful conclusions can be drawn.

Olive investigations

Study sites

The characteristics of the olive trees sampled in Stanislaus County are given in table 1. In the medfly spray zone, we selected 13 sites containing a total of 82 trees. We sampled 54 of the 82 trees on each sample date. In the unsprayed zone, we sampled 54 of 80 trees which were distributed among 15 sites. In both areas, all sites contained at least 2 trees per site and the same trees were sampled each time. We were particularly concerned that the trees in both zones were comparable in terms of insecticide history, irrigation, and pruning, as these practices can have considerable influence on population dynamics of the scale pests involved. After interviewing the owners of the trees, we were able to select sample trees which (1) had not been sprayed with any insecticide in recent years and (2) would not be treated with any insecticide during the course of our investigations. The majority of the trees in each area received some form of irrigation during the hot, dry summer, and some of the trees were pruned during the course of the study. None of the trees was in an urban area. Three sites in each zone had citrus trees nearby. This was noted because black scale is a pest of both citrus and olive.

In western Stanislaus County there is essentially no commercial olive production. Therefore, our study sites were either dooryard plantings or roadside stands. The spatial distribution of these sites (fig. 3) reflects our efforts to obtain an even distribution of trees in and out of the spray zone. Virtually all the available olive trees in the spray zone were surveyed, along with most all of the trees within approximately 5 miles (8 km) of the spray zone. The region to the west of the spray zone is rangeland and no trees were available for study. A small portion of the spray zone received more than 19 applications, although none of our sites was in this region.

In Stockton, we sampled 19 trees (at six sites) in the spray zone and 20 trees (at nine sites) in the adjacent unsprayed zone (fig. 4). The spatial pattern of these sites is indicative of the clumped nature of the olive trees in the region. In these cases, a site contained from two to five trees, usually planted between the sidewalk and the street, and all trees were free of recent insecticide application. None of the trees was treated with insecticide during the course of our investigations.

Sampling methods

On a given sample date, 24 twigs were cut from around the skirt of the tree. These were placed in a plastic bag, returned to the laboratory and stored at 10° C. In the laboratory, individual twigs were examined with the aid of a dissecting microscope. Ten consecutive leaves and the four attendant internodes were carefully examined for black scale (*Saissetia oleae* [Olivier]), olive scale (*Parlatoria oleae* [Colvee]) and latania scale (*Hemeberlesia lataniae* [Signoret]). Although latania scale is not under good biological control in this region, it was censused because of its abundance. Nymphs and adults were also dissected to determine rates of parasitization. The major parasites associated with olive scale were *Aphytis paramaculicornis* DeBach and Rosen and *Coccophagoides utilis* Doutt. Black scale was parasitized by numerous species, including *Metaphycus helvolus* (Compere), *M. lounsburyi* (Howard), *Scutellista cyanea* Motsch., and at least three species of *Coccophagus.* The olives in Stanislaus County were sampled on 4 dates (fig. 2) whereas those in Stockton were sampled only once (September 1982).

Citrus investigations

Study sites

All of the citrus investigations were carried out in Stanislaus County. In this region, there is very little commercial citrus production. Therefore, we exclusively sampled dooryard trees which, according to the owners, had not been treated with insecticide in recent years, and which would not be treated during the course of our investigations. In the medfly spray zone, we sampled 63 of 102 trees located among 19 sites; in the adjacent unsprayed area, we sampled 63 of 90 trees distributed among 14 sites (table 2). Virtually all of the sample trees were well cared for (irrigated during the summer) and in most cases there were no olive trees nearby. The latter condition was noted because black scale is a pest on both olive and citrus. As in the olive investigations, the spatial arrangement of the various study sites was not random (fig. 5). However, these sites represent most of the available trees that we considered appropriate for this study and the distribution of sites appears adequate for comparing sprayed versus unsprayed areas. Only one site (5) in the area was sprayed more than 19 times.

Sampling methods

The citrus trees were sampled at the same time as the olive trees (see fig. 2). Normally, 15 twigs were cut from around the skirt of a tree. These were placed in a plastic bag, transported to the laboratory and stored at 10° C. Each twig was then examined with the aid of a dissecting microscope. Five consecutive older leaves, plus five attendant internodes, were carefully inspected for black scale, brown soft scale (*Coccus hesperidium* Linn.), cottony-cushion scale (*Icerya purchasi* Maskell), citricola scale (*Coccus pseudomagnoliarum* [Kuwana]) and citrophilus mealybug (*Pseudococcus calceolariae* [Maskell]). Only black scale and brown soft scale were abundant enough to warrant detailed analysis. Nymphs and adults of all pests were also dissected to determine percent parasitization. Parasites associated with brown soft scale in this region include *Metaphycus luteolus* (Timberlake) and at least two species of *Coccophagus.* The parasite complex associated with black scale is apparently the same as for this scale on olive in the area.

Walnut investigations

Study sites

Western Stanislaus County is a major walnut-producing region and thus we were able to conduct our studies in commercial walnut orchards. Walnut orchards in the region normally receive either one (second generation) or two (first and second generations) applications of insecticide (usually Zolone) for control of codling moth (*Laspeyresia pomonella* [Linn.]). In an intensive survey, we were able to locate 12 orchards which would eventually be sprayed only once (second generation) for codling moth. These were equally divided between sprayed and unsprayed zones (fig. 6). Some characteristics of these orchards are listed in table 3. There were several commercial varieties involved; however, we are aware of no substantial evidence that population dynamics of walnut aphid (*Chromaphis juglandicola* [Kaltenbach]), the pest of interest, is greatly influenced by commercial varieties of walnut. These orchards were similar in age but not necessarily in size. More importantly, all of the orchards received one application of Zolone (for codling moth) anywhere from June 30 through July 9. Orchard number five in the spray zone also received an application of metasystox (for walnut aphid) on August 26, 1982, and was then dropped from the sampling program.

In Stockton, we selected 20 trees—10 in the spray zone and 10 in the adjacent unsprayed area—which, according to their owners, had not been chemically treated in recent years and would not be treated during our study. The spatial distribution of these trees is given in figure 7. As in previous investigations, these trees were chosen because they were appropriate to our study and represented an even distribution of trees in the sprayed versus unsprayed areas.

Sampling methods

In Stanislaus County orchards, trees to be sampled were chosen at random from the central region of the orchard. Ten consecutive rows of trees near the center of the orchard were selected at the beginning of the season. A buffer zone of at least five rows of trees surrounded this sample zone. In most cases, the buffer zone to either side of the center zone was greater than five rows. On each sample date, one tree was chosen at random from each row. Ten compound leaves around the skirt of the tree were inspected for walnut aphid (living and mummified). A sample of live aphids was dissected in the laboratory to determine percent parasitization. The major parasite of walnut aphid is *Trioxys pallidus* (Haliday). A sample of the mummies was also returned to the laboratory. These were held individually in gelatin capsules so that emerging primary or hyperparasites could be recorded. Normally, samples were taken every 7 to 14 days (see fig. 2). In Stockton, the same 20 trees (see fig. 7) were sampled weekly (10 leaves per tree, etc.).

Laboratory bioassays

The fallout deposition of malathion-bait sprays, as measured by Oshima et al. (1982), was highly variable, both in terms of droplet size and droplets per unit of surface area. We therefore designed a laboratory bioassay in which droplet size and density were relatively conservative, that is, resulting in less active ingredient per surface unit than in the field.

Our purpose was to assess the toxicity of both malathion-bait and bait alone to a series of pest and natural-enemy species.

The experimental unit was devised as follows. Both ends of a 1 pint (550 cc) cardboard ice-cream carton were removed. A pyrex petri-dish bottom served as the bottom of the container. Five drops (0.5 mm in diameter) of either malathion bait, bait only, or water were placed in the central portion of the dish. The malathion bait was prepared as follows: eight parts of Staley's Protein Bait plus two parts of 91 percent malathion concentrate. Ten test insects were placed in the container and the top covered with 90-mesh cotton organdy. For each test species, the experiment was replicated four times. All containers were placed under a fume hood during the test so as to allow for air movement. Normally, results could be taken after 4 hours.

Statistical analysis

Due to the variation encountered in the field studies and because of the design constraints discussed previously, our approach to statistical analysis of the data was relatively conservative. We first analyzed the data by means of a one way Analysis of Variance (ANOVA) comparing treatments. When significant differences were detected, we then analyzed the same data employing a repeated-measures ANOVA so as to assess both treatment and site effects. The Bonferroni method was used to locate significant differences. These statistical procedures were used to analyze all of the olive and citrus data, plus the walnut data from Stanislaus County. The walnut data from Stockton were analyzed using the "t" test as were the data for percent parasitization. In the laboratory bioassays, the data were subjected to a one way ANOVA; the "lsd" test was employed to locate significant differences.

RESULTS

Pests of olive

On the first sample date in Stanislaus County, we were able to sample not only living scales, but also the old black scales which remained on the twigs from previous months. The densities of these "old black scales" are shown in table 4. Whereas there were considerably fewer first and second instar (and total) scales present in the spray zone (presumably due to the malathion-bait sprays), the densities of old female scales in the sprayed versus unsprayed zones were comparable. In other words, the black scale populations at the time the malathion-bait spraying began (August 1981) were probably about the same in the sprayed and unsprayed zone. In this case, we have a kind of indirect pretreatment assessment. As might be expected, percent parasitization of old black scales was consistently higher in the unsprayed area compared to the spray zone (table 5).

Densities of living scales in March of 1982 are summarized in table 6. On this first posttreatment sample date, latania scale was more abundant in the unsprayed area whereas olive scale was somewhat more abundant in the spray zone. First and second instar black scale were actually more abundant in the unsprayed area; however, total numbers of black scale per twig were about the same in each zone. Percent parasitization among the various sites in and out of the spray zone was generally low (table 7). However, the effect of the malathion-bait sprays was apparent in the case of the parasites of black scale, that is, parasitized black scales were detected only in the unsprayed area. Thus, after 19 applications of malathion-bait spray, massive secondary pest outbreaks were not recorded immediately, although some initial evidence of ecological disruption was detected.

Data derived from the May samples were generally similar to those from the previous March (table 8). Latania scale, although less abundant overall than in March, was again more abundant in the unsprayed area. Olive scale was detected at only two sites (both in the spray zone). However, the general "absence" of olive scale is probably an artifact: At this time of the year the scale population is composed largely of very small individuals and these simply were not detected by our sampling method. In May, the bulk of the black scale population was mature females, and there was no difference in female density between sprayed and unsprayed zones. However, figures for percent parasitization again indicated that the malathion-bait sprays had disrupted the parasite complex associated with black scale (table 9). As in samples from the previous March, parasitized black scales were only detected in the unsprayed zone. However, even in the unsprayed area, total percent parasitization of black scale was quite low. Thus, by the summer of 1982 the available evidence suggested that, while latania scale was actually suppressed by malathion-bait sprays, these treatments would not be as disruptive to biological control as might be expected.

The latter suggestion was shattered by the results obtained from the August samples (table 10). Latania scale was again less abundant in the spray zone; however, secondary outbreaks of olive scale (as in March) and black scale were apparent. The outbreak of black scale was particularly apparent in the field. During August, most of the black scale population was either first or second instar scales. Densities of these instars, plus that for total scales, increased in the spray zone by factors of 1.8×, 3.6×, and 2.2×, respectively. However, percent parasitization of scales was generally low at all sites (table 11). This was especially surprising because one would expect considerably higher levels of parasitization in the unsprayed area.

The last samples taken in Stanislaus County (March 1983) revealed patterns similar to those detected during the previous August (table 12). Latania scale was again more abundant in the unsprayed zone whereas olive scale and black scale were more abundant in the spray zone. In other words, 1 year after the malathion-bait sprays ended, their effects (positive and negative) on nontarget organisms were still apparent. Values for percent parasitization were again generally low, except for parasitized female black scale (table 13).

The only posttreatment samples taken from olive trees in the Stockton spray zone revealed a pattern similar to that observed in Stanislaus County in the case of black scale (table 14). In this case, densities of third instar, female, and total scales were higher in the spray zone by factors of 5.6×, 2.9×, and 2.1×, respectively. However, percent parasitization was not commensurately lower in the spray zone (table 15).

Pests of citrus

All of the citrus investigations were carried out in Stanislaus County and, as in the olive investigations, we were able to assess the density of "old black scales" on the first sample date. In this case, old black scales were generally rare; however, densities (especially females) were comparable in the sprayed and unsprayed zone (table 16). Thus, it is reasonable to assume that black scale populations on citrus (as on olive) in this region were comparable before the medfly eradication program. Percent parasitization of old black scales was generally low also (table 17). Assessment of densities of living scales at this time revealed a slightly higher density of brown soft scale in the spray zone whereas black scale population levels were comparable in both areas (table 18). These results parallel those obtained for olive pests in the same region, that is, the first posttreatment samples revealed no major secondary pest outbreaks in the region. Percent parasitization of these scales was very low and showed no apparent trend (table 19).

Samples taken in May generally conformed to those from the previous March. However, in this case there were no apparent differences at all in terms of scale densities in the sprayed versus unsprayed zones (table 20). Percent parasitization of brown soft scale was low whereas no parasitized black scales were even detected (table 21). Thus, 2 months after the last application of malathion-bait spray in the region there was no obvious pest upset with respect to brown soft scale, black scale, or any other scale on citrus. However, as in the case of the olive pests, the secondary outbreaks would be detected in the near future.

In August a secondary outbreak of brown soft scale was detected, along with a smaller outbreak of black scale (table 22). Increases of brown soft scale in the spray zone were as follows: first instar, 2.5×; second and third instar, 5.1×; and total scales, 3.9×. The paucity of female brown soft scale is probably a generation effect. Most of the population was in the prereproductive age class. Although differences in density of black scale and brown soft scale were evident, there were no commensurate differences in percent parasitization (table 23). In the case of black scale, parasitized scales were only found at one site. Thus, secondary outbreaks of brown soft scale, and black scale to a minor extent, were first detected on citrus 1 year after the first malathion-bait sprays were applied.

The last samples were taken in March 1983. By this time, levels of brown soft scale were generally comparable in the sprayed versus unsprayed zones whereas population levels of black scale were at about the same levels as detected the previous August (table 24). In other words, the secondary outbreak of brown soft scale had subsided 1 year after the last sprays were applied, but the increase in black scale had persisted. As in previous samples, overall percent parasitization was low and showed no major trend (table 25).

Walnut pest

The only pest of interest on walnut in both Stanislaus County and Stockton was walnut aphid. Densities of the aphid during the 1982 growing season in Stanislaus County are summarized in table 26. The data obtained from May 6 through June 30 warrant discussion because these represent walnut aphid abundance from the time malathion-bait sprays ceased (mid-March) until the point when all orchards were being treated with Zolone for control of second-brood codling moth (early July). Thus, only these data should be used in assessing the possible effects of malathion-bait sprays on biological control of walnut aphid.

In many ways, the results obtained were counter intuitive. That is, walnut aphid was actually more abundant in the unsprayed zone, rather than in the spray zone as one might expect. Although this difference in density was small, it was consistent and even statistically significant on two dates. During this period, percent parasitization in the spray zone (20.7) was not significantly different from that obtained in the unsprayed area (34.1). Thus, there is no clear evidence that differential rates of parasitization could have led to the events observed here. We suspect that the malathion-bait sprays applied during the fall of 1981 in some way led to this rather unexpected situation. We will return to this aspect in the section on Discussion.

The data obtained in Stockton were more in line with what one might expect (fig. 8). In this case, a major secondary outbreak of walnut aphid occurred in the spray zone. Density of walnut aphid in the adjacent unsprayed zone was very low, as expected. Interestingly, the walnut aphid outbreak in the spray zone subsided before the last application of malathion-bait spray. From mid-August through the end of September the population levels in sprayed versus unsprayed areas remained at very low levels.

Laboratory bioassays

The results of laboratory bioassays clearly show that the parasites tested were highly susceptible to malathion bait, whereas the pests tested were either moderately susceptible or relatively resistant to the doses administered (table 27). In these experiments, oleander scale and the last six parasites listed were chosen as indicator species due to their availability and because other pertinent parasites *(Aphytis paramaculicornis, Coccophagoides utilis)* were rarely collected in the field. These data, plus the pertinent evidence in the literature on malathion (Bartlett 1963, 1966; Luck and Dahlsten 1975; Kirknel 1974; Washburn et al. 1983), suggest that malathion is generally more toxic to parasites (and possibly predators) than to herbivorous insect pests. In the present case, there is even some evidence that the dried malathion bait is toxic after 3 weeks and that the bait itself can even lead to death of the test insect.

DISCUSSION

Scales on olive

Densities of latania scale were consistently lower in the spray zone compared to the adjacent unsprayed area (fig. 9). This is good evidence for a beneficial effect of the malathion-bait sprays, namely, chemical suppression of a nontarget pest. In addition, the data in table 27 reveal that the crawler of this species is susceptible to malathion bait. Latania scale was comparatively abundant both in and out of the spray zone and was in fact the dominant diaspidid scale on the olives sampled. Because it is generally free of parasites (at least in this region), this scale may well become a serious pest of olive in the future. In fact, when we sampled olive fruit during the fall of 1982, latania scale infested an average of 51.7 percent and 58.1 percent of the mature olives in the sprayed and unsprayed zones, respectively. Evidently, the malathion-bait sprays were not sufficient to reduce the rate of scale-infested fruits in the spray zone. In contrast, olive scale (which is under excellent biological control) infested less than 1 percent of the fruit in either zone.

Olive scale was introduced into California in the 1930s, became a very serious pest, and was eventually brought under virtual complete biological control. Two introduced aphelinid parasites, *Aphytis paramaculicornis* DeBach and Rosen and *Coccophagoides utilis* Doutt, are responsible for control of the scale (Huffaker et al. 1962; Kennett et al. 1966; and Huffaker and Kennett 1966), and the project now qualifies as a text book example of a success in classical biological control. Thus, it should be of great interest to assess the impact of malathion-bait sprays on this host-parasite system. The data summarized in figure 10 place into perspective the data briefly discussed in the previous section. Clearly, olive scale was consistently more abundant in the spray zone compared to the unsprayed area. Furthermore, this difference was detected even though the scale was very rare. In addition, when we compared the proportion of infested trees in March and in August (1982), there was a significant increase in this variable in the spray zone but not in the unsprayed. It is our belief that these differences in density are real and that they resulted from malathion-induced mortality of *A. paramaculicornis* or *C. utilis,* or both. Unfortunately, these parasites were so rare that we were unable to accumulate enough of them for a malathion bioassay. However, it should be borne in mind that all of the parasites tested in the laboratory were highly susceptible to malathion bait. It is significant that the olive scale increase in the spray zone persisted into 1983, if not longer. This is not surprising because olive scale is bivoltine and could conceivably require several generations to reach levels comparable to those prevalent in the unsprayed areas.

Black scale was introduced into California before 1880 (Quayle 1911) and, over the years, has been a serious pest of both olive and citrus. Approximately 50 species of predators and parasites have been introduced for control of black scale, and at present, numerous species are established throughout the state; these provide generally good biological control of black scale on citrus but not so on olive (Smith and Compere 1928; Flanders 1965; Bartlett 1978; and Bennett et al. 1976). For the present study, the data summarized in figure 11 place the situation on olive into perspective. In the sprayed and unsprayed areas, black scale populations were probably at similar levels before the medfly eradication program. Then, following 19 applications of malathion-bait spray (for a period of over 7 months), no secondary outbreak of black scale was detected until 1 year after the spraying commenced, or about 5 months after the last bait sprays were applied. Such a delayed secondary outbreak is probably because black scale is univoltine in this region. We hypothesize that this outbreak was due to destruction of natural enemies of black scale by malathion. These natural enemies are presumed to be chiefly parasites, and include *Metaphycus helvolus* (Compere), *M. lounsburyi* (Howard), *Scutellista cyanea* Motsch. (a facultative predator/parasite) and *Coccophagus* spp. According to Kennett (1980, and pers. comm.), the dominant parasite in this region is probably *M. helvolus.* The data in table 27 clearly show that the dose of malathion bait required to kill most *M. helvolus* was actually nontoxic to most black scale crawlers. Unfortunately, the critical evidence for the overall hypothesis of parasite destruction is lacking, that is, lower rates of parasitization in the spray zone compared to the unsprayed area. However, it should be noted that parasitized scales were detected only in the unsprayed zone for the first two posttreatment samples. Also, the adult of *M. helvolus* "host feeds" and kills the host in the process (Flanders 1942). Such predation by this parasite would not have been detected by our sampling methods. Predation on black scale by other species (coccinellids) was not measured either. Finally, the remnant of the secondary outbreak of black scale detected in March 1983 indicates that in a univoltine species such as this, a few to several generations may be required before population levels return to pretreatment levels.

Scales on citrus

Brown soft scale is a cosmopolitan scale which feeds on numerous host plants. In California, it is evidently under good biological control on citrus; this control is effected by a complex of parasites, of which *Metaphycus luteolus* (Timberlake) is presumed dominant (see Bartlett and Ewart 1951; Bartlett and Ball 1964, 1966; and Bartlett 1978). In the present study, the population trends of brown soft scale on citrus (fig. 12) were similar to those observed for black scale on olive (fig. 11). In other words, following 19 applications of malathion-bait spray over a period of approximately 7 months, populations of brown soft scale remained at low levels in both sprayed and unsprayed areas. It was not until 1 year after the first sprays were applied (5 months after the last spray) that an outbreak of this scale was detected. There are at least two hypotheses to account for this outbreak: (1) destruction of natural enemies (primarily parasites) and (2) pest stimulation by malathion. Hart and Ingle (1971) showed that fecundity of this scale could be increased with methyl parathion; however, in the same study, they were unable to demonstrate any stimulatory effect with respect to malathion. We therefore suggest that the outbreak of brown soft scale on citrus following malathion-bait sprays was due to destruction of natural enemies of the scale. The data for rates of parasitization of brown soft scale are unfortunately equivocal with respect to this hypothesis. However, two forms of biotic mortality associated with brown soft scale were not measured in this study, that is, host feeding (= predation) by *M. luteolus* (see Bartlett 1953) and predation by coccinellids. Unlike black scale on olive, the outbreak of brown soft scale on citrus had dissipated by March 1983. This is not surprising because this scale is multivoltine and thus population changes can take place in a shorter period of time, compared to a univoltine scale.

The summary of population trends of black scale on citrus (fig. 13) is similar to that of black scale on olive (fig. 11). That is, scale densities before medfly eradication measures were probably comparable in sprayed versus unsprayed areas and no secondary outbreak was detected until 1 year after the first spray, or 5 months after the last spray. Also, the black scale increase in the spray zone was still evident in March 1983. Our explanation of the scale outbreak on citrus is the same as for the outbreak on olive: Malathion-bait sprays suppressed parasites of black scale *(M. helvolus, Coccophagus* spp., *S. cyanea, M. lounsburyi)* and the scale increased accordingly. Because the scale is univoltine in this region, it may take a few years for population density to return to pretreatment levels.

It is puzzling that cottony-cushion scale, citrophilus mealybug, and citricola scale remained at low levels in the spray zone. Cottony-cushion scale has been under complete biological control in California for almost 100 years (see Quezada and DeBach 1973), whereas citrophilus mealybug has been under complete biological control for over 50 years (see Compere and Smith 1932). Citricola scale is evidently under good biological control also (see Bartlett 1953, 1978). Thus, one might expect these pests to increase in the spray zone in a manner similar to black scale and brown soft scale. However, this was simply not the case. It may be that, because these insects were so rare, any malathion-induced increases in their densities were undetectable according to the sampling methods employed in this study. On the other hand, the malathion-bait sprays simply may not have had an adverse effect on the biological control of these pests. The latter possibility is of particular interest and should be the subject of future investigations.

Walnut aphid

Walnut aphid is an exotic pest of English walnut and was introduced into California before 1900. It eventually became a major pest and was recently (c. 1970) brought under excellent biological control by the introduced aphidiid parasite, *Trioxys pallidus* (Haliday) (Frazer and van den Bosch 1973; van den Bosch et al. 1979). The secondary outbreak of walnut aphid during malathion-bait spraying in Stockton (fig. 8) is consistent with what experienced observers would expect. In this case it is quite reasonable to assume that this outbreak was triggered by the destruction of *T. pallidus* by malathion, allowing the aphid to increase accordingly. Further evidence in support of this explanation is found in table 27, that is, doses of malathion bait which killed most *T. pallidus* were generally nontoxic to walnut aphid. The fact that walnut aphid increased greatly in Stockton during the spraying is further evidence that this aphid is comparatively resistant to malathion-bait sprays as employed in the medfly eradication program. However, the aphid population did crash in Stockton before the cessation of spraying. This could have been due to high levels of residual malathion which accumulated in the spray zone. However, this is only a hypothesis. There is also evidence that walnut aphid populations may crash simply due to high temperatures (see Sluss 1967).

The data for walnut aphid from Stanislaus County are more difficult to interpret. It could be argued that malathion-bait sprays in the fall of 1981 killed a large portion of the aphids, resulting in fewer overwintering eggs, which then resulted in lower aphid densities in the spray zone during the spring of 1982. However, the evidence suggests that walnut aphid is not really susceptible to malathion bait. On the other hand, if the aphid were eventually killed after several sprays (as suggested in the Stockton study), then the hypothesis becomes tenable. Another hypothesis involves secondary parasites. In this case, it is feasible that the malathion-bait sprays destroyed most of the secondary parasites during the late summer and fall of 1981, thereby permitting higher levels of parasitization by *T. pallidus* the following spring, resulting in lower aphid densities. Although secondary parasites in the genera *Aphidencyrtus, Pachyneuron, Asaphes,* and *Alloxysta* were reared from walnut aphid mummies in the region, there was no detectable difference in parasitization by *T. pallidus* in the spring of 1982. To summarize, we simply have no adequate explanation for these findings and suggest that future research be directed toward determining whether or not chemical insecticides applied in the fall of one year can affect the biological control of walnut aphid the following year.

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TABLES

TABLE 1

CHARACTERISTICS OF OLIVE TREES SAMPLED IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, 1982-83)

	No. of Trees					
Site	Present	Sampled	Contiguous	Irrigated	Pruned	Citrus Present
(Spray Zone)						
1	22	10	variable	yes	no	yes
2	6	4	yes	no	no	yes
3	9	5	variable	no	yes	no
4	4	4	yes	yes	no	no
5	3	3	variable	yes	yes	no
6	3	3	no	yes	no	no
7	2	2	no	yes	no	no
8	2	2	no	yes	no	no
9	3	3	no	yes	yes	no
10	4	4	no	yes	no	yes
11	6	3	yes	no	no	no
12	3	3	no	yes	no	no
13	15	8	variable	no	no	no
	82	54				
(Unsprayed Zone)						
1	3	3	variable	yes	yes	yes
2	2	2	no	yes	yes	no
3	2	2	yes	no	no	yes
4	7	3	no	no	no	no
5	4	4	yes	no	no	no
6	7	7	variable	yes	yes	yes
7	7	4	yes	yes	no	no
8	8	4	variable	yes	no	no
9	14	5	variable	yes	no	no
10	3	3	variable	no	yes	no
11	3	3	no	yes	yes	no
12	2	2	yes	yes	yes	no
13	10	4	variable	yes	no	no
14	4	4	no	yes	no	no
15	4	4	yes	yes	yes	no
	80	54				

TABLE 2
CHARACTERISTICS OF CITRUS TREES SAMPLED IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, 1982-83)

Site	No. of Trees Present	No. of Trees Sampled	Contiguous	Irrigated	Olive Present
(Spray Zone)					
1	11	5	no	yes	yes
2	3	3	yes	yes	yes
3	4	4	variable	yes	no
4	4	2	yes	yes	no
5	5	4	no	yes	no
6	11	5	variable	yes	no
7	3	3	no	yes	no
8	15	5	no	yes	no
9	5	5	variable	yes	no
10	4	4	yes	yes	no
11	3	2	yes	yes	no
12	2	2	no	yes	no
13	2	2	no	yes	yes
14	2	2	no	yes	no
15	2	2	no	yes	no
16	3	2	no	yes	no
17	13	5	yes	yes	no
18	3	3	yes	yes	no
19	7	3	yes	yes	no
	102	63			
(Unsprayed Zone)					
1	7	4	no	yes	yes
2	6	6	no	no	no
3	6	3	no	no	yes
4	5	4	no	yes	yes
5	2	2	no	yes	no
6	3	3	no	yes	no
7	4	4	variable	yes	no
8	3	3	no	yes	no
9	15	7	variable	yes	no
10	6	5	no	yes	no
11	13	5	yes	yes	no
12	5	5	yes	yes	no
13	7	6	yes	yes	no
14	8	6	yes	yes	no
	90	63			

TABLE 3
CHARACTERISTICS OF WALNUT ORCHARDS SAMPLED IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, 1982)

Orchard		Variety	Age (yrs.)	Acres (Ha)
Spray Zone	1	Eureka	18	30 (12.2)
	2	Payne	18	57 (23.1)
	3	Serr	10	20 (8.1)
	4	Payne + Eureka	15	9 (3.6)
	5	Ashley	12	13 (5.3)
	6	Payne	15	80 (32.4)
Unsprayed Zone	1	Payne	15	67 (27.1)
	2	Serr	13	136 (55.1)
	3	Payne	18	69 (27.9)
	4	Payne	20	80 (32.4)
	5	Payne	16	102 (41.3)
	6	Payne + Eureka + Hartley	20	4 (1.6)

TABLE 4
DENSITIES OF OLD BLACK SCALE ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

Site	Average density in the spray zone[a/]				
	N_1	N_2	N_3	♀	Total
1	0.3	0.2	0.4	1.2	2.1
2	0.5	4.0	4.0	3.8	12.3
3	0.2	0.2	0.0	0.6	1.0
4	0.0	0.0	0.0	4.8	4.8
5	0.0	0.0	0.0	0.3	0.3
6	0.0	0.0	0.3	2.3	2.7
7	0.0	0.5	0.0	0.0	0.5
8	0.5	9.5	9.5	11.5	31.0
9	0.0	0.3	1.7	1.7	3.7
10	8.5	3.5	6.3	2.0	20.3
11	0.0	1.0	2.3	0.7	4.0
12	0.0	0.3	3.0	1.0	4.3
13	0.3	1.6	1.1	3.8	6.7
Average[b/]	0.8	1.3	1.7	2.3	6.8
Difference[c/]	*	NS	NS	NS	*
Average[b/]	5.4	15.5	1.8	2.5	25.2
15	0.0	0.0	0.0	0.0	0.0
14	0.0	1.3	0.8	0.5	2.5
13	0.0	4.3	0.0	0.8	5.0
12	0.5	1.5	7.0	3.0	12.0
11	0.0	1.0	1.7	1.7	4.3
10	25.7	15.0	4.3	1.3	46.3
9	2.4	0.2	0.0	0.4	3.0
8	3.0	37.5	0.8	2.0	43.3
7	20.5	73.5	8.5	5.3	107.8
6	0.0	7.4	2.1	2.7	12.3
5	1.8	24.5	1.0	1.5	28.8
4	21.7	14.0	1.0	14.7	51.3
3	18.5	54.5	1.5	7.5	82.0
2	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0

[a/]Density = total number of scales/24 twigs/tree; N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b/]Average density = total number of scales ÷ total number of trees sampled.

[c/]Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 5

PARASITIZATION OF OLD BLACK SCALES ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

	Percent parasitization in the spray zone[a]					
				♀		
Site	N_1[b]	N_2[b]	N_3	Sc	Ml	$\sum$
1	0.0	0.0	0.0	0.0	0.0	0.0
2	100.0	36.3	7.6	50.0	25.0	75.0
3	-	0.0	-	0.0	3.3	3.3
4	-	-	-	28.6	0.0	28.6
5	-	-	-	-	-	-
6	-	-	0.0	0.0	0.0	0.0
7	-	0.0	-	-	-	-
8	100.0	26.3	0.0	17.4	13.0	30.4
9	-	0.0	0.0	0.0	80.0	80.0
10	0.0	0.0	0.0	0.0	12.5	12.5
11	-	0.0	0.0	0.0	50.0	50.0
12	-	100.0	0.0	0.0	33.3	33.3
13	0.0	15.4	0.0	3.3	3.3	6.6
Average[c]	40.0	17.8	0.8	9.1	20.0	29.1
Difference[d]	NS	*	NS	NS	NS	NS
Average[c]	48.5	46.3	15.6	15.5	29.4	44.9
15	-	-	-	-	-	-
14	-	40.0	0.0	0.0	0.0	0.0
13	-	88.2	-	0.0	0.0	0.0
12	100.0	33.3	0.0	66.6	0.0	66.6
11	-	0.0	20.0	20.0	20.0	40.0
10	44.2	84.4	76.9	0.0	80.0	80.0
9	33.3	0.0	-	50.0	0.0	50.0
8	58.3	61.3	0.0	12.5	62.5	75.0
7	50.0	62.0	52.7	0.0	55.0	55.0
6	-	75.0	6.6	5.2	36.8	42.1
5	42.8	19.2	0.0	0.0	83.3	83.3
4	0.0	40.5	0.0	4.8	2.4	7.3
3	51.4	51.5	0.0	26.7	13.3	40.0
2	-	-	-	-	-	-
1	-	-	-	-	-	-

[a]Key to symbols: N_1 and N_2 = first and second instar black scale, N_3 = nongravid + gravid ♀♀ black scale, ♀ = black scale in the ovisac stage, Ml = Metaphycus lounsburyi, Sc = Scutellista cyanea, - = no scales present.

[b]Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

[c]Avg. = $\sum$ (% parasitization/site) ÷ number of sites with scales present.

[d]Key to symbols: NS = not significant, * = significant at the 5% level.

TABLE 6
DENSITIES OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

	Average density in the spray zone[a]						
	Latania	Olive	Black scale				
Site	scale	scale	N_1	N_2	N_3	♀	Total
1	21.6	0.3	0.3	2.4	2.9	0.0	5.6
2	250.0	4.2	1.5	0.5	24.0	0.8	26.8
3	17.2	0.0	0.2	1.2	0.6	0.6	2.6
4	142.8	28.5	0.0	0.8	8.8	0.0	9.5
5	0.3	0.0	0.0	0.0	0.0	0.0	0.0
6	21.3	5.0	0.0	0.3	20.0	0.0	20.0
7	52.5	3.0	0.5	1.5	25.0	0.0	27.0
8	94.0	11.5	0.0	3.0	75.5	0.0	78.5
9	68.0	6.0	0.0	2.0	21.0	0.0	23.0
10	64.3	2.3	6.8	6.5	40.8	1.3	55.3
11	20.3	0.0	0.0	0.7	10.3	1.3	12.3
12	5.7	0.0	0.0	0.3	14.7	0.3	15.3
13	30.0	0.1	3.5	4.3	22.6	1.1	31.5
Average[b]	55.7	3.8	1.2	2.1	16.8	0.5	20.5
Difference[c]	NS	NS	NS	*	NS	NS	NS
Average[b]	99.7	0.6	6.8	6.2	10.4	2.0	25.3
15	3.5	1.5	0.3	0.5	1.3	0.0	2.0
14	61.0	0.0	0.0	1.3	6.5	0.0	7.5
13	131.3	0.0	1.3	2.0	5.0	0.0	8.3
12	0.5	0.0	2.5	9.5	20.5	0.0	32.5
11	14.3	0.0	0.3	1.0	4.7	0.0	6.0
10	19.0	0.3	38.7	25.7	13.7	1.7	79.7
9	162.6	0.0	0.4	2.8	1.2	0.0	4.4
8	153.3	0.3	4.5	4.0	14.0	2.3	24.8
7	265.5	0.0	18.5	13.5	27.5	7.8	67.3
6	48.6	0.0	18.7	3.1	18.3	7.1	47.3
5	172.5	1.8	1.0	2.8	7.3	0.0	11.0
4	0.7	0.0	1.3	16.7	2.3	0.7	24.0
3	383.0	10.0	2.0	26.0	37.5	2.0	67.5
2	5.5	2.5	0.0	0.0	0.0	0.0	0.0
1	68.3	0.0	0.0	0.0	0.3	0.0	0.3

[a] Density = total number of scales/24 twigs/tree. Data for latania and olive scales represent adults + nymphs. For black scale, N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b] Average density = total number of scales ÷ total number of trees sampled.

[c] Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 7
PARASITIZATION OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

	Percent parasitization in the spray zone[a]									
		Olive scale			Black scale					
								♀		
Site	Latania scale[b]	Ap	Cu	∑	N_1[c]	N_2[c]	N_3	Sc	Ml	∑
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.0	8.5	0.0	8.5	-	0.0	0.0	-	-	-
5	0.0	-	-	-	-	-	-	-	-	-
6	0.0	6.6	0.0	6.6	-	0.0	0.0	-	-	-
7	0.0	17.6	0.0	17.6	0.0	0.0	0.0	-	-	-
8	0.0	4.3	0.0	4.3	-	0.0	0.0	-	-	-
9	0.0	16.6	0.0	16.6	-	0.0	0.0	-	-	-
10	0.0	11.1	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	-	-	-	-	0.0	0.0	0.0	0.0	0.0
12	0.0	-	-	-	-	0.0	0.0	-	-	-
13	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Average[d]	0.1	8.1	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0
Difference[e]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[d]	0.4	8.6	0.0	8.6	0.1	3.2	0.6	4.7	11.2	15.9
15	0.0	16.7	0.0	16.7	0.0	0.0	0.0	-	-	-
14	0.0	-	-	-	-	0.0	0.0	-	-	-
13	0.0	-	-	-	0.0	0.0	0.0	-	-	-
12	-	-	-	-	0.0	0.0	0.0	-	-	-
11	0.0	-	-	-	0.0	0.0	0.0	-	-	-
10	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	40.0	40.0
9	0.0	-	-	-	0.0	0.0	0.0	-	-	-
8	2.9	0.0	0.0	0.0	0.0	25.0	1.7	9.1	9.1	18.2
7	0.8	-	-	-	0.0	11.3	6.4	0.0	23.6	23.6
6	0.9	-	-	-	0.0	0.0	0.0	24.1	5.8	29.9
5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	-	-	-	0.0	4.1	0.0	0.0	0.0	0.0
3	2.0	10.0	0.0	10.0	0.0	1.9	0.0	0.0	0.0	0.0
2	0.0	25.0	0.0	25.0	-	-	-	-	-	-
1	0.0	-	-	-	-	-	-	-	-	-

[a]Key to symbols: Ap = Aphytis paramaculicornis, Cu = Coccophagoides utilis, N_1 and N_2 = first and second instar black scale, N_3 = nongravid + gravid ♀♀ black scale, ♀ = black scale in the ovisac stage, Ml = Metaphycus lounsburyi, Sc = Scutellista cyanea, - = no scales present.

[b]Probably parasitized by A. paramaculicornis.

[c]Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

[d]Avg. = ∑ (% parasitization/site) ÷ number of sites with scales present.

[e]Key to symbols: NS = not significant, * = significant at the 5% level.

TABLE 8
DENSITIES OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MAY 25-26, 1982)

	Average density in the spray zone[a/]					
	Latania	Olive	Black scale			
Site	scale	scale	N_2	N_3	♀	Total
1	1.9	0.0	0.0	0.2	2.9	3.1
2	62.8	0.5	0.0	1.3	13.5	14.8
3	1.2	0.0	0.0	0.0	1.6	1.6
4	0.7	0.0	0.0	0.3	7.7	8.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.7	0.0	0.0	0.3	8.7	9.0
7	1.0	0.0	0.0	0.0	21.0	21.0
8	26.0	6.5	0.0	0.0	47.5	47.5
9	11.7	0.0	0.0	0.3	9.3	9.7
10	29.8	0.0	0.3	2.3	20.0	22.5
11	5.0	0.0	0.0	0.3	3.7	4.0
12	1.0	0.0	0.3	0.0	20.7	21.0
13	3.4	0.0	0.6	1.9	12.1	14.6
Average[b/]	10.1	0.3	0.1	0.6	10.3	11.1
Difference[c/]	NS	NS	NS	NS	NS	NS
Average[b/]	37.4	0.0	2.3	1.9	8.4	12.6
15	0.0	0.0	0.0	0.0	0.0	0.0
14	15.3	0.0	0.0	1.5	9.3	10.8
13	13.3	0.0	0.0	0.0	11.5	11.5
12	4.0	0.0	1.5	0.5	23.0	25.0
11	4.3	0.0	0.0	1.0	10.3	11.3
10	4.3	0.0	2.0	1.3	4.0	7.3
9	107.2	0.0	0.4	0.2	1.0	1.6
8	103.2	0.0	7.8	8.0	3.8	19.6
7	178.0	0.0	13.0	11.5	37.5	62.0
6	2.4	0.0	3.8	1.0	1.9	6.7
5	7.0	0.0	0.3	0.5	5.0	5.8
4	0.7	0.0	0.3	0.7	10.7	11.7
3	40.5	0.0	0.0	0.5	21.5	22.0
2	0.5	0.0	0.0	0.0	0.0	0.0
1	32.6	0.0	0.0	0.0	1.3	1.3

[a/]Density = total number of scales/24 twigs/tree. Data for latania and olive scales represent adults + nymphs. For black scale, N_2 = second instar nymphs, N_3 = nongravid + gravid third instar ♀ , and ♀ = third instar ♀♀ in the ovisac stage.

[b/]Average density = total number of scales ÷ total number of trees sampled.

[c/]Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 9

PARASITIZATION OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MAY 25-26, 1982)

	Percent parasitization in the spray zone[a]								
					Black scale				
	Latania	Olive scale					♀		
Site	scale[b]	Ap	Cu	$\sum$	N_2[c]	N_3	Sc	Ml	$\sum$
1	17.8	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0
3	0.0	-	-	-	-	-	0.0	0.0	0.0
4	0.0	-	-	-	-	0.0	0.0	0.0	0.0
5	-	-	-	-	-	-	-	-	-
6	0.0	-	-	-	-	0.0	0.0	0.0	0.0
7	0.0	-	-	-	-	-	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0
9	2.4	-	-	-	-	0.0	0.0	0.0	0.0
10	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0
11	0.0	-	-	-	-	0.0	0.0	0.0	0.0
12	0.0	-	-	-	0.0	-	0.0	0.0	0.0
13	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0
Average[d]	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Difference[e]	NS	NA	NA	NA	NS	NS	NS	NS	NS
Average[d]	3.2	-	-	-	13.9	1.3	1.1	2.6	3.7
15	-	-	-	-	-	-	-	-	-
14	0.0	-	-	-	-	0.0	0.0	0.0	0.0
13	0.0	-	-	-	-	-	0.0	0.0	0.0
12	0.0	-	-	-	0.0	0.0	0.0	2.2	2.2
11	0.0	-	-	-	-	0.0	0.0	0.0	0.0
10	0.0	-	-	-	83.3	0.0	0.0	0.0	0.0
9	0.3	-	-	-	0.0	0.0	0.0	0.0	0.0
8	7.2	-	-	-	3.2	3.1	0.0	0.0	0.0
7	2.7	-	-	-	21.5	11.0	0.0	19.3	19.3
6	0.0	-	-	-	3.7	0.0	7.6	7.6	15.3
5	26.3	-	-	-	0.0	0.0	4.5	4.5	9.0
4	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0
3	1.2	-	-	-	-	0.0	2.3	0.0	2.3
2	0.0	-	-	-	-	-	-	-	-
1	7.1	-	-	-	-	-	0.0	0.0	0.0

[a] Key to symbols: Ap = Aphytis paramaculicornis, Cu = Coccophagoides utilis, N_1 and N_2 = first and second instar black scale, N_3 = nongravid + gravid ♀♀ black scale, ♀ = black scale in the ovisac stage, Ml = Metaphycus lounsburyi, Sc = Scutellista cyanea, - = no scales present.

[b] Probably parasitized by A. paramaculicornis.

[c] Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

[d] Avg. = $\sum$ (% parasitization/site) ÷ number of sites with scales present.

[e] Key to symbols: NS = not significant, * = significant at the 5% level, NA = not analyzed.

TABLE 10
DENSITIES OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, AUGUST 9-10, 1982)

	Average density in the spray zone[a]						
Site	Latania scale	Olive scale	Black scale N_1	N_2	N_3	♀	Total
1	28.3	0.2	107.3	96.5	19.1	0.6	223.5
2	41.8	0.3	207.5	286.3	22.0	2.8	518.5
3	11.4	0.2	28.2	58.4	2.8	0.6	90.0
4	78.6	54.6	109.0	91.3	26.3	1.3	228.0
5	0.3	0.0	0.7	0.0	0.0	0.0	0.7
6	34.0	3.3	207.0	81.0	18.3	1.7	308.0
7	63.0	13.0	197.0	92.5	9.0	3.5	302.0
8	154.5	26.0	350.5	315.0	25.5	24.0	714.5
9	30.3	2.7	126.0	102.3	4.0	0.3	232.7
10	13.7	6.5	169.3	333.8	12.0	5.3	520.4
11	27.7	0.0	27.0	9.0	0.0	2.0	38.0
12	7.3	0.0	116.3	447.7	0.3	2.3	566.7
13	16.6	0.4	108.9	169.6	37.5	2.8	318.9
Average[b]	31.5	3.2	121.6	152.9	16.2	2.7	293.3
Difference[c]	NS	*	*	*	NS	NS	*
Average[b]	50.4	0.6	68.5	43.3	17.9	5.6	135.3
15	0.3	0.0	3.3	6.8	0.0	0.5	10.5
14	82.8	1.3	67.0	45.3	4.0	3.0	119.3
13	125.5	2.0	62.0	52.3	17.0	0.8	132.0
12	0.5	0.0	165.0	96.5	11.0	1.0	273.5
11	20.3	0.7	11.3	12.7	7.3	0.3	31.7
10	6.3	0.0	48.0	50.0	4.3	2.3	104.7
9	129.4	0.4	29.0	40.8	27.4	0.4	97.6
8	97.8	1.0	232.3	26.2	5.8	7.0	271.3
7	93.5	1.3	85.0	100.8	29.8	8.0	223.6
6	16.8	0.3	89.1	55.1	59.3	24.3	227.9
5	32.0	0.0	22.0	26.0	1.5	0.8	50.3
4	4.0	0.0	116.0	23.3	5.7	4.0	149.0
3	54.5	3.5	82.5	123.0	42.5	14.0	262.0
2	3.5	0.0	1.5	0.0	0.0	0.0	1.5
1	6.0	0.0	5.7	7.6	6.0	0.3	19.6

[a] Density = total number of scales/24 twigs/tree for latania and olive scale and total number of scales/12 twigs/tree for black scale. Data for latania and olive scales represent adults + nymphs. For black scale, N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b] Average density = total number of scales ÷ total number of trees sampled.

[c] Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 11

PARASITIZATION OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, AUGUST 10-11, 1982)

	Percent parasitization in the spray zone[a]									
					Black scale					
	Latania	Olive scale						♀		
Site	scale[b]	Ap	Cu	∑	N_1[c]	N_2[c]	N_3	Sc	Ml	∑
1	2.4	0.0	0.0	0.0	0.0	0.3	1.0	0.0	0.0	0.0
2	1.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
3	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	3.4	0.6	2.3	2.9	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	-	-	-	0.0	-	-	-	-	-
6	1.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
7	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.6	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
9	4.4	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0
10	5.4	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0
11	0.0	-	-	-	0.0	0.0	-	0.0	0.0	0.0
12	0.0	-	-	-	0.0	0.2	0.0	14.2	14.2	28.4
13	1.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	8.6	8.6
Average[d]	2.6	0.06	0.23	0.3	0.0	0.2	0.1	9.5	1.9	11.4
Difference[e]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[d]	3.1	0.0	0.0	0.0	0.06	2.3	0.3	10.5	2.0	12.5
15	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
11	1.6	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0
10	0.0	-	-	-	0.0	0.0	0.0	0.0	28.5	28.5
9	2.1	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
8	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.8	0.0	0.0	0.0	0.3	2.5	2.5	6.3	0.0	6.3
6	0.8	0.0	0.0	0.0	0.6	12.8	0.5	34.6	0.0	34.6
5	7.0	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	-	-	-	0.0	0.0	0.0	8.3	0.0	8.3
3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	3.5
2	0.0	-	-	-	0.0	-	-	-	-	-
1	27.7	-	-	-	0.0	17.3	0.0	0.0	0.0	0.0

[a] Key to symbols: Ap = *Aphytis paramaculicornis*, Cu = *Coccophagoides utilis*, N_1 and N_2 = first and second instar black scale, N_3 = nongravid + gravid ♀♀ black scale, ♀ = black scale in the ovisac stage, Ml = *Metaphycus lounsburyi*, Sc = *Scutellista cyanea*, - = no scales present.

[b] Probably parasitized by *A. paramaculicornis*.

[c] Predominantly parasitized by *Metaphycus helvolus* and *Coccophagus* spp.

[d] Avg. = ∑ (% parasitization/site) ÷ number of sites with scales present.

[e] Key to symbols: NS = not significant, * = significant at the 5% level.

TABLE 12

DENSITIES OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 30, 1983)

	Average density in the spray zone[a]						
	Latania	Olive	Black scale				
Site	scale	scale	N_1	N_2	N_3	♀	Σ
1	7.0	0.6	84.6	12.9	14.7	1.1	113.3
2	11.8	0.0	140.0	28.5	21.8	4.0	194.3
3	2.8	0.0	68.6	5.2	6.2	2.0	82.0
4	75.7	33.0	15.0	5.6	13.0	0.0	33.7
5	1.3	0.0	0.0	0.0	0.0	0.0	0.0
6	51.7	0.3	3.0	9.7	3.3	0.0	16.0
7	15.0	13.0	33.5	27.0	19.5	0.5	80.5
8	17.5	8.5	173.5	16.5	23.0	0.5	213.5
9	42.7	0.7	13.3	29.0	21.3	1.0	64.7
10	5.3	0.0	55.7	2.0	2.3	1.7	61.7
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	1.0	0.0	18.7	53.7	45.3	0.7	118.3
13	6.1	0.1	51.6	9.9	16.6	0.6	78.8
Average[b]	14.9	2.9	55.6	14.2	14.2	1.0	85.0
Difference[c]	NS	NS	NS	NS	*	*	*
Average[b]	33.1	0.1	21.5	8.6	6.3	0.3	35.1
15	11.8	0.3	29.0	1.8	0.5	0.0	31.3
14	16.3	0.5	24.3	26.0	9.7	0.0	60.0
13	58.8	0.0	51.5	2.0	12.5	0.0	66.0
12	3.0	0.0	63.0	4.5	13.5	0.0	81.0
11	7.0	0.0	49.3	7.7	1.0	1.7	59.7
10	19.7	0.0	23.7	11.0	4.0	0.0	38.7
9	69.6	0.0	18.4	3.2	1.6	0.4	23.6
8	75.3	0.3	3.5	27.0	8.0	0.0	38.5
7	103.0	0.0	38.7	3.3	5.0	1.0	48.0
6	13.4	0.2	5.9	6.1	8.4	0.3	21.4
5	49.0	0.0	4.5	5.0	10.3	0.0	19.8
4	1.3	0.7	1.0	9.7	4.0	3.3	15.0
3	†	†	†	†	†	†	†
2	18.0	0.0	6.5	2.0	8.3	0.0	9.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a]Density = total number of scales/24 twigs/tree for latania and olive scale and total number of scales/12 twigs/tree for black scale. Data for latania and olive scales represent adults + nymphs. For black scale, N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b]Average density = total number of scales ÷ total number of trees sampled.

[c]Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 13
PARASITIZATION OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 30, 1983)

Percent parasitization in the spray zone[a]

Site	Latania scale[b]	Olive scale			Black scale					
								♀		
		Ap	Cu	∑	N_1[c]	N_2[c]	N_3	Sc	Ml	∑
1	1.4	0.0	16.6	16.6	0.7	6.4	1.1	0.0	27.3	27.3
2	0.0	-	-	-	0.0	11.2	1.3	0.0	31.3	31.3
3	6.6	-	-	-	0.0	0.0	3.2	0.0	10.0	10.0
4	0.0	0.0	8.1	8.1	0.0	0.0	0.0	-	-	-
5	0.0	-	-	-	-	-	-	-	-	-
6	0.6	0.0	0.0	0.0	0.0	3.7	0.0	-	-	-
7	0.0	0.0	11.5	11.5	0.0	0.0	0.0	0.0	100.0	100.0
8	0.0	0.0	11.8	11.8	0.0	0.0	0.0	0.0	100.0	100.0
9	0.0	0.0	0.0	0.0	0.0	11.3	0.0	33.3	0.0	33.3
10	0.0	-	-	-	0.0	0.0	0.0	0.0	100.0	100.0
11	-	-	-	-	-	-	-	-	-	-
12	0.0	-	-	-	0.0	0.6	0.7	0.0	100.0	100.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	100.0	100.0
Average[d]	0.7	0.0	6.8	6.8	0.06	3.0	0.6	3.7	63.1	75.2
Difference[e]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[d]	0.2	0.0	0.0	0.0	5.7	0.3	1.5	27.2	47.8	75.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
13	1.5	-	-	-	0.0	1.0	0.0	-	-	-
12	0.0	-	-	-	0.0	0.0	7.4	-	-	-
11	0.0	-	-	-	0.0	0.0	0.0	80.0	20.0	100.0
10	0.0	-	-	-	1.4	3.0	8.3	-	-	-
9	0.0	-	-	-	0.0	0.0	0.0	50.0	50.0	100.0
8	0.7	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
7	0.0	-	-	-	0.0	0.0	0.0	0.0	66.6	66.6
6	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	50.0	50.0
5	0.0	-	-	-	0.0	0.0	2.4	-	-	-
4	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3	0.0	33.3
3	†	†	†	†	†	†	†	†	†	†
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
1	-	-	-	-	-	-	-	-	-	-

a/Key to symbols: Ap = Aphytis paramaculicornis, Cu = Coccophagoides utilis, N_1 and N_2 = first and second instar black scale, N_3 = nongravid + gravid ♀♀ black scale, ♀ = black scale in the ovisac stage, Ml = Metaphycus lounsburyi, Sc = Scutellista cyanea, - = no scales present, † = site not sampled.

b/Probably parasitized by A. paramaculicornis.

c/Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

d/Avg. = ∑ (% parasitization/site) ÷ number of sites with scales present.

e/Key to symbols: NS = not significant, * = significant at the 5% level.

TABLE 14
DENSITIES OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STOCKTON, SEPTEMBER 27, 1982)

	Average density in the spray zone[a]						
	Latania	Olive	Black scale				
Site	scale	scale	N_1	N_2	N_3	♀	Total
1	26.7	0.3	33.3	31.3	114.7	19.3	198.7
2	4.0	0.0	7.3	5.7	16.0	16.0	45.0
3	20.7	0.0	2.7	2.3	8.0	3.3	16.3
4	25.8	0.6	16.0	36.8	23.8	6.0	82.0
5	35.0	0.0	3.3	13.3	25.7	9.7	52.0
6	44.5	0.0	11.0	27.0	38.5	29.5	106.0
Average[b]	25.1	0.2	12.7	20.8	37.7	13.9	83.3
Difference[c]	NS	NS	NS	NS	*	*	NS
Average[b]	32.0	0.1	12.8	14.6	6.7	4.8	39.9
9	41.0	0.5	13.0	3.5	0.0	0.5	17.0
8	1.5	0.0	7.8	0.3	0.0	1.8	9.8
7	6.0	0.5	28.5	28.0	18.0	12.0	86.5
6	35.0	0.5	5.0	8.5	2.5	0.0	16.0
5	18.0	0.0	3.0	0.5	0.0	0.5	4.0
4	7.0	0.0	16.5	82.5	12.5	16.0	127.5
3	4.8	0.0	28.5	4.2	9.3	5.3	47.3
2	185.0	0.0	9.0	21.5	18.5	9.5	58.0
1	47.5	0.0	0.0	2.0	1.0	0.5	3.5

[a] Density = total number of scales/12 twigs/tree. Data for latania and olive scales represent adults + nymphs. For black scale, N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b] Average density = total number of scales ÷ total number of trees sampled.

[c] Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 15
PARASITIZATION OF SCALE INSECTS ON OLIVE TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STOCKTON, SEPTEMBER 27, 1982)

	Percent parasitization in the spray zone[a]									
					Black scale					
	Latania	Olive scale						♀		
Site	scale[b]	Ap	Cu	∑	N_1[c]	N_2[c]	N_3	Sc	Ml	∑
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	-	-	-	0.0	11.6	4.1	8.3	0.0	8.3
3	9.6	-	-	-	25.0	0.0	8.3	50.0	10.0	60.0
4	1.5	0.0	0.0	0.0	0.0	1.1	0.8	0.0	0.0	0.0
5	0.0	-	-	-	0.0	0.0	0.0	0.0	3.4	3.4
6	3.4	-	-	-	0.0	0.0	0.0	5.0	0.0	5.0
Average[d]	2.1	0.0	0.0	0.0	4.2	2.1	2.2	10.6	2.2	12.8
Difference[e]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[d]	0.5	0.0	0.0	0.0	0.0	0.3	0.5	14.2	0.0	14.2
9	1.2	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
8	0.0	-	-	-	0.0	0.0	-	14.3	0.0	14.3
7	0.0	0.0	0.0	0.0	0.0	1.7	0.0	25.0	0.0	25.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
5	2.8	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	-	-	-	0.0	1.2	0.0	28.1	0.0	28.1
3	0.0	-	-	-	0.0	0.0	0.0	14.3	0.0	14.3
2	0.8	0.0	0.0	0.0	0.0	0.0	2.7	31.5	0.0	31.5
1	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0

[a]Key to symbols: Ap = Aphytis paramaculicornis, Cu = Coccophagoides utilis, N_1 and N_2 = first and second instar black scale, N_3 = nongravid + gravid ♀♀ black scale, ♀ = black scale in the ovisac stage, Ml = Metaphycus lounsburyi, Sc = Scutellista cyanea, - = no scales present.

[b]Probably parasitized by A. paramaculicornis.

[c]Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

[d]Avg. = ∑ (% parasitization/site) ÷ number of sites with scales present.

[e]Key to symbols: NS = not significant, * = significant at the 5% level.

TABLE 16
DENSITIES OF OLD BLACK SCALE ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

	Average density in the spray zone[a]				
Site	N_1	N_2	N_3	♀	Total
1	0.0	0.0	0.0	0.2	0.2
2	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0
8	0.0	0.2	0.6	1.2	2.0
9	0.0	0.0	0.0	0.0	0.0
10	0.3	0.3	0.0	0.8	1.4
11	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.5	0.5
17	0.2	0.0	0.0	2.8	3.0
18	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0
Average[b]	0.03	0.03	0.05	0.4	0.5
Difference[c]	NS	NS	NS	NS	NS
Average[b]	0.8	0.0	0.05	0.3	1.2
14	0.0	0.0	0.0	0.0	0.0
13	6.1	0.0	0.0	0.2	6.3
12	3.2	0.0	0.6	2.4	6.2
11	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0
2	0.2	0.0	0.0	0.2	0.4
1	0.0	0.0	0.0	0.5	0.5

[a] Density = total number of scales/15 twigs/tree. N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b] Average density = total number of scales ÷ total number of trees sampled.

[c] Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 17

PARASITIZATION OF OLD BLACK SCALES ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

	Percent parasitization in the spray zone[a]					
				♀		
Site	N_1[b]	N_2[b]	N_3	Sc	Ml	$\sum$
1	-	-	-	0.0	0.0	0.0
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	100.0	0.0	0.0	0.0	0.0
9	-	-	-	-	-	-
10	0.0	0.0	-	0.0	0.0	0.0
11	-	-	-	-	-	-
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	-
15	-	-	-	-	-	-
16	-	-	-	0.0	0.0	0.0
17	100.0	-	-	0.0	0.0	0.0
18	-	-	-	-	-	-
19	-	-	-	-	-	-
Average[c]	50.0	50.0	0.0	0.0	0.0	0.0
Difference[d]	NS	NA	NS	NS	NS	NS
Average[c]	41.85	-	0.0	0.0	0.0	0.0
14	-	-	-	-	-	-
13	83.7	-	-	0.0	0.0	0.0
12	0.0	-	0.0	0.0	0.0	0.0
11	-	-	-	-	-	-
10	-	-	-	-	-	-
9	-	-	-	-	-	-
8	-	-	-	0.0	0.0	0.0
7	-	-	-	-	-	-
6	-	-	-	0.0	0.0	0.0
5	-	-	-	-	-	-
4	-	-	-	-	-	-
3	-	-	-	-	-	-
2	-	-	-	0.0	0.0	0.0
1	-	-	-	0.0	0.0	0.0

[a]Key to symbols: N_1 and N_2 = first and second instar scales, N_3 = nongravid + gravid ♀♀ scales, ♀ = ♀♀ in the ovisac stage, Sc = Scutellista cyanea, Ml = Metaphycus lounsburyi, and - = no scales present.

[b]Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

[c]Average = $\sum$ (% parasitization/site) ÷ number of sites with scales present.

[d]Key to symbols: NS = not significant, * = significant at the 5% level, NA = not analyzed.

TABLE 18

DENSITIES OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

	Average density in the spray zone[a]									
	Brown soft scale					Black scale				
Site	N_1	N_2	N_3	♀	Σ	N_1	N_2	N_3	♀	Σ
1	1.2	1.2	0.4	0.6	3.4	0.0	0.0	0.0	0.0	0.0
2	2.0	5.0	1.6	1.3	10.0	0.0	0.0	0.0	0.0	0.0
3	14.3	23.5	7.8	4.5	50.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.5
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	5.8	12.8	13.2	9.6	41.4	2.0	28.4	9.0	0.0	39.4
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.5	0.3	0.8	0.0	2.0	0.5	0.0	2.5
11	20.5	25.0	47.5	9.0	102.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	1.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0
13	17.5	43.0	44.0	11.0	116.0	0.0	0.5	0.5	0.0	1.0
14	59.0	91.0	88.0	2.5	240.5	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0
17	2.4	1.4	3.2	1.2	8.2	11.2	16.0	2.0	0.0	29.2
18	1.7	4.7	3.3	0.3	10.0	0.0	0.0	0.0	0.0	0.0
19	5.3	5.7	4.7	4.3	20.0	0.0	0.0	6.3	0.0	6.3
Average[b]	5.2	8.5	8.1	2.3	24.1	1.0	3.7	1.2	0.0	5.9
Difference[c]	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
Average[b]	3.1	6.6	4.8	0.5	14.9	1.5	2.1	0.6	0.0	4.2
14	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.6
13	0.2	0.8	1.2	0.0	2.1	15.5	16.3	1.3	0.0	33.2
12	0.0	1.6	0.4	0.2	2.2	0.0	2.2	2.2	0.0	4.4
11	0.0	0.2	0.6	0.0	0.8	0.0	0.0	0.0	0.0	0.0
10	0.0	0.2	0.8	0.0	1.0	0.0	0.0	0.0	0.0	0.0
9	0.0	1.1	0.7	0.1	2.0	0.0	0.0	0.0	0.0	0.0
8	0.7	6.3	0.0	0.0	7.0	0.0	7.0	4.7	0.0	11.7
7	2.5	1.3	1.0	0.0	4.8	0.0	0.3	0.0	0.0	0.3
6	10.3	37.7	31.0	1.7	80.7	0.0	0.0	0.0	0.0	0.0
5	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
4	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
3	1.0	14.0	9.7	1.0	25.7	0.0	0.0	0.0	0.0	0.0
2	25.3	33.2	25.5	3.0	87.7	0.0	0.2	0.3	0.0	0.5
1	0.0	0.0	0.3	0.5	0.8	0.0	0.0	0.0	0.0	0.0

[a] Density = total number of scales/15 twigs/tree. Key to symbols: N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b] Average density = total number of scales ÷ total number of trees sampled.

[c] Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 19

PARASITIZATION OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 8-10, 1982)

	Percent parasitization in the spray zone[a]									
	Brown soft scale[b]				Black scale					
								♀		
Site	N_1	N_2	N_3	♀	N_1[c]	N_2[c]	N_3	Sc	Ml	$\sum$
1	0.0	0.0	0.0	0.0	-	-	-	-	-	-
2	0.0	0.0	0.0	0.0	-	-	-	-	-	-
3	0.0	0.0	0.0	0.0	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	0.0	-	0.0	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-
8	0.0	0.0	3.0	20.8	0.0	0.7	0.0	-	-	-
9	-	-	-	-	-	-	-	-	-	-
10	-	-	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	2.1	5.5	-	-	-	-	-	-
12	-	-	0.0	-	-	-	-	-	-	-
13	0.0	2.8	11.5	0.0	-	0.0	0.0	-	-	-
14	0.0	6.6	9.6	0.0	-	-	-	-	-	-
15	-	-	0.0	0.0	-	-	-	-	-	-
16	-	-	0.0	0.0	-	-	-	-	-	-
17	0.0	0.0	0.0	0.0	0.0	5.0	0.0	-	-	-
18	0.0	0.0	10.0	0.0	-	-	-	-	-	-
19	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Average[d]	0.0	0.9	2.4	2.0	0.0	1.1	0.0	0.0	0.0	0.0
Difference[e]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[d]	0.0	1.4	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	-	0.0	0.0	-	0.0	0.0	0.0	-	-	-
13	0.0	0.0	0.0	-	0.0	0.0	0.0	-	-	-
12	-	0.0	0.0	-	-	0.0	0.0	-	-	-
11	-	0.0	0.0	-	-	-	-	-	-	-
10	-	0.0	0.0	-	-	-	-	-	-	-
9	-	0.0	0.0	0.0	-	-	-	-	-	-
8	-	5.2	-	-	-	0.0	0.0	-	-	-
7	-	0.0	0.0	-	-	0.0	-	-	-	-
6	0.0	2.6	7.5	0.0	-	-	-	-	-	-
5	-	-	-	-	-	0.0	-	-	-	-
4	0.0	-	-	-	-	-	-	-	-	-
3	0.0	4.8	12.9	0.0	-	-	-	-	-	-
2	0.0	3.0	3.6	0.0	-	-	0.0	0.0	0.0	0.0
1	-	-	0.0	0.0	-	-	-	-	-	-

a/ Key to symbols: N_1 and N_2 = first and second instar scales, N_3 = nongravid + gravid ♀♀ scales, ♀ = ♀♀ in the ovisac stage, Sc = Scutellista cyanea, Ml = Metaphycus lounsburyi, and - = no scales present.

b/ Predominantly parasitized by Metaphycus luteolus and Coccophagus spp.

c/ Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

d/ Average = $\sum$ (% parasitization/site) ÷ number of sites with scales present.

e/ Key to symbols: NS = not significant, * = significant at the 5% level.

TABLE 20

DENSITIES OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MAY 25-26, 1982)

	Average density in the spray zone[a]									
	Brown soft scale					Black scale				
Site	N_1	N_2	N_3	♀	$\sum$	N_1	N_2	N_3	♀	$\sum$
1	0.0	0.6	1.0	2.8	4.4	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.7	4.0	4.7	0.0	0.0	0.0	0.0	0.0
3	0.8	2.5	1.3	19.0	23.3	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.8	2.2	6.0	4.0	12.8	0.0	0.4	0.4	20.8	21.6
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.3	0.3	0.5	0.0	0.0	0.0	6.8	6.8
11	7.5	2.5	14.0	15.0	39.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0
13	7.0	3.0	6.5	5.5	22.0	0.0	0.0	0.0	0.0	0.0
14	2.0	3.5	6.5	8.0	20.5	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	2.0	2.0
17	4.4	4.7	7.0	9.8	25.8	0.0	0.2	3.6	15.2	19.0
18	0.3	1.7	0.7	0.3	3.0	0.0	0.0	0.0	0.0	0.0
19	2.7	3.7	8.3	14.0	28.7	0.0	0.0	0.0	3.7	3.7
Average[b]	1.3	1.3	2.6	4.2	9.1	0.0	0.05	0.3	3.5	3.9
Difference[c]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[b]	1.9	1.7	2.5	2.6	8.8	0.02	0.0	0.3	1.4	1.7
14	0.0	0.0	0.5	1.0	1.5	0.0	0.0	0.0	0.8	0.8
13	0.2	0.2	0.2	1.2	2.0	0.0	0.0	1.0	7.4	8.4
12	0.0	0.0	0.2	0.6	0.8	0.0	0.0	0.0	1.2	1.2
11	0.0	0.4	0.8	0.6	2.2	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0
8	0.0	0.3	1.7	3.7	6.0	0.0	0.0	0.7	0.3	1.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	8.3	5.3	9.7	30.3	60.7	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.3	1.0	1.3	0.0	0.0	0.0	0.0	0.0
2	15.3	14.3	9.3	5.5	49.5	0.7	0.0	0.8	0.7	1.7
1	0.3	0.5	0.5	0.8	2.0	0.0	0.0	1.3	9.0	10.3

[a]Density = total number of scales/15 twigs/tree. Key to symbols: N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage.

[b]Average density = total number of scales ÷ total number of trees sampled.

[c]Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 21
PARASITIZATION OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MAY 25-26, 1982)

	Percent parasitization in the spray zone[a]								
	Brown soft scale[b]				Black scale				
							♀		
Site	N_1	N_2	N_3	♀	N_2[c]	N_3[c]	Sc	Ml	Σ
1	-	0.0	0.0	0.0	-	-	-	-	-
2	-	-	0.0	0.0	-	-	-	-	-
3	0.0	0.0	0.0	0.0	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	0.0	-	-	-
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	0.0	60.0	62.0	0.0	-	0.0	0.0	0.0	0.0
9	-	-	-	-	-	-	-	-	-
10	-	-	0.0	0.0	-	-	0.0	0.0	0.0
11	0.0	0.0	7.1	6.6	-	-	-	-	-
12	-	-	50.0	0.0	-	-	-	-	-
13	0.0	0.0	30.7	9.0	-	-	-	-	-
14	0.0	42.8	30.7	29.4	-	-	-	-	-
15	-	-	-	0.0	-	-	-	-	-
16	-	-	-	0.0	-	-	0.0	0.0	0.0
17	0.0	0.0	2.8	0.0	-	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	-	-	-	-	-
19	0.0	0.0	16.0	0.0	-	-	0.0	0.0	0.0
Average[d]	0.0	11.4	16.6	3.2	-	0.0	0.0	0.0	0.0
Difference[e]	NS	NS	NS	NS	NA	NS	NS	NS	NS
Average[d]	0.0	3.4	6.2	3.2	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0
13	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	50.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	11.0	4.3	0.0	0.0	0.0	0.0	0.0
7	-	-	-	-	-	-	-	-	-
6	0.0	31.2	42.0	14.2	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
3	-	-	0.0	33.3	-	-	-	-	-
2	0.0	11.6	34.1	15.1	-	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0

[a] Key to symbols: N_1 and N_2 = first and second instar scales, N_3 = nongravid + gravid ♀♀ scales, ♀ = ♀♀ in the ovisac stage, Sc = Scutellista cyanea, Ml = Metaphycus lounsburyi, - = no scales present, † = not sampled.

[b] Predominantly parasitized by Metaphycus luteolus and Coccophagus spp.

[c] Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

[d] Average = Σ (% parasitization/site) ÷ number of sites with scales present.

[e] Key to symbols: NS = not significant, * = significant at the 5% level, NA = not analyzed.

TABLE 22
DENSITIES OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, AUGUST 9-10, 1982)

	Average density in the spray zone[a]								
	Brown soft scale				Black scale				
Site	N_1	$N_2 + N_3$	♀	Σ	N_1	N_2	N_3	♀	Σ
1	32.4	239.8	4.0	276.2	0.4	1.2	1.0	0.2	2.8
2	7.7	80.3	7.3	95.3	0.3	0.3	0.3	1.0	2.0
3	7.5	97.5	0.5	105.5	0.0	0.0	1.0	0.0	1.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.3	0.0	0.5	0.0	0.5	0.0	4.0	4.5
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	171.8	46.0	0.4	218.2	46.2	152.0	9.8	13.6	221.6
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	28.0	6.0	0.0	34.3	0.5	0.5	0.0	5.3	6.3
11	1.5	183.5	2.5	187.5	0.0	1.0	10.0	0.0	11.0
12	0.0	15.0	0.0	15.0	0.0	9.5	1.5	0.0	11.0
13	0.0	45.5	0.0	45.5	0.0	0.5	14.5	0.0	15.0
14	10.5	63.5	2.0	76.0	0.0	5.0	8.0	0.0	13.0
15	5.0	13.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0
16	0.5	20.5	1.5	22.5	8.0	0.0	0.0	4.0	12.0
17	165.2	660.4	11.2	836.8	1.0	0.8	5.2	12.0	19.0
18	0.7	10.7	0.0	11.3	0.0	0.0	0.0	0.0	0.0
19	60.7	358.7	0.3	419.7	1.3	3.3	1.7	0.7	7.0
Average[b]	54.6	160.9	2.3	217.8	6.0	18.8	3.5	4.0	32.2
Difference[c]	NS	*	NS	*	NS	NS	*	NS	*
Average[b]	22.2	31.6	1.8	55.6	7.0	4.6	0.9	0.5	13.0
14	1.2	1.7	0.2	3.0	0.2	0.2	0.0	0.0	0.3
13	2.8	0.0	0.0	2.8	60.8	53.4	0.0	3.4	117.6
12	1.4	0.0	0.0	1.4	2.0	0.0	0.0	0.4	2.4
11	0.8	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	197.3	0.3	0.0	197.7	23.0	0.0	0.0	0.7	23.7
7	17.0	36.0	9.0	62.0	0.0	0.3	3.3	0.5	4.0
6	42.0	380.3	16.7	439.0	0.0	0.0	10.0	0.0	10.0
5	30.5	1.0	0.0	31.5	0.0	0.0	0.0	0.5	0.5
4	0.3	1.0	0.0	1.3	0.0	0.3	0.8	0.3	1.3
3	-	-	-	-	-	-	-	-	-
2	54.0	63.7	2.1	119.8	0.3	0.0	0.2	0.0	0.5
1	6.3	21.0	0.0	27.3	0.0	0.0	0.0	0.0	0.0

[a] Density = total number of scales/15 twigs/tree. Key to symbols: N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage, - = not sampled.

[b] Average density = total number of scales ÷ total number of trees sampled.

[c] Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 23

PARASITIZATION OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, AUGUST 9-10, 1982)

	Percent parasitization in the spray zone[a/]								
	Brown soft scale[b/]			Black scale					
							♀		
Site	N_1	$N_2 + N_3$	♀	N_1[c/]	N_2[c/]	N_3	Sc	Ml	$\sum$
1	0.0	8.8	6.6	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	37.9	7.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	2.4	0.0	-	-	0.0	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	0.0	-	0.0	-	-	0.0	0.0	0.0
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	0.2	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	-	-	-	-	-	-	-	-	-
10	0.0	25.0	0.0	0.0	0.0	-	0.0	0.0	0.0
11	0.0	5.5	0.0	-	0.0	0.0	-	-	-
12	-	3.0	-	-	0.0	0.0	-	-	-
13	-	0.0	-	-	0.0	0.0	-	-	-
14	0.0	12.6	0.0	-	0.0	0.0	-	-	-
15	0.0	42.3	-	-	-	-	-	-	-
16	0.0	35.4	66.6	0.0	-	-	0.0	0.0	0.0
17	0.0	19.2	5.4	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	13.5	-	-	-	-	-	-	-
19	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average[d/]	0.02	15.1	8.6	0.0	0.0	0.0	0.0	0.0	0.0
Difference[e/]	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[d/]	0.0	7.1	20.5	0.0	2.4	0.0	0.0	0.8	0.8
14	0.0	-	0.0	0.0	0.0	-	-	-	-
13	0.0	-	-	0.0	7.2	-	0.0	5.5	5.5
12	0.0	-	-	0.0	-	-	0.0	0.0	0.0
11	0.0	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-
8	0.0	0.0	-	0.0	-	-	0.0	0.0	0.0
7	0.0	9.2	23.5	-	0.0	0.0	0.0	0.0	0.0
6	0.0	5.9	12.0	-	-	0.0	-	-	-
5	0.0	0.0	-	-	-	-	0.0	0.0	0.0
4	-	0.0	-	-	0.0	0.0	0.0	0.0	0.0
3	†	†	†	†	†	†	†	†	†
2	0.0	29.6	7.1	0.0	-	-	0.0	0.0	0.0
1	0.0	4.7	0.0	-	-	-	-	-	-

a/Key to symbols: N_1 and N_2 = first and second instar scales, N_3 = nongravid + gravid ♀♀ scales, ♀ = ♀♀ in the ovisac stage, Sc = Scutellista cyanea, Ml = Metaphycus lounsburyi, - = no scales present, † = not sampled.

b/Predominantly parasitized by Metaphycus luteolus and Coccophagus spp.

c/Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

d/Average = $\sum$ (% parasitization/site) ÷ number of sites with scales present.

e/Key to symbols: NS = not significant, * = significant at the 5% level, NA = not analyzed.

TABLE 24
DENSITIES OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 30, 1983)

	Average density in the spray zone[a]									
	Brown soft scale					Black scale				
Site	N_1	N_2	N_3	♀	$\sum$	N_1	N_2	N_3	♀	$\sum$
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	0.5	0.0	0.3	0.0	0.8	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.3	0.0	4.8
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	1.8	1.8	0.4	0.0	4.0	16.6	196.6	1.8	0.0	215.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	1.8	0.8	0.0	2.8	17.0	87.8	1.0	0.0	106.0
11	0.5	2.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.1	0.0	0.5	2.0	0.0	0.0	2.5
13	24.5	26.0	10.0	1.5	63.5	24.0	2.5	0.0	0.0	26.5
14	170.0	109.0	13.0	0.0	292.0	0.0	1.0	1.0	0.0	2.0
15	0.0	0.5	0.0	0.0	0.5	0.0	3.0	0.5	0.0	3.5
16	0.0	4.0	2.0	0.0	6.5	4.5	11.0	1.5	0.0	17.5
17	11.0	11.4	3.6	0.0	26.4	4.8	32.2	3.0	0.0	40.0
18	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
19	0.7	1.0	0.0	0.0	2.0	0.3	1.7	0.0	0.0	2.0
Average[b]	8.8	6.6	1.4	0.02	17.0	4.4	28.9	0.6	0.0	33.9
Difference[c]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average[b]	5.9	11.9	3.2	0.0	21.2	9.3	3.9	0.9	0.0	14.2
14	0.0	1.0	0.7	0.0	1.7	158.0	5.3	0.3	0.0	163.7
13	0.0	0.2	0.0	0.0	0.2	1.8	8.8	0.2	0.0	10.8
12	0.0	1.0	0.3	0.0	1.3	0.0	0.3	0.3	0.0	0.6
11	0.0	0.4	0.4	0.0	0.8	0.0	0.4	0.2	0.0	0.6
10	0.0	0.2	0.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	4.7	6.0	0.3	0.0	11.0	1.7	42.3	14.3	0.0	58.3
7	10.5	17.3	3.0	0.0	30.8	0.5	0.0	0.0	0.0	0.5
6	60.0	173.7	51.7	0.0	285.3	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	7.0	1.0	0.0	8.0
4	0.0	0.8	0.0	0.0	0.8	0.3	0.0	0.0	0.0	0.3
3	-	-	-	-	-	-	-	-	-	-
2	13.7	4.2	0.8	0.0	18.7	1.8	0.4	0.0	0.0	2.2
1	0.5	0.5	0.0	0.0	1.0	1.8	2.0	0.0	0.0	3.8

[a]Density = total number of scales/15 twigs/tree. Key to symbols: N_1 and N_2 = first and second instar nymphs, N_3 = nongravid + gravid third instar ♀♀, and ♀ = third instar ♀♀ in the ovisac stage, - = not sampled.

[b]Average density = total number of scales ÷ total number of trees sampled.

[c]Key to symbols: NS = not significant, * = significant at 5% level.

TABLE 25
PARASITIZATION OF SCALE INSECTS ON CITRUS TREES IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, MARCH 30, 1983)

	Percent parasitization in the spray zone[a]									
	Brown soft scale[b]				Black scale					
								♀		
Site	N_1	N_2	N_3	♀	N_1[c]	N_2[c]	N_3	Sc	Ml	$\sum$
1	†	†	†	†	†	†	†	†	†	†
2	†	†	†	†	†	†	†	†	†	†
3	0.0	-	0.0	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	0.0	0.0	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-
8	0.0	0.0	-	-	1.2	0.1	0.0	-	-	-
9	-	-	-	-	-	-	-	-	-	-
10	-	14.2	0.0	-	0.0	0.3	0.0	-	-	-
11	0.0	0.0	-	-	-	-	-	-	-	-
12	-	-	-	-	0.0	0.0	-	-	-	-
13	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-
14	0.0	0.0	0.0	-	0.0	0.0	-	-	-	-
15	-	0.0	-	-	-	0.0	0.0	-	-	-
16	0.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	1.7	6.3	-	4.1	0.6	0.0	-	-	-
18	0.0	-	-	-	-	-	-	-	-	-
19	0.0	33.3	-	-	0.0	0.0	-	-	-	-
Average[d]	0.0	6.5	1.1	0.0	0.7	0.1	0.0	-	-	-
Difference[e]	NS	NS	NS	NA	NS	NS	NS	NA	NA	NA
Average[d]	0.0	2.0	0.2	0.0	0.0	0.0	0.0	-	-	-
14	-	0.0	0.0	-	0.0	0.0	0.0	-	-	-
13	-	0.0	-	-	0.0	0.0	0.0	-	-	-
12	-	0.0	0.0	-	-	0.0	0.0	-	-	-
11	-	0.0	0.0	-	-	0.0	0.0	-	-	-
10	-	0.0	0.0	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-
8	0.0	0.0	0.0	-	0.0	0.0	0.0	-	-	-
7	0.0	6.7	0.0	-	0.0	-	-	-	-	-
6	0.0	5.8	1.9	-	-	-	-	-	-	-
5	-	-	-	-	0.0	0.0	-	-	-	-
4	-	0.0	-	-	-	-	-	-	-	-
3	†	†	†	†	†	†	†	†	†	†
2	0.0	9.5	0.0	-	0.0	0.0	-	-	-	-
1	0.0	0.0	-	-	0.0	0.0	-	-	-	-

[a] Key to symbols: N_1 and N_2 = first and second instar scales, N_3 = nongravid + gravid ♀♀ scales, ♀ = ♀♀ in the ovisac stage, Sc = Scutellista cyanea, Ml = Metaphycus lounsburyi, - = no scales present, † = not sampled.

[b] Predominantly parasitized by Metaphycus luteolus and Coccophagus spp.

[c] Predominantly parasitized by Metaphycus helvolus and Coccophagus spp.

[d] Average = $\sum$ (% parasitization/site) ÷ number of sites with scales present.

[e] Key to symbols: NS = not significant, * = significant at the 5% level, NA = not analyzed.

TABLE 26

DENSITIES OF WALNUT APHID IN THE MEDFLY SPRAY ZONE (UPPER) AND IN THE ADJACENT UNSPRAYED ZONE (LOWER) (STANISLAUS COUNTY, 1982)

	Average density in the spray zone[a]												
	May		June			July[b]		August[b]			September[b]		
Orchard	6	25	9	17	30	9	19	2	18	26	2	9	21
1	.01	0	0	0	.29	.02	.01	.10	3.79	1.28	1.08	1.00	1.58
2	0	.01	.02	.05	1.44	.17	.17	.20	1.44	.79	-	.47	4.9
3	0	0	0	.03	.24	.15	0	.02	.98	7.75	67.10	106.26	65.70
4	.03	0	0	.01	.22	0	0	0	0	.05	.22	.59	2.30
5	0	.03	.02	.16	.46	.08	.01	0	4.24	-	-	-	-
6	.01	-	0	.16	1.45	.05	0	.02	2.52	.47	1.63	6.27	12.14
Average	.008	.008	.007	.068	.683	.078	.032	.057	2.18	2.07	17.51	22.92	17.32
Difference[c]	NS	NS	NS	*	*	NA	NA	NS	NS	NS	NS	NS	NS
Average	.055	.058	.062	.585	2.94	5.25	.144	0.95	3.13	2.56	3.45	4.01	44.93
6	.01	.01	0	1.03	4.89	.57	0	0	1.27	.89	8.13	19.43	259.41
5	.08	0	.13	.27	.01	.04	.01	0	.01	.03	.07	.12	1.36
4	.15	.02	.02	.72	4.52	.60	-	.04	2.90	10.79	7.54	2.82	4.36
3	.03	.32	.20	1.10	4.39	9.20	.01	0	-	.22	-	1.00	.12
2	.05	0	.01	.15	1.81	15.98	.16	3.21	8.32	.58	1.03	.55	3.95
1	.01	0	.01	.24	2.02	5.10	.54	2.46	-	2.82	.50	.16	.40

a/Density = mean number of aphids per compound leaf (n = 100); dash indicates orchard not sampled.

b/Samples taken after Zolone application for codling moth.

c/Key to symbols: NS = not significant, * = significant at the 5% level, NA = not statistically analyzed.

TABLE 27
EFFECT OF MALATHION BAIT ON SELECTED INSECT SPECIES IN LABORATORY BIOASSAYS

Species	Insects Tested No.	Insects Tested Stage	Exposure Time (hrs.)	Avg.[d] Percent Mortality Water	Avg.[d] Percent Mortality Bait	Avg.[d] Percent Mortality Malathion + Bait
Black scale[a]	40	Crawler	4	5a	5a	17.5a
Latania scale[a]	120	Crawler	3	8.3a	9.9a	47.4b
Oleander scale[b]	120	Crawler	4	25.8a	34.1a	61.6b
Cottony-cushion scale[a]	40	Crawler	4	12.5a	22.5a	65b
Walnut aphid[a]	40	Adult	4	0a	2.5a	12.5a
Metaphycus helvolus[b]	40	Adult	3	7.5a	17.5a	95b
Trioxys pallidus[a]	37	Adult	4	18.4a	30.7a	97.2b
Trioxys pallidus[c]	37	Adult	4	16.1a	27.2a	70.4b
Aphytis melinus[b]	40	Adult	3	5a	7.5a	95b
Aphytis melinus[c]	40	Adult	2	10a	25a	95b
Platygaster californica[a]	40	Adult	4	0a	2.5a	100b
Torymus koebelei[a]	40	Adult	4	3.3a	10a	67.5b
T. baccharidis[a]	40	Adult	4	5a	7.5a	92.5b
Zatropis capitis[a]	40	Adult	4	6.6a	6.6a	72.5b

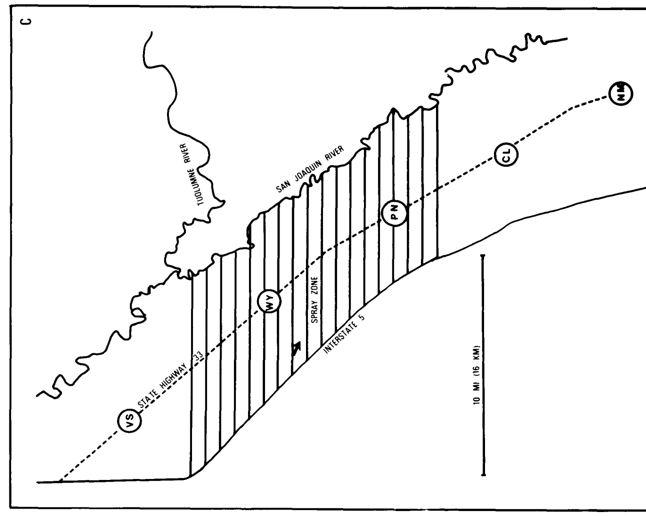
[a]Collected in the field near Davis (Yolo County).

[b]From a laboratory culture supplied by Rincon-Vitova Insectaries, Inc.

[c]Exposed to treatments three weeks after application.

[d]Row means followed by the same letter are not significantly different at the 5% level.

FIGURES



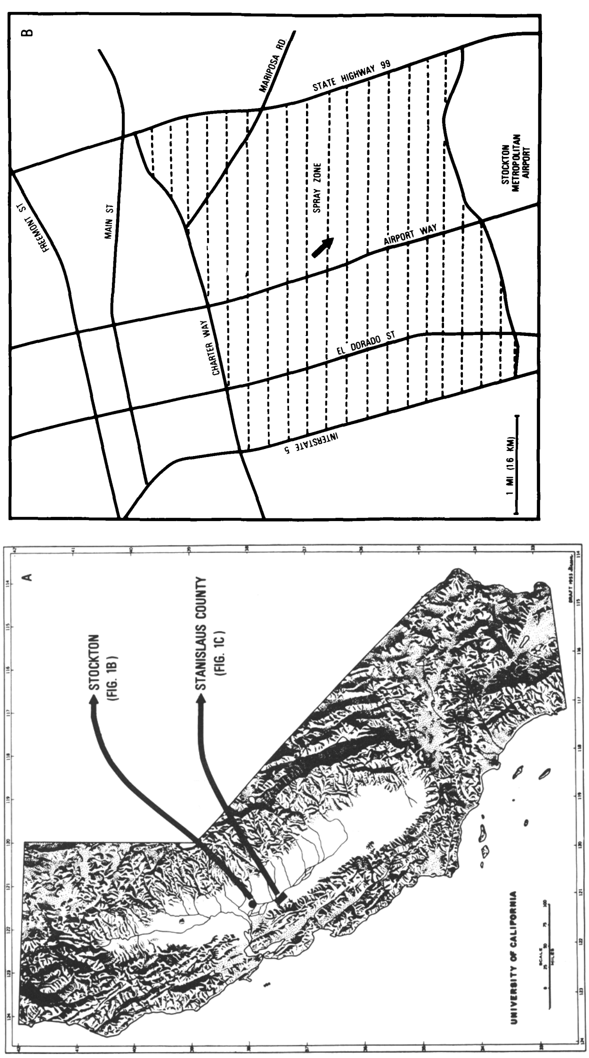


Fig. 1. Locations of Mediterranean fruit fly eradication zones in the northern San Joaquin Valley of California (1A), with detailed maps of the Stockton (1B) and Stanislaus (1C) spray zones. Arrows indicate location of original medfly discovery. In 1C, VS = Vernalis, WY = Westley, PN = Patterson, CL = Crow's Landing and NM = Newman.

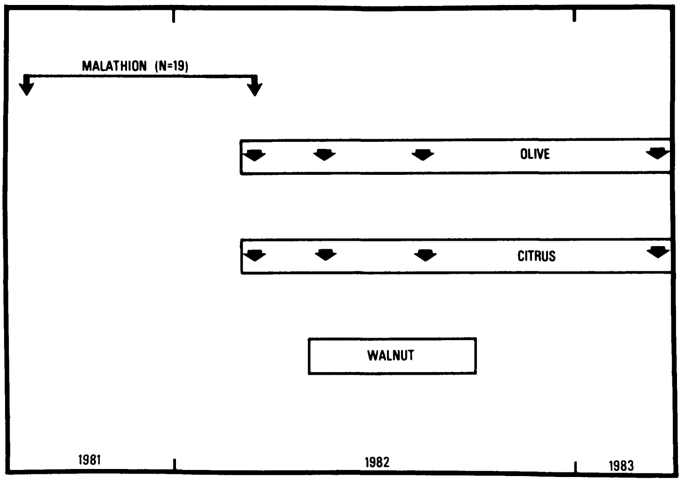


Fig. 2. Sampling periods in Stanislaus County relative to applications of malathion-bait spray. Arrows indicate sample dates for olive and citrus; walnut orchards were sampled every 7-14 days during the indicated period.

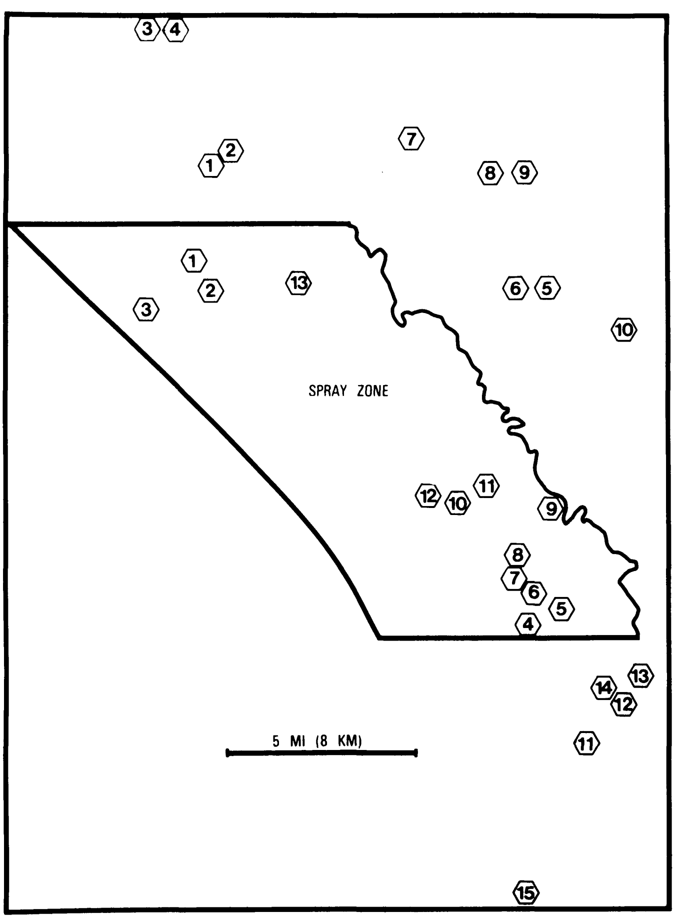


Fig. 3. Distribution of olive sites in the spray zone and in the adjacent unsprayed zone (Stanislaus County).

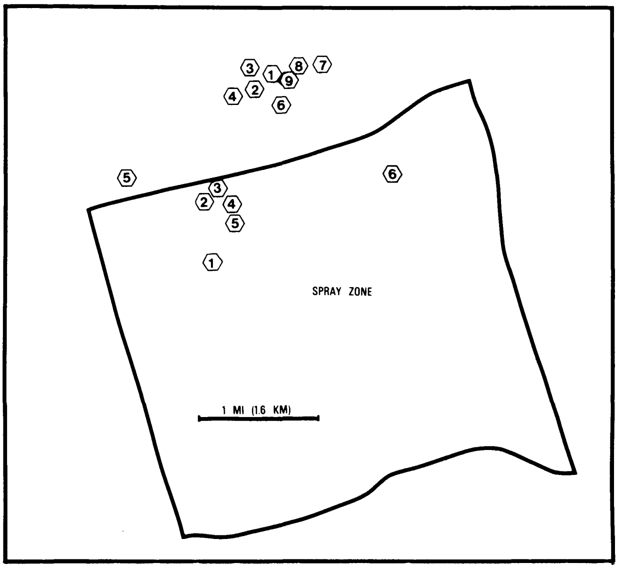


Fig. 4. Distribution of olive sites in the Stockton spray zone and in the adjacent unsprayed zone.

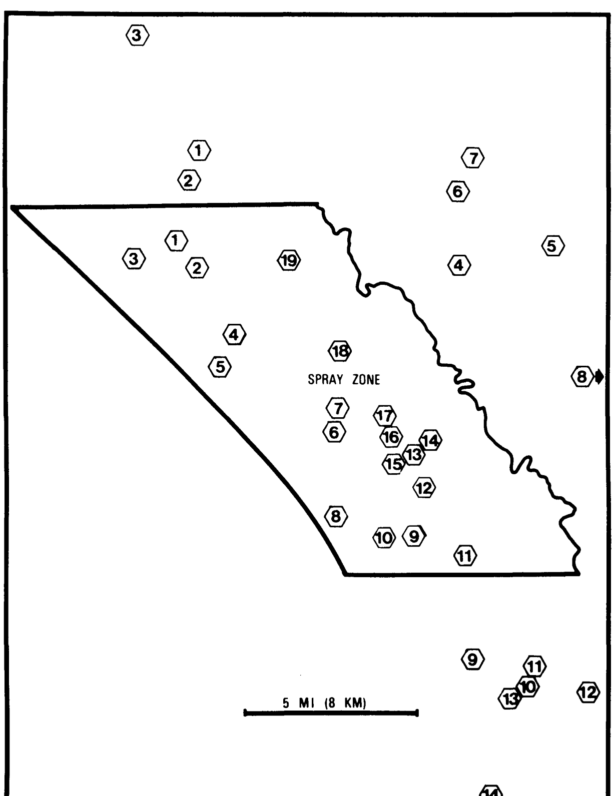


Fig. 5. Distribution of citrus sites in the spray zone and in the adjacent unsprayed zone (Stanislaus County). Site 8 is actually 2 miles to the east.

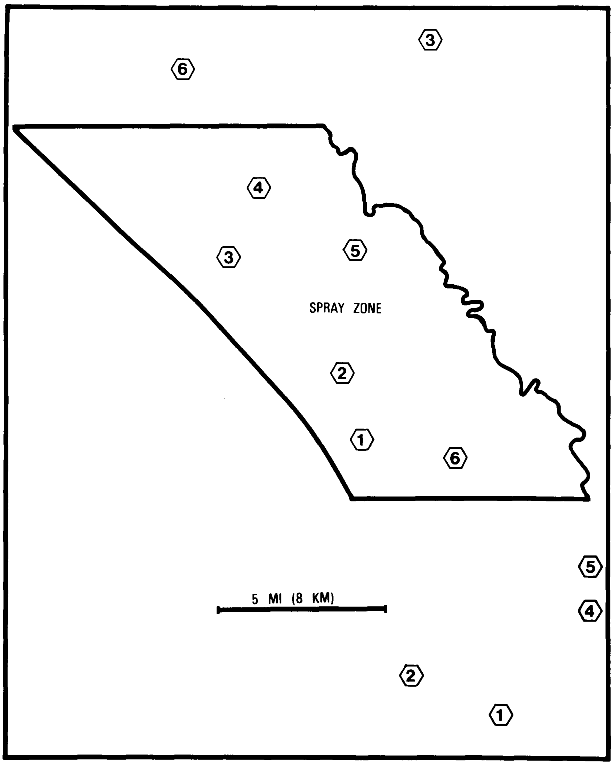


Fig. 6. Distribution of walnut orchards in the spray zone and in the adjacent unsprayed zone (Stanislaus County).

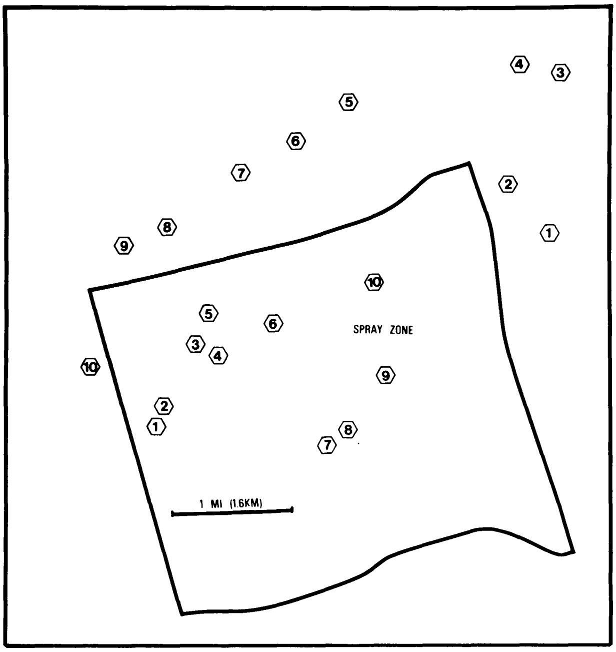


Fig. 7. Distribution of walnut trees in the Stockton spray zone and in the adjacent unsprayed zone.

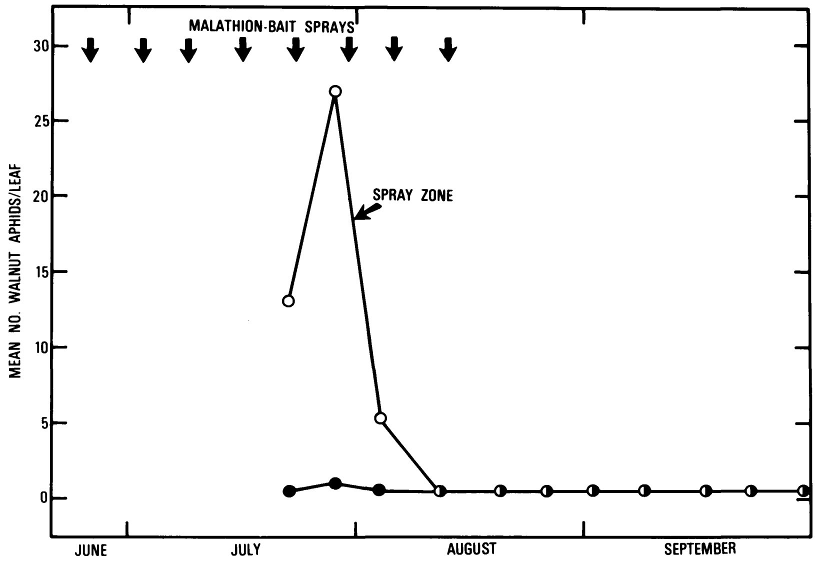


Fig. 8. Population trends of walnut aphid in the Stockton spray zone (open circles) and in the adjacent unsprayed zone (closed circles). The first three points in the spray zone are significantly different (5% level) from those in the unsprayed area.

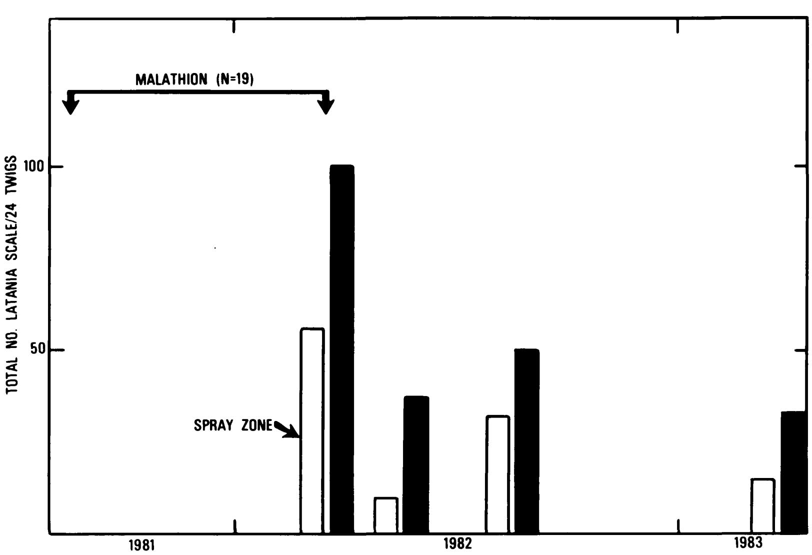


Fig. 9. Population trends of latania scale on olive in the spray zone and adjacent unsprayed zone (Stanislaus County) following 19 applications of a malathion-bait spray.

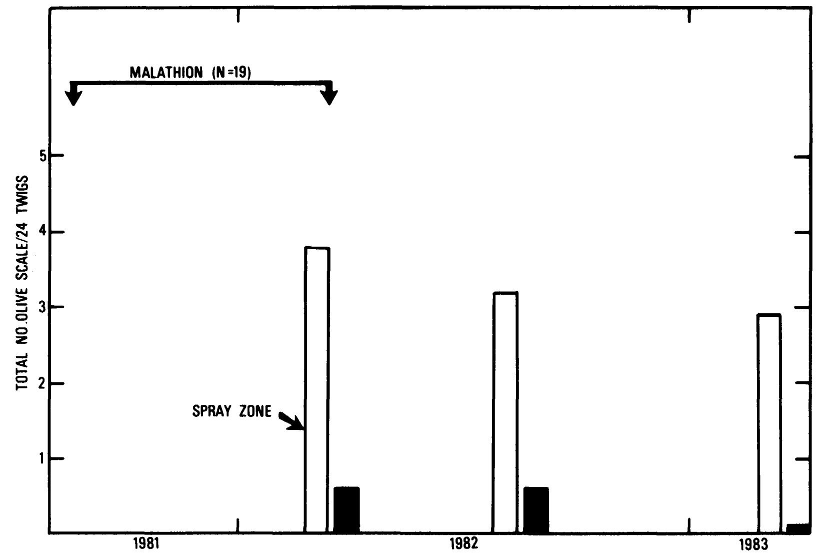


Fig. 10. Population trends of olive scale on olive in the spray zone and adjacent unsprayed zone (Stanislaus County) following 19 applications of malathion-bait spray.

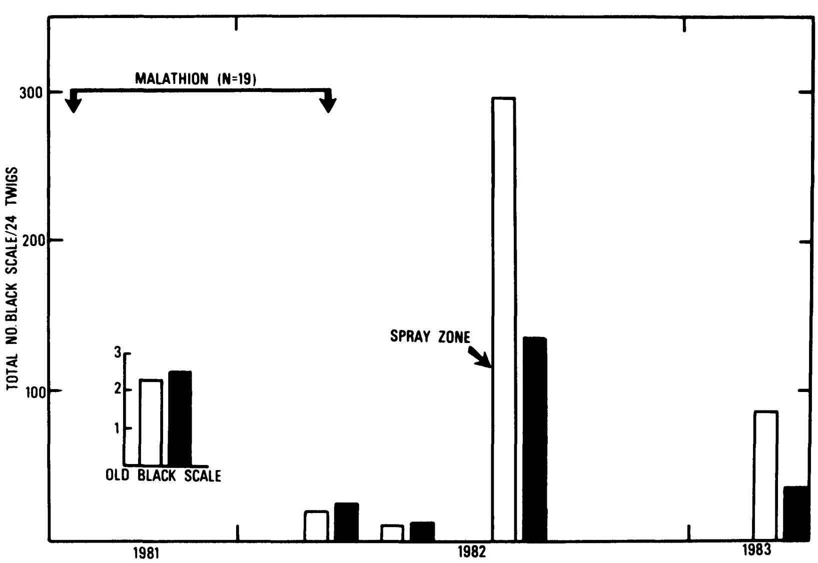


Fig. 11. Population trends of black scale on olive in the spray zone and adjacent unsprayed zone (Stanislaus County) following 19 applications of malathion-bait spray. Data for old black scale represent adult females only.

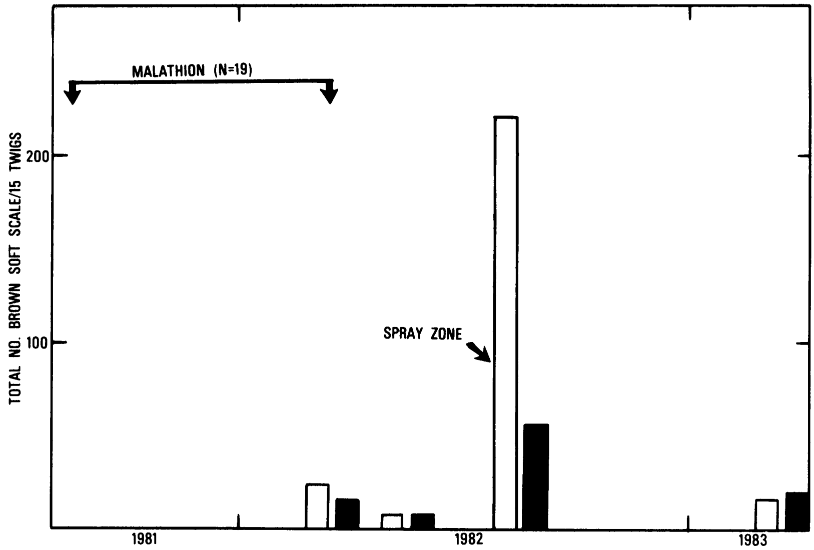


Fig. 12. Population trends of brown soft scale on citrus in the spray zone and adjacent unsprayed zone (Stanislaus County) following 19 applications of malathion-bait spray.

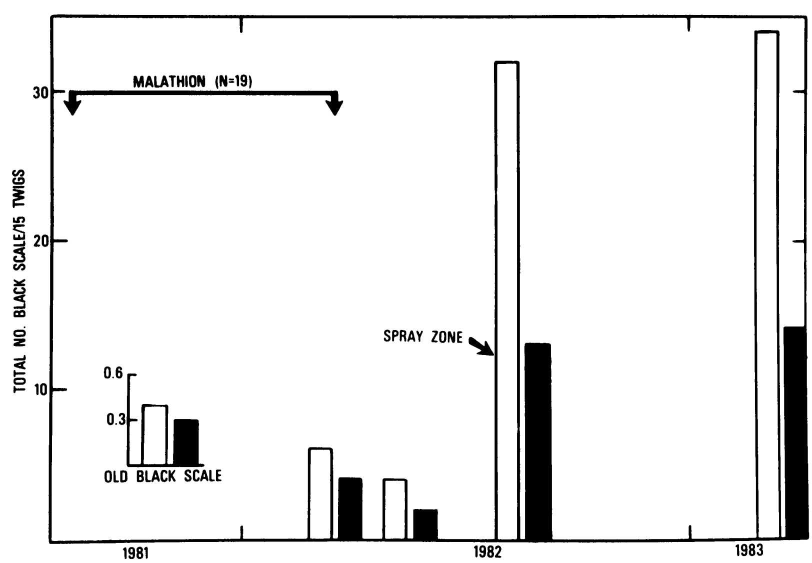


Fig. 13. Population trends of black scale on citrus in the spray zone and adjacent unsprayed zone (Stanislaus County) following 19 applications of malathion-bait spray. Data for old black scale represent adult females only.

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