Environmental upsets caused by chemical eradication

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An inordinate number of invading insect pests have been detected during the past 11 years in southern San Diego County. The first was citrus whitefly in 1966, then woolly whitefly later in 1966, the Japanese beetle in 1973, and the Oriental fruitfly in 1971 and 1974 (along with occasional captures of Mexican fruitflies in McPhail traps).

All of these invaders, except the Mexican fruitfly, have recently been subject to eradication programs utilizing pesticides. Two of the programs—the attempts against citrus whitefly and woolly whitefly—failed. Those against the Japanese beetle and the Oriental fruitfly are currently considered successful.

DDT, carbaryl, chlordane, Diazinon, and dicofol were the pesticides used during these various eradication attempts, all in residential areas. Our primary purpose here is to document some of the undesirable consequences of one eradication project.

In 1973, when the Japanese beetle was found in San Diego, an area comprising about 100 residential blocks was declared an eradication zone by the California State Department of Food and Agriculture. During 1971, a large part of San Diego, including this area, had been colonized with introduced parasites of woolly whitefly (*California Agriculture*, May 1976), and outstanding biological control of woolly whitefly had been achieved in the proposed eradication zone by 1973. Other citrus pests, such as armored and soft scales, mealybugs, and mites, were known from previous studies to be under good biological control throughout the eradication zone.

On the basis of this information and previous studies documenting biological control upsets caused by pesticides, we established a program to measure the effects of the pesticides used for Japanese beetle eradication—carbaryl, chlordane, and dicofol—on natural enemies of woolly whitefly and on the citrus ecosystem in the treated area.

Woolly whitefly population levels were determined during the first week of August 1973, shortly before eradication treatments began. After the first pesticide treatments ended, 100 residential sites with citrus trees were selected for study—50 in the eradication zone and 50 outside the treated area. The two areas were separated by a three-block buffer zone to avoid the effects of pesticide drift.

Thereafter, woolly whitefly population densities were measured every other month. We also studied the abundance and species composition of natural enemies of the woolly whitefly, over time, to show any differential effects on the imported hymenopterous parasites, *Amitus spiniferus* Brethés and *Cales noacki* De Santis, which were responsible for the initial low woolly whitefly population levels throughout the residential area.

Five additional sites with several different citrus varieties were also selec-

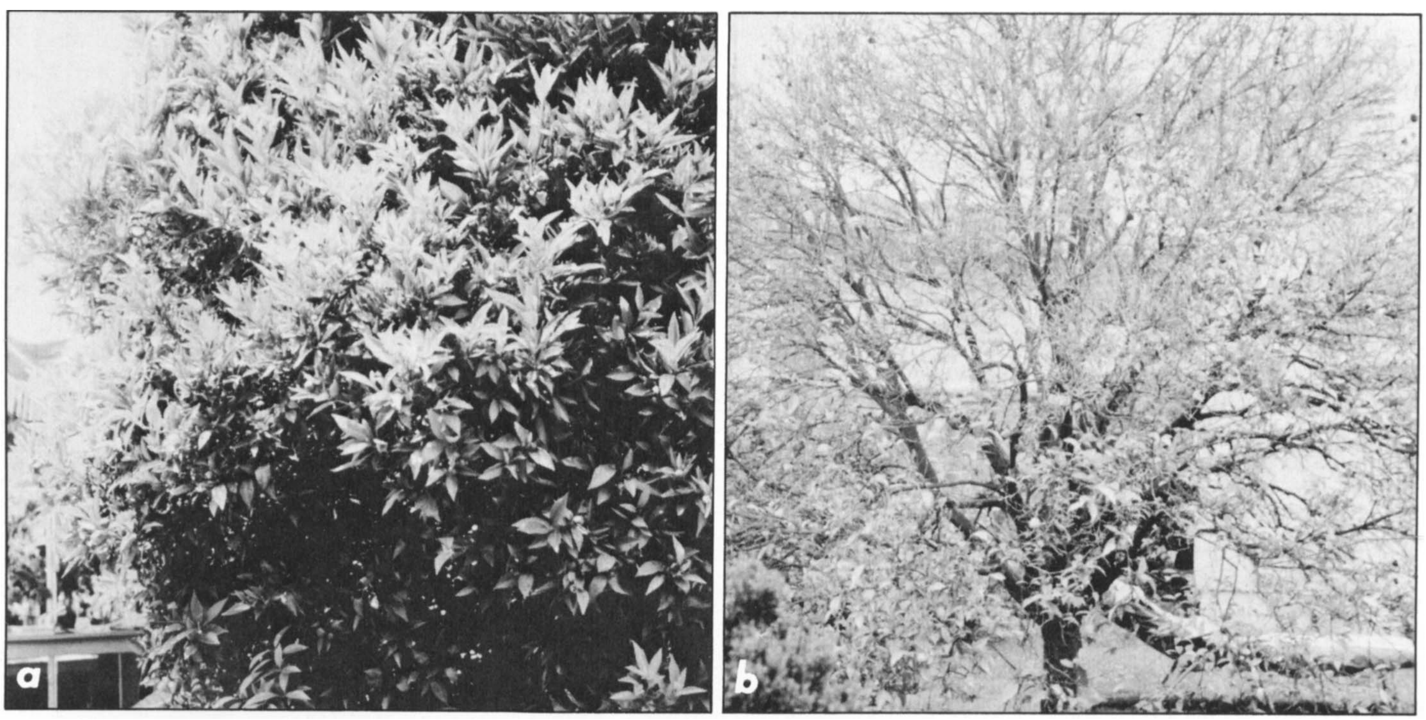

Fig. 1. (a) August 1973, before chemical eradication treatments; all pests under good biological control. After the first series of carbaryl treatments, dense citrus red mite populations developed, and woolly whitefly and purple scale numbers increased. (b) June 1975, just before tree was cut down because of severe damage from woolly whitefly, citrus red mite, and purple scale.

Fig. 2. Acute defoliation and tree damage caused primarily by purple scale on woody portions of citrus tree. The light "bark" is actually scale coverings of young purple scale.

ted for more detailed, monthly, pest-density studies in the eradication zone. These five sites and many of the 100 comparison sites were selected in cooperation with a project leader for the California State Department of Food and Agriculture.

Before eradication treatments, woolly whitefly population densities averaged less than one live immature whitefly per leaf. The parasites *A. spiniferus* and *C. noacki* were censused and found to be generally distributed. All other citrus pests were also found to be under good biological control.

Pesticide applications

By December 1973, about three months after the initial foliar carbaryl treatments and ground application of chlordane, no live woolly whitefly parasites could be found in the eradication zone. Outside the area, the parasites remained abundant.

Woolly whitefly populations would be expected to increase after natural enemies were killed, but the overall effect on the citrus ecosystem was more complex. The citrus red mite population in the eradication zone increased so rapidly that acute defoliation occurred on a massive scale; more than 80 percent of the study trees were significantly affected. Carbaryl is believed to have physiological effects on citrus, which may make the foliage a more suitable habitat for citrus red mite.

Defoliation eliminated a substantial part of the woolly whitefly population (which occurs only on leaves), along with any surviving natural enemies, and probably also severely reduced natural enemies of citrus red mite. At the same time, citrus mealybug and purple scale populations were generally on the increase in the eradication zone.

During the second eradication season—summer and fall, 1974—acute defoliation occurred on most of the study sites in the eradication area. In some cases, 90 percent of the foliage dropped, and, at one time, nearly 90 percent of the treated trees were affected to some degree. Woolly whitefly populations increased dramatically on those trees where defoliation was not chronic but invariably were greatly reduced when the additional stress of citrus red mites caused defoliation. During the same period, purple scale was continually increasing, because *Aphytis lepidosaphes* Compere, its major natural enemy, had been largely destroyed by carbaryl. Such pest population fluctuations did not occur in the untreated control area.

A single dicofol application was made throughout the eradication zone during the 1974 treatment period to control the exploding citrus red mite population. Unfortunately, dicofol is much more harmful to the most prevalent predaceous mite (*Amblyseius hibisci*) than to citrus red mite, by a ratio of about 50 to 1. By September and October 1974, the citrus red mite was devastating the eradication area, whereas no comparable damage occurred in the biological control area.

Treatments ended

During 1974, woolly whitefly, purple scale, and their parasites were substantially reduced by carbaryl as well as by defoliation. When carbaryl treatments ended in September 1974, woolly whitefly and purple scale, freed of both biological and chemical restraints, began to increase rapidly. Defoliation soon followed and again reduced woolly whitefly populations. Because purple scale was living primarily on the woody portions of the trees, it was not as drastically affected.

As early as December 1974, some citrus trees began to die from the combined stresses caused by the three major upset pests—woolly whitefly, purple scale, and citrus red mite. By May-June 1975, some trees had been completely destroyed (see fig. 1). Purple scale severely damaged four of the five trees studied monthly in the eradication area.

After eradication treatments ended, natural enemies of woolly whitefly began to reenter and reproduce in the previously treated area. By October 1975, both *Amitus spiniferus* and *Cales noacki* had become well reestablished but had not yet had time to achieve biological control again. At this time, the woolly whitefly population in the eradication area was 1,200 percent greater than in the untreated area.

Mites predaceous on citrus red mite disperse and reproduce more slowly than do the natural enemies of either woolly whitefly or purple scale. Citrus red mite populations thus continued to cause damage, most notably during the first six months of 1975.

Even though *Aphytis lepidosaphes* became abundant after eradication treatments ended, purple scale populations were still increasing. The pest had reproduced more rapidly than its parasite, because carbaryl had depleted the parasite populations, and massed, overlapping purple scales effectively shielded many scales from parasites.

Up to this time, our studies of the purple scale upset had been largely observational, because the major emphasis had been on the woolly whitefly. Because of the obvious effects of carbaryl, we decided to compare the population densities of purple scale and the relative abundance of its parasite *A. lepidosaphes* in the eradication zone, the untreated control area, and the three-block buffer zone.

Scale surveys

Before eradication treatments, purple scale was generally distributed but harmless to citrus in these areas. By October 1974, purple scale had so increased in the treated area that more than 60 percent of the study trees were injured to some degree. Figure 2 illustrates the high population levels purple scale attained on some trees. Such trees could not support appreciable woolly whitefly populations.

During September 1975, an average of 0.49 purple scales were found per standard sample on each of approximately 50 study trees in the untreated control area. In the eradication zone, an average of nearly 2,100 scales were counted per standard sample on each study tree—a population difference of about 4,000 to 1. In the buffer zone, the average was 38.8 scales, which indicated pesticide drift had occurred.

At the same time, the parasitization rate within the eradication zone was 5.3 percent, and only 42.8 percent of the purple scales were dead. In the untreated area, the rate of parasitization was 19.8 percent, and 77.5 percent of the purple scales were dead. About 1,200 live scales occurred in the eradication zone for each 0.1 live scale in the untreated control area — a 12,000 to 1 ratio.

Conclusions

Our results support previous findings that insect eradication programs cause environmental disruptions and involve both known and unknown dangers inherent in toxic chemical use. Carbaryl was more injurious to most natural enemies than to pest insects; the insecticide was not highly selective to the target pest, the Japanese beetle, and also is suspected of having a physiological effect on citrus that makes the foliage more suitable for citrus red mite reproduction. Dicofol, the acaracide used to control exploding citrus red mite populations, was 50 times more effective at killing the most prevalent predaceous mite than at killing the target pest. Chlordane, which was broadcast over lawns and planting beds in a high-density residential area, is now severely restricted in its use by the Environmental Protection Agency, because it has been shown to be carcinogenic.

Because of the magnitude and scope of both the probable and the unforeseen deleterious effects on the environment, wildlife, and humans, we believe that any decision to use chemical eradication must be supported by multi-disciplinary, in-depth studies of all aspects of the issue. Ecologists, biologists, and economists, at least, should be brought into the decision-making process to decide whether eradication is a proper approach or whether other methods, such as biological control, might make eradication attempts unnecessary.

Paul DeBach is Professor of Biological Control, and Mike Rose is Staff Research Associate, Experiment Station, University of California, Riverside. This research was funded in part by the California State Department of Food and Agriculture and the California Citrus Advisory Board for research on biological control of woolly whitefly and by NSF Grant 75-04223, "Principles, Strategies, and Tactics of Pest Population Regulation and Control in the Citrus Ecosystem." The authors also appreciate the assistance of D. McEnery, S. Olson, M. Reynolds, M. Thornton, S. Warner, and W. White.

Fungicides protect apricot trees against dieback

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California produces more than 95 percent of the nation's apricot crop and this versatile tree fruit is also a favorite for home orchards. Limb dieback is a major cause of premature tree decline and death in the northern part of the state. The causal fungus, *Eutypa armeniacae* (impf. *Cytosporina*), spreads by means of spores carried in the air during rainstorms, and, when the spores find their way into fresh pruning wounds, the disease begins. Unpruned apricots are not affected.

Spores germinate and grow in the wood tissues, and darkened, malformed branch or trunk cankers become apparent around the old pruning wounds 2 to 3 years later. Diseased branches frequently wilt and collapse in mid to late summer. The dead branches on otherwise green apricot trees are a striking symptom of *Eutypa* dieback (fig. 1). Most orchardists remove recently collapsed branches from trees with a chain saw while they are readily visible.

Studies were made to determine the best time for removal of dead, infected branches and to find a satisfactory