Effects of malathion sprays on the ice plant insect system

Jan A. Washburn □ Richard L. Tassan □ Kenneth Grace
Eric Bellis □ Kenneth S. Hagen □ Gordon W. Frankie

Few adult natural enemies survived one spray, but populations recovered quickly

Aerial application of malathion-bait sprays to eradicate the Mediterranean fruit fly in 1981 received considerable publicity because of its potential impact on nontarget organisms, primarily humans. We report here on studies showing the short-term effect these sprays had on a nontarget insect system, the accidentally introduced ice plant scale, *Pulvinariella mesembryanthemi*, and its native and introduced natural enemies.

Ice plants, *Carpobrotus* spp., are grown extensively as ground cover associated with freeways, private residences, industrial parks and coastal areas. Since its detection in Napa, California, in 1971, ice plant scale has spread into 17 counties, threatening a large portion of the freeway landscaping maintained by the California Department of Transportation (Caltrans).

During the past four years, Caltrans has funded the development of an integrated pest management program to allow continued use of ice plant without heavy reliance on insecticides. As an integral part of this program natural enemies of ice plant scale from South Africa have been imported and established (*California Agriculture*, September-October 1982). To date, two introduced parasitic Hymenoptera, *Metaphycus funicularis* and *M. stramineus*, and a coccinellid, *Exochomus flavipes*, have become established in northern California. An additional parasitic Hymenoptera, *Encyrtus saliens*, and a coccinellid, *Hyperaspis senegalensis hottentotta*, are currently being released. Several species of native (such as *Coccophagus lycimnia*) and previously established natural enemies (*M. helvolus* and *Rhizobellius ventralis*, introduced against other pestiferous Homoptera) also attack ice plant scales.

Substantial ice plant acreage in freeway landscaping was within the aerial malathion-bait spray zones in Santa Clara and Alameda counties. We monitored scale and natural enemy populations at a field site in Alameda County, the interchange of state routes 92 and 17 (Jackson Street, San Leandro), for six weeks before and eight weeks after a single aerial malathion-bait spray treatment. Selection of this site was fortuitous, since there was no way to predict which areas would be included in the aerial spray program, or whether any areas would receive only a single treatment permitting us to measure the responses of the ice plant system presented in this paper.

Bait spray detection cards placed weekly at the field site indicated that the interchange received one application during the study period, on 16 October 1981. The per-acre rate of the aerial spray was 2.4 ounces (68 grams) of 91 percent malathion mixed with 9.6 ounces (272 grams) of Staley's protein bait; the pH of the mixture was approximately 3.0.

We sampled field populations every two weeks from 1 September to 11 December, measuring for each date the lengths of 100 randomly selected immature scales and computing a mean. The scale reproduces without mating, and during the period of scale reproduction, 15 September through 30 October, we dissected 50 ovisacs (reproductive females) to determine egg and crawler abundance.

The activity period of adult parasitoids was estimated from their entrapment in yellow pan traps filled with automobile anti-freeze: two traps were placed at the field site on 16 August and emptied every two weeks thereafter. One imported parasite, *Metaphycus stramineus*, and one native parasite, *Coccophagus lycimnia*, were sufficiently abundant at this site to indicate adult activity trends before and after the chemical application.

In laboratory trials with first-stage scales (crawlers) and two of the imported natural enemies, *Metaphycus funicularis* and *Hyperaspis senegalensis hottentotta*, we tested the toxicity of malathion-sprayed plants to foraging insects. These two natural enemies were the only species being cultured in sufficient numbers during the aerial spray program to permit such tests.

To test malathion toxicity to ice plant scale, we placed individually potted ice plants (collected from a site outside the spray zone) in field sites within the spray zone in the afternoon before the evening spraying. We covered control plants with a polyethylene canopy. The next morning we took sprayed and control plants to the laboratory and added 100 newly hatched scale crawlers to each of two sprayed and two unsprayed plants. The first set of plants was inoculated on the day after spraying (day 1), and two more sprayed and unsprayed plants were inoculated each day for the next 11 days (days 2 to 12). Before adding crawlers, we kept the plants outdoors with exposure to full sunlight. Two weeks after infestation, we examined sprayed and unsprayed plants to find out how many scales had successfully colonized each plant.

For laboratory studies on toxicity to natural enemies, we collected plant material from a spray field site (Interstate 280/Saratoga Avenue, Cupertino, Santa Clara County) on the morning after an aerial application of malathion. Adult female *M. funicularis* and male and female *H. s. hottentotta* in individual Dixie cups containing treated leaves were assessed for mortality at 24, 48, and 72 hours after their introduction. (Control plant material for *M. funicularis* tests was collected from a freeway field site in Berkeley, outside the spray zone; control *H. s. hottentotta* were placed in containers without any plants.) *Metaphycus funicularis* was tested with plant material sprayed one, two and eight days previously, and *H. s. hottentotta* was tested with one-day-old material only. Plants were aged in full sunlight in the same manner as those in scale tests.

Field samples of ice plant scale showed that the single malathion application occurred during the middle of the reproductive period (16 September to 15 November — bar at top of fig. 1A) when generation 1 consisted of immature females and ovisacs that were producing eggs and crawlers, and generation 2 consisted of crawlers and settled first stages (settlers).

At the first post-spray sample (30 October), generation 1 females had completed ovisac formation and were not measured. The reduction in mean size of generation 2 scales and contraction of the standard deviation between 16 and 30 October suggest that the post-spray population was primarily newly settled crawlers that had emerged after the spray, and that survival of scales that had settled immediately before the spray was low. This reduction in mean settler size did not occur outside the spray zone. In previous laboratory tests (unpublished data) we have found that first-stage crawlers and settlers are the most susceptible to chemicals; crawlers and eggs still within ovisacs are less susceptible (see also *California Agriculture*, October 1978).

In the laboratory, crawlers foraging on treated plants suffered higher mortality and lower colonization rates when compared with controls for the entire 12 days after spraying (fig. 2A). Successful crawler colonization for days 1 to 10 following the spraying was consistently low (0 to 16 percent), but increased slightly on days 11 and 12 (26 and 23 percent, respectively). This indicates that malathion-bait sprays remain toxic to scale crawlers for at least 12 days at field dosages.

Parasite trap catches of both *M. stramineus* and *C. lycimnia* at the field site increased during the three sampling periods before spraying, suggesting a local buildup of the natural enemy complex. In the first post-spray sample (30 October), trap catches of *C. lycimnia* and *M. stramineus* declined 79 and 90 percent, respectively, from the high period in mid-October (fig. 1B). Although these two species were not tested in the laboratory, another parasite, *M. funicularis*, seemed highly sensitive to treated plant material (fig. 2B). Cumulative mortality on plants sprayed one, two and eight days previously was higher than in controls, indicating that the effects of malathion on this parasite persist with no apparent decrease in toxicity for at least eight days after spraying. It is reasonable to assume that the mortality curves for *C. lycimnia* and *M. stramineus* would be similar to the one generated for *M.*

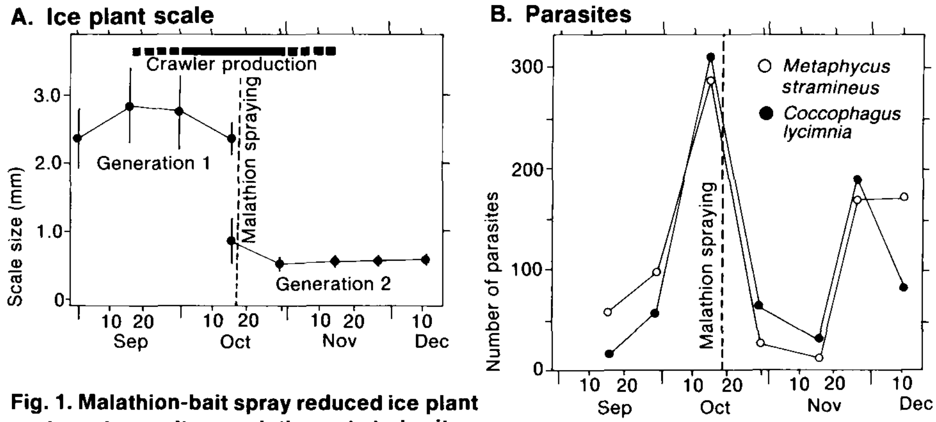


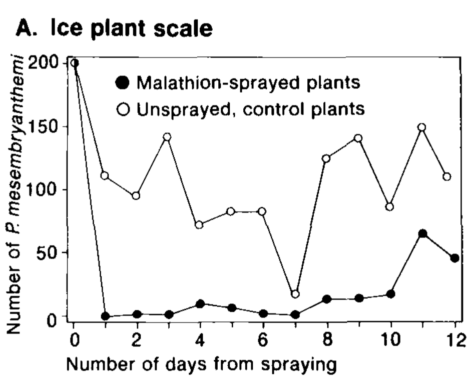
Fig. 1. Malathion-bait spray reduced ice plant scale and parasite populations at study site: (A) Scale growth and development (bars = one standard deviation). (B) Parasites trapped.

funicularis, and that the observed field decrease in adult activity immediately following spraying is attributable to the spray.

The coccinellid predator, *H.s. hottentotta* showed similar but less dramatic mortality from exposure in the laboratory to sprayed plant material (fig. 2C). Since this species is not established, we can only speculate that the aerial application would be detrimental to adults under field conditions. Larvae of this and other coccinellids, however, often feed for several.days on scale eggs and crawlers within the mature ovisacs, and may therefore be somewhat protected from the spray's toxic effects.

Although adult parasite counts dropped in the initial pan trap sample after spraying, subsequent catches suggeted reestablishment. Adults in these later samples could have originated from three sources: (1) adults surviving the spray regime, (2) adults emerging, after the period of high toxicity, from mature scales that had survived and harbored parasite larvae and pupae, and (3) adults immigrating from other areas. We feel that the second source is the most likely. Mature scales are less susceptible to the aerial spray (unpublished data), and immature parasites inside these scales are protected from contact with the chemical. Our results and field observations suggest that relatively few adult parasites survive the spraying, and since the field site was surrounded by other spray corridors, immigration was probably minimal.

The ultimate effect of aerial malathion spraying on ice plant scale and its natural enemy complex depends on several factors. Maximum reduction in scale numbers would result from chemical application during reproductive periods when more vulnerable, smaller stages are present. For *P. mesembryanthemi* in northern California, these reproductive peaks occur during late spring and fall. The frequency of spraying is perhaps the most important factor for the natural enemy complex. Generally malathion has a relatively short half-life, but the very low pH in the bait spray formulation apparently extends its residual toxicity considerably. Although the parasite populations we surveyed recovered rather quickly when no further sprays were applied, residual toxicity would persist from one application to the next under a weekly spray regime. Emerging parasites would be exposed constantly to treated plant surfaces. Toxic effects would be most pronounced when the spraying period coincided with peak parasite emergence. These peaks are synchronized with host development, and different parasite species have different emergence times, based on different host



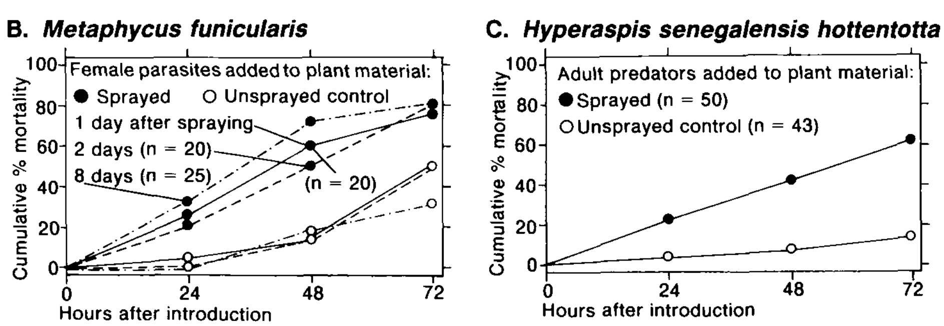


Fig. 2. Periods of sensitivity to spray residues in laboratory: (A) Scale crawlers that successfully colonized plants. (B and C) Parasite and predator mortality.

Director
Agricultural Experiment Station
University of California
Berkeley, California 94720

PUBLICATION
Penalty for Private Use $300

POSTAGE PAID
U.S. DEPARTMENT OF
AGRICULTURE
AGR 101

THIRD CLASS
BULK RATE

stage preferences. Therefore, timing of spray regimes could qualitatively as well as quantitatively alter the community composition. Whether the balance of the system is shifted to favor the scale or the natural enemies depends on the frequency and seasonal timing of the applications. We have recently received funding from the California Department of Food and Agriculture to further evaluate the long-term impact of aerial malathion-bait spraying on this insect community.

Jan Washburn is Graduate Research Assistant, Richard L. Tassan is Staff Research Associate, Kenneth Grace is Graduate Research Assistant, Eric Bellis is an undergraduate student, and Kenneth S. Hagen and Gordon Frankie are Professors of Entomology. All are with the Department of Entomological Sciences, University of California, Berkeley. *Research funds were provided by a grant from the California Department of Transportation: Gordon Frankie and Kenneth Hagen, principal investigators. The authors thank Daniel V. Cassidy, of Caltrans, for support and encouragement.*

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Imported scale pest destroys ice plants widely used as groundcover. Infra-red aerial photo of study site shows scale-damaged areas (green). Healthy plants are reddish.