Two years after introduction of ice plant scale natural enemies, highway planting has almost recovered from severe scale damage.

Imported natural enemies established against ice plant scales in California

Richard L. Tassan ☐ Kenneth S. Hagen ☐ Daniel V. Cassidy

Two introduced species of soft scales, now spread throughout much of California, attack the ground cover commonly known as ice plant, as well as other plants in the families Aizoaceae and Crassulaceae. Since 1978 we have been conducting a biological control program against these scales, concentrating on California Department of Transportation (Caltrans) landscaping. This report summarizes our results through 1981.

The scales, *Pulvinariella mesembryanthemi* and *Pulvinaria delottoi*, are thought to be native to southern Africa and to have been inadvertently introduced into California, possibly as early as 1949, when a scale was first detected on ice plant at the U.C. Botanical Garden in Berkeley. Scales infesting ice plants, *Carpobrotus* spp., in the Bay Area were reported several more times between 1949 and 1970, but apparently none of the infestations was serious enough to require control measures: there is no record of damage to affected plants, and the scales either died out or subsided to levels that went unnoticed. No further information exists on these populations.

The situation changed in 1971, when dense populations of *P. mesembryanthemi* on ice plant at two private residences in Napa, California, were brought to the attention of local and state officials. Several plants were dead, apparently the result of the high number of scales, and for the first time the scales' potential to cause damage was recognized. An eradication program was undertaken, in which infested plants were treated with malathion. Because inspections of the infested areas in 1972 were negative, the scale was assumed to have been eradicated; however, it reappeared in Napa in 1973.

That spring, University, county, state and federal entomologists, and Caltrans personnel conducted surveys of ice plant used to landscape Interstate 80 and Interstate 580 in Alameda County. Two types of scales were found at 14 locations, and for the first time, possible evidence of a second species surfaced. Biological studies (*California Agriculture*, October 1978) added further evidence that a second species was present, and it was subsequently described by Ray Gill, California Department of Food and Agriculture, as a new species, *Pulvinaria delottoi*. It has only one life cycle per year and colonizes the mature, lower portions of the plant, whereas *Pulvinariella mesembryanthemi* has two life cycles each year and usually colonizes the new terminal growth.

It was not until 1976 that the scales' ability to damage ice plant was manifested by large dead patches in freeway landscaping following dense scale populations. By 1978, the scales had been reported in six Bay Area counties and in Monterey and Santa Cruz counties. By 1981, they had spread north to Sacramento County and south to San Diego.

Caltrans, which maintains some 6,000 acres of ice plant throughout the state, estimated the cost at $20 million should they lose the ground cover and be forced to replant freeway landscape with some other plant. Chemical control of the scales was not satisfactory, requiring repeated, costly applications (about $75 per acre). Caltrans decided to pursue biological control to reduce scale densities to tolerable levels, and in July 1978 funded a three-year program through the U.C. Division of Biological Control.

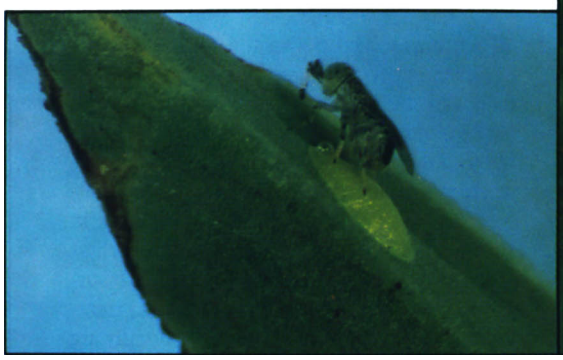
South Africa, thought to be the native region of ice plant and ice plant scales, was selected as the area to search for the scales' natural enemies. In April and May 1978, natural enemies were collected at 21 locations, representing a wide variety of climates, from the subtropical Natal Coast to the temperate Mediterranean climate of the southern Cape Province. Samples were taken from both natural habitats and ornamental plantings.

Five species of natural enemies were successfully processed through quarantine in sufficient numbers to allow culture and subsequent field releases:

Two Hymenoptera, the small parasitic wasps *Metaphycus funicularis* and *Metaphycus stramineus*, deposit one or more eggs in an immature scale, depending on the developmental stage or size of the scale. The wasp larvae feed inside the scale, killing it before becoming the next generation's adults. *M. funicularis*, the larger of the two species, is somewhat more limited than *M. stramineus* in its ability to parasitize smaller scales. Their two- to three-week life cycles are much shorter than those of the scales. Both species now appear to be firmly established in northern and southern California.

Another of the Hymenoptera, *Coccophagus cowperi*, is a solitary parasite: only one can develop inside a scale, and it is limited to attacking late second to early third stage scale. The parasitized scale acquires a distinct black coloration before the *Coccophagus* adult emerges. To date, no field recoveries of this species have been made.

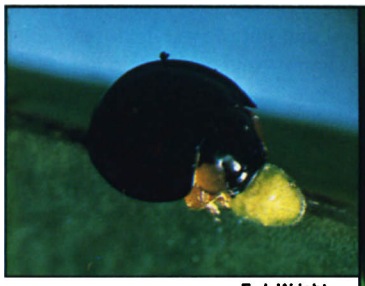
Although previous attempts to establish the predatory lady beetle *Exochomus flavipes* (Coccinellidae) against red scale and grape mealybug in California have failed, this species has proved to be a voracious feeder of ice plant scale and has become established in



Predator *Metaphycus funicularis* laying eggs in scale *Pulvinariella mesembryanthemi.*

Predator *M. stramineus* laying eggs in *P. mesembryanthemi.*

Community of predatory *Metaphycus* larvae developing inside ice plant scale.



E. J. Wright

Predator, *Exochomus flavipes*, adult female feeding on ice plant scale.

Patrick Craig

Third and fourth stage *Exochomus flavipes* larvae feeding on and searching for ice plant scales.

E. J. Wright

Female *Encyrtus saliens*, after inspection, parasitizes ice plant scale and causes it to mummify.

Patrick Craig

H. senegalensis hottentotta, shown among mature scales, is not yet well established here.

northern California.

The larva of another coccinellid, the lady beetle *Hyperaspis senegalensis hottentotta*, has a white waxy covering giving it the appearance of the egg sack of the mature female scale. The larva seems to prefer to burrow into the scale's egg sack and feed on the eggs, although both adult and larva feed on all sizes of scale. *Hyperaspis* has only a tenuous foothold in northern California.

Subsequent natural enemy collections by a South African entomologist have yielded two additional parasitic wasps—*Encyrtus saliens*, a solitary parasite whose wingless females have an antlike appearance, and a *Metaphycus* sp. that is very similar in appearance and biology to *M. stramineus*. *Encyrtus saliens* is colonized in two locations in northern California, the *Metaphycus* sp. has yet to be recovered in the field.

Metaphycus funicularis, M. stramineus, and *Exochomus flavipes* are considered to be established in northern California and are spreading from freeway landscaping into residential landscaping. The ability of *M. funicularis* and *M. stramineus* to disperse is indicated by their occurrence in Marin and Santa Cruz counties, despite their not being released in those counties. Since the initial releases in 1978, each species has completed numerous generations in the field and has survived three winters (1978 through 1981). In repeated instances, substantial reductions in *P. mesembryanthemi* populations have occurred, and negligible new ice plant mortality has been observed within three scale generations (18 to 24 months) after natural enemies have colonized a site. Similar, but less dramatic, reductions in *P. delottoi* populations have been observed in the greater Bay Area.

The expectation that these natural enemies will continue to keep the scales at tolerable levels has led Caltrans to begin an extensive redistribution program designed to accelerate the spread of the natural enemies in freeway landscaping.

The appearance of *P. mesembryanthemi* in Sacramento, Yolo, and Los Angeles counties in the fall of 1979, Orange and Monterey counties in 1980, and San Luis Obispo, Santa Barbara, and Ventura counties in 1981 greatly expanded the scope of the biological control program. Natural enemy releases began shortly after the scale was detected in these counties. Even though the introduced natural enemies have reproduced and multiplied in the field, it is still too early to make any conclusions regarding their success in bringing the scale populations under biological control there. But, based on our experience in the Bay Area, the outlook is promising.

The cost of this project (about $190,000 to date) represents a relatively small investment in relation to the expected long-term benefits of succesful biological control, which will preserve the landscaping but reduce the use of pesticides.

Richard L. Tassan is Staff Research Associate, and Kenneth S. Hagen is Professor of Entomology and Entomologist, Division of Biological Control, Department of Entomological Sciences, University of California, Berkeley. Daniel V. Cassidy is Landscape Specialist, Maintenance Department, California Department of Transportation. *The authors gratefully acknowledge the assistance provided by many University and Caltrans personnel. Prepared in cooperation with the State of California, Business and Transportation Agency, Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration. 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.*