

Pine foliage showing few pine needle scale on the current foliage, an indicator of a collapsing population. Note the preyed-upon scale on the previous year's growth.

Natural a PINE SCALE at South

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IN THE SUMMER of 1968, a small scale insect, the pine needle scale (*Chionaspis (Phenacapis) pinifoliae*, Fitch), was discovered in high densities within the city limits of South Lake Tahoe. The city lies within natural stands of lodgepole and Jeffrey pine and both tree species were heavily infested with the scale. The infestation encompassed a total area of some 1300 acres. Investigations of the scale outbreak were initiated by the Division of Biological Control, University of California, Berkeley, the State Division of Forestry, the State Bureau of Vector Control and Solid Waste Management, and Mosquito Control Service Area No. 3.

Preliminary study

The preliminary study suggested that the outbreak was associated with the weekly application of the insecticide malathion against a complex of mosquitoes considered to be a nuisance. The malathion was applied by a thermal fogger mounted on a pickup truck driven through the streets. Such drift-induced scale outbreaks have occurred in citrus where insecticide drifts from adjacent crop acreages. This selectively killed the scale's natural enemies, allowing the pest

to increase. The same mechanism was strongly suspected in the pine needle scale outbreak. As a consequence, it was recommended that the fogging cease and that source elimination and reduction be initiated as a means of mosquito control.

Bio-control

The Division of Biological Control initiated an investigation to obtain information on the following: (1) the natural enemy complex associated with the pine needle scale; (2) the role, if any, of the fogging activity in the scale outbreak; and (3) the rate of recovery of the natural enemy complex following cessation of fogging.

Biological study of the scale on its host trees, lodgepole and Jeffrey pine, revealed that there were three parasitoids and two predators associated with it. The parasite complex on lodgepole included *Prospaltella bella*, and *Physcus howardi*. Parasites associated with Jeffrey pine included *Achrysocharis phenacapsia*, and *Aphytis* sp. The predator complex was similar on both trees, and consisted of *Cryptoweisia atronitens*, and *Chilocorus orbis* var. *monticolus*. During the first year follow-

RELATIONSHIP BETWEEN PINE NEEDLE SCALE DENSITY AND PARASITIZATION BY *PROSPALTELLA BELLA* ON LODGEPOLE PINE

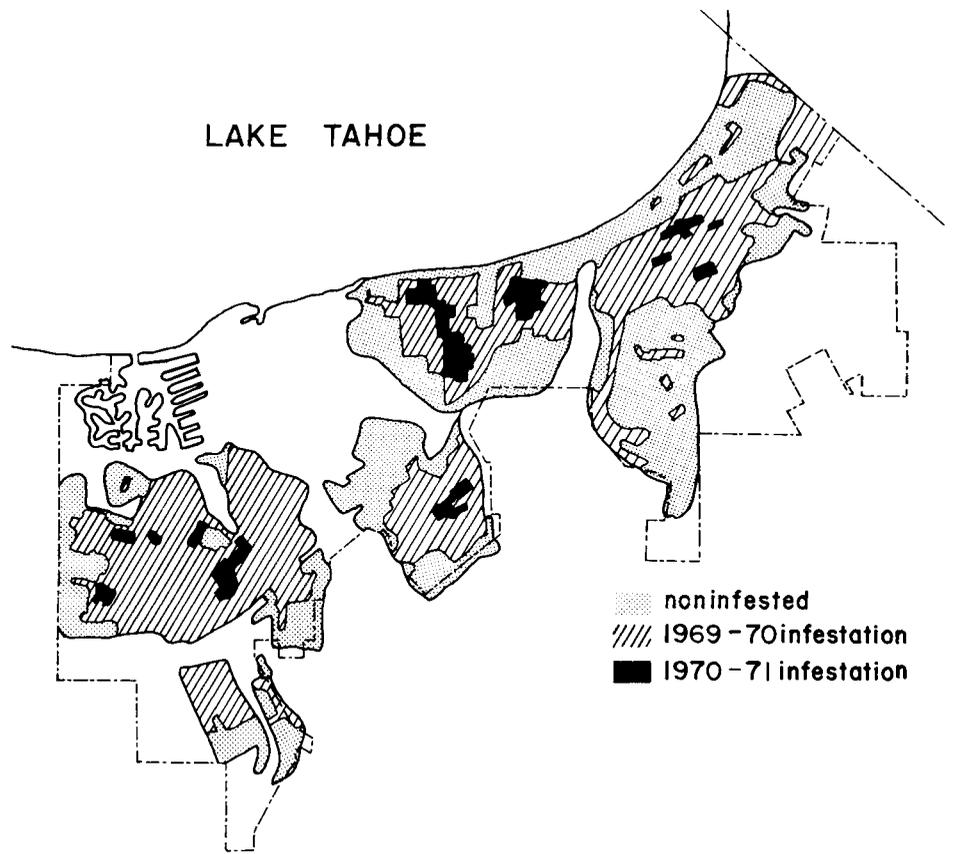
Year	Number Mature ♀ Scales/Needle	% Parasitization
1969	16	15
1970	2	57
1971	>1	>6

ing the cessation of fogging, the natural enemies were rare, but by the second year two of the parasites and both predators had increased in abundance. By the third year the predators were extremely common and were often observed voraciously feeding on female scale (see photos).

Fogging tests

Malathion fogging tests were conducted under conditions similar to those in actual mosquito control; the equipment employed in the tests as well as the personnel involved were the same. The objective of the tests was to determine if the malathion residues resulting from the fogging were sufficient to cause parasite mortality. The tests consisted of exposing parasites to either treated or untreated foliage for a period of 24 hours. Mortality was assessed after the 24-hour period and was found to be consistently higher on

decline of
NEEDLE
population
Lake Tahoe



Map of South Lake Tahoe showing original pine needle scale infestation and decline to December 1970.



Photo 1. A twice-stabbed lady bird beetle larva, *Chilocorus orbis*, feeding on the pine needle scale. (Photos by F. E. Skinner)

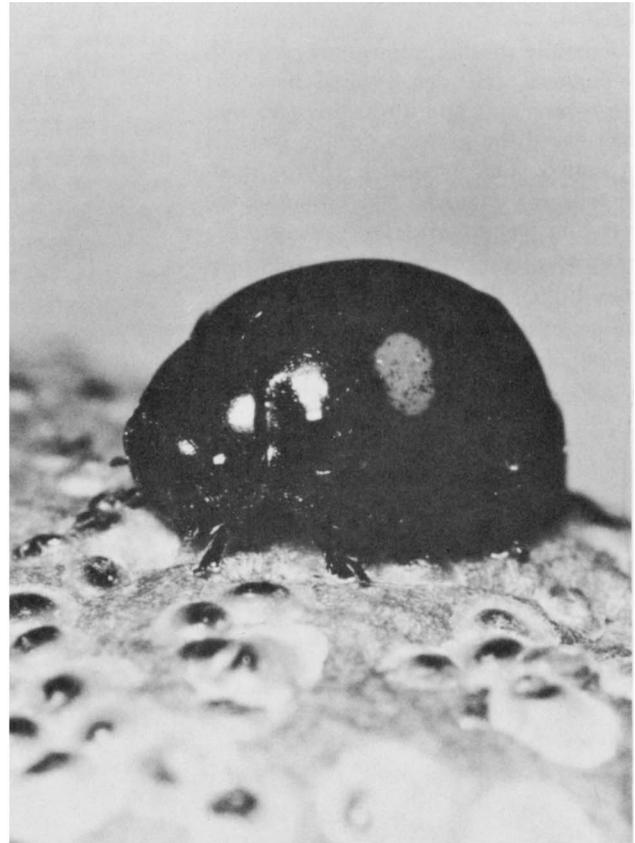


Photo 2. The adult twice-stabbed lady bird beetle, (*Chilocorus orbis* var. *monticolus*) feeding on a factitious host in the laboratory.

the sprayed foliage tips than on the untreated controls. The residual effect of the malathion lasted for a period of at least five days and was effective to a distance of at least 50 ft from the road edge. It is clear from these tests that the weekly applications of malathion caused sufficient residue to prevent the parasites from effectively searching the treated foliage for scale.

Natural enemies

Three plots—two in lodgepole, one in Jeffrey pine—were established for intensive sampling. The objective of the intensive sampling was to determine if the natural enemies would reduce the high densities of scale to levels which would no longer damage the tree.

The results showed that the greatest mortality suffered by the scale occurred during the crawler stage between the time of egg hatch and the location of a suitable settling site. The factors responsible for this mortality are unknown. This, however, was not sufficient by itself to cause the scale population to decline. Instead, the combined action of both lady beetle predators and, in one area a parasite, *Prospaltella bella* (photo 3) were necessary before the scale population declined (see table).

Generally speaking, the study plot with the highest scale density had been the Jeffrey pine area and it was this area that experienced the greatest decline in scale population. The reduction in this population was a hundred times that of the preceding generation. In contrast, the lower population density lodgepole pine areas did not show as dramatic a decline. The major agent responsible for reducing the populations in all study plots was predation (photo 4).

Extensive sample

An extensive sample was made, based on the sessile life habits of the scale. The current scale population on the new needles was compared with the preceding generation on the older needles. Lack of, or few, living scale occurring on the new foliage—compared with the dense scale of the preceding generation—indicated a declining scale population (see photo, page 10).

The 1970-71 and 1971-72 generations were sampled using the above index. In the winter of 1970-71, a block-by-block survey was conducted in the residential areas of South Lake Tahoe. A sample unit consisting of three tips was selected from different trees in the middle of each block. Color codes were used, and the conditions were recorded on a map on a block-by-block basis. The survey was repeated in 1971-72 in areas which were heavily infested in 1970-71. Areas which had declined in 1970-71 were spot checked in 1971-72.

Survey results

The 1970-71 survey revealed that the previously infested trees usually were found on the periphery of infested stands. Of the 1300 acres of infestation, approximately 1150 acres showed evidence of a dramatic decline while 150 acres still showed indications of heavy scale populations (see map).

The 1971-72 survey showed that populations in the 150 acres of heavily infested pine had declined. Two areas of lodgepole pine still showed low residual populations of scale but they appeared heavily parasitized.

The extensive sample had confirmed the general trend observed in the intensive sample plots. Examination of the scale coverings on the surveyed tips sug-

gested that predation was the major cause of the decline. However, the predators are high density feeders only—which reduce the scale population to low enough densities for the parasite complex to resume regulation. The insecticide probably caused the initial disruption in the parasite-scale interaction and as the scale population increase, the insecticide probably inhibited the effectiveness of the predators also.

The mosquito control program had been in operation for 5 years (1963-1968) spraying at weekly intervals from approximately June 1 to September 15 each year. The tragedy is that recent testing of fogging as a mosquito control technique at South Lake Tahoe has strongly suggested its ineffectiveness: the feeding rate by mosquitoes was only temporarily reduced for a few hours following treatment, and trapping of adult mosquitoes after fogging showed little if any effect on the adult population density. The price paid for the ineffective program was an outbreak of scale that—had it continued—could have seriously affected the survival of the trees as well as their aesthetic value.

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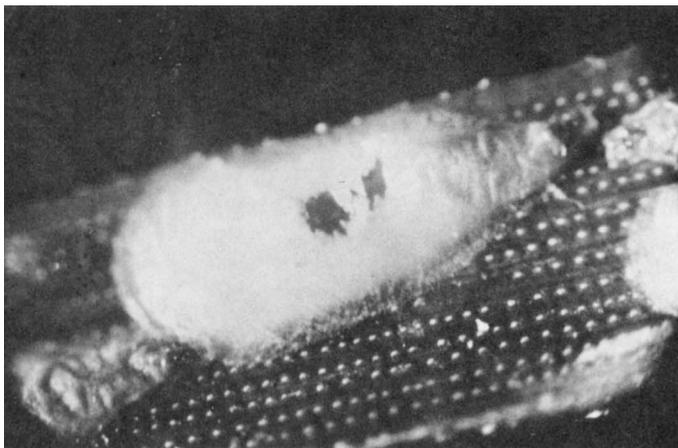


Photo 3. Close-up of a pine-needle scale showing the emergence hole of a small parasitic wasp.



Photo 4. Close-up of pine needle showing the evidence of predation. Note the broken and chewed scale coverings.