Presence-absence sampling of citrus red mite on lemons

Citrus groves suffering water stress induced by Santa Ana winds can be severely damaged by citrus red mite. (Photo courtesy Dr. Robert Brown)

immature stages on each leaf surface was recorded. The values for each tree were collated into total active stages, and the following indices of population density were calculated: proportion of leaves infested with at least one female on the top surface of the leaf, proportion of leaves infested with at least one female on the bottom surface of the leaf, and proportion of leaves infested on either side with at least one adult female. The adult female was chosen because of its relatively large size and lower density, compared with the other stages.

Linear regression was used to determine which of the infestation indices was best related to the total population. The regression was forced through the origin because, if there are no mites, the percentage infestation must also be 0.

Sampling strategies

Sampling, as described here, was conducted on five plots at the following location and times: Two plots of 15-year-old 'Lisbon' lemons at the UC Citrus Research Center (CRC) in Riverside were studied (30 trees sampled in early summer 1982, and 20 trees in late winter 1983). Three plots of 13-year-old 'Eureka' lemons in the Fallbrook area of San Diego County were sampled in summer 1982 (25 trees), early fall 1982 (29 trees), and late fall 1982 (21 trees). Several groves and times were chosen to incorporate grove and seasonal effects on population structure.

To determine the number of trees necessary for sampling, the relationship between the mean number of mites per tree and the variation in the number of mites between trees must be known. To establish this relationship, we used "Taylor's power law," developed by Dr. L. R. Taylor at the Rothamsted Experimental Station in England. We used data from four plots each consisting of 48 trees; each plot was sampled weekly for seven consecutive weeks in southern California between spring 1981 and summer 1982. One plot was at CRC, Riverside, and two were in Ventura County's Saticoy area (all Lisbon lemons); the fourth plot was in San Diego County's Oceanside area (Eureka lemons). Trees were sampled, as described, except that the hairspray was eliminated. A mite-brushing machine was used to count the mean number of mites per leaf for each tree.

Results

The best relationship was found between the total active stages per leaf and the proportion of leaves whose lower

TABLE 1. Constant precision sequential sampling chart for citrus red mite on lemons

No. trees sampled	No. leaves infested	Mean no. of mites per leaf	Cumulative no. of mites/leaf*	Sampling stops if cumulative no. mites/leaf is ≧ †
1	7	1.13	1.13	403.7
2	12	3.33	4.46	73.9
3	10	2.31	6.77	27.4
4	3	0.21	6.98	13.6
5	14	4.53	11.51 ------------→	7.8
6				5.0
7				3.4
8				2.5
9				1.9
10				1.4

$$\text{Mean} = \frac{11.51}{5} = 2.3 \text{ mites/leaf}$$

* To calculate the areawide mean, divide the cumulative number of mites per leaf by the number of trees sampled.
† Fixed level of precision = 0.25.

TABLE 2. Presence-absence intra-tree sampling plan for citrus red mite on lemons

No. leaves infested per 30-leaf sample	Tree mean no. mites/leaf
1	.02
2	.09
3	.21
4	.31
5	.58
6	.83
7	1.13
8	1.48
9	1.87
10	2.31
11	2.80
12	3.33
13	3.90
14	4.53
15	5.20
16	5.91
17	6.68
18	7.48
19	8.34
20	9.24
21	10.19
22	11.18
23	12.22
24	13.31
25	14.44
26	15.62

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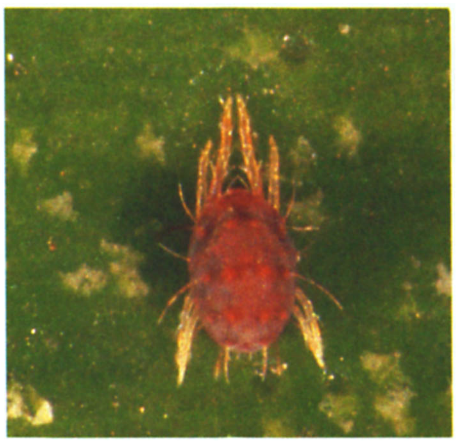
surface was infested with at least one adult female. The equation accounts for 97 percent of the variation in the data: $\hat{Y} = 4.56X$ (Y = square root total number of active stages per leaf, X = proportion of the 30-leaf sample with the lower surface infested with at least one adult female). Use of this relationship enables rapid estimation of the mite population on a per-leaf basis from the proportion of leaves infested. There were no significant differences among plots, indicating that this method can be used throughout the year in different lemon-growing areas and on different lemon varieties.

Analysis of mite populations between trees showed that Taylor's power law accurately predicts the relationship between the mean and variance and accounts for 87 percent of the variation in the data. Again, this relationship held true for all plots, suggesting that the sampling plan was not affected by season, grove, variety, or differences in predator populations. With knowledge of the relationship between the mean and variance provided by Taylor's power law, a constant precision sequential sample can be derived. The constant precision sequential sample, based on the repeatability of an estimate, was used instead of the more common sequential sample that relies on attainment of a predetermined threshold. This was done because the relationship between citrus red mite feeding and yield reductions has not been quantified. This way, the researcher and pest control advisor can determine accurately the mean number of mites per leaf on a particular tree or areawide and decide whether the population level warrants treatment.



The citrus red mite is the most important mite pest of lemon, orange, and grapefruit in California, causing leaf and fruit drop and twig dieback.

The size of the area sampled should be based on the minimum-size area to which a grower would apply treatment. Trees within this area should be randomly selected and a 30-leaf sample should be taken. The leaves sampled should all be fully expanded and collected randomly from the outer periphery of the tree between 2 and 6 feet above the ground. There should be no bias towards sampling trees (or leaves on a tree) with either obviously high or low populations. If there are known "hot spots," they should be monitored separately and not included in the sampling plan.

The sampling table provided works in the following manner. The number of leaves in a 30-leaf sample, with at least one adult female on the lower surface, is placed next to the tree number sampled. In our example (table 1), 7, 12, 10, 3, and 14 leaves were infested on the five separate trees. The mean number of mites per leaf is found in table 2 and entered in column 3 of table 1. The values of the tree means are then added in the fourth column. When the value in the fourth column is greater than or equal to the number in the fifth column, sampling stops and the areawide mean is determined by dividing the value in column 4 by the number of trees sampled as shown in the table.

The time savings possible with the sequential sample is demonstrated by examining four plots consisting of 30 trees each. Using the sequential sample, an average of 7 trees out of a possible 30 trees had to be sampled to estimate accurately the areawide mean. The means obtained in this fashion were all within ± 1 standard error of the mean calculated by sampling all 30 trees in each plot. In addition, because only the presence or absence of adult females on the lower surface must be assessed, time savings over counting each female makes use of these plans even more attractive.

This sampling plan provides a rapid estimate of citrus red mite population levels with minimal effort. However, because it relies on the location of adult females on the leaf, use of this method immediately after application of certain pesticides (such as Morestan), which have been shown to repel citrus red mite, may yield erratic results. The goal of future research will be to determine whether the relationships presented here can be used on orange and grapefruit.

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