Dimethoate-resistant spider mite predator survives field tests

Richard T. Roush ☐ William L. Peacock
Donald L. Flaherty ☐ Marjorie A. Hoy

Spider mites have become increasingly important agricultural pests during the past 25 years. The ability of spider mites to tolerate or develop resistance to pesticides that destroy their predators is a major factor in this trend. A partial solution to spider mite problems created by pesticides is to develop and establish predators that are resistant to these pesticides or that can tolerate commercial application rates.

The phytoseiid mite *Metaseiulus (= Typhlodromus) occidentalis* (Nesbitt) is an important predator of the Pacific spider mite (*Tetranychus pacificus* McGregor), a serious grape pest in the southern San Joaquin Valley. Dimethoate (Cygon, Defend) is commonly used in these vineyards to control the grape leafhopper (*Erythroneura elegantula* Osb.), the most important pest of grapes in the San Joaquin Valley, but it is also applied to control flower thrips (*Frankliniella* sp.).

Dimethoate is toxic at low concentrations to *M. occidentalis*, although the predators in some vineyards are more resistant to the pesticide than are those in other vineyards. Table 1 shows the results of a vineyard survey conducted in 1977. At least 20 predators were collected from each vineyard to initiate colonies reared for slide dip analysis. This analysis was done by mounting gravid females on their backs on sticky tape attached to glass microscope slides. The slides were dipped for 5 seconds into different concentrations of dimethoate (25 percent wettable powder) and held for 48 hours at 27.5 ° C and about 90 percent relative humidity. The number of live females was then determined by whether the mites' appendages moved when probed with a fine brush. An LC_{50} (the concentration of pesticide that kills 50 percent of the mites under test conditions) was calculated for all of the vineyards shown in table 1.

Our purpose was to develop a predatory mite more resistant to dimethoate and establish it in a commercial vineyard. If *M. occidentalis* were resistant to the rates of dimethoate used to control leafhoppers and thrips, there would probably be fewer Pacific mite outbreaks.

A strain of *M. occidentalis* was selected for dimethoate resistance in the laboratory in early 1978. About 30 to 50 individuals of all the colonies shown in table 1, as well as colonies collected from pears, apples, and blackberries in California and apples from Washington, were combined into a single strain. About 500 to 1,000 individuals were treated in each round of selection to give about 70 to 90 percent mortality.

Dimethoate is an organophosphorous (OP) insecticide. Resistance to OPs is widespread in *M. occidentalis*, and this selection program was designed to concentrate those factors conferring resistance to dimethoate in a single strain. After eight rounds of selection, the selected strain was more resistant than any *M. occidentalis* strain yet found in nature (table 1; table 2, released resistant strain), but an additional six rounds of selection increased resistance only slightly.

This selected strain was then released into an Italia vineyard near Dinuba, Tulare County (the Ketenjian vineyard of table 2) in the summer of 1978 to test its ability to survive a dimethoate application, to determine if it survived in sufficient numbers to control spider mites, and to find out if the resistance characteristics would carry over into the next spring. In this experiment, the only spider mite species present was the Willamette spider mite, *Eotetranychus willamettei* (McGregor). This mite is not generally considered to be a pest, because it does little damage to grape vines. In fact, it is a beneficial species in that it is an alternate food source for *M. occidentalis* and thereby helps to ensure that the predator will be present to control infestations of Pacific mite, which tend to occur later in the season.

The vineyard was divided into a series of plots of four predator-dimethoate spray combinations. The combinations were: (1) resistant predators released and vines sprayed with dimethoate; (2) no predators released and vines sprayed; (3) resistant predators released and vines left unsprayed; and (4) no predators released and the vines left unsprayed. Eighteen leaves were sampled from each plot on each sample date to assess predator and prey populations (fig. 1 to 4). *Metaseiulus occidentalis* recovered from the field were colonized in the laboratory and tested for their levels of resistance (table 2). Six hundred adult females of the resistant strain were released per plot on May 3, 1978. Dimethoate (8 pounds of 25 percent wettable powder per acre) was applied with a concentrate sprayer on May 9.

The laboratory-selected strain was superior to the native predators already present in the vineyard, but not sufficiently resistant to survive in high numbers at the commercial rate of 2 pounds active ingredient (a.i.) per acre (about 1 pound a.i. per 100 gallons). Resistance levels of the native predators were low (table 2). The dimethoate application reduced the *M. occidentalis* populations by at least 90 percent in all of the treated plots (fig. 1 and 3), but the dimethoate-resistant predators eventually increased in numbers toward the end of the sampling period (fig. 1), whereas the susceptible predators did not (fig. 3). It is important to note that, although slide dip tests can be used to compare various strains, the results cannot be easily extrapolated to the field, because factors such as temperature, coverage, and residue differ.

Willamette mite populations were reduced by the dimethoate application by about 40 percent (fig. 1 and 3), but this difference disappeared 3 to 4 weeks after treatment. Although dimethoate appears to be weakly toxic to the spider mites and highly toxic to the predatory *M. occidentalis*, the selective acaricide propargite (Omite) does not affect the predators nearly as much as the prey. The experimental rows were left untreated, but the drift from a propargite application on nearby rows reduced prey populations so severely in late June that some predators died from starvation (fig. 2 and 4).

Laboratory slide dip tests of *M. occidentalis* collected from the plots indicated that the resistant predators persisted through 30 June, the last sample date in 1978 (table 2). Predators recovered from the vineyard in April 1979 were not as resistant as those found in June 1978, but there was still an approximately twofold difference between the resistance levels in the release compared with nonrelease plots.

Laboratory studies indicate that the dimethoate resistance is due to several genes acting together. These genes probably become reshuffled when resistant predators mate with susceptible predators, thereby breaking up the desired gene sets and leading to increased susceptibility. The predators recovered from one of the four release-treated plots, for example, had an LC_{50} of

2.0, which probably reflects a low level of interbreeding with susceptible predators in that particular area.

This work demonstrated that laboratory-selected predators could colonize the vineyard and that higher levels of laboratory-induced resistance can persist in nature. Unfortunately, the level of resistance in this selected strain is not satisfactory. One possible solution is to reduce dimethoate application rates where lower rates can give adequate pest control. Another possibility is to use a different organophosphorous pesticide less toxic to *M. occidentalis*. Research into both approaches is continuing.

Richard T. Roush was a Graduate Student in the Department of Entomology, University of California, Berkeley; William L. Peacock and Donald L. Flaherty are Farm Advisors, Cooperative Extension, Tulare County; Marjorie A. Hoy is Assistant Professor and Assistant Entomologist, University of California, Berkeley. We thank Simon Ketenjian for his generous cooperation and the use of his vineyard. This project was supported in part by the California Raisin Advisory Board, the California Table Grape Commission, and a National Science Foundation Predoctoral Fellowship to the first author.

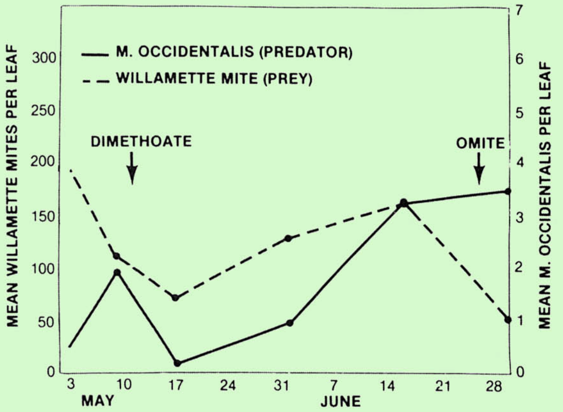

Fig. 1. *Metaseiulus occidentalis* and Willamette mite population counts for dimethoate-sprayed predator-release plots.

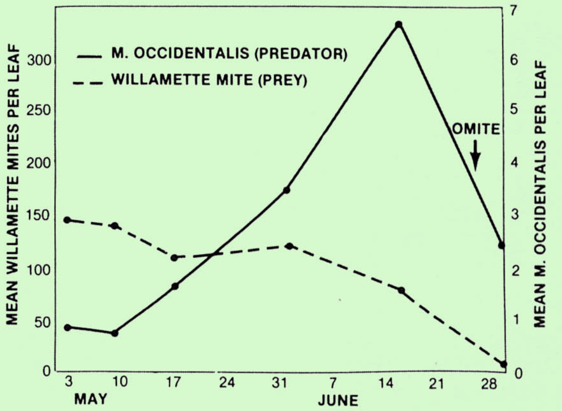

Fig. 2. *Metaseiulus occidentalis* and Willamette mite population counts for unsprayed predator-release plots.

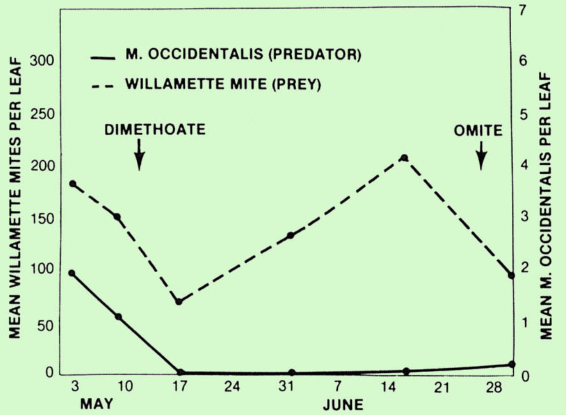

Fig. 3. *Metaseiulus occidentalis* and Willamette mite population counts for dimethoate- sprayed nonrelease plots.

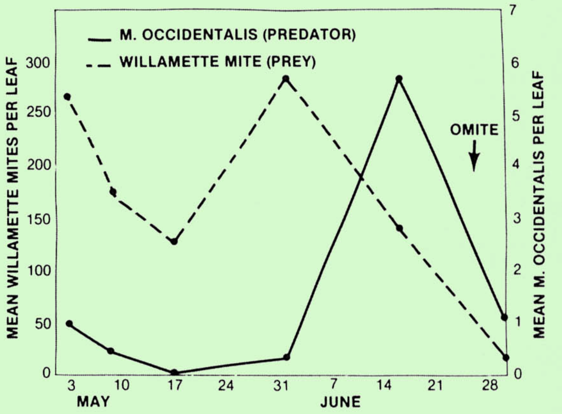

Fig. 4. *Metaseiulus occidentalis* and Willamette mite population counts for unsprayed nonrelease plots.

TABLE 1. Toxicity of Dimethoate to Gravid *M. occidentalis* Females from 1977 Survey Using Slide Dip Analysis

Vineyard	LC$_{50}$ (lb a.i./100 gal water)
Fresno County	
Nakata vineyard	0.37
Browley vineyard	.33
Clovis at Manning vineyard	.87
Dickenson at Jensen vineyard	.59
Kern County	
Shafter vineyard	.75
Valet vineyard	.61
Madera County	
Bidegain vineyard	.63
Urena vineyard	.97
Radovich vineyard	.34
Bomprezzi vineyard	.50
Tulare County	
Hays vineyard	.091
Setrakian vineyard	.38
Monson vineyard	.50
Kinosian vineyard	.40

TABLE 2. Toxicity of Dimethoate to Gravid *M. occidentalis* Females in 1978 Field Experiment Using Slide Dip Analysis

Predators	LC$_{50}$ (lb a.i./100 gal water)
Natives from Ketenjian vineyard sampled May 3, 1978	0.50
Released resistant strain (laboratory)	2.2
Strains recovered June 30, 1978 from release-treated plots	1.9
Strains recovered April 19, 1979, from release-treated plots	1.1
Strains recovered April 19, 1979, from nonrelease-treated plots	.62
Predators	**Mean percent mortality at 1-lb challenge dose**
Before releases	
Natives, sampled May 3, 1978	83
Released resistant strain (laboratory)	16
After releases, sampled June 30, 1978	
Release-treated	26
Nonrelease-treated	88
Release-untreated	47
Nonrelease-untreated	75