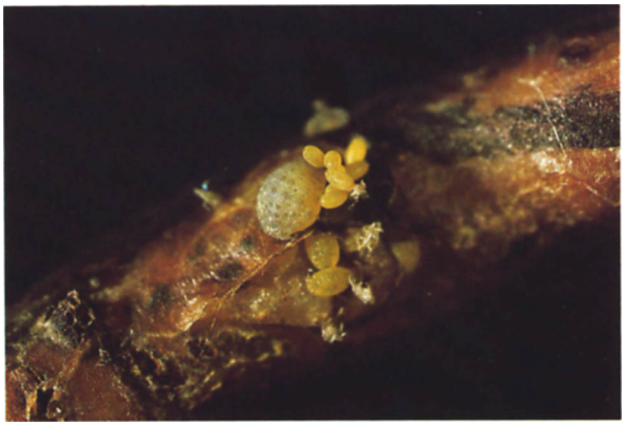
Grape phylloxera in California

Jeffrey Granett ☐ Austin C. Goheen ☐ Lloyd A. Lider

New biotype poses some risk in coastal vineyards



Jack Kelly Clark

Phylloxera feeding on grape roots cause galls, which are necessary for the insects' nutrition.

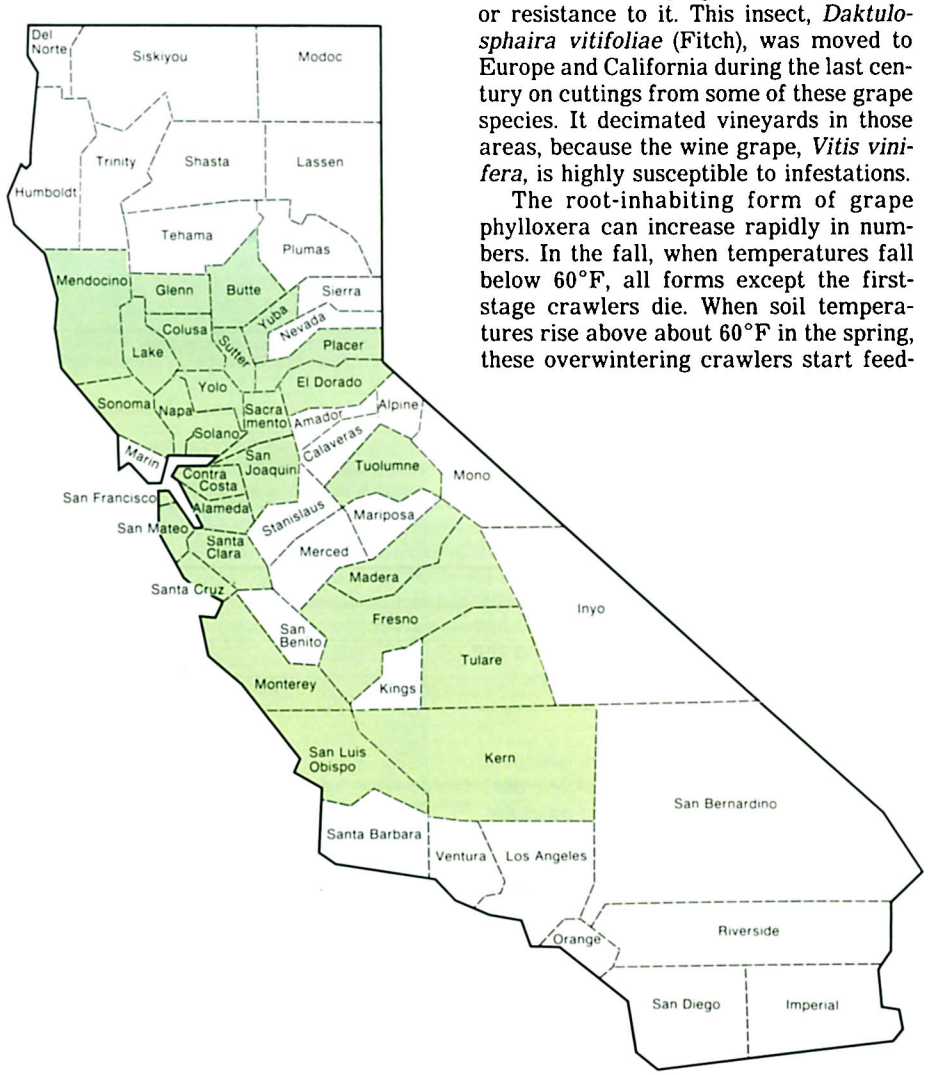
Grape phylloxera is an aphidlike pest native to the eastern and southern United States, where it lives on wild grape species that have varying levels of tolerance or resistance to it. This insect, *Daktulosphaira vitifoliae* (Fitch), was moved to Europe and California during the last century on cuttings from some of these grape species. It decimated vineyards in those areas, because the wine grape, *Vitis vinifera*, is highly susceptible to infestations.

The root-inhabiting form of grape phylloxera can increase rapidly in numbers. In the fall, when temperatures fall below 60°F, all forms except the first-stage crawlers die. When soil temperatures rise above about 60°F in the spring, these overwintering crawlers start feeding. They molt four times, reaching adulthood in about a month. In California, all phylloxera are females and may lay up to 250 eggs. There may be as many as five generations a year under favorable conditions.

Phylloxera need favorable temperatures, soil type, and hosts for survival. Soil temperatures must be between about 60° and 90°F; at levels very much above or below this range, phylloxera do not feed and will die. They grow well on roots in clay soils but do poorly in sandy soils, for reasons that are not known.

Interaction with the host plant is necessary. As it attempts to feed, the phylloxera injects saliva into roots. The saliva causes a susceptible host to form swellings, or galls, and gall formation seems to be required for the insect to feed properly. Some American *Vitis* species and hybrids of these with *V. vinifera* do not form galls or do not form them well; these plants are resistant to the grape phylloxera.

The technology for using phylloxera-resistant rootstocks (either pure American *Vitis* species or hybrids) was developed over 100 years ago, but selection of rootstocks for use in vineyards depends on many viticultural characteristics in addi-



Phylloxera distribution by counties. Most of this is type A. Type B has thus far been discovered only in Napa and Sonoma counties. (From CDFA data)

Grape phylloxera decimated California vineyards during the last century, because the wine grape rootstock, *Vitis vinifera,* was highly susceptible to infestations. Planting resistant rootstocks effectively controlled the insect. This photo shows damage from type B phylloxera.

tion to resistance to phylloxera. Trials have been established in several California grape-growing areas with different scion/rootstock combinations to evaluate viticultural characteristics along with resistance.

Phylloxera problems

Phylloxera is well distributed in California's viticultural regions, but the problems it causes vary.

Although the insect infests the coastal valleys, growers occasionally take the risk of planting susceptible own-rooted vines. Phylloxera are generally found in such vineyards within 5 to 10 years of planting; within another 5 to 10 years after the first discovery, the vineyards decline to a level of nonproductivity. Currently, a number of vineyards in Monterey, Napa, Lake, and Mendocino counties are on susceptible roots and have phylloxera populations. Because there are no accepted, reliable chemical treatments for phylloxera eradication, these vineyards will eventually have to be replanted on resistant rootstocks.

Another phylloxera problem exists in Central Valley vineyards. Soil temperatures there tend to be above 90°F to some depth in midsummer, causing phylloxera mortality. Some Valley soils are also very sandy and therefore not optimal for phylloxera. Although a number of Central Valley locations have grape phylloxera populations, the infestations tend to be limited in size and severity. Growers have been able to deal with the problem by cultural methods. This situation has been known for a long time and does not seem to be worsening.

A third phylloxera problem is new to California: the recent discovery of phylloxera biotypes, or forms of the insect that are not different species but that differ in some important biological characteristic. The characteristic of importance to phylloxera is the ability to utilize a resistant rootstock as a food source. Phylloxera biotypes able to survive on partially resistant *V. vinifera* × *V. rupestris* crosses have been known worldwide since around 1915 (as reported by researcher A. I. Perold in England in 1927; C. Borner, Germany, 1943; A.B. Stevenson, Canada, 1970; C.A. De Klerk, South Africa, 1979; and P.D. King and G. Rilling, New Zealand, 1985). These biotypes, however, have not been seen in California before now. We began research to determine whether phylloxera damage observed in a Napa Valley vineyard was caused by a new biotype and, if so, to evaluate rootstocks against this new form.

Biotypes

Our initial observations of phylloxera biotypes in California came about when a Napa Valley grower came to the University with a problem: Cabernet Sauvignon vines grafted on what he thought was the resistant rootstock AxR-1 were declining and dying. Extremely high numbers of phylloxera were found on the roots. After looking at 46 sucker canes of the rootstocks taken from the vineyard in June 1985, we determined that 23 of the rootstocks were AxR-1. The other 23 were another *V. vinifera* × *V. rupestris* hybrid, XX or 95-3 C, which we know to be susceptible in general to phylloxera.

Next we brought phylloxera from the AxR-1 plants into the laboratory to test them on genuine AxR-1 root pieces from the Department of Viticulture vineyard at UC Davis. We placed eggs on 1.5-inch root pieces, which we kept moist by wrapping one end with moist cotton. For each phylloxera type tested, we used 50 to 120 eggs per experiment and replicated the experiment five times, comparing the new phylloxera strain with another strain in development time to the adult stage, generation time, longevity of individuals, and reproductive rates.

Analysis of the data with life-table statistics indicated that the phylloxera from the newly infested vineyard differed from the other California population in having a faster development and rate of egg laying on AxR-1 (table 1).

As a final test to ascertain biotypes, we interplanted a small rootstock trial in the affected vineyard in 1984. (This trial was also used to determine resistance of various rootstocks.) We used a randomized block design with 20 plants of each of five rootstocks, and four replications. These plants were analyzed for vigor in October 1985 on a scale of 0 to 9, with five people rating each plant independently. In July 1986, the plants were dug and infestations on the roots determined.

The ratings averaged for the five observers indicated that AxR-1 was relatively susceptible when compared with S04, St. George, and 1202 C rootstocks (table 2). Based on all the data, we concluded that there are at least two phylloxera biotypes in California and that one (type B) is able to utilize AxR-1 as a host.

To date, we have identified three vineyards in Napa and Sonoma counties that are infested with type B. The vineyards are grafted primarily onto AxR-1 rootstocks, but susceptible root types are intermixed. We do not know the significance of this interplanting. We also do not know whether the current finds of type B are the limit of type B distribution in California.

Resistance of other rootstocks

We screened selections of grapes for resistance to type B phylloxera. For these tests we used methods similar to the previously described life-table tests in the laboratory. Each rootstock experiment included 50 eggs, and all experiments were replicated three times. The criterion

TABLE 1. Population growth parameters of grape phylloxera on AxR-1 root pieces in the laboratory†

Parameter	Population parameters (mean ± standard deviation) Type A	Type B	Paired t-test
Developmental time (days)	41 ± 5.2	30 ± 3.5	*
Generation time (days)	54 ± 5.7	38 ± 6.1	*
Gross reproductive rate (eggs/female)	63 ± 32	128 ± 25	*
Increase/generation (individuals/female)	12 ± 6.8	22 ± 15	NS
Population doubling time (days)	17 ± 4.6	9 ± 1.8	*

† Phylloxera from vineyards infested with indicated biotype.
* Statistical significance at $P<0.05$, df=4, NS indicates nonsignificance, $P>0.05$, df=4.

TABLE 2. Field trial results with rootstocks in vineyard infested with type B phylloxera

Variety	Number of vines	Vigor rating (Mean ± SD)†	Infestation category (number of vines)‡ None	Light	Heavy
May 1984 plantings:					
S04	20	6.8 ± 1.5	20		
1202 C	20	6.1 ± 1.1	5	15	
St. George	20	6.5 ± 0.9	5	14	1
AxR-1	20	3.1 ± 0.8		8	12
Chenin Blanc.	20	1.0 ± 1.2		1	19
May 1985 plantings:					
0 39-16	15	6.3 ± 1.4	13	2	
0 44-4	6	6.8 ± 0.7	5	1	
0 43-43	15	5.5 ± 1.2	3	11	1
171-6	6	5.2 ± 1.2		6	
110 R	10	5.2 ± 1.4	1	8	1

† Vigor evaluations are based on a 0-9 scale, with the highest numbers indicating the most vigorous plants.
‡ For the infestation rating, "none" indicates no phylloxera found on the entire root system, "light" indicates 10 or fewer galls found, "heavy" indicates more than 10 galls.

TABLE 3. Laboratory tests evaluating standard and experimental rootstocks for resistance to type B phylloxera

Parentage	Variety	Evaluation†
Pure *Vitis* species		
V. vinifera	Cabernet Sauvignon	S
V. champini	Dogridge	I
V. champini	Salt Creek	R
V. riparia	Riparia Gloire	I
V. rupestris	St. George	R
Hybrids of *Vitis vinifera*		
V. rupestris × *V. vinifera*	AxR-1	S
	1202 C	S/R
	XX (93-5 C)	S
V. rotundifolia × *V. vinifera*	0 43-43	S
	0 39-16	I
	0 44-4	I
V. rufotomentosa × *V. vinifera*	171-6	R
Complex parentage	1613 C	I
Complex parentage	Harmony	R
Complex parentage	Freedom	I
Hybrids with no *Vitis vinifera* parentage		
V. berlandieri × *V. riparia*	5 A	I
	5 BB	I
	S04	I
V. berlandieri × *V. rupestris*	99 R	R
	110 R	R
V. riparia × *V. rupestris*	3306 C	R
	3309 C	I

† The evaluation assumes the AxR-1/type A interaction represents minimal resistance under California conditions. S, susceptible (doubling time<12 days); R, resistant (doubling time>12 days); I, immune (no calculable doubling time); S/R, equivocal results.

for resistance was based on the assumption that AxR-1 has minimal resistance to type A phylloxera under California conditions. Therefore, if the calculated population doubling time for type B phylloxera on the rootstock being considered was more than that value for the AxR-1/type A interaction, the rootstock was considered resistant.

In general, the results mirrored susceptibilities as might be expected based on parentage (table 3). That is, rootstocks with no *V. vinifera* parentage are resistant to type B. Some rootstocks with *V. vinifera* parentage are resistant; some are not. The *V. vinifera* hybrids with *V. rupestris*, AxR-1, XX, and possibly 1202 C, appear susceptible. These findings seem to indicate that the type B population has become adapted to rootstocks with partial phylloxera resistance.

We expanded the rootstock trial in the vineyard infested with type B to evaluate additional rootstocks and corroborate the laboratory screening (table 2). The results indicate that a number of the nonvinifera rootstocks are tolerant of populations of type B phylloxera. Of particular interest is St. George, which is almost immune to type A phylloxera but will tolerate a type B population without an apparent decrease in vigor.

Significance of biotype B

The phylloxera infestations found on own-rooted vines in California's coastal valleys or in the Central Valley have all been type A insects thus far. The type B insects are consequently of importance only to coastal vineyards now planted on AxR-1 rootstocks. Here the full significance has yet to be determined.

From work before 1986, we confirmed only three vineyards with type B phylloxera in Napa and Sonoma counties. In 1986, we found additional phylloxera-infested sites in these counties, which we are studying to determine the insect type. The number of localities remains small, however, possibly as small as three epicenters.

To determine the magnitude of risk from type B phylloxera, we need to know how the biotype originated, how it was distributed, and whether it is likely to spread very far from its present epicenters. Circumstantial evidence suggests that the biotype originated only once and that it was subsequently distributed by humans from the original center in California. We feel that such distribution occurred between 1969 and 1972, but we have no hard evidence to substantiate this belief. Once the insect became established in an epicenter, it spread slowly by natural means (as crawlers and possibly by wind).

Our best guess as to the future significance of type B phylloxera is that vineyards on AxR-1 rootstocks close to epicenters are at more risk than those that are remote from such sites. We therefore recommend that growers be aware of the risk potential and check weak vines in their vineyards for the presence of phylloxera as well as off-type rootstocks. Rootstocks that are resistant to type B phylloxera exist, and county farm advisors can make recommendations for planting new vineyards or for replanting old ones in high-risk areas.

Future work

We will continue to work on this problem, surveying more vineyards for the presence of type B infestations. We will try to determine the nature of the virulence noticed in the type B population, hoping to find a rapid way of detecting it. We also will compare type B with other biotypes identified in the eastern and southeastern United States and in Europe.

Jeffrey Granett is Associate Professor, Department of Entomology; Austin C. Goheen is Adjunct Lecturer, Department of Plant Pathology; and Lloyd A. Lider is Professor Emeritus, Department of Viticulture. All are associated with the University of California, Davis.