HILGARDIA

A Journal of Agricultural Science Published by the California Agricultural Experiment Station

VOLUME 24 NOVEMBER, 1955 NUMBER 6

THE BIOLOGY OF THE GRAPE BUD MITE ERIOPHYES VITIS (PGST.)

HIROSHI KIDO and EUGENE M. STAFFORD

UNIVERSITY OF CALIFORNIA · BERKELEY, CALIFORNIA

THE SEASONAL ACTIVITY of the recently discovered bud-mite strain of the grape erineum mite, *Eriophyes vitis* (Pgst.), is described in this study, undertaken to provide a basis for developing control measures.

Field observation and laboratory studies, conducted on Carignane grape buds at Davis, have shown the grape bud mite to be capable of inflicting severe injury that may result in loss of crop and death of the infested vines. Typical symptoms of bud-mite injury are: deformation of the primordial clusters, distortion of the basal leaves, stunting of the main growing point of the buds, and death of the overwintered buds. Evaluation of mite damage in the field is often complicated by abnormal growth caused by diseases and other grape pests.

Morphologically identical with the erineum form, the bud-mite strain of *Eriophyes vitis* (Pgst.) is distinguishable by the damage it causes and by its habitat on the vine. Infestation was heaviest in the first ten basal buds, the seventh containing the largest number of mites and eggs throughout the season.

In the spring, overwintering mites are carried up with the elongating shoots to newly formed buds; they may also crawl up the canes. Progressive penetration of the buds occurs from May to December, infestation of the primordial clusters occurring as early as July and increasing until December. The mortality rate of the overwintering mites, primarily adult females, is usually high.

A field experiment with White Malaga grapes showed no relation between estimated degree of bud-mite infestation and growth symptoms or yield.

HILGARDIA

A Journal of Agricultural Science Published by the California Agricultural Experiment Station

VOL. 24 NOVEMBER, 1955 No. 6

THE BIOLOGY OF THE GRAPE BUD MITE ERIOPHYES VITIS (PGST.)[1]

HIROSHI KIDO[2] and EUGENE M. STAFFORD[3]

ERIOPHYID MITES found in grape buds were first associated with certain abnormal symptoms of grapevines in 1938 by H. A. Weinland, then Farm Advisor for Sonoma County. They were later identified (Keifer, 1944) as a physiologically distinct strain of the common erineum mite, *Eriophyes vitis* (Pgst.).

Anatomically identical, the two strains can be distinguished by their habitat on the vine and by the damage they cause. The bud-mite strain lives only in the buds, causes no erinea on the leaves, and produces deformities on grapevines not attributed to the leaf-inhabiting erineum mite. Damage to California vineyards by the erineum strain has been negligible, but the injury caused by the bud-mite strain can result in loss of crop and, possibly, the eventual death of the vines.

A similar case is reported by Lamiman (1939) in the biology of the pear leaf blister mite. The pear bud mite is also identified as being the same morphologically as the leaf-inhabiting pear leaf blister mite, but the bud mite does not form leaf blisters and confines itself entirely to the buds.

Distribution. In California the grape bud mite has been found in Sonoma, Yolo, San Joaquin, Stanislaus, Merced, Madera, Fresno, Tulare, Napa, and Kings counties. The erineum strain of *Eriophyes vitis* (Pgst.) occurs in California wherever European varieties of grapes are grown (Essig, 1926). Other species of eriophyid mites have been found in Europe, infesting grapes and causing injuries similar in certain respects to those caused by the bud-mite strain (Fulmek, 1913; Ibos, 1923; Schellenberg, 1928; Menzel and Schellenberg, 1930; Stellwaag, 1931).

Host Range. The grape species *Vitis vinifera* L. is the only known host of the grape bud mite. Smith and Stafford (1948) found that the following varieties were infested by the mite: Alicante Bouschet, Berger, Carignane, Chardonnay, Emperor, Grand noir, Black Malvoisie, Mataro, Orange Muscat, Pedro Zumbon, Pinot blanc, Ribier, Sauvignon blanc, Thompson Seedless,

[1] Received for publication October 25, 1954.

[2] Senior Laboratory Technician in Entomology, Davis.

[3] Associate Professor of Entomology and Associate Entomologist in the Experiment Station, Davis.

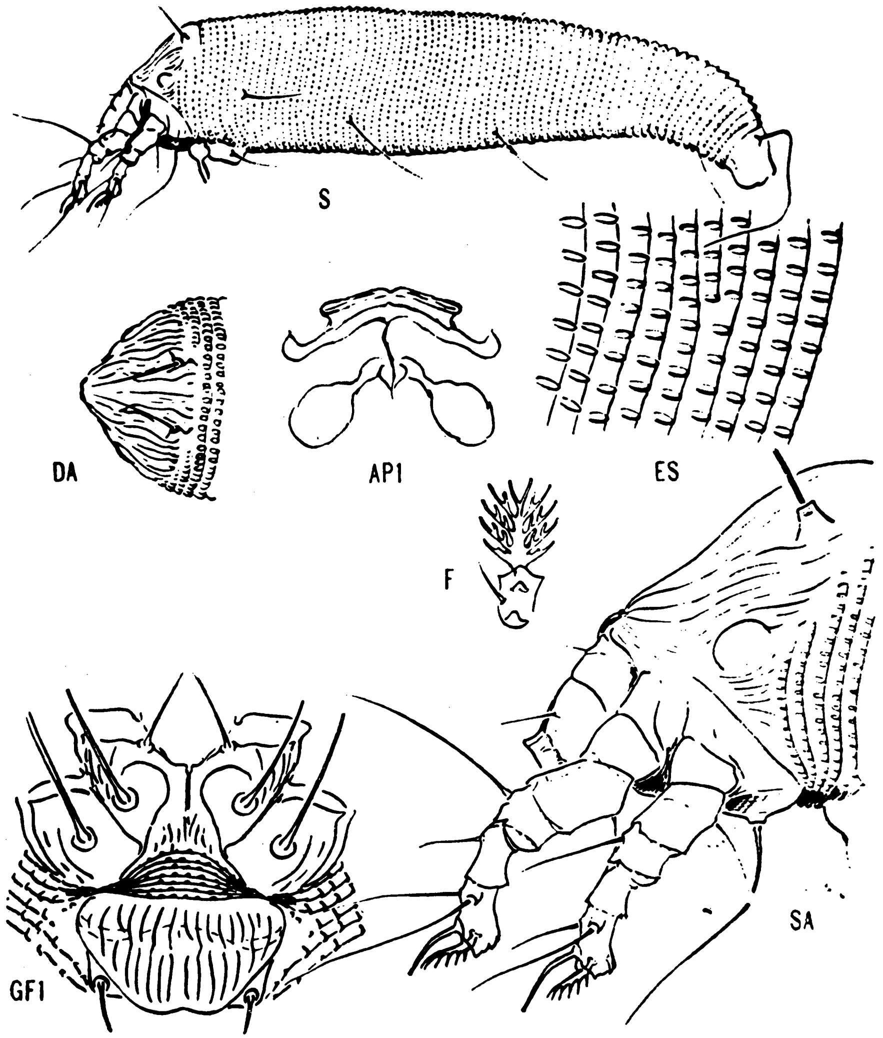

Fig. 1. *Eriophyes vitis* (Pgst.): *S*, side view of mite; *DA*, dorsal view of anterior section; *API*, internal female genitalia; *F*, featherclaw; *ES*, side skin structure; *GFI*, female genitalia and coxae from below; *SA*, side view of anterior section (after Keifer, 1944).

Tokay, White Malaga, and Zinfandel. They state that there is no indication that any variety of grapes is immune to the mite.

Description of the Adult Stage. The grape bud mite was identified by H. H. Keifer (1944) as morphologically identical with the grape erineum mite, which was first described by Pagenstecher in 1857. Keifer's work on the taxonomy of the species contains the following description:

Female 160–200 μ long, 40 μ thick, wormlike, pale yellowish. Rostrum 21 μ long, curved down. Shield 27 μ long, 32 μ wide, blunt, triangular, numerous longitudinal lines, an ocellus-like lateral spot; dorsal tubercles 15 μ apart, ahead of rear margin; dorsal setae

18 μ long, projection ahead and centrad. Forelegs 30 μ long, tibia 7 μ long, tarsus 8 μ long, claw 8 μ long, tapering; featherclaw 5 rayed. Hindleg 26 μ long, tibia 4 μ long, tarsus 7 μ long, claw 10.5 μ long. Coxae with setae I ahead of junction of anterior coxae; setae II ahead of line through setae III. Abdomen with 65–70 rings, completely microtuberculate, the microtubercles slightly pointed. Lateral seta 19 μ long, on about ring 7; first ventral 38 μ long, on about ring 22; second ventral accessory seta missing. Female genitalia somewhat appressed to hind coxae, the anterior apodeme shortened in ventral view; 20 μ wide, 10 μ long, coverflap with 16 or more furrows interrupted across center; seta 14 μ long. Male 140–160 μ long, 35 μ wide.

Fig. 2. White Malaga grape bud showing the primary and two secondary buds.

SEASONAL CYCLE AND LOCATION OF MITES AND EGGS

Methods. As a necessary adjunct to the development of a control of this pest a study of its biology was undertaken. These investigations were conducted on the Carignane variety of grape at Davis, California. Eight canes were picked at random from the vines at weekly intervals. The buds on every third node of each cane were examined.

A grape bud is a compound structure containing both leaf and fruit primordia. It consists of three growing points: the central or main bud and the secondary buds on either side of the main bud (fig. 2). The main bud usually contains two cluster primordia. Each growing point is enclosed by numerous scales which are covered with a mass of plant hairs (Perold, 1927).

The Carignane buds were severed from the canes, and each bud scale was peeled back and examined microscopically. There are approximately 12 bud scales in the mature Carignane bud. The cluster primordia in the central portion were recorded as the center of the bud. A count was made of the total number of mites and eggs found on each bud scale. In this paper the

TABLE 1

RESULTS OF WEEKLY AND MONTHLY OBSERVATIONS OF THE GRAPE BUD MITE ON 8 CARIGNANE GRAPE CANES

Date	Total mites	Total eggs	Average number of mites per infested scale	Number of cluster primordia infested	Number of buds examined
August 8, 1950	3,015	733	22.5	0	72
August 17	3,819	696	22.0	0	72
August 24	1,366	679	12.4	0	72
August 31	2,686	982	24.9	0	72
September 7	1,948	592	13.9	0	72
September 14	2,054	738	13.3	0	72
September 22	2,464	419	15.4	1	72
September 28	3,525	634	17.3	2	72
October 9	3,601	262	19.3	0	72
October 13	6,197	523	23.3	3	72
October 24	6,909	477	29.3	2	72
November 6	3,945	279	21.6	4	72
November 13	8,476	441	37.5	7	72
November 27	9,709	336	35.6	7	72
December 4	7,406	147	28.8	9	72
December 12	5,615	96	25.5	5	72
December 18	5,073	43	23.3	7	72
December 27	5,594	56	25.2	4	72
January 4, 1951	4,900	9	20.8	8	72
January 11	3,375	15	21.5	4	72
January 22	5,010	20	22.1	3	64
January 31	3,030	13	14.7	9	64
February 7	3,785	1	21.6	3	59
February 14	3,592	3	19.8	4	59
February 21	3,025	1	12.5	6	62
February 28	2,956	7	17.8	2	59
March 7	2,470	13	15.5	6	61
March 14	3,122	7	13.5	11	62
March 22	2,001	205	14.2	2	60
March 29*	403	104	7.8	3	16
April 4*	446	758	8.0	5	16
April 11†	575	900	9.1	1	16
April 20†	605	833	11.0	0	16
April 26†	799	773	15.1	0	16
May 2‡	88	118	22.0	0	26
May 10	535	432	38.2	0	32
May 17	223	447	9.7	0	47
May 24	516	599	19.8	0	47
June 1	174	305	8.3	0	47
June 15	1,148	1,166	17.7	0	72
June 22	1,062	1,119	16.6	0	72
July 3	2,210	2,199	26.3	0	72
July 11	3,434	1,863	31.8	0	72
July 18	3,046	1,174	27.7	0	72
July 25	1,877	1,199	18.6	0	72
August 3	3,502	1,010	29.7	0	72
August 30	2,642	493	22.2	1	72
September 18	2,427	399	20.7	1	71
October 11	3,132	182	19.8	5	72
November 7	2,777	138	21.2	5	67
December 5	3,138	22	24.9	2	64

* Canes cut back to 4th node; only buds 2 and 4 examined.

† Counts include mites on 4 spur buds together with mites and eggs on the new growth.

‡ Observations made on new growth only.

outer scale is designated as number *1* and the innermost scale as number *12*. From bud to bud, and even from bud scale to bud scale in the same bud, the number of mites and eggs found varied widely. Many buds contained no mites, while as many as 1,000 were found in others. The number of infested scales per bud indicated the depth of penetration of the mites into the bud.

Weekly examinations began on August 10, 1950, and continued to August 3, 1951. To check these findings, five additional counts were made at longer intervals from August 30, 1951, to December 5, 1951. The weekly and monthly data are shown in tables 1 and 2.

TABLE 2

MONTHLY SUMMARY OF FIELD OBSERVATIONS OF BUD-MITE INFESTATION ON CARIGNANE GRAPE CANES

Month (1950–1951)	Average number of mites per cane	Per cent of buds infested	Number of infested bud scales per infested bud	Average number of eggs per cane
August	340	51.7	3.6	96
September	312	52.8	4.5	74
October	696	62.8	5.3	53
November	922	55.2	6.2	44
December	740	59.5	6.4	11
January	510	51.0	6.5	2
February	417	52.7	6.1	0
March	316	55.7	5.3	7
April*	70	83.7	4.0	84
May	43	27.6	1.4	50
June	99	22.0	2.8	108
July	330	38.2	3.7	201

* Canes cut back to 4th node March 24; only buds 2 and 4 examined. The count made on March 29, 1951, is included with the April counts.

Seasonal Cycle. Briefly, the general seasonal cycle was as follows: The mites spent the winter in the buds mostly as adult females (fig. 3). As the weather grew warmer in the spring and the buds started to swell, egg laying increased rapidly. Many of the overwintered mites and eggs were carried out on the new shoots and were found under the stipular scales at the base of the petioles of the basal leaves. Soon the new buds in the axils of the leaves became infested. The mites increased in number and moved farther out on the canes through the summer months. With the approach of winter, egg laying almost ceased.

The counts taken during the winter months from December to late March showed that the total bud-mite population was steadily declining. This reduction was due not only to very low egg production but also to the gradual dying off of the overwintered mites. In some of the buds examined during this period all the mites found were dead. This accounted for the decrease in the number of infested bud scales during the period from February to early April (table 2).

During the winter months the surviving mites remained in the buds they had infested before activity began to decline in December. This trend is indicated by the fact that the percentage of infested buds (and the number of infested bud scales per infested bud) remained fairly constant. If the mites had moved to other uninfested buds, the percentage of infested buds (and bud scales) would have increased.

Egg production began in late March, when the mites surviving in the overwintered buds started laying their eggs in these buds. A sharp increase occurred early in April and thereafter egg production on the old canes decreased somewhat. On the new canes the number of eggs rose steadily until a peak was reached in July, then gradually declined.

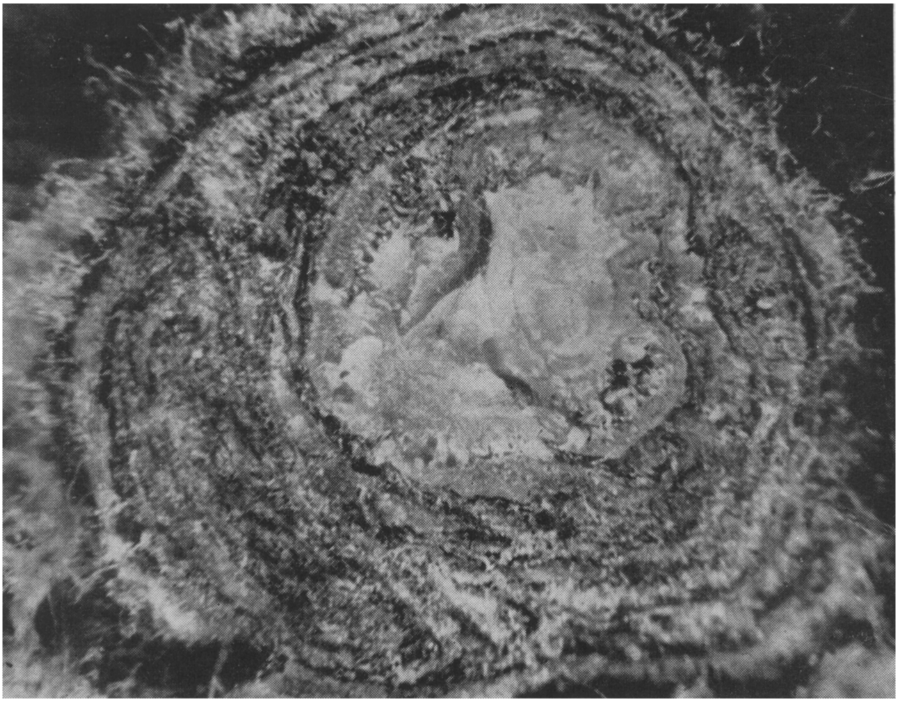

Fig. 3. Transverse section of a Carignane grape bud showing bud-mite infestation of the primary bud.

In late March the buds began to swell, and in early April new shoots emerged from the old buds. The mites that had penetrated deep enough into the old buds were carried up with the elongating shoots.

In late March the canes of the grapevines in the observation plot were pruned back to form short spurs with only four basal buds. This accounts for the much higher percentage of infested buds per cane (or spur in this case) recorded for April (table 2), since more buds were infested at the basal nodes than at the more distal portion of the cane.

In May the weekly counts were confined to the new shoots. The greatest number of mites and eggs was found on the stipular scales and the leaf axils of the new shoots. As the buds developed at the leaf axils, the mites were found on the outer bud scales of the newly formed buds. In the first part of

May the number of infested buds and bud scales increased, but in late May and early June a slight decrease was noted. This decline was due partly to the death of the overwintered bud mites and partly to the fact that although egg production increased at this time, the mites could not produce enough eggs to compensate for the loss in numbers caused by the death of old mites.

From June to November the shoots of the grapevines elongated into long, mature canes. Although the degree of infestation varied somewhat from bud to bud, the total mite population increased steadily from June to July. It leveled off in August and September but increased rapidly during October and November, reaching its maximum in the latter part of November.

From May to November the mites were quite active. During this period they were found to be moving from bud to bud. The percentage of infested buds increased steadily from June to October, when the greatest number of infested buds was recorded. By this time the more distal buds on the canes were also becoming infested.

The number of infested bud scales per infested bud (table 2) also increased as the mites penetrated deeper into the buds. The trend of the mite population in midsummer is interpreted from data taken during the last six months of 1950 and the first half of 1951. Additional counts in August, September, October, and November, 1951, substantiated the general observations that had been made. Fall population trends between these two years differed in this respect—in 1950 the population count rose steadily to a peak in November, whereas in 1951 it leveled off. In comparison with the rest of the season, however, the mite population in 1951 was also greatest during the fall months. Particularly favorable environmental factors may have been responsible for the striking increase in 1950.

Location of the Mites and Eggs. The locations of the mites and eggs on the cane are shown in tables 3 and 4. The calculations summarized in these tables were based on the total number of buds examined, whether infested or not.

The mites were confined mostly to the periphery of the bud scales and to the crevices formed by the folds in the bud scales. In general, most of the mites were found in the main bud of the compound bud and in the basal portion of the cane.

In late March, after the canes were pruned back to the fourth node, the mites were confined to the four basal buds. The greatest number of mites was found in the second bud of the pruned spur. In the latter part of April and first part of May, when the new shoots developed from the old buds, some of the mites were carried up with the elongating shoots, but most remained behind in the bud scales of the overwintered buds. These scales of the old bud formed a whorl at the base of the new shoot.

In May the greatest number of mites was found in the second bud of the new shoot, in June in the fourth bud, and in July in the seventh (table 3). The seventh bud contained the greatest number, on the average, throughout the rest of the season except in March when the tenth bud was found to have the highest number of mites.

The location of eggs in the buds along the canes showed the same general trend as did mite distribution (table 4).

After total mite population reached its peak in November, the number of

TABLE 3

LOCATION OF BUD MITES ON CARIGNANE GRAPE CANES AND AVERAGE NUMBER OF MITES PER BUD (INFESTED OR NOT)

Month (1950–1951)	Bud*								
	2	4	7	10	13	16	19	22	25
August	47.7	73.3	90.3	87.9	29.1	5.6	4.0	2.1	0.3
September	58.5	66.5	86.6	57.9	22.7	11.8	2.9	2.2	3.2
October	109.9	125.8	201.4	147.6	79.6	15.9	7.0	3.0	5.7
November	156.0	201.8	254.7	227.3	61.4	6.6	10.9	2.6	1.1
December	137.5	156.7	227.5	124.6	44.0	43.0	0.1	11.1	0.1
January	101.2	110.9	162.6	102.9	22.5	5.0	3.7	0.7	0.5
February	83.4	72.9	124.7	88.9	42.2	4.9	0.2	0.9	0.0
March	57.5	65.5	58.1	67.5	44.4	15.7	5.5	4.1	0.0
April†	42.6	28.1	....	....	....	....	....	....	....
May	34.6	7.6	0.4	0.0	0.0	0.0	....	....	....
June	39.5	43.2	13.5	2.5	0.6	0.9	0.1	....	....
July	74.2	98.6	120.7	27.5	6.8	0.7	0.6	0.1	0.9

* Node no. 2 basal, no. 25 distal.
† Canes cut back to 4th node March 24; only buds 2 and 4 examined. The count made on March 29, 1951, is included with the April counts.

TABLE 4

LOCATION OF EGGS ON CARIGNANE GRAPE CANES AND AVERAGE NUMBER OF EGGS PER BUD (INFESTED OR NOT)

Month (1950–1951)	Bud*								
	2	4	7	10	13	16	19	22	25
August	9.3	12.2	24.3	22.5	14.1	3.4	5.8	4.5	0.4
September	10.4	10.6	15.4	16.8	11.1	3.3	3.2	2.2	1.4
October	7.2	10.4	14.1	8.5	7.6	1.3	2.5	1.5	0.3
November	7.2	7.9	14.6	10.5	2.0	0.0	1.6	0.3	0.0
December	1.7	1.7	4.4	1.4	0.6	0.7	0.0	0.3	0.0
January	0.2	0.5	0.5	0.4	0.2	0.0	0.0	0.0	0.0
February	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
March	0.9	0.4	1.0	2.0	2.6	0.0	0.0	0.0	0.0
April†	52.8	31.3	....	....	....	....	....	....	....
May	38.3	11.1	0.5	0.0	0.0	0.0	....	....	....
June	35.3	47.4	19.5	4.5	1.2	0.2	0.0	....	....
July	30.7	57.4	66.7	32.4	9.1	1.7	1.1	0.3	1.6

* Node no. 2 basal, no. 25 distal.
† Canes cut back to 4th node March 24; only buds 2 and 4 examined. The count made on March 29, 1951, is included with the April counts.

mites in the first 13 buds tended to become equal. This was due to the fact that the number of mites decreased in the buds with higher populations.

In order to determine where the heaviest infestation occurred throughout the season, each bud was ranked according to the number of mites and eggs found in it. Number *1* was used to indicate the highest number of mites, and number *9* the lowest. Concentrations were much higher (1–5) in the first ten buds than in the more distal portion of the cane; the lower ranks (6–9) occurred after the tenth bud.

Considering the season as a whole, the seventh bud contained the largest number of mites and eggs throughout the season. Slightly higher percentages of infested buds, however, occurred on the second and fourth nodes (table 5). Beyond the seventh node the percentage of infested buds decreased rapidly.

The percentage of infested buds fluctuated from month to month, but there was a general increase from May to October (table 2). The fluctuation was partly due to the fact that the vines in the field were not uniformly infested.

In the month of May, since the newly developed shoots were small, the number of nodes examined varied from two to four in the early part of the month to as many as 16 in the latter part of the month. In the summer and fall months the canes bore at least 24 nodes. In the winter months the tips of the old canes were often killed by frost, so that in many cases the number of buds examined did not include those in the distal portion of the canes.

TABLE 5

PERCENTAGE OF BUDS INFESTED BY BUD MITES ACCORDING TO LOCATION ON THE GRAPE CANE

Month (1950–1951)	Bud*								
	2	4	7	10	13	16	19	22	25
August	75	78	84	66	66	25	31	28	9
September	84	81	78	66	47	28	28	34	34
October	87	83	92	67	62	25	37	29	33
November	87	96	87	75	40	25	37	30	10
December	97	91	87	78	53	44	64	25	22
January	97	91	84	66	34	9	9	5	12
February	84	84	72	69	53	16	9	17	0
March	87	83	83	57	67	21	8	23	0
April†	90	77	..	..	..	..	..	..	..
May	78	47	16	0	0	0	..	..	..
June	75	58	50	33	8	4	6	..	..
July	91	81	66	50	28	6	16	6	3
Average	79.7	79.4	72.2	58.0	44.1	19.6	19.0	21.1	15.6

* Node no. 2 basal, no. 25 distal.

† Canes cut back to 4th node; only buds 2 and 4 examined. The count made on March 29, 1951, is included with the April counts.

The depth of penetration of the mites into the bud is summarized in table 6. In general, they penetrated deeper as the season progressed from May to September. As the new shoots elongated in the spring, most of the mites were found in the leaf axils and stipular scales at the nodes of the shoots. Most of the mites that were located at the axils and bracts were carried there by the elongating shoots. With the formation of the buds at the leaf axils of the shoots, the mites moved from the outer bracts and leaf axils into the newly formed bud scales. In May they had penetrated as far as the fourth bud scale, the first bud scale containing the largest number. In June and July the greatest number was located on the second bud scale, and mites were found as deep as the sixth bud scale. In August they had penetrated to the ninth bud scale, with the largest number occurring in the third. In 1950 the first occurrence of mites on the primordial cluster was recorded in mid-September, and

TABLE 6

PERCENTAGE OF TOTAL MITE POPULATION FOR EACH MONTH IN LOCATIONS INDICATED

Month (1950–1951)	Percentage of total mite population							Greatest depth of penetration into bud
	1st outer scale	2nd outer scale	3rd outer scale	Scales 1–3	Scales 4–12	Cluster primordium	Axils and bracts	
August	17.7	23.5	27.8	69.0	29.8	0.0	1.2	9th scale
September	15.9	16.8	17.1	49.8	49.1	0.2	0.9	Primordium
October	9.9	11.5	14.5	35.9	63.3	0.2	0.6	Primordium
November	4.9	12.9	12.0	29.8	69.2	1.0	0.0	Primordium
December	6.2	10.4	13.8	30.4	68.7	0.9	0.0	Primordium
January	5.5	11.7	13.7	30.9	68.0	1.1	0.0	Primordium
February	5.0	9.2	16.5	30.7	68.7	0.6	0.0	Primordium
March	4.9	12.7	17.9	35.5	63.3	1.2	0.0	Primordium
April	10.5	24.4	21.3	56.2	43.4	0.4	0.0	Primordium
May	22.4	7.3	1.3	31.0	0.1	0.0	68.9	4th scale
June	28.3	36.3	26.0	90.6	7.5	0.0	1.9	6th scale
July	16.2	32.9	29.8	78.9	20.5	0.1	0.5	Primordium

TABLE 7

PERCENTAGE OF TOTAL EGG PRODUCTION FOR EACH MONTH IN LOCATIONS INDICATED

Month (1950–1951)	Percentage of total egg production							Greatest depth of penetration into bud
	1st outer scale	2nd outer scale	3rd outer scale	Scales 1–3	Scales 4–12	Cluster primordium	Axils and bracts	
August	26.7	22.8	16.8	66.3	31.0	0.0	2.7	11th scale
September	22.3	14.2	14.6	51.1	48.4	0.0	0.5	12th scale
October	15.6	11.7	11.6	38.9	60.3	0.2	0.6	Primordium
November	3.9	5.7	8.9	18.5	81.2	0.2	0.1	Primordium
December	7.6	5.9	9.7	23.2	72.7	4.1	0.0	Primordium
January	3.5	1.8	7.0	12.3	87.7	0.0	0.0	11th scale
February	8.3	16.7	33.3	58.3	41.7	0.0	0.0	11th scale
March	0.0	4.9	5.2	10.1	89.9	0.0	0.0	9th scale
April	9.7	28.4	13.7	51.8	48.2	0.0	0.0	9th scale
May	38.1	16.9	3.5	58.5	0.0	0.0	41.5	3rd scale
June	22.5	33.9	28.6	85.0	13.4	0.0	1.6	6th scale
July	14.4	35.4	31.1	80.9	18.9	0.0	0.2	9th scale

in this instance the mites continued to increase in number until December. In 1951 the first infested primordial cluster was found in late July.

Infested primordia occurred largely within the first ten buds. Of the total infested primordia, 78 per cent occurred at the second and fourth buds. Considering only the second and fourth buds from November to March, 23 per cent of those examined were found to have infested primordia.

The location of eggs in the buds followed a pattern similar to that found for the mites. In May the greatest depth at which eggs were found was the third scale. In June they were found on the sixth bud scale, in July on the ninth, in August on the eleventh, and in September they had penetrated to the twelfth bud scale. Eggs were found on the cluster primordia from October to December. The decrease in the number of eggs found deep inside the buds between January and March is due to the fact that very few were laid. The eggs laid during this time were found only on the outer bud scales, where mite population was greatest. The location of the eggs in the buds is shown in table 7.

TABLE 8

AVERAGE DISTRIBUTION OF ADULTS AND NYMPHS OF THE GRAPE BUD MITE*

Month	Percentage of bud mites	
	Adults	Nymphs
August	78.0	22.0
September	85.0	15.0
October	88.0	12.0
November	91.0	9.0
December	98.0	2.0
January	98.5	1.5
February	98.8	1.2
March	99.2	0.8
April	62.0	38.0
May	38.0	62.0
June	46.0	54.0
July	55.0	45.0

* A total of 3,822 mites examined.

BEHAVIOR AND DISSEMINATION

Habits. Numerous attempts to rear individual mites under laboratory conditions failed. Although eggs that were laid by the adult mites hatched, nymphal forms did not survive when the bud scales were exposed for observation. One nymphal form did reach the adult stage in 14 days at which time it died.

Keifer (1952) states that eriophyids have a simple, direct development after hatching. The mites pass through two nymphal instars, the second producing the adult after a resting period or "pseudopupa." In the resting stage, the genitalia form and protrude through the body wall. Growth from egg to adult takes about 10 to 14 days.

The eggs are deposited either singly or in groups of two to ten or more. Of the eggs that hatched under observation in the laboratory, the incubation time was between 5 and 9 days in December. The eggs are oval and translucent or white. They averaged approximately 58 μ in length and 38 μ in width.

Mites were also collected at random from the buds in the vineyard throughout the season, and a record was made of the number of adult and nymphal forms found in the buds (table 8). The mites were mounted in Berlese fluid and examined microscopically. The presence of genital organs in the adults distinguished them from the nymphs. Both males and females were present.

The nymphs appeared in numbers in the early part of April. In May 62

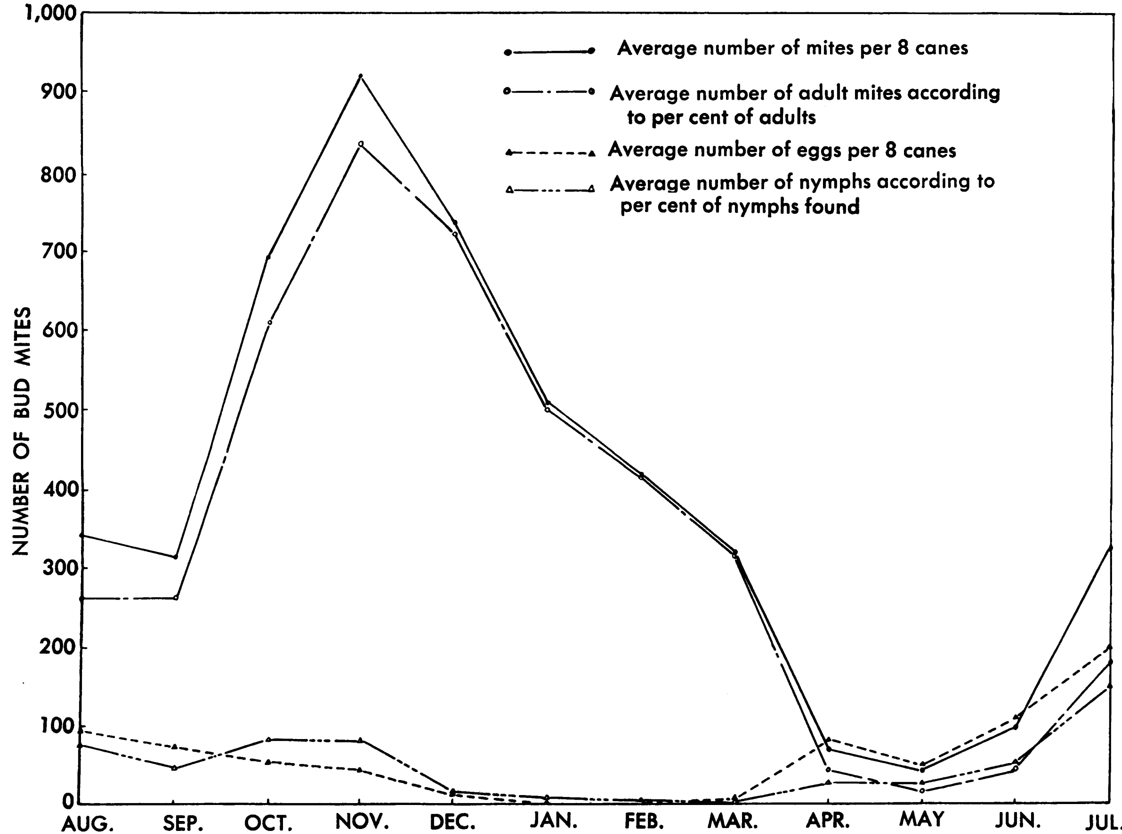

Fig. 4. Average distribution of total mite population, adult and nymphal forms, and eggs. (Based on weekly examinations of eight canes. Observations made from August, 1950, through July, 1951.)

per cent of the mites were nymphs. After the month of May the nymphs declined, and the number of adults increased. The overwintering forms were predominantly adult females.

If the average numbers of mites as given in table 2 were separated into nymphal and adult forms according to the proportions shown in table 8, the number of nymphal forms would parallel the number of eggs laid. This is shown in figure 4. The high level of adult forms during the fall and winter months in comparison with the number of eggs laid can best be explained by assuming that the mites survive for several months.

In order to determine the influence of temperature on activity, a number of mites were placed in a small, enclosed water condenser. The condenser consisted of six microscope slides placed together to form three small chambers one above the other. They were arranged so that water at various temperatures could flow through the upper and lower chambers. Thermometers were placed at the inlet of the upper chamber and outlet of the lower chamber so that the water temperature could be measured and kept constant. Ten mites were placed inside the center chamber and observed microscopically for approximately ten minutes at each of the following temperatures. Their activity at various temperatures (degrees Fahrenheit) was as follows:

50°	No movement
60°	3 mites crawling, 7 inactive
70°	8 mites crawling, 2 inactive
80°	All mites crawling
90°	All mites crawling
100°	3 mites crawling, 7 inactive
110°	No movement

According to this experiment, mite activity seemed to begin at approximately 60° F.

To determine the influence of temperature on mite population under field conditions, weekly degree-hours over 60° F were computed from records obtained from a hygrothermograph which was placed outdoors.

In general, there seemed to be very little correlation between mite activity and weekly temperatures. Very high temperatures seemed to kill the mites. In the week of August 31 to September 7, 1950, daily temperatures ranged up to 105° F, and examinations made during this period showed that numerous mites were dead, apparently from the high temperature.

Some relationship between egg production and temperature apparently existed. As the weather became warmer in March, egg production increased. Egg production was highest in July, and the temperature reached a peak in August. Both declined gradually after the peaks were reached. One reason for the August decline in egg production may have been that the peak temperatures were a deterrent to high egg production.

Dissemination of the Bud Mites. Each grape bud is surrounded by numerous layers of scales. In the spring, as the shoots elongate, the inner bud scales are carried along with the shoots and form the two stipular scales at the base of the petiole of each leaf. If these inner bud scales are infested with mites, the mites are transported along with the scales. In late April and early May the majority of the mites and eggs found on the newly developed shoots were in the leaf axils and on the two stipular scales at the base of the leaf petioles.

Later, as the buds develop at the leaf axils of the shoots, the mites are able to infest the newly formed buds. The number of buds that become infested on the newly developed shoots depends on the depth of penetration of the mites into the overwintered buds. Since the terminal portion of the growing point of the shoots lies in the center of the overwintered buds, greater penetration of the mites into the dormant buds results in greater numbers of buds becoming infested on the new shoots.

Movement of the mites by crawling along the canes may be another means of dissemination. To determine whether any sort of migration took place, attempts were made to trap the mites outside the buds along the internodes of the canes. A sticky band, Deadline, was placed at frequent intervals around the internodes of two canes in the field. After a period of time ranging from 6 to 18 days, the canes were cut off at the base and brought back to the laboratory. Each bud on the canes was examined for the presence of mites. The portion of the internode with the sticky band was cut off and the sticky band dissolved in xylene. The xylene solution was placed in a test tube and spun in a centrifuge for several minutes. The solution was then decanted and the sediment examined for the presence of mites.

In all cases mites were present on the canes, but the degree of infestation in the buds varied. The degree of infestation of the buds was recorded in three classes: no mites, few mites (less than 25), and many mites (25 or more). In some cases buds falling into the third class had as many as several hundred mites, but the average number was 50.

As the new shoots developed in the spring, the mites were first trapped in May. A greater number was caught in June, and the greatest number in July. The number of mites caught from September to October was small. None were caught from February to April.

Most of the mites were caught in the basal portion of the canes where the infestation was heaviest. The number caught in the sticky band was very low in comparison with the total number of mites found in the distal portion of the cane. The weekly mite counts showed an increased infestation in the distal portion of the canes during the period from September to December.

Although movement of the mites along the canes may be one means of infesting the distal portion of the canes, this movement could not be detected by the sticky-band method.

To determine the effectiveness of the sticky-band method for detecting mite migration, the experiment performed in the field was simulated in the laboratory. A sticky band was placed around 20 grape canes and 500 live mites were placed on each sticky band. After seven days, the sticky band was removed from 10 of the canes by using the same procedure as in the field experiment, and the sediment was examined for the number of mites visible. The sticky band was removed from the other 10 canes after 14 days.

Total recovery at the end of the 7-day period was 243, or 48.6 per cent of the 500 mites placed on the sticky bands. Total recovery after 14 days was 188 mites, or 37.6 per cent of the total of 500. This experiment indicated that migration to the distal portion of the canes may not be detected if the numbers caught in the sticky band are small. Some of the mites were probably lost when the solution was decanted and when the mites were transferred from the centrifuge tube to the microscope slides.

The results of the field experiment with the sticky-band method tend to show that there was no period of mass migration, but that the movement of the mites extended over the late spring and summer months.

The movement of the mites from one bud to another began in May when the shoots were small, tender, and green. Many of the mites were found in the stipular scales and the leaf axils at this time. Since the shoots were small, the distance between the buds was short, and the mites traveled easily from bud to bud.

Later in the season the movement seemed to be correlated with the drying and lignification of the overwintered bud scales and stipular scales which no longer formed suitable habitats and forced the mites to move to another location.

Infestation of a vineyard may take place in various ways. Keifer (1946) states that eriophyid mites in general must depend on wind, insects, birds, and plants that are being moved for transportation to an uninfested area. In the case of the citrus bud mite, Boyce and Korsmeier (1941) report that nursery stock is the best medium of dissemination. Grape bud mites are probably most commonly transported from one vineyard to another with cuttings and rootstocks.

In the area where the weekly population counts were being made, the mite-infested cuttings were taken for the purpose of propagation. These cuttings were fumigated with methyl bromide at 2 pounds per 1,000 cubic feet at 72° F. They were then rooted and transplanted to another area in March, 1950. Examination of the buds of these transplanted vines showed that not all the mites were killed by the fumigation. Further examinations made in 1951 and 1952 showed a progressive increase in the mite infestation throughout the new plot.

NATURE OF INJURY

In order to observe the nature of injury caused by the mites, on February 25, 1952, 100 canes with dormant buds were cut in the field and brought to the laboratory. Only the basal portion of the canes just below the eighth node was taken. All buds except the seventh were removed. The canes were placed in a pan of water and the buds forced to grow. Shoot development began after 19 days. The recording of observations as to the nature of growth was begun when the new shoots were approximately 1 inch long. The buds and shoots were then examined microscopically for the presence of mites. The final examination was made 36 days after the canes were placed in the water.

Of the 97 buds examined at the seventh node, 42 were infested and 55 were not. Of the 42 infested buds, 38 (90.5 per cent) were normal in growth, and 4 (9.5 per cent) showed one or more types of injury characteristic of mite damage. Of the 55 uninfested buds, 48 (87.3 per cent) had normal growth, 7 (12.7 per cent) abnormal. Six buds with abnormal growth were found to have dead centers, and one had two lateral shoots. The results also show that the infested buds had a slightly higher percentage of normal growth.

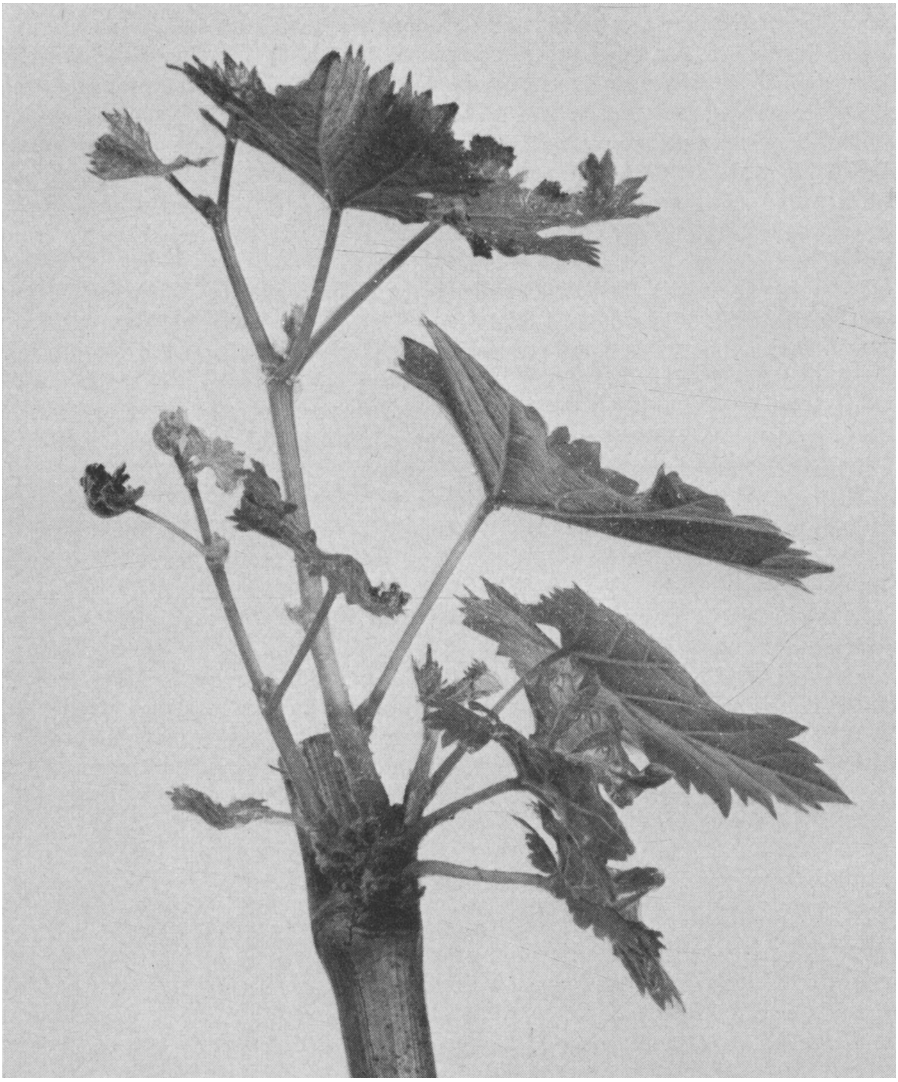

Fig. 5. Bud-mite symptoms on Carignane grape. Infestation of the primary bud has caused lateral shoots to develop along with the primary shoot.

Since most of the damage to the buds by mites appeared in the basal portion of the cane, another attempt was made to determine the extent of mite damage on the fourth bud. On March 25, 1952, the experiment was repeated with 165 grape canes cut just above the fourth node. All buds except the fourth were removed. The buds were again forced and observations were made when the shoots were approximately 1 inch long.

Of the 68 uninfested buds, 62 (91.2 per cent) had normal growth. One

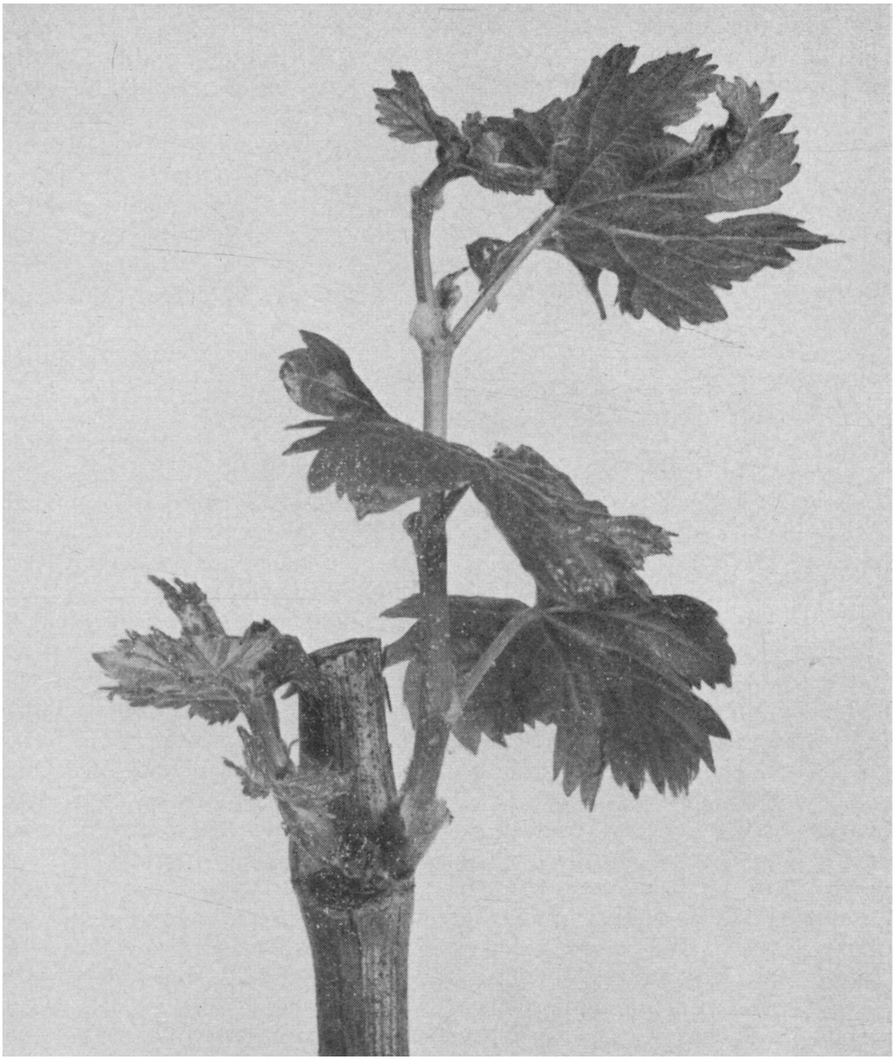

Fig. 6. Bud-mite symptoms on Carignane grape. Mite infestation has caused the death of the primary shoot and the development of the two lateral shoots.

of the 6 (8.8 per cent) showing signs of abnormal growth had a double shoot and 5 did not develop. The central portion of these undeveloped buds contained dead tissues, the cause of which was unknown. Of 97 infested buds examined, 58 (59.8 per cent) showed normal growth. The 39 (40.2 per cent) with abnormal growth showed typical mite symptoms, 32 showing injury to the growing point and 7 showing injury to the basal leaves and primordial clusters.

On January 29, 1952, 100 canes were obtained from White Malaga grapes at Madera, California, and the fourth buds were forced to grow. The shoots began to develop after 25 days in the water, and the observations on the canes continued for 67 days. Of the 75 uninfested buds examined, 74 (98.7 per cent) showed normal growth. The one bud (1.3 per cent) showing signs of abnormality had a double shoot. Growth was normal for 9 (36 per cent) of the 25 infested buds examined, abnormal for 16 (64 per cent). All infested shoots with abnormal growth showed injury to the primordial clusters.

A comparison of the results of the fourth and seventh buds showed that mite injury is more extensive at the more basal nodes. The fourth bud suffers a greater degree of injury because it is infested earlier and the mites are thus able to penetrate deeper.

Evaluation of mite damage in the field is difficult, though mite infestation can be detected by the presence of brown tissue scarrings and dried brown and white cast skins of the mites on the bud scales. Smith and Stafford (1948) found that attempts to control the mites in the field were complicated by three factors: 1) the mites failed to appear in the spring so the symptoms were not apparent in either the treated or untreated portions of the vineyard; 2) the symptoms appeared in some portion of the vineyard far removed from the mite locations of the year before; or 3) the mites appeared in such small numbers in the spring and in such unpredictable locations that interpretations of experimental results were extremely difficult.

Determination of mite damage in the field is also hampered by the fact that gross symptoms similar to the ones inflicted by the mites may also be caused by other factors. For example, Barnes *et al.* (1952) showed that apparent bud-mite injury occurring in Mataro grapes in southern California was related to pruning time in head-pruned vines. Midwinter-pruned vines of this variety closely resembled vines suffering from bud-mite infestation. In early- and late-pruned vines the symptoms were much less severe. Pruning-time responses have also been demonstrated in Sonoma County by R. L. Sisson (1952).

Several diseases cause symptoms that may easily be confused with bud-mite injury. Hewitt (1951) described a virus disease, fanleaf, as being characterized by early season dwarfing, shoot and leaf deformities, slight mottling in young leaves, and irregular zigzag growth of shoots. Pierce's disease of grapevines is characterized by delayed foliation and dwarfing of the vines (Hewitt *et al.*, 1942). Dead-arm disease of grapevine, caused by a fungus, can kill a number of buds, and Armillaria root rot causes a decline in vigor and cessation of shoot growth (Jacob and Winkler, 1950).

Other vineyard pests inflict damage similar to that of the grape bud mite. Phylloxera and nematode infestations of grapevines may cause sparse, stunted, and slow growth of the vines and a reduced yield (Nougaret and Lapham, 1928; Snyder, 1936). The feeding by the larvae of the California grape rootworm on the roots causes stunted growth (Quayle, 1908).

Identification may also be made difficult when sodium arsenite is applied as a dormant spray for black measle control to the canes, arms, and trunks of grapevines on dry-soil plots. Such applications cause appreciable injury to the vines. The work of Nelson *et al.* (1949) indicated that a large number of buds of sprayed vines failed to produce new growth in the spring.

Experiments were conducted in a White Malaga vineyard in Madera, California, to determine whether a relationship existed between bud-mite infestations and the nature of growth of the vines in the field.

Each plot consists of 36 rows with 58 vines in each row. Every sixth vine in each row was examined. Nine vines in each row were examined. On October 31, November 12, and December 14, 1951, ten buds were collected from the seventh node of the canes from each of these vines. The buds were examined microscopically for the presence of mites. The vines were then listed according to the number of infested buds found in the ten examined.

TABLE 9

GROWTH AND YIELD DATA ON WHITE MALAGA GRAPES IN RELATION TO BUD-MITE INFESTATION AT MADERA, CALIFORNIA, 1952

Number of infested buds per 10 buds	Number of vines examined	Average number of spurs per vine	Average number of shoots per vine	Average number of shoots per spur	Per cent shoots without fruit	Per cent spur buds with double shoots	Per cent shoots with laterals	Average shoot length (cm)*	Average yield per vine (lbs.)
0	22	11.0	31.3	2.8	15.9	10.8	24.6	11.1	43.7
1	34	11.6	32.3	2.8	15.9	10.1	16.0	10.9	49.2
2	57	11.6	31.4	2.8	15.5	10.2	22.3	10.7	50.3
3	52	11.2	32.0	2.8	14.2	9.5	19.0	11.1	50.4
4	38	11.1	29.4	2.6	11.7	7.9	21.0	11.6	50.8
5	34	11.4	31.4	2.7	12.1	7.9	18.3	10.8	55.4
6	11	12.0	33.0	2.7	14.6	8.8	14.9	10.6	49.0
7	6	9.7	27.2	2.8	11.7	7.9	19.6	11.5	53.4

* Shoot measured to 5th node.

On June 26 and 27, 1952, general observations were made on the same vines, and the following characteristics were noted: 1) the number of spurs on each vine; 2) the number of shoots developing from each spur; 3) the number of shoots without any fruit cluster; 4) the number of spur buds with double or lateral shoots; and 5) the length of the shoots up to the fifth node. The data are tabulated in table 9.

On October 29 and 30, 1952, the yield from each vine was recorded. Some of the vines showed so-called "shot berry" symptoms, the cause of which was not known. These vines were excluded from the results. The yield data are also shown in table 9. The results indicated that there was no relationship between the number of infested buds and the nature of growth of the vines.

NATURAL ENEMIES

Keifer (1946) states that the most common predators of eriophyid mites are the predaceous mites of the *Seius pomi* (*Typhlodromus* spp.) type. Another type of predaceous mite mentioned is the cheylitid. He also states that cecidomyid maggots, chalcid larvae, tortricid caterpillars, lacewing larvae, and syrphid maggots are among the other predators of eriophyid mites. Fungi may also be a factor in reducing the mite population. Bailey (1940) reports that the black hunter thrips, *Leptothrips mali* (Fitch), may feed on eriophyid mites.

Observations made during the weekly counts revealed that predaceous mites were present either under the bud scales or near the buds. Mites identified as *Typhlodromus pomi* McG. by F. M. Summers were found feeding on the bud mites. Another predaceous mite found on the bud was *Protomatus* sp.

General observations indicate that the predaceous mites could not penetrate deep inside the buds. They were observed only on the outer bud scales. Apparently, the close overlapping of the bud scales and the thick plant hairs within the buds confined the activity of the predators to the outer bud scales.

Predaceous mites apparently can be detrimental to the bud-mite population only in the spring when the newly developed shoots have just begun their growth and the bud mites are well exposed at the stipular scales and the leaf axils of the petiole.

DISCUSSION

The characteristic type of injury to the bud-scale tissues is the brown scarification. Numerous mites feeding on the tissues also cause the formation of blisterlike growths on the bud scales. They do not produce erinea.

The following diagnostic plant characteristics have been proposed as symptoms of bud-mite injury (Smith and Stafford, 1948): 1) short basal internodes, 2) slight scarification of green bark of shoots, 3) flattened canes, 4) dead terminal buds on new canes, 5) witches'-broom growth of new shoots, 6) zigzagged shoots, and 7) dead overwintered buds.

The effects of mite injury as observed in the laboratory were: 1) distortion of the basal leaves; 2) injury to the basal grape clusters; 3) stunting of the main growing point of the buds; and 4) death of the overwintered buds. The principal loss from these symptoms would be reduced yield.

The distortion of the basal leaves is caused by the mites feeding on the leaf primordia which are found between the bud scales. If the mites penetrate deeper into the buds, they feed on the cluster primordia. As the shoots elongate, these clusters on the shoots showed browned, scarred tissues caused by mites feeding on the cluster primordia.

The most serious type of injury was caused by the mites feeding on the growing points of the buds. The infestation of mites on the growing points of the main buds stunted shoot growth so that the lateral buds were able to develop. Usually, when the growth of the main shoots was suppressed, the two lateral buds developed. In other instances, there was a latent growth of the main shoots after the lateral shoots developed, and the result was a witches'-broom type of growth.

Very severe mite infestations have apparently caused the death of entire buds, judging from the presence of numerous mites and extensive bud injury typical of mite infestation.

Although the laboratory results on the nature of injury caused by the mites support the symptoms described by Smith and Stafford, the field experiment conducted to determine the influence of mites on the growth and yield of the vines showed no differences between infested and uninfested vines. The conditions of growth in the spring may affect the appearance of symptoms due to bud mites. It should be remembered that the conditions under which buds were forced to grow in the laboratory were quite different from those under which buds develop in the field on established vines.

Winkler (1933) states that the fruiting habit of the vines, or the extent to which the three growing points of the dormant buds are fruitful, determines the crop that can be produced. This condition varies with different varieties of grapes. For instance, in Thompson Seedless, usually only the primary growing point of the dormant bud is fruitful, and little or no crop is produced if the first grape clusters are destroyed. In the Malaga variety, frequently one lateral growing point of the dormant bud is fruitful, and if the primary bud is killed, the vine is still capable of producing one half to one quarter of the normal crop. In other varieties of grapes—such as Tokay, Muscat, Alicante Bouschet, Carignane, and Zinfandel—two or more fruitful growing points are present in the dormant buds; thus, almost a full crop of fruit can be produced even though the primary growing point is killed.

The extent of yield losses as a result of mite damage would therefore differ according to the variety of grapes. In some cases the injury to the primary bud might result in substantial reduction in yield, while in others the effect of mite infestation would be small.

Field evaluation of mite damage is difficult for several reasons: 1) the mites are not easily visible—both because they are minute and because, for the most part, they are well hidden within the buds; 2) the symptoms are similar to other types of abnormal growth caused by diseases and other grape pests; and 3) infestation is often sporadic and scattered throughout the vineyard.

The method of estimating mite injury in the field was not entirely satisfactory. Each bud that was observed microscopically for the presence of mites had to be severed from the cane; therefore these buds were destroyed. The examination was time-consuming and tedious, and the number in the sample was relatively small. This type of examination may show the general trend of the infestation in the vineyard, but the relationship between mite population and the nature of growth of the individual vines may not be constant, since the infestation on a single vine was not uniform. One part of the vine may be inhabited by the mites and the rest be relatively free. For an accurate evaluation of damage, the infestation on each individual bud on a vine must be recorded, and this would be highly impractical.

Temperature seemed to have little influence on mite activity during the season, but there is some indication of a relationship between the general rise in temperature during the spring and increased egg production. Jacob and Winkler (1950) report that vinifera grapes start growth in the spring soon after the daily mean temperature reaches 50° F. Mite activity and the stimulus for egg production in the spring may be related to bud development, and thus be indirectly influenced by the temperature.

If chemical materials are to be used as a means of control, the primary consideration would be the chemical's ability to penetrate into the buds. The materials must kill the mites deep inside the buds, but at the same time they must be nontoxic to the growing points. Such materials have not yet been found.

Time of application would be another important consideration. Damage to the buds takes place in late summer or early fall when the mites feed on the primordial clusters; therefore, control measures must be applied before this period. Later applications may eliminate the mites, but normal bud growth in the following season would not be assured since the damage may be accomplished before the application. Furthermore, the mites are most vulnerable in the early spring when they are well exposed at the axils of the leaf petioles and on the stipular scales.

SUMMARY

The seasonal activity of the bud-mite strain of the grape erineum mite, *Eriophyes vitis* (Pgst.), was recorded through weekly observations of Carignane grape buds at Davis, California.

As the overwintered buds begin to develop in the spring, the mites are carried up with the elongating shoots to the newly formed buds along the shoots. Progressive penetration of the buds occurs from May to December.

The primordial clusters in the center of the buds were first observed to be infested in September in 1950 and in July in 1951. Increased numbers of primordial clusters became infested from September to December.

Infestation was heaviest in the first ten basal buds. The seventh bud contained the largest number of mites and eggs throughout the season. The mites overwinter primarily as adult females, and usually the mortality rate at this time is high.

Dissemination of the mites along the canes may be accomplished in two ways: they may ride out with the bud scales that form the stipular scales on the elongating shoots, or they may crawl up the canes.

On spurs cut from vines in the field and forced to grow in the laboratory, the general symptoms caused by the mites were: 1) deformation of the primordial clusters, 2) distortion of the basal leaves, 3) stunting of the main growing point of the buds, and 4) death of the overwintered buds.

Evaluation of mite damage in the field is difficult and often complicated by abnormal growth caused by diseases and other grape pests. A field experiment with White Malaga grapes showed no relation between estimated degree of bud-mite infestation and growth symptoms or yield.

LITERATURE CITED

BAILEY, S. F.
1940. The black hunter, *Leptothrips mali* (Fitch). Jour. Econ. Ent. **33**(3):539–44.

BARNES, M. M., C. L. HEMSTREET, and C. L. TURZAN
1952. Pruning time studies on grapes. California Agr. **6**(2):6, 14.

BOYCE, A. M., and R. B. KORSMEIER
1941. The citrus bud mite, *Eriophyes sheldoni* Ewing. Jour. Econ. Ent. **34**(6):745–56.

ESSIG, E. O.
1926. Insects of Western North America. 1,035 p. (See p. 49.) Macmillan Company, New York, N.Y.

FULMEK, L.
1913. Die Kräuselkrankheit (Akarinose) des Weinstockes. N.d. 32 p. *Abstracted in:* Rev. Appl. Ent., Series A, **1**:468–70. 1913.

HEWITT, W. B.
1951. Virus and virus-like grape diseases. Wines and Vines **32**(8):14–15.

IBOS, J.
1920. Diseases of grapevines due to mites in Hungary. Kisérlet. Közlem. **23**(1):1–41. *Abstracted in:* Rev. Appl. Ent., Series A, **11**:241. 1923.

JACOB, J. E., and A. J. WINKLER
1950. Grape growing in California. California Agr. Exp. Sta. Cir. **116**:1–80.

KEIFER, H. H.
1944. Eriophyid studies XIV. California Dept. Agr. Bul. **33**(1):21.
1946. A review of the North American economic eriophyid mites. Jour. Econ. Ent. **39**(5):563–70.
1952. The eriophyid mites of California. California Insect Survey Bul. **2**(1):1–123.

LAMIMAN, J. F.
1939. Pear bud injury and the pear leaf blister mite. Jour. Econ. Ent. **32**(1):41–43.

MENZEL, R., and H. SCHELLENBERG
1930. Die Milben oder Kräuselkrankheit (Akarinose) der Reben. Schweiz. Ztschr. f. Obst. u. Weinbau **39**(7):172–76. *Abstracted in:* Rev. Appl. Ent., Series A, **18**:385. 1930.

NELSON, K. E., W. B. HEWITT, and R. A. BREAK
1949. Arsenite spray injury to grape canes through leaf scars. Phytopathology **39**: 71–75.

NOUGARET, R. L., and M. H. LAPHAM
1928. A study of phylloxera infestation in California as related to types of soils. U. S. Dept. Agr. Tech. Bul. **20**:1–39.

PAGENSTECHER, H. A.
1857. Über Milben, besonders die Gattung *Phytoptus*. Verh. D. Nat. Vereins zu Heidelberg. 1857–1859. (See Bd. I, p. 48.)

PEROLD, A. I.
1927. A treatise on viticulture. 696 p. Macmillan Company, New York, N.Y.

QUAYLE, H. J.
1908. The California grape rootworm. California Agr. Exp. Sta. Bul. **195**:1–28.

SCHELLENBERG, H.
1928. Zur Bekämpfung der Kräuselkrankheit der Reben. Schweiz. Ztschr. f. Obst. u. Weinbau **37**(5):83–85. *Abstracted in:* Rev. Appl. Ent., Series A, **16**:341. 1928.

SISSON, R. L.
1952. The effect of differentially timed pruning on grapevines in Sonoma County and further observations on the grape bud mite. California Agr. Ext. Serv. Mimeo. Jan., 1952.

SMITH, L. M., and E. M. STAFFORD
1948. The bud mite and the erineum mite of grapes. Hilgardia **18**(7):317–34.

SNYDER, E.
1936. Susceptibility of grape rootstocks to root knot nematode. U. S. Dept. Agr. Cir. **405**:1–15.

STELLWAAG, F.
1919. Zunahme der Akarinose am Wein in der Bayer Rheinpfalz. Zeitschr. f. Angew. Ent. **5**(1):128. *Abstracted in:* Rev. Appl. Ent., Series A, **8**:272. 1920.
1931. Die Milbenkräuselkrankheit des Rebstockes in ihrer Differentialdiagnose gegenüber ähnlichen Schäden im Weinbaugebiet der Rheinpfalz. Anz. f. Schädlingsk. **7**(7):73–77. *Abstracted in:* Rev. Appl. Ent., Series A, **19**:510. 1931.
WINKLER, A. J.
1933. The treatment of frosted grape vines. Amer. Soc. Hort. Sci. Proc. **30**:253–57.

4*m*-11,'55(B2329)BEB

The journal *Hilgardia* is published at irregular intervals, in volumes of about 600 pages. The number of issues per volume varies.

Subscriptions are not sold. The periodical is sent as published only to libraries, or to institutions in foreign countries having publications to offer in exchange.

You may obtain a single copy of any issue free, as long as the supply lasts; please request by volume and issue number from:

Agricultural Publications
Room 22, Giannini Hall
University of California
Berkeley 4, California

The limit to nonresidents of California is 10 separate issues on a single order. A list of the issues still available will be sent on request.