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THE BUD MITE AND THE ERINEUM MITE OF GRAPES

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THE BUD MITE AND THE ERINEUM MITE OF GRAPES[1]

LESLIE M. SMITH[2] and EUGENE M. STAFFORD[3]

IN THE COURSE of the investigation reported in this paper the writers became convinced that two and possibly three psysiologically distinct strains of the grape erineum mite, *Eriophyes vitis* (Pgst.), exist on grapes in California. These are named the bud-mite strain, the erineum strain, and the leaf-curl strain in this paper. The reasons for regarding these strains as distinct, and the methods of recognizing the symptoms they produce on grapes are given in the following report.

Injury to grapevines now known to be caused by the bud-mite strain has been observed in California for at least twenty years. The minute size of the mites and the obscure nature of their attack, however, prevented the symptoms from being diagnosed definitely until 1938. In that year, H. A. Weinland, County Agent of Sonoma County, called the writers' attention to a few specimens of eriophyid mites associated with these same symptoms. The mites were sent to H. H. Keifer of the California State Department of Agriculture, who identified them as the common erineum mite, *Eriophyes vitis* (Pgst.), which had previously been associated only with irregular blisters on the upper surface of the grape leaf and felty patches of hair (erinea) on the lower surface beneath the blisters. Because the damage to the vines was so extensive and severe, and because the number of mites was so few, it seemed doubtful that the erineum mite was the causal agent.

In 1938, the writers began a series of field and laboratory observations to establish the causal relationship. They have continued these observations to the present time.

THE BUD-MITE STRAIN

Diagnostic Symptoms of Injury. During the past nine years the writers have had opportunities to study what is now known as bud-mite damage to many varieties of grapes in most of the grape-producing areas of the state. As a result, the diagnostic characters can be listed: (1) short basal internodes; (2) slight scarification of green bark of shoots; (3) flattened canes;

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Fig. 1.—Bud-mite injury on Muscat grape: Left, zigzagged stem and development of lateral shoots; right, terminal bud killed and lateral shoots developing; lower, winter spur and spring cane growth. The terminal bud has been killed, and several lateral shoots have developed.

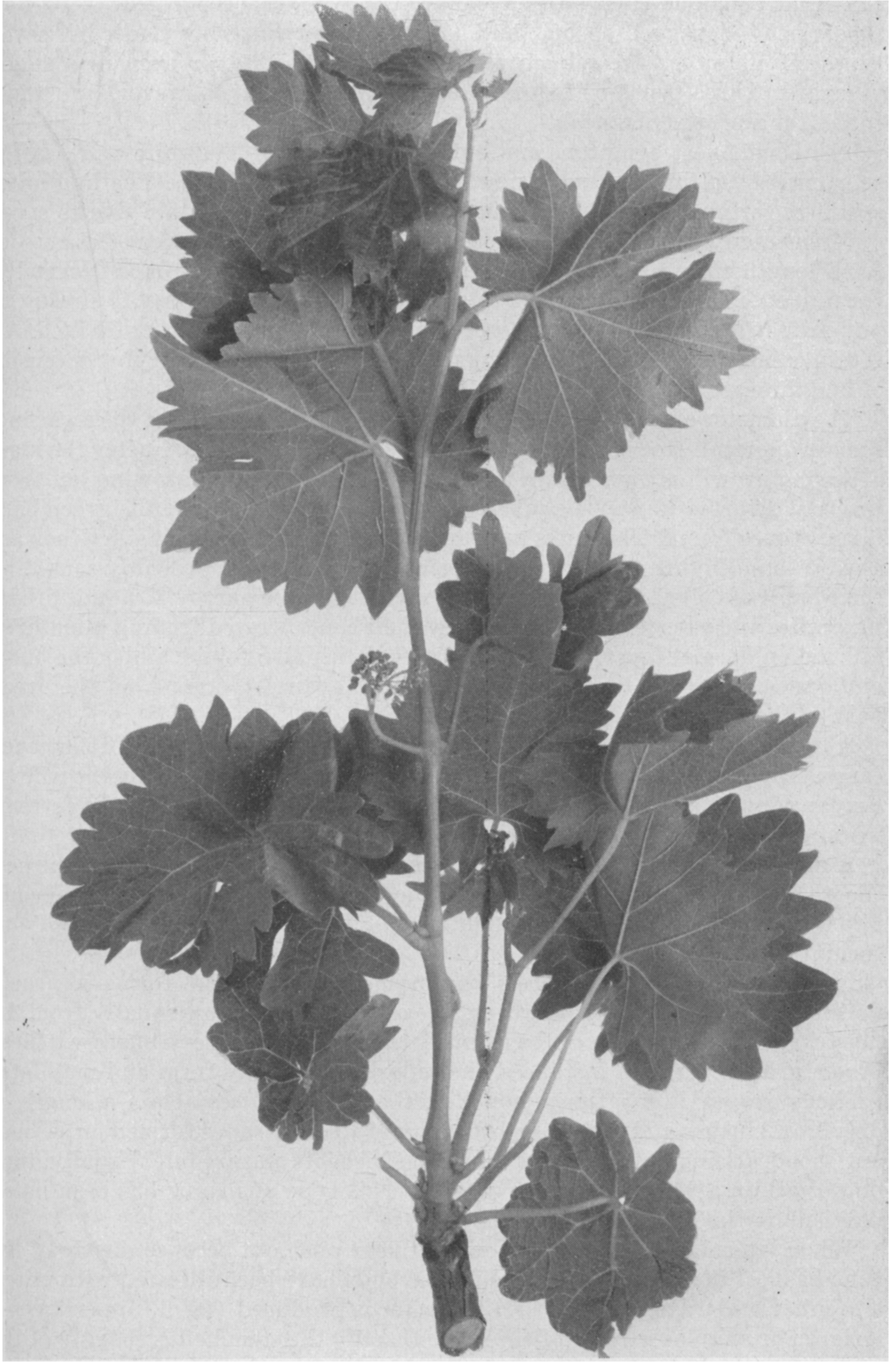

Fig. 2.—Bud-mite symptoms of Muscat grape. Winter spur and spring cane showing first 5 nodes severely shortened.

(4) dead terminal buds on new canes; (5) witches'-broom growth of new shoots; (6) zigzagged shoots; and (7) dead overwintering buds. All seven types of symptoms are seldom found on a single vine, or even in a single vineyard. Three types of injury are usually apparent, however, and these suffice for a proper diagnosis.

The commonest symptom and surest indication of bud-mite work is the shortened basal internodes of new canes (figs. 1 to 4, incl.). The bud mites spend the winter inside the dormant spur buds which contain five to seven differentiated nodes. In some obscure manner, the mites prevent these nodes from lengthening properly when the spring growth takes place. Normally, the first six nodes should reach a total length of 12 to 18 inches. As a result of bud-mite injury, these nodes may be shortened to a total length of 1 inch. All intermediate conditions of dwarfing occur as a result of the varying intensity of bud-mite attack.

The diameter of an injured shoot, regardless of the severity of the dwarfing, remains normal. Nodes differentiating from the terminal bud after the start of spring growth always attain normal length even though growing out from severely dwarfed nodes. A slight scarification or browning of the green bark is sometimes found. The mites appear to be gregarious in habit since they are always found living close together in a colony; but this is probably caused by their habit of collecting in tight crevices which are too narrow to admit predatory mites and insects. Such colonies, by their concentrated feeding punctures, kill the epidermal layer. This scarification is usually found under the outer bud scales of dormant buds and occasionally as brown streaks on the green bark of the basal nodes of young shoots.

A symptom of less common occurrence is the development of flattened canes. Apparently, as a result of injury to the terminal bud during the winter, the cane develops with an oblong rather than a round cross section. In extreme instances, the cane may be 1 inch wide but only $\frac{1}{4}$ inch thick.

A more common type of injury is the killing of the terminal bud of the new shoot. When this occurs, the primary shoot usually attains a length of only 4 to 6 inches (fig. 1, upper right and lower). The lateral buds then push out, forming secondary shoots.

Usually one of these laterals assumes dominance and forms a nearly normal cane. Occasionally, however, five or six laterals grow equally from the shortened five or six nodes of the primary cane. This produces a bushy witches'-broom growth. In such instances, the inflorescences may form and may later produce grapes. Many times, however, the inflorescences attain a length of only 1 or 2 inches and then turn brown and fall off. Grapes formed on secondary shoots arising at the base of the primary shoots mature late. Usually, they do not attain a very high sugar content. This type of injury has been noted particularly in Thompson Seedless.

When lateral cane buds of the current year push out because the tip of the cane has lost dominance, and when these buds have been infested with mites, a peculiar and distinct diagnostic character is produced (fig. 1, upper left)—a zigzag or angular growth of the stem. Usually the stem bends sharply at the node to form about a 15-degree angle with the direction of the shoot. At the next node an equal bend is made in the opposite direction, and so on. This produces a crooked, zigzagged shoot. Such canes lie flat since all bends lie in the same plane.

The most serious type of damage consists of killing the overwintering buds on the spurs (fig. 5). This results only from an abnormally heavy infestation of bud mites. Buds, killed in this manner during the winter, do not swell or show signs of growth the following spring. On Thompson Seedless grapes the buds most often killed are those on the basal portion of the canes.

Geographical Distribution and Host Range. The writers have seen mite damage and have authenticated the presence of bud mites by microscopic examination in Sonoma, Yolo, San Joaquin, Madera, Fresno, Tulare, and Kings counties. Hence, it is apparent that this pest is widely distributed in California, and that it is capable of producing serious damage under both cool, humid coastal conditions and hot, dry interior valley conditions. Since no survey has been conducted, it seems likely that the bud mite occurs in other grape-producing counties not listed here.

The writers have found the following varieties damaged in commercial vineyards. In each instance, the presence of bud mites was determined microscopically: Alicante Bouschet, Berger, Carignane, Emperor, Grand Noir, Black Malvoisie, Mataro, Orange Muscat, Pinot Blanc, Ribier, Sauvignon Blanc, Thompson Seedless, Tokay, White Malaga, and Zinfandel. Under laboratory conditions, the varieties Pedro Zumbon and Chardonnay were successfully infested. No evidence has come to our attention, either in the field or laboratory, to indicate that any variety is immune to bud mites.

Evidence that Eriophyes vitis (Pgst.) is Causal Agent. The relation between bud mites and the symptoms of injury is not easily apparent from casual observation. This relationship was carefully studied in the field, and experimental infestations were established on bench-grown vines. In the field in the spring, mites were found where symptoms of injury were detected. Conversely, mites were seldom found on vines which showed no symptoms of injury. Vineyards showing a good population of bud mites and considerable bud-mite damage were surveyed on numerous occasions for erinea on the leaves, but in the great majority of instances none was found.

Field evidence indicated that the bud mite was extensively preyed upon by several species of predatory mites, particularly *Seiulus* sp. These predators frequently reduced the bud-mite population nearly to extinction in certain vineyards. The fact that vines infested with bud mites normally developed no erinea, could be explained in three ways: (1) Sulfur dusting for mildew control may have effected a complete control of mites which wandered out onto the leaves and attempted to form erinea. (2) Such erineum-forming mites may have been killed by predators, whereas those remaining under the bud scales escaped. (3) The bud mite actually might be a distinct physiological strain in which the ability to produce erinea has been lost. To test these possibilities, mites were cultured on potted vines.

Culture on Potted Vines. Rooted vines of Pedro Zumbon, Chardonnay, and Cabernet Sauvignon varieties were set in 8-inch pots. Cuttings of Zinfandel and Mataro were rooted in sand with bottom heat, then transplanted to soil in 8-inch pots. Two cane buds on each rooted cutting were allowed to produce canes. These were tied to a stake inserted in the potted soil. Three separate

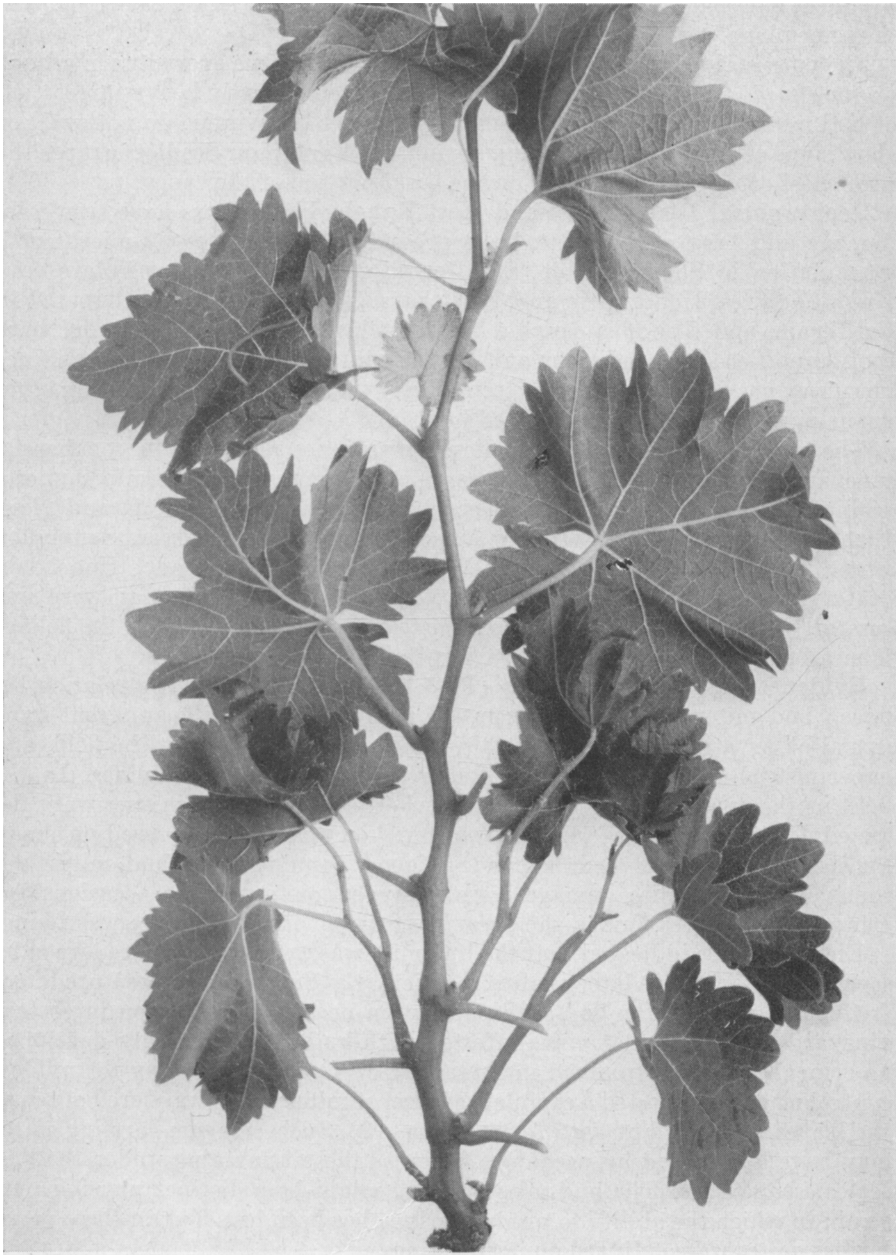

Fig. 3.—Mild injury caused by bud mite on Muscat grape. Basal nodes are somewhat shortened; inflorescences absent. Compare with figure 4.

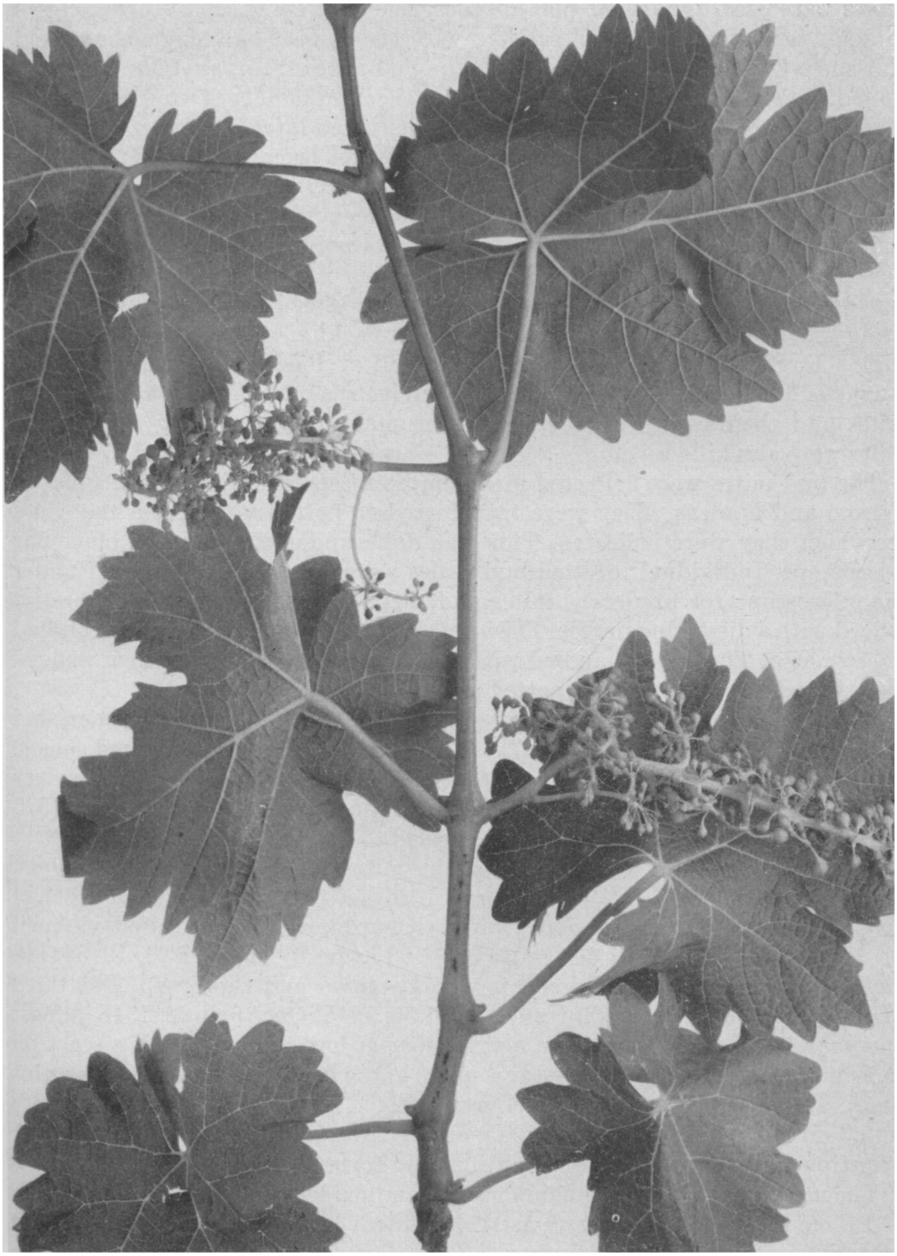

Fig. 4.—Normal cane of Muscat grape showing length of basal nodes and the development of inflorescences. Figures 1 to 4 show canes of the same age.

tables were used to hold the potted vines. Each table was separately enclosed in a shelter 4 feet high with cellotex wire-screen roof and shade-cloth sides and ends. One table was used to rear the bud-mite strain, another table contained the erineum strain, and a third table contained check vines and a few plants infested with the leaf-curl strain (discussed later).

All potted vines were fumigated with methyl bromide before they were artificially infested with the desired strain of mites. This killed predatory mites and insects and removed all wild specimens of *Eriophyes vitis* which could contaminate the desired strain. Methyl bromide was used at 2½ pounds per 1,000 cubic feet, introduced into a 15-inch vacuum. Since this process caused considerable injury to succulent shoots, later fumigations were made using 2 pounds per 1,000 cubic feet, without vacuum, at temperatures of 65° to 68° F. Such fumigations gave a total kill of Pacific mites, *Tetranychus pacificus* McG.; grape russet mite, *Calepitrimerus vitis* (Nal.); and erineum mites and their eggs within erinea. Presumably all predatory insects and mites were also killed.

The bud mites were collected on Thompson Seedless and Malaga vines at Fresno and Madera. They were transferred to potted vines from the canes on which they were collected. This was done under a dissecting binocular microscope. Individual infested bud scales were removed and studied under the microscope for predatory mites and their eggs. If found, these were removed with a dissecting needle. The number of mites on each scale was counted or estimated. The scales, handled with fine-pointed forceps, were then wedged into the axils of leaves on the potted plants.

In all, seventeen potted vines were artificially infested in this manner, and mites were recovered from four. These four vines produced zigzagged shoots, as described under symptom number six. The first of these plants—variety Pedro Zumbon—was infested on April 6, 1945, by placing on it about 575 mites and 1,400 eggs. This plant was allowed to develop many shoots.

On May 30, 1945—54 days after infesting, mites were found in axillary buds. On August 29, 1945—145 days after infesting, this vine had two crooked dwarfed shoots. The second plant, variety Chardonnay, was infested on April 11, 1945, by placing on it 369 mites and 199 eggs. By August 29, 1945—140 days after infesting, all new shoots were dwarfed and zigzagged. The third plant, Pedro Zumbon, was infested April 30, 1945. On April 22, 1946, almost one year later, the shoots were nearly normal but showed feeding scars on their basal parts. On this date 3 live mites and a few eggs were found on this plant. The fourth plant, Zinfandel, was infested on June 21, 1945. Mites were found on this plant on July 25, 1945, and by August 29, 1945—35 days after infesting—new shoots showed typical zigzag form.

The mites living on these plants were examined by H. H. Keifer who identified them as *Eriophyes vitis* (Pgst.). No sulfur or other acaricides were put on the vines during this experiment. Predators were kept at a minimum. *No erinea developed on these plants during the year they were kept under observation.*

Consequently, it must be assumed that *Eriophyes vitis*, the well-known erineum-producing mite, has given rise to a physiologic strain which is no longer capable of producing erineum galls.

Seasonal Cycle of the Bud Mite. The bud mites pass the winter under the bud scales and as deep in the buds as they are able to penetrate. They usually are found under the second layer of scales and rarely deeper than the third layer. When vine growth starts in the spring, the mites remain for the most part under the same bud scales where they spent the winter. These scales form a whorl around the base of the new shoot.

In table 1, the distribution of mites in the spring is indicated as well as symptoms produced at that time. This table shows that up to the time the shoots are 2 or 3 inches long and have five or six leaves, the mites have not migrated out to the new buds to any extent. On the second shoot (table 1), the

TABLE 1

DISTRIBUTION OF BUD MITES ON GRAPE SHOOTS IN THE SPRING

Shoot		Bud mites		Stem zigzagged	Feeding scars		Mites up on stem
Length (inches)	Number of leaves	Number of mites	Number of eggs		Bracts	Stem	
0.25	0	200	800	−	+	+	−
1.5	4	300	500	+	+	+	+
1.5	5	75	100	−	+	−	−
1.5	4	12	27	+	+	−	−
1.5	4	20	25	−	+	−	−
1.0	3	300	150	−	+	+	−
3.0	7	200	50	−	+	−	−
0.5	1	30	10	−	+	−	−
2.0	5	9	14	−	+	−	−
0.75	2	10	10	−	−	−	−
1.0	3	5	5	−	−	−	−

+ = present; − = absent.

mites had wandered out to the axils of the leaves. Their distribution along the new shoot was: basal node, 16 mites; second node, 0 mites; third node, 2 mites; fourth node, 1 mite; and terminal bud, 0 mites. As the summer advances, the mites can be found under the scales of buds progressively farther out on the canes. Apparently the entire life cycle is completed under the bud scales since eggs, young, and adult mites have repeatedly been found there. All attempts to rear individual mites in small cages attached to leaf surfaces failed.

Identity and Probable Origin. Mites collected in the field and mites cultured on potted plants have been examined by H. H. Keifer on a number of occasions and found to be anatomically identical to the erineum mite, *Eriophyes vitis* (Pgst.). The bud mite must therefore be known by this specific name. From evidence obtained in the field and laboratory the writers believe that the bud mite is a true physiological strain which differs from the erineum strain in that: (1) it cannot produce erinea; (2) it lays eggs and breeds under the dormant bud scales; (3) it spends the entire year in the buds and axils of the leaves; (4) it may wander over the open leaf surface in migrating from bud to bud, but probably will never lay eggs on the leaves by choice; and (5) it produces the deformities described above by feeding under the bud scales, whereas the erineum strain does not produce these.

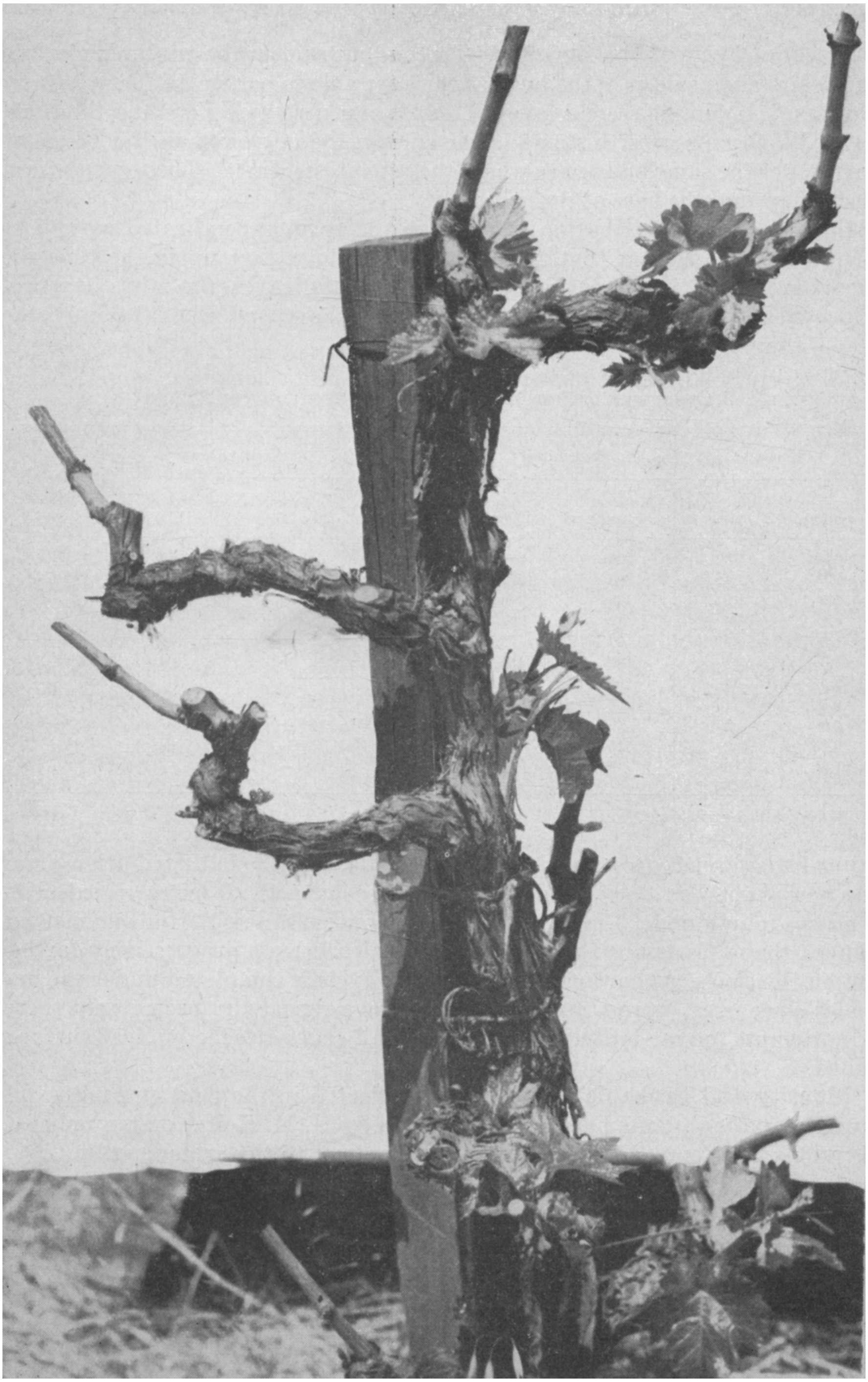

Fig. 5.—Bud-mite injury to Zinfandel. Note the length of water-sprout growth from the base of the trunk. Uninjured spur buds would have produced longer canes than these suckers.

Since the erineum strain is easily killed by dusting with sulfur, the bud-mite's habit of remaining in the buds and under the bud scales gives it a high chance of survival. It therefore seems likely that the bud-mite strain has been selected from the erineum strain by the lethal action of sulfur on the latter.

Economic Losses. From the description of diagnostic symptoms, it can be seen that the economic losses caused by bud-mite attack are: (1) loss of crop, and (2) death of the vines. Loss of crop is the predominant result of mite damage. Vines normally bearing inflorescences on two of the basal six or seven nodes are usually devoid of crop, or mature small bunches of a dozen or more berries. In vineyards where mite damage occurs, losses in tonnage of fruit often approximate 50 per cent; and the writers have seen vineyards where the crop was totally lacking. In contrast to these manifestations of severe injury, bud-mite damage often occurs on vines scattered throughout the vineyard, but is so light that it escapes the attention of the grower. In June of 1944, the following notes were made on the number of inflorescences per vine in a portion of a Ribier vineyard near Sanger:[4]

Total number of vines	92
Number of bud-mite vines	5
Per cent bud-mite vines	5.4
Number of inflorescences per normal vine	30.5
Number of inflorescences per infested vine	9.6

No more than two vines showing bud-mite symptoms were found together in this vineyard. The writers believe that the occurrence of bud-mite-damaged vines in such a scattered pattern is widespread throughout the grape-growing regions of the state. Obviously, the total acreage damaged by this pest, although certainly large, could not be accurately estimated.

The dwarfing of the basal nodes and loss of inflorescences do not adversely affect the vigor of the vines, since subsequent cane growth is usually sufficient to produce an abundant leaf canopy.

However, when the spur buds are killed during the winter (fig. 5), serious injury is done to the vines. In fact, the writers have seen practically all of the buds killed in occasional vineyards. When this occurs, serious pruning problems arise. It is necessary to establish new spurs from water-sprouts and, in some instances, new arms from the trunk. This type of injury occurring in several consecutive years seriously reduces the size of the vines. Often the main (central) growing point of damaged buds fails to grow. Shoots developing from either or both of the side growing points do not usually make such vigorous growth as those normally developing from the main growing point. Thus, the grower may have only poor canes to leave for next year's crop.

When the basal nodes of new canes are severely dwarfed, so that the total length of the first six nodes is about an inch, pruning to a suitable spur is difficult. In such instances, perhaps even the seventh and eighth nodes are left to carry the spur buds, and shoots which arise from the dwarfed nodes the following spring are removed at suckering. On Thompson Seedless grapes the overwintered buds on the basal part of the cane often fail to grow.

Control of Bud-Mite Strain. On the basis of reduction in bud-mite symptoms, the writers have seen only one case of successful control in the field. In

[4] This data is taken from notes made in coöperation with D. F. Barnes, Bureau of Entomology and Plant Quarantine, U.S.D.A., while investigating control of the grape-bud beetle.

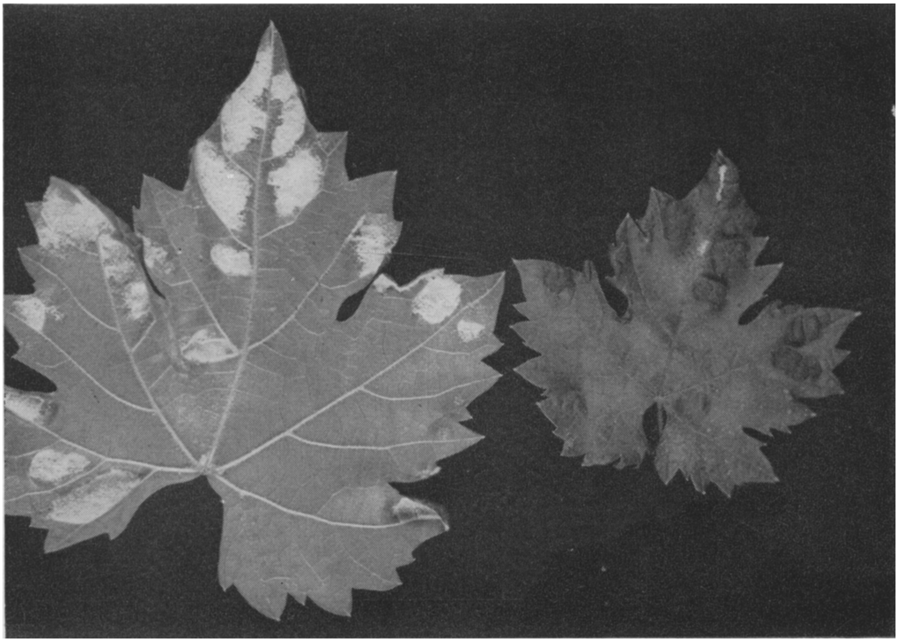

Fig. 6.—Leaves showing mature erinose galls.

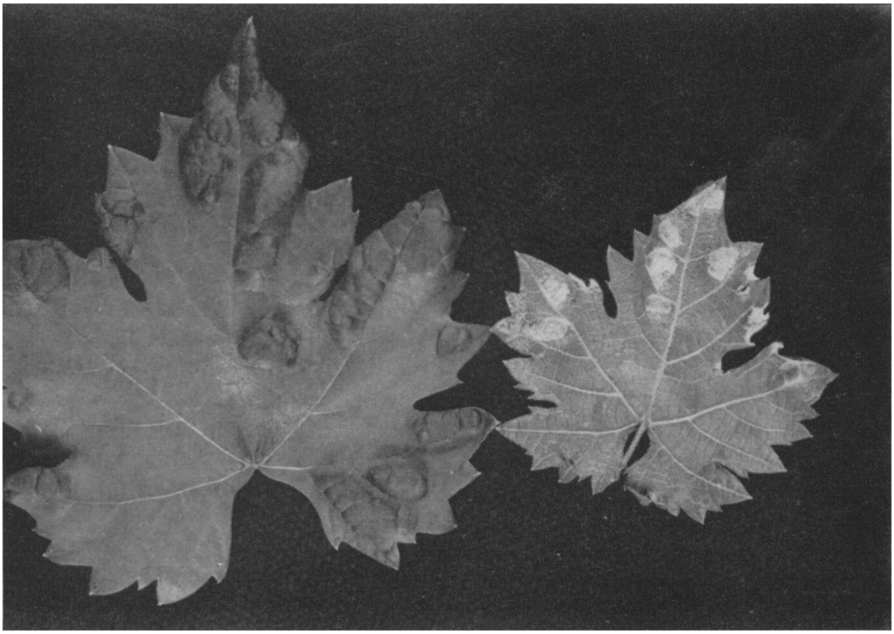

Fig. 7.—The reverse sides of the same two leaves shown in figure 6.

the fall of 1939, Mr. Weinland applied a spray composed of 3 gallons of oil emulsion and 5 gallons of lime-sulfur solution per 100 gallons of water. At the time of spraying in one section of the vineyard the vines had lost their leaves, while in another section the leaves were still on the vines. When this vineyard was examined in May, 1940, it appeared that where the spray had been applied to defoliated vines no bud-mite control resulted. In contrast, where the spray had been applied to vines still in foliage good mite control was achieved, since this section showed very little dwarfing of the shoots.

TABLE 2

CONTROL OF GRAPE BUD MITES ON EMPEROR GRAPES AT WOODLAKE BY SPRAYS OF LIME-SULFUR PLUS WETTABLE SULFUR*

Row number (87 vines in each row)	Date of treatment	Number of vines showing bud-mite symptoms			Increase or decrease in total number of bud-mite vines	Number of mites per 25 buds
		Fall	Spring			
			Repeats	Total		
1	October 20, 1944	19	9	9	−10	28
2	October 20, 1944, and April 6, 1945	15	3	5	−10	56
3	October 20, 1944	10	5	16	+6	30
4	April 6, 1945	17	16	32	+15	12
5	April 6, 1945	14	11	19	+5	62
6	Untreated	6	4	4	−2	38
7	Untreated	4	0	2	−2	62
8	Untreated	6	2	7	+1	..

* The writers wish to acknowledge the assistance of Norman Frazier in this test.

All attempts made by the writers to control the bud mite in the field by the application of fall or early spring sprays have been complicated by three factors: (1) Either the mites failed to appear in the spring, so that bud-mite symptoms were not apparent in treated or untreated portions of the vineyard; or (2) the symptoms appeared in some portion of the vineyard far removed from the bud-mite location of the year before; or (3) the mites appeared in such low numbers in the spring and in such unpredictable locations that interpretation of experimental results was extremely difficult.

As an example of the latter conditions, the results of an experiment to control bud mites at Woodlake are given in table 2. A portion of a vineyard of Emperor grapes was surveyed and mapped in the fall of 1944. A spray of 1½ gallons liquid lime-sulfur, 4 pounds of dusting sulfur, and 2 ounces of 33½ per cent dioctyl sodium sulfosuccinate per 100 gallons of water was applied October 20 to three rows of vines. Each row contained 87 vines. On April 6, 1945, when growth was very short and tender, a spray of 2½ gallons of liquid lime-sulfur, 4 pounds dusting sulfur, and 5 ounces blood-albumin spreader per 100 gallons of water was applied to one row of vines sprayed the preceding October and to two rows not sprayed the previous October. On May 12, 1945, the vineyard was again surveyed and mapped for bud-mite symptoms. In the table of results appear only those vines showing moderate or more severe bud-mite symptoms. In the column headed "Repeats" are given the number of

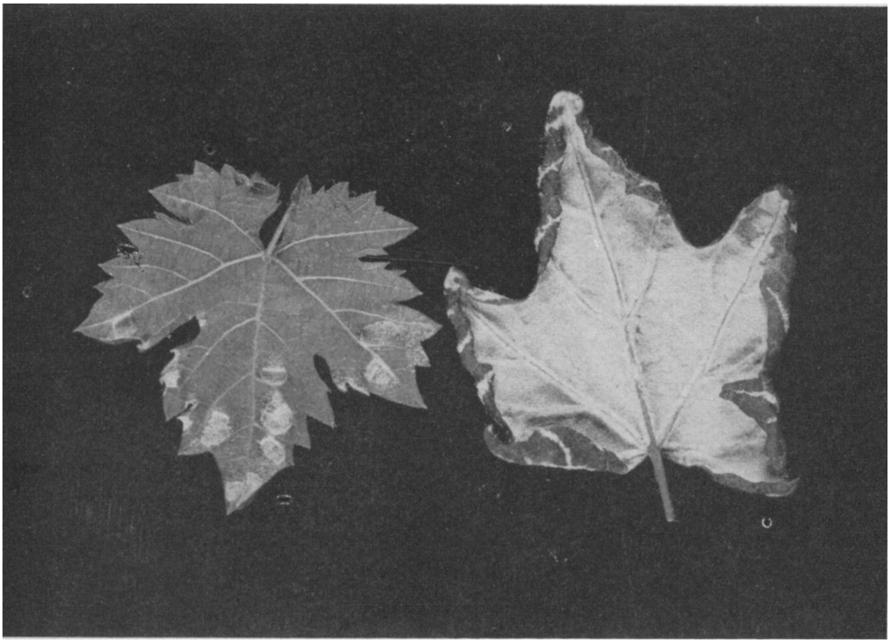

Fig. 8.—Moderate and severe erineum; erineum covers the entire lower surface of the leaf at the right.

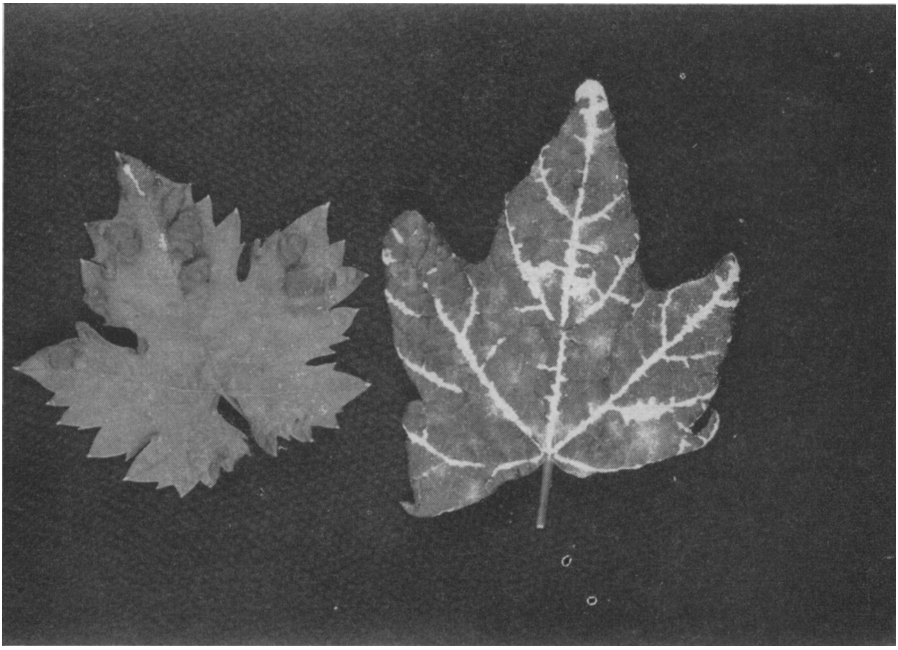

Fig. 9.—Dorsal surfaces of leaves in figure 8. Erinose has developed along the main veins.

vines which showed at least moderate bud-mite symptoms both in the fall of 1944 and in the spring of 1945.

The table shows no clear trend in the number of vines having bud-mite symptoms. In one instance, the fall spray shows a reduction in total number of bud-mite vines; in another, an increase. This same variation is also encountered in the untreated rows. That live mites were present is indicated by the last column in the table. As the 1945 season progressed, the bud-mite symptoms were less and less noticeable. In fact, by midseason it became apparent that little, if any, damage could be attributed to bud-mite injury.

Many spray materials tested as fall sprays in other years could not be evaluated because of the erratic behavior of the bud mites. Among these were: summer oils, Selocide, ammonium polysulfide, derris extract, thialdine, and the dicyclohexylamine salt of 2,4-dinitro ortho secondary isobutyl phenol.

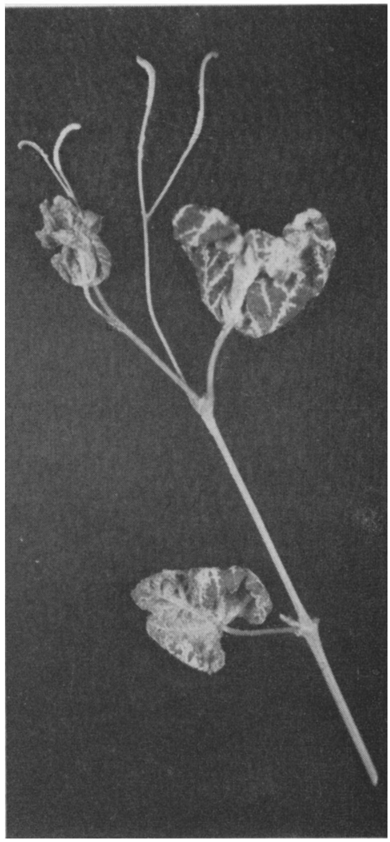

Fig. 10.—Severe erineum-mite damage. These leaves fail to develop further and soon die. Note erineum on the tendrils.

THE ERINEUM STRAIN

Diagnostic Symptoms of Injury. The erineum strain produces very characteristic leaf galls (fig. 7). These are nearly hemispherical in shape, with the concavity always opening on the lower leaf surface. The concavity is densely lined with abnormal curled plant hairs, whereas the upper convex surface of the gall does not differ in color or texture from the adjacent, unaffected upper leaf surface. The diameter of a mature gall is about 3/8 inch. When the infestation is severe, the galls merge into a single large erinose area (figs. 8 and 9). When this occurs, the leaf may reach a diameter of about 2 inches, then die (fig. 10). Since it remains attached to the cane, the mites can leave the erinea and move to new leaves. A leaf which has 20 or 30 galls will expand to full size, and appears to carry on its normal functions. It matures and drops in the fall somewhat earlier than a noninfested leaf.

Geographical Distribution. The erineum strain is apparently distributed throughout the grape-growing areas of California, but its effects are seldom seen. Galls occasionally occur in numbers in the early spring in commercial vineyards or may be abundant throughout the season on abandoned vines or back-yard vines which are not sulfured. Wherever a normal program of sulfur dusting is followed, the erineum mite is rare to entirely absent. The writers have found erinea in both the coastal and the central valleys; it seems equally well adapted to both types of climates.

Culture of Erineum Strain on Potted Vines. Twelve potted vines were artificially infested with the erineum strain by pinning fresh galls to the undersides of the leaves of the potted vines. All of the infestations were successful, except those on the variety Pedro Zumbon. There is some evidence to indicate that this variety may be resistant to erineum formation (as discussed under leaf-curl strain). The varieties artificially infested which developed abundant galls were Zinfandel, Cabernet Sauvignon, and Mataro. The original mites used in these tests were collected at Woodlake, California, May 12, 1945, by A. J. Winkler. When attempting to artificially establish this strain, about 50 galls were pinned to each plant. One month later, under summer-weather conditions, the test plants had developed approximately 200 galls each.

Age of Leaves Susceptible to Gall Formation. It was noted that although infested galls were pinned to older leaves, no galls developed on these leaves, but many galls appeared on younger leaves near the tips of the canes. Galls were then pinned to the three basal leaves of some plants, and a sticky band was placed between the third and fourth nodes. No galls developed on such plants.

To more accurately determine the age of the leaves susceptible to gall formation the following test was conducted. Two single-cane plants were artificially infested on each leaf. Plant A had eight leaves and plant B had eleven leaves when the mites were added. The infestation was done on June 8, 1946, and 27 days later, on July 5, 1946, the number of galls was recorded as follows:

Leaf number	Plant A	Plant B
1 (basal)	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	30	0
8	30*	0
9	8	0
10	0	15
11	—	½ galled*
12	—	⅛ galled
13	—	8
14	—	0
15 (tip)	—	1

* Indicates tipmost leaf when mites were added.

This list indicates that only the tipmost leaf and the leaf directly below it are susceptible to gall formation. In both instances, this lower leaf was about ¼ inch in diameter. Leaves ½ inch and larger in diameter have passed the physiological stage at which the mites can stimulate gall formation. The presence of galls on leaves not present when the mites were added indicates that mites migrated from the pinned galls to the tips of the test plants for several days after infestation. The absence of galls on the youngest leaves on

July 5 indicates that migrants no longer came from the infesting galls, and, more importantly, that the mites established in new galls did not leave these to form additional galls.

Seasonal Cycle of the Erineum Strain. The adults of the erineum mite overwinter under the outer layers of bud scales of the dormant buds. As far as the writers could discover, these adults do not lay eggs and breed during the winter. As soon as the buds open in the spring, the adult mites migrate to the unfolding leaves. That two or three adults have been found in very young galls is some evidence that the mites behave gregariously and associate in small groups during the formation of the first erinea.

When first formed, the galls are bright red dorsally and white erinose ventrally. The red soon fades to yellow and then assumes the normal green of the leaf. The convex, ventral surface of the gall is covered with dense white hairs. Early in August, the ventral surface of the gall turns brown. This is caused by the death and collapse of the hairs, beginning at the dome of the gall, and proceeding slowly, over a period of several weeks, until the entire ventral surface is brown. This is not the result of feeding by the mites, since there is no evidence that they feed on the gall hairs. They apparently feed only on the lower leaf epidermis between the hairs.

When young red or yellow galls on potted plants were fumigated with methyl bromide, all of the mites and their eggs were killed. The galls then continued to develop normally and reached nearly normal size, but the hairs on the ventral concavity were sparse as compared with an inhabited gall. Evidently the course of development of the gall is determined in the first few days of feeding, but gall hairs may be provoked by the mites much later in the development of the gall. Since an undetermined number of generations is completed by the time the gall hairs die, in very populous galls the mites appear to be stacked like cordwood among the hairs.

From the middle of August to leaf drop, the adult mites migrate to the axils of the leaves and crawl in under the bud scales. This migration occurs only at night. Since the mites are very susceptible to killing by dessication, a great mortality would occur if they left the galls in the day time.

Economic Losses. Economic losses from the erineum mite are apparently very light in the state. In most instances, growers notice the characteristic symptoms on the young leaves early in the growing season. By midseason, growers show little concern for this pest.

Control of Erineum Strain. The erineum strain is easily killed by dusting with sulfur. Since all grapes are normally dusted several times a year to control mildew, the erineum mite is incidentally controlled. Where symptoms appear very early the first sulfur dust application is also made early.

POSSIBLE LEAF-CURL STRAIN

Specimens of *Eriophyes vitis* (Pgst.) were found near Modesto on August 7, 1945, on Black Corinth (Zante Currant). These mites were producing a type of injury entirely distinct from that of the bud mite or the erineum mite. Affected leaves were bowed up dorsally until nearly hemispherical. No erinose galls were present. Specimens were sent to H. H. Keifer, who identified them as *Eriophyes vitis* (Pgst.).

Mites were transferred to five potted vines, including Zinfandel, Chardonnay, and Mataro varieties. Infested leaves of Black Corinth were pinned to leaves of the test plants. In all tests the mites transferred to the potted plants successfully. They came to lie in the axils of the larger veins and at the overlap of leaf serrations. Feeding at these points no doubt had been responsible for the cupping of leaves of Black Corinth.

The artificial infestations were made on August 7, 1945. Three weeks later the mites were well established, but no leaf curl developed except with Chardonnay, on which mild symptoms appeared. A plant of Pedro Zumbon, adjacent to the infested plants, became infested and showed distinct leaf curl. The mites caused a few abnormal plant hairs to grow on spots chosen for colonizing, but no typical erinose galls appeared on the plants at any time. In the spring of 1946, these plants developed normally, showing no signs of damage by bud mite, erineum mite, or leaf-curl mite. The strain had evidently died out during the winter.

SUMMARY

Mites associated with stunted cane growth were identified as *Eriophyes vitis* (Pgst.), the common erineum mite. The symptoms commonly associated with these mites are short basal internodes, scarification of the bark of new shoots, flattened canes, dead terminal buds on new canes, witches'-broom growth of new shoots, zigzagged shoots, and dead overwintering buds. Leaf galls (erinea) are absent.

Field observations and culture on bench-grown vines indicated that these symptoms were produced by a physiological strain of the erineum mite which is herein called the bud-mite strain. This strain has lost the ability to produce, or the habit of producing, leaf erinea. It overwinters in the spur buds, and, when the new canes are about 6 inches long, migrates to the axils of the leaves and into the new buds. Field data indicate that the bud mite causes considerable loss of crop and is responsible in part for hitherto unexplained low-tonnage yields.

Parallel cultures of the erineum strain were maintained on bench-grown vines, and the habits of this strain and the symptoms it produces are described.

A single infestation of a leaf-curling strain was discovered, and some observations on this strain were made.

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