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VIRUSES THAT INDUCE BREAKING IN COLOR OF FLOWER PETALS IN PANSIES AND VIOLAS[1]

HENRY H. P. SEVERIN[2]

INTRODUCTION

PANSIES (*Viola tricolor* var. *hortensis*) and violas, or tufted pansies (*Viola cornutus*) in California home gardens, nurseries, and seed farms frequently show a conspicuous breaking in the color of flower petals. The flowers, especially violas, are often dwarfed and malformed. Such plants are frequently stunted. An investigation was undertaken to determine the cause.

When the trouble was found to be due to two viruses—celery-calico and western-cucumber-mosaic—the method of transmission and control of the diseases were investigated. A study was made of the symptomatology on pansies and violas infected with these viruses and with common-cucumber-mosaic virus (which has not been reported in California). Experiments were also conducted with viruses known to cause breaking in flower petals of other ornamentals, to determine whether any of these would induce the disease in pansies and violas. This paper reports the results of these investigations.

A review of the literature indicates that three references to a mosaic disease in species of *Viola* in the United States have appeared. Martin[3] (1926) mentions a "yellows—undetermined mosaic type" on pansy (*Viola tricolor*) in Washington, D.C. Edson and Woods (1936) report a mosaic on *Viola* sp. in the state of Washington. Perone (1939) lists pansy among twenty-nine ornamental flowering plants affected with mosaic in New Jersey, and in a general description of symptoms reports "breaking of blossoms on these host plants."

In England, Smith (1935, 1936*a*, 1936*b*, 1937) reported breaking in violas and stated that inoculation experiments "seem to show that the virus causing this variegation is a strain of cucumber-mosaic virus (cucumber virus I)." Moore (1933–1942) reported a mosaic on several pansies and violas in Somerset in 1936.

In New Zealand, Chamberlain (1936) described foliage symptoms and breaking in pansy, viola, and violet.

In New South Wales, Dunn (1941), in notes contributed by the biological branch, recorded for the first time a "mosaic (virus) of pansy (*Viola tricolor*) in Sydney, Metropolitan area."

[1] Received for publication December 30, 1946.
[2] Entomologist in the Experiment Station.
[3] See "Literature Cited" for data on citations, referred to in the text by author and date.

MATERIALS AND METHODS

Sources of Viruses. The principal sources of the celery-calico virus were naturally infected pansies and violas. Infected pansies were collected in nurseries and gardens in Berkeley, Albany, El Cerrito, San Pablo, and Salinas. Infected Papilio, Radio, Blue Perfection, and unknown varieties of violas were obtained in Berkeley, San Pablo, and Salinas. The virus was identified by inoculating celery with the virus extract from naturally infected pansies and violas; the celery developed typical symptoms. Later, celery and other host plants were used as virus sources. The virus was maintained by repeated mechanical inoculation in and aphid transmission to pansies and violas.

The original source of most of the western-cucumber-mosaic virus used in experimental work was an infected Honey Dew melon plant (*Cucumis melo* var. *inodorus*) collected on November 7, 1932, at Keyes, in the San Joaquin Valley. The virus was maintained by repeated mechanical inoculation of various host plants, and also the virus extract was kept in cold storage at −18° C. After the experimental work was started, natural infection of pansies and violas growing in the San Joaquin Valley was demonstrated.

Common-cucumber-mosaic virus was kindly sent to me by James Johnson, University of Wisconsin.

Virus Extract. In preparation of juice from the leaves of pansies, violas, and other host plants, the leaves were washed in distilled water and ground to a pulp in a mortar. The pulp was placed in two layers of cheesecloth, a thick jellylike juice was pressed out by hand. This juice was diluted with sterile, distilled water.

Centrifugation. The diluted, extracted juice was centrifuged for 1 hour at a speed of 3,500 revolutions per minute.

Mechanical Inoculation. The carborundum method of mechanical inoculation described by Rawlins and Tompkins (1936) was used. Shortly after inoculation, the carborundum and inoculum were washed from the leaves with water.

Aphids. The methods of rearing and transferring aphids and the production of noninfective aphids have been described in a previous paper (Severin and Freitag, 1938).

CELERY-CALICO VIRUS

The celery-calico virus is a cucumber-mosaic virus which is common in the coastal fog belt and also occurs in the hot interior regions of California. Celery calico has been found in all of the large celery districts of this state (Severin and Freitag, 1938). The geographical distribution of the celery-calico virus includes California (Severin and Freitag, 1938), Washington, and Idaho (Severin, 1942*a*).

Transmission from Naturally Infected Host Plants. The celery-calico virus was transmitted by mechanical inoculation to pansies and violas from the following naturally infected host plants:

Chenopodiaceae:
- Spinach (*Spinacia oleracea*)

Cucurbitaceae:
- Cucumber (*Cucumis sativus*)
- Squash (*Curcurbita* sp.)

Ranunculaceae:
Perennial delphinium (hybrids and horticultural varieties)
Larkspur (*Delphinium ajacis*)
Solanaceae:
Tomato (*Lycopersicon esculentum*)
Umbelliferae:
Celery (*Apium graveolens* var. *dulce*)
Violaceae:
Pansy (*Viola tricolor* var. *hortensis*) and viola (*V. cornuta*)

The virus was recovered from a large number of naturally infected varieties of pansies and violas collected in the East Bay districts and transmitted to healthy pansies and violas grown from seeds.

Symptoms on Pansies. The foliage symptoms of celery calico on naturally infected pansies are not conspicuous in the early stages of the disease. The first symptom on the youngest leaves is a clearing of the veins and veinlets. The youngest leaves are dwarfed and malformed. When a large number of infected pansies are examined, an occasional plant shows typical symptoms resembling celery calico (Severin and Freitag, 1938). Some of the older leaves of such a pansy are amber yellow except for small green areas enclosed in yellow veins and veinlets. In the later stages of the disease, the plant turns yellow. Young infected plants are stunted with shortened internodes and plants finally die.

The color changes involved in breaking of flower petals vary according to the normal color of the pansies. Red varieties develop red streaks, which later become yellow and then white. Purple varieties show purple streaks and later white streaks. Dark-blue and pale-blue varieties develop dark-blue and pale-blue streaks followed by white streaks. So-called black varieties show black streaks, which turn purple, and then white. All of the petals may show breaking, or all but the lowest, or only the two upper petals.

Pansies infected in the flats, when transplanted in the home gardens, develop malformed and dwarfed flowers. Pansies infected when older may continue to blossom and develop ruffled flowers or flowers with the margins rolled inward. Frequently breaking occurred on one or more branches while on other stems on the same plant the flowers were normal.

A brief description of the early and late symptoms on flowers of varieties of French bedding pansies follows:

Adonis: Purple streaks appear on the upper two petals and on the margins of the remaining petals; later, the purple streaks become white on the pale-blue flower.

Victoria: The petals show pale-red streaks; later, turn yellow, and then white.

Emperor William: The petals develop dark-blue streaks, which later become white and are more pronounced on the lower surface of the dark navy-blue flower.

King of the Blacks: The petals first show black streaks, which become purple. Blotches of purple appear on the petals; later, the streaks become white.

Light Blue: Pale-blue streaks alternating with white streaks occur on all petals; later, the two upper petals become blanched.

Lord Beaconsfield: The two upper petals are white with purple streaks on the lavender, heliotrope, and purple flowers.

Prince Henry: Purple and white streaks occur on the two upper petals, which later become blanched on the dark-blue flower.

Breaking in color of the flower petals in varieties of Giant Mastodon pansies are briefly described as follows:

Geneva Giant mixed: Short yellow or white streaks occur in the margin of the petal of the many-colored flowers.

Madame Steele: White streaks or bands appear on the two lateral and the lowest petals. The flowers are malformed.

Sea Blue: Numerous short white streaks develop on all petals.

Vulcano: Yellow alternating with red streaks occur on the petals.

Swiss Giant pansies inoculated with the virus showed the following symptoms on the flowers:

Dark Blue: Short white streaks occur on all petals.

Dark Red: The early flower symptoms consist of a few yellow streaks alternating with dark red; later white streaks alternate with pale-red streaks.

Lake of Thun, or Ullswater: White streaks appear on all petals, and later, blanching occurs on the blue flower with a blue-black center.

Infected Mastodon Jumbo pansies show a wide range of colors, shades, and markings (plate 1). The golden-yellow strains develop yellow streaks which later become white. Infected blue and yellow Jumbo pansies have blue, purple, and yellow bands. The brown pansy shows yellow and brown bands. The purple strain shows pale- and dark-purple streaks. White streaks appear on the petals of the blue strain.

Symptoms on Violas. When Papilio viola was inoculated with the sap expressed from perennial delphinium naturally infected with the celery-calico virus, the earliest foliage symptom was a clearing of the veinlets usually appearing at the base of the youngest leaves (plate 2, *B*) and sometimes spreading to the remaining portion of the leaves (plate 2, *C*). Later small chlorotic circular areas (plate 2, *D*) sometimes appear on the younger leaves. The oldest leaves develop lemon-yellow blotches (plate 2, *E*) which coalesce and spread over the entire leaves (plate 2, *F*). In the advanced stage of the disease, the plants are stunted with short upright stems bearing thick, linear leaves, frequently mottled with dark-green areas.

Of all varieties of violas examined in nurseries, Papilio violas show the most severe breaking in the color of the petals (plate 3, *B*). The flowers are dwarfed and malformed, with numerous white streaks (plate 3, *C*).

An intensive study was made of breaking in the petals of Radio viola. Conspicuous white streaks appear on some flowers (plate 4, *B*), followed by blanching with a few streaks of the normal color of the flower (plate 4, *C, D, E*) and finally the flower becomes pale blue (plate 4, *F*) and then white without streaks. Blotching may appear on some flowers (plate 4, *G, H*), followed by streaking (plate 4, *I, J*), and blanching (plate 4, *K*). The flowers may be dwarfed, malformed, and have white streaks (plate 4, *L*).

In some varieties of violas, the first symptom to appear is white streaks. In other varieties, the streaks are paler than the normal color of the variety. Blotches of white often appear in the normal color. Blanching of the flowers frequently occurs, with pale streaks or bands of the normal color.

A brief description of breaking in varieties of violas inoculated with celery calico follows:

Blue Perfection: White streaks occur on all petals.

Chantreyland: The apricot petals show pale-yellow streaks on the upper and lateral petals.

Heavenly Blue: White streaks appear on the petals; later, the petals become pale blue and then white.

Jersey Gem: A slight breaking in color of the violet-purple petals occurs.

Lilac: White streaks appear on all petals; later, the petals become blanched with purple streaks.

Tufted "Pansy Violet": The flowers are dwarfed.

Papilio: Numerous white streaks develop on the blue petals (plate 3, *B*). The flowers are frequently dwarfed and malformed (plate 3, *C*).

Papilio Violet Lilac: White streaks occur on all blue petals.

Purple King: Pale-purple streaks develop in the pale-purple color of the flower.

Radio: Blotches of white with pale-blue streaks appear on the blue petals (plate 4, *G*, *H*, *I*, *J*, *K*); later, white streaks occur between the veins (plate 4, *B*, *L*) and finally the pale-blue streaks along the veins become broken (plate 4, *C*, *D*, *E*), and then disappear, and the petals become pale blue (plate 4, *F*) or white.

Rose Queen: White streaks and bands occur on all petals.

Royal Blue: Pale-blue streaks develop on the petals.

Recovery of Virus. The celery-calico virus was recovered from experimentally infected varieties of pansies and violas (with one exception) by mechanical inoculation of the extracted, centrifuged juice into celery and cucumbers. (The virus was transferred more readily to cucumbers than to celery.) Jersey Gem violas infected with celery-calico virus developed breaking in color of the flower petals, but numerous attempts made to recover the virus by mechanical inoculation yielded negative results.

WESTERN-CUCUMBER-MOSAIC VIRUS

Western cucumber mosaic occurs only in the interior regions of California and not in the coastal fog belt.

Transmission from Naturally Infected Host Plants. The host plants naturally infected with western-cucumber-mosaic virus include the following plants in four families:

Chenopodiaceae:
- Sugar beet (*Beta vulgaris*)
- Swiss chard (*Beta vulgaris* var. *cicla*)
- Spinach (*Spinacia oleracea*)

Cucurbitaceae:
- Cucumber (*Cucumis sativus*)
- Honey Dew melon (*Cucumis melo* var. *inodorus*)

Solanaceae:
- Tomato (*Lycopersicon esculentum*)

Umbelliferae:
- Celery (*Apium graveolens* var. *dulce*)

Symptoms on Pansies. The symptoms of western cucumber mosaic on pansies and violas cannot be distinguished from those induced by the celery-calico virus. The identity of each virus can only be determined by symptoms produced on other host plants.

A brief description of breaking in color of flower petals in varieties of French bedding pansies follows:

Adonis: The veins of the two upper and two lateral petals are purple with ashy-gray interveinal areas on the pale-blue flowers.

Emperor William: Numerous white streaks develop in the dark navy-blue petals.

King of the Blacks: Usually purple bands alternating with black streaks appear on the petals.

Light Blue: The veins are pale blue, with interveinal white areas; later the upper petals become blanched and all petals are ruffled.

Lord Beaconsfield: The two upper petals become blanched with purple veins, white blotches appear on the two lateral petals with purple veins, and a white blotch appears at the basal central margin, with purple veins near the margin of the basal petal of the lavender, heliotrope, and purple flower.

Prince Henry: The dark-blue flowers usually show diffuse blue streaking or blotches on all petals when severely affected by the disease. Such flowers are dwarfed, and their petals are curled, with the margins rolled inward.

The symptoms on varieties of Giant Mastodon pansies inoculated with the western-cucumber-mosaic virus follow:

Giant Geneva mixed: White streaks appear on the petals of the many-colored flowers.

Light Blue: The upper petals become blanched; on all other petals the veins are pale blue with interveinal white areas. The blossoms are dwarfed with ruffled petals.

Madame Steele: White streaks develop on the petals.

Sea Blue: White streaks are occasionally conspicuous on the lower surface of the flower; other flowers on the same plant may be normal.

Vulcano: Yellow streaks alternating with red streaks occur on the upper two petals.

The symptoms on inoculated Swiss Giant pansies are as follows:

Dark Blue: The petals develop white streaks, and the margins are rolled inward.

Dark Red: Yellow or white streaks appear on the upper and lateral petals.

Lake of Thun: The petals show white streaks and later blanching (plate 5, *H*) on the blue flower with a black center.

Symptoms on Violas. The symptoms on inoculated varieties of violas, briefly described, are as follows:

Blue Perfection: The flowers are dwarfed with white streaks on all petals.

Chantreyland: The upper and lateral petals of this apricot variety fade to a yellow color with a few white streaks on the upper petals.

Heavenly Blue: White blotches followed by white streaks appear on the upper petals and white bands on the lateral petals (plate 5, *B*).

Jersey Gem: The margins of the petals are curled inward, and a few white streaks may appear on the violet-blue petals.

Lilac: White streaks develop on the petals, and later blanching (plate 5, *E, J*).

Papilio: White blotches, streaks, and bands occur on the blue petals. The flowers are dwarfed, with the margins of the petals curled inward. The symptoms induced by the western-celery-mosaic and celery-calico viruses are identical on this variety of viola since all gradations of blotches, streaks, and bands occur on plants infected with these viruses.

Papilio Violet Lilac: White streaks occur on all petals.

Purple King: Dark-purple streaks appear with interspaces or blotches of pale purple. The deep-blue flowers are dwarfed with the two upper and lower petals cupped inward.

Rose Queen: The flowers are dwarfed with short white streaks on the petals.

Tufted "Pansy Violets": The plants are difficult to infect by mechanical inoculation and rarely does a flower show breaking (plate 5, *D, G*). The virus was rarely recovered; only 1 of 30 Zucchini squash plants developed symptoms of western cucumber mosaic with six virus extractions.

Recovery of Virus. The virus of western cucumber mosaic was readily recovered from all varieties of pansies, with the exception of Adonis, by inoculating cucurbits, but difficulty was experienced in recovering the virus

from violas. Although no symptoms were observed on Victoria Blood Red pansy, the virus was recovered. The virus was recovered from all varieties of violas, after many trials with some varieties, and transferred to cucumbers and Zucchini squash.

COMMON CUCUMBER MOSAIC

Common cucumber mosaic is a destructive disease of cucumbers and other host plants in middle western and eastern United States, but is not known to occur in California.

In many of the varieties of pansies and violas tested, no flower symptoms appeared even though repeated inoculations were made with both infected cucumbers and *Nicotiana glutinosa* as sources of virus. The virus was not recovered from such plants.

Symptoms on Pansies. The first symptom to appear on some varieties of pansies and violas is a clearing of the veins and veinlets on the youngest leaves. Later, infected plants are stunted with shortened internodes. The older leaves are mottled and the younger leaves are small and narrow and turn yellow in the later stage of the disease. A brief description of flower breaking in varieties of inoculated pansies follows:

Lord Beaconsfield: The petals show dark-purple streaks with pale-purple bands between them on the lavender, heliotrope, and purple flower.

Madame Steele: Pale-purple streaks develop which appear as white streaks on the lower surface of the petals.

Lake of Thun, or Ullswater: Short white streaks appear on the buds and on all petals after the bud expanded (plate 6, *D*) of the blue flower with a blue-black center.

Symptoms on Violas. A brief description of breaking in inoculated varieties of violas follows:

Chantreyland: The apricot flowers are dwarfed (plate 6, *C*) frequently with pale, yellow, ruffled upper and lateral petals.

Papilio: White streaks appear on upper and lateral pale-blue petals.

Papilio Violet Lilac: White streaks appear on upper and lateral pale-blue petals; the margins are frequently rolled inward.

Heavenly Blue: The blue petals become blanched with a few pale-blue blotches and streaks (plate 6, *B*).

Purple King: Pale-purple blotches and streaks develop in the normal deep-blue color of the flower.

Recovery of Virus. Common-cucumber-mosaic virus was recovered and transferred to cucumbers, to *Nicotiana glutinosa,* or to Turkish tobacco (*N. tabacum*) by mechanical inoculation from only eight varieties of pansies and violas showing breaking as follows: Lord Beaconsfield, Prince Henry, Lake of Thun (Ullswater), Madam Steele, Chantreyland, Papilio, Papilio Violet Lilac, and Purple King. The virus was recovered from Tufted "Pansy Violet", Prince Henry, and Victoria, though they showed no symptoms. Repeated failures were obtained in attempts to recover the virus from the following varieties of pansies which showed breaking: Adonis, Emperor William, Geneva Giant mixed, King of the Blacks, Blue Perfection, and Heavenly Blue.

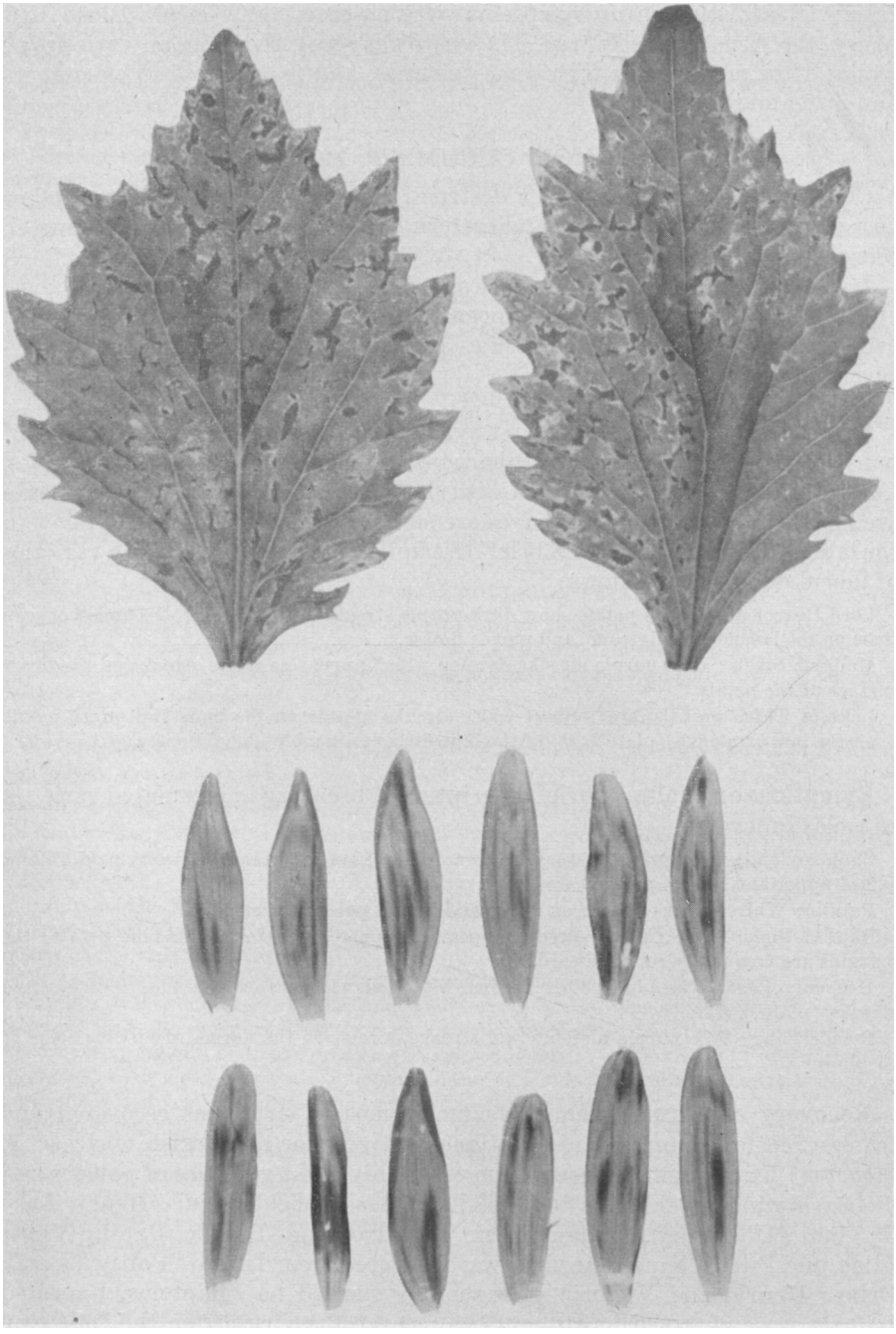

Fig. 1.—China aster (*Callistephus chinensis*) infected with the virus of spotted wilt: upper, leaves showing necrosis; lower, petals showing breaking in color.

VIRUSES CAUSING BREAKING IN OTHER FLOWERS

As reported by Tompkins (1939), the author demonstrated that the false cabbage or turnip aphid, *Lipaphis pseudobrassicae* (Davis) is the vector of mild and severe mosaic viruses in annual stock, or gilliflower (*Matthiola incana* var. *annua*) in nature. Experimental transmission was obtained in greenhouse tests with this species of aphid, and also with the cabbage aphid, *Brevicoryne brassicae* Linneaus, and the green peach aphid, *Myzus persicae* (Sulzer).

The false cabbage or turnip aphid was used in tests to determine whether the mild-mosaic virus induces breaking in violas. Noninfective, mature, wingless aphids reared on mild-mosaic stock plants were transferred in lots of 20 aphids to each of 5 Blue Perfection, 5 Ruby, 5 White Eye violas, and 5 stock plants. Breaking occurred only in the stock plants.

Since the lily aphid, *Myzus circumflexus* (Buckton) is a vector of the celery-calico virus, tests were made with this aphid to determine whether this virus causes breaking in annual stock plants. Mature, wingless aphids reared on Papilio violas infected with celery-calico virus were transferred in lots of 20 aphids to each of 10 healthy stock plants, but no breaking occurred.

The virus extract prepared from stock plants infected with mild mosaic was mechanically inoculated into 5 Blue Perfection violas, 5 Papilio violas, and 5 stock plants. Breaking occurred only in the stock plants.

The virus extract from Papilio violas infected with celery calico was mechanically inoculated in 5 Papilio violas and 5 stock plants. Breaking occurred in the violas but not in stock plants.

Tomato-spotted-wilt virus induced breaking of China asters (*Callistephus chinensis*) (fig. 1), but this virus failed (in mechanical-inoculation experiments) to cause breaking in Papilio violas grown from seeds and Radio violas from cuttings. Celery-calico virus from infected violas failed to induce breaking in China asters.

APHID TRANSMISSION OF VIRUSES

The other paper in this issue (Essig, 1947) discusses the characters, distribution, and food plants of aphid species which have been reported on pansies and violas under natural conditions. Five of these that occur in California were tested to determine whether they transmit celery-calico virus to pansies and violas, and three were tested with western-cucumber-mosaic virus. Some aphids that breed on celery but have not been reported on pansies and violas under natural conditions were also tested for transmission of celery-calico virus.

Vectors of Celery-Calico Virus. The following species of aphids, which have been reported to occur on pansies and violas, or tufted pansies, under natural conditions, were demonstrated to be vectors of the celery-calico virus from infected pansies, violas, and celery to pansies and violas:

Cotton or melon aphid, *Aphis gossypii* Glover
Lily aphid, *Myzus circumflexus* (Buckton)
Foxglove aphid, *Myzus solani* (Kaltenbach)
Violet aphid, *Micromyzus violae* (Pergande)

The celery-calico virus was transmitted from celery to pansies and violas by the following aphid species, which breed on celery under natural conditions (see Essig, 1938):

Celery leaf aphid, *Aphis apigraveolens* Essig
Celery aphid, *Aphis apii* Theobald (*A. helianthi* Monell?)[4]
Rusty-banded aphid, *Aphis ferruginea-striata* Essig
Erigeron root aphid, *Aphis middletonii* Thomas
Yellow willow aphid, *Cavariella capreae* (Fabricius)
Green peach aphid, *Myzus persicae* (Sulzer)
Honeysuckle aphid, *Rhopalosiphum conii* (Davidson)

Vectors of Western-Cucumber-Mosaic Virus. The following species of aphids are vectors of the western-cucumber-mosaic virus:

Cotton or melon aphid, *Aphis gossypii* Glover
Bean or dock aphid, *Aphis rumicis* Linnaeus
Green peach aphid, *Myzus persicae* (Sulzer)

INSECTS WHICH FAILED TO TRANSMIT CELERY-CALICO VIRUS

Severin (1943) reported breaking in color of flower petals of phlox (*Phlox drummondii*) induced by the California aster-yellows virus transmitted by the short-winged aster leafhopper, *Macrosteles divisus* (Uhler) and the long-winged aster leafhopper, a biological race of the same species (Severin, 1940). Tests were made to determine whether either of these could transmit the celery-calico virus. Sixteen lots of 25 or 35 noninfective males of each vector were fed for 2 days on Papilio violas infected with celery-calico virus, and then each lot was transferred to a healthy Papilio viola grown from seeds. No breaking occurred in the 16 plants exposed to the leafhoppers.

CONTROL

Field investigations were carried on for the past twelve years to determine the source of the celery-calico-virus infection in pansies and violas and the spread of this disease in home gardens. Many retail nurseries were visited in the East Bay districts, and it soon became evident that nurserymen who do not spray to control aphids on pansies and violas disseminate the disease to home gardens by selling infected plants. In one retail nursery all of the flats containing Papilio violas showed breaking and the plants were covered with aphids. When the flats were removed from the racks and the violas were allowed to dry in the nursery, the infective aphids spread to pansies, violas, other susceptible ornamental host plants, and weeds. Home gardeners should avoid purchasing pansies and violas showing breaking and aphid infestation.

One nurseryman made cuttings from the perennial Radio viola. An examination of the cuttings in the greenhouse showed breaking in a high percentage. This nurseryman rogued all of the diseased Radio violas grown out of doors and sprayed weekly to control the aphids. The following year not a single cutting showed breaking in the flowers in the greenhouse.

The recommendation for controlling celery calico and western cucumber mosaic in pansies and violas is to spray these plants and susceptible economic

[4] According to E. O. Essig (personal interview), *Aphis apii* may be identical with *A. helianthi*.

plants weekly until the vegetation on the foothills becomes dry, since many species of aphids fly from the foothills. The spray should be applied to the lower surface of the leaves, those which spread on the ground being raised with the fingers. During the summer, spraying can be discontinued, since aphids do not multiply during hot weather. All pansies and violas showing breaking should be rogued and burned. Avoid purchasing pansies and violas showing breaking and aphid infestation.

The insecticide which gave satisfactory results to control aphids was three teaspoons of Black Leaf 40 to a gallon of water, with Volck or soap used as an adherent.

SUMMARY

The symptoms induced by three cucumber-mosaic viruses which cause breaking in color of flower petals of varieties of pansies (*Viola tricolor* var. *hortensis*) and violas, or tufted pansies (*V. cornuta*) are described in this paper. Of these cucumber-mosaic viruses, celery calico and western cucumber mosaic occur in California, but common cucumber mosaic is not known to occur here. Celery calico is common in the coastal fog belt and also occurs in the hot interior regions of California. Western cucumber mosaic occurs only in the interior regions of California and not in the coastal fog belt.

The following species of aphids which have been reported to occur on pansies and violas under natural conditions were demonstrated to be vectors of the celery-calico virus:

Cotton or melon aphid, *Aphis gossypii* Glover
Lily aphid, *Myzus circumflexus* (Buckton)
Foxglove aphid, *Myzus solani* (Kaltenbach)
Violet aphid, *Micromyzus violae* (Pergande)

Infections of pansies and violas with celery-calico virus were obtained with the following aphid species, which breed on celery under natural conditions and also transmit the celery-calico virus to this host plant:

Celery leaf aphid, *Aphis graveolens* Essig
Celery aphid, *Aphis apii* Theobald (*A. helianthi* Monell?)
Rusty-banded aphid, *Aphis ferruginea-striata* Essig
Erigeron root aphid, *Aphis middletonii* Thomas
Yellow willow aphid, *Cavariella capreae* (Fabricius)
Green peach aphid, *Myzus persicae* (Sulzer)
Honeysuckle aphid, *Rhopalosiphum conii* (Davidson)

The following species of aphids have been proved to be vectors of the western-cucumber-mosaic virus:

Cotton or melon aphid, *Aphis gossypii* Glover
Bean or dock aphid, *Aphis rumicis* Linnaeus
Green peach aphid, *Myzus persicae* (Sulzer)

Aphids transmitting the viruses of celery calico and western cucumber mosaic to pansies and violas can be controlled by using a Black Leaf 40 spray.

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Plate 1. Jumbo pansy (*Viola tricolor* var. *hortensis*) naturally infected with celery-calico virus: top row, Golden Yellow strain, the left showing yellow streaks, the right, white streaks; center row, left, blue and yellow pansy with blue, purple, and yellow bands; center row, right, brown pansy with yellow and brown bands; bottom row, left, purple strain showing pale- and dark-purple streaks; bottom row, right, blue pansy showing white streaks on the petals.

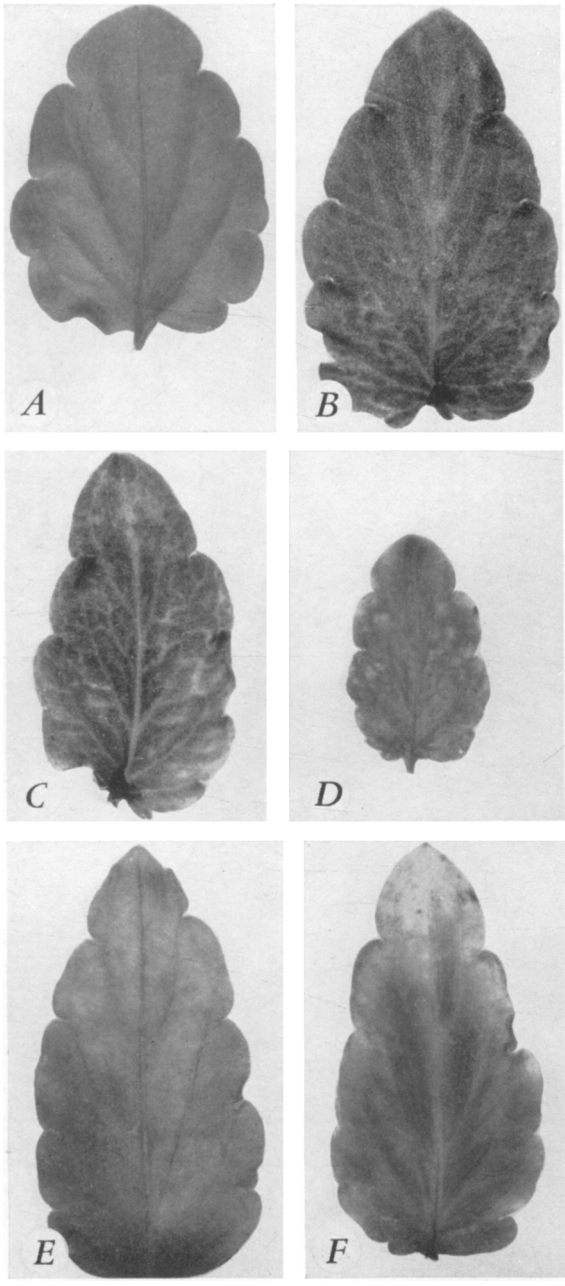


Plate 2. Symptoms of celery calico on the leaves of Papilio viola (*Viola cornuta*): *A*, leaf from healthy check or control plant; *B*, cleared venation on basal half of leaf; *C*, cleared veins and veinlets on entire leaf; *D*, small, chlorotic, circular areas; *E*, yellowing of leaf; *F*, lemon-yellow at tip and margin of leaf.

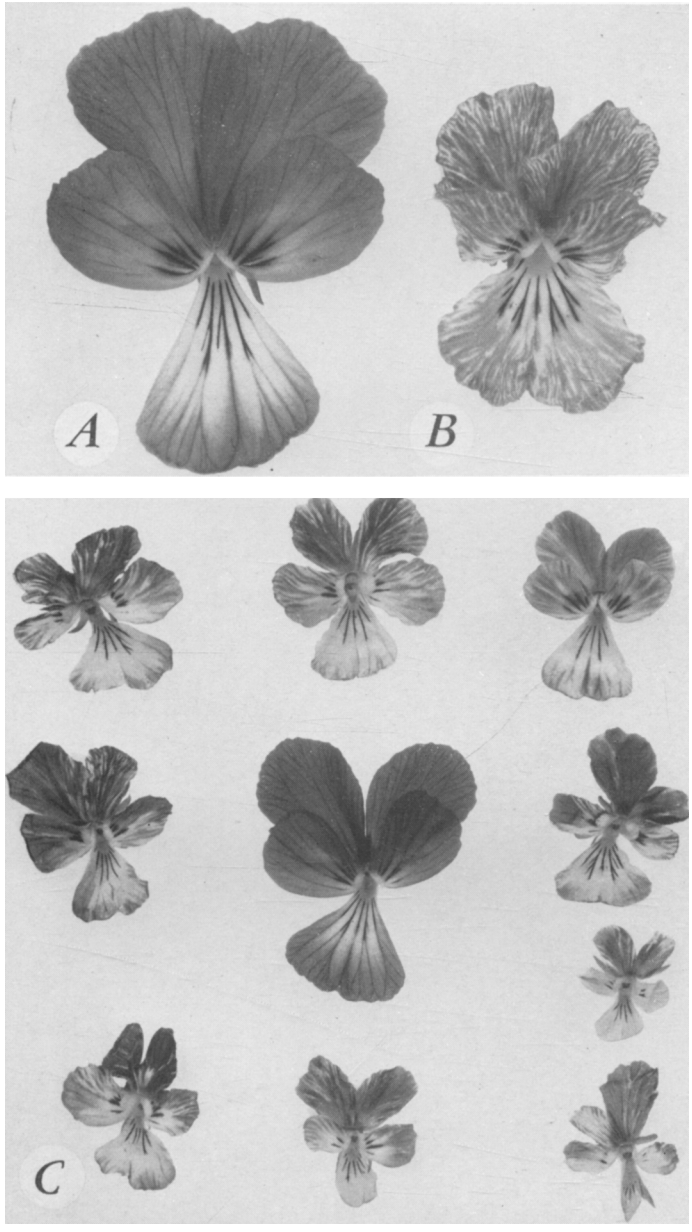


Plate 3. Breaking in color of flower petals of Papilio viola (*Viola cornuta*): *A*, flower from healthy plant; *B*, flower showing white streaks on petals, from a plant inoculated with the virus extract from perennial delphinium naturally infected with celery calico collected at Colma November 6, 1937; *C*, center: normal flower from a healthy plant. Grouped around it are dwarfed flowers showing breaking in the color of the petals, from plants naturally infected with the celery-calico virus. (El Cerrito, May 29, 1935).

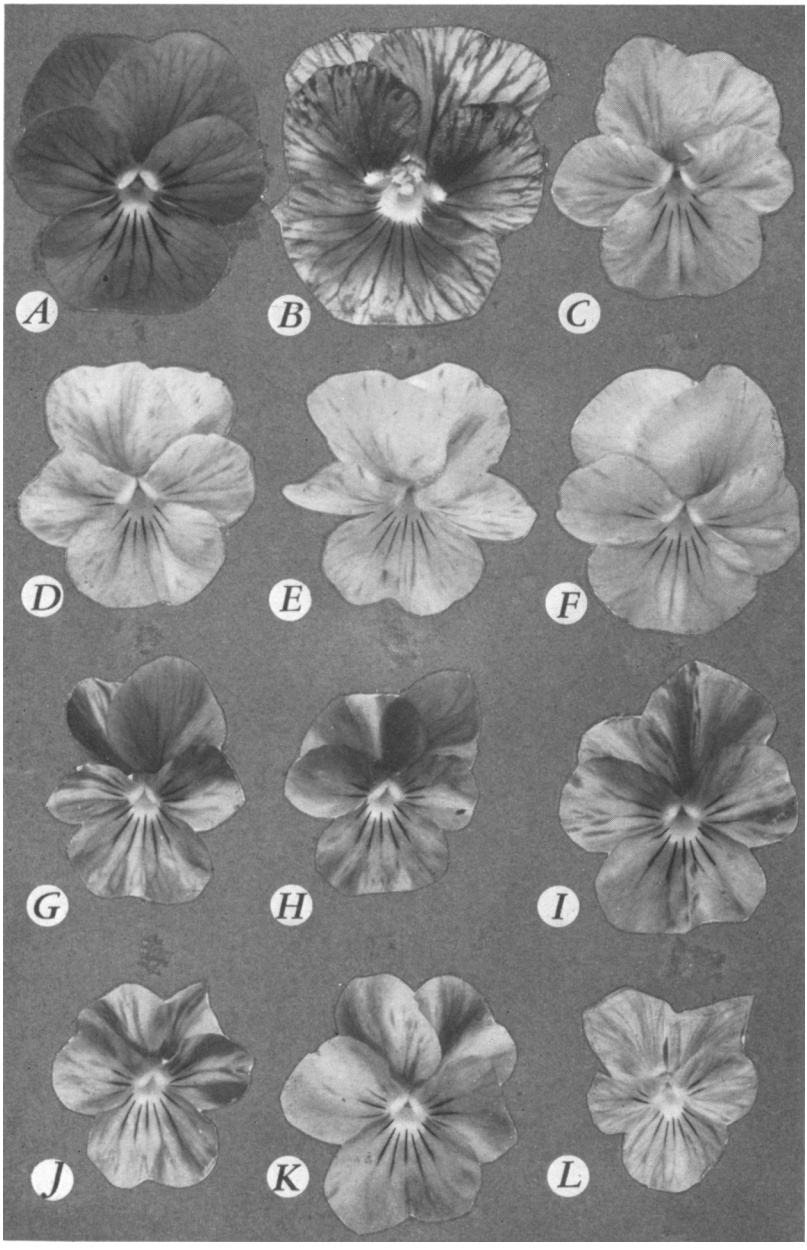


Plate 4. Radio viola (*Viola cornuta*) showing breaking in color of petals from plants naturally infected with celery-calico virus: *A*, flower from healthy plant; *B*, flower showing white streaks; *C*, *D*, *E*, successive stages in blanching with few streaks of normal color of flower; *F*, blanched flower showing no streaks (Berkeley, August 23, 1934); *G*, *H*, *I*, *J*, *K*, blotching and streaking; *L*, dwarfed flower showing white streaks (Berkeley, June 16, 1936).

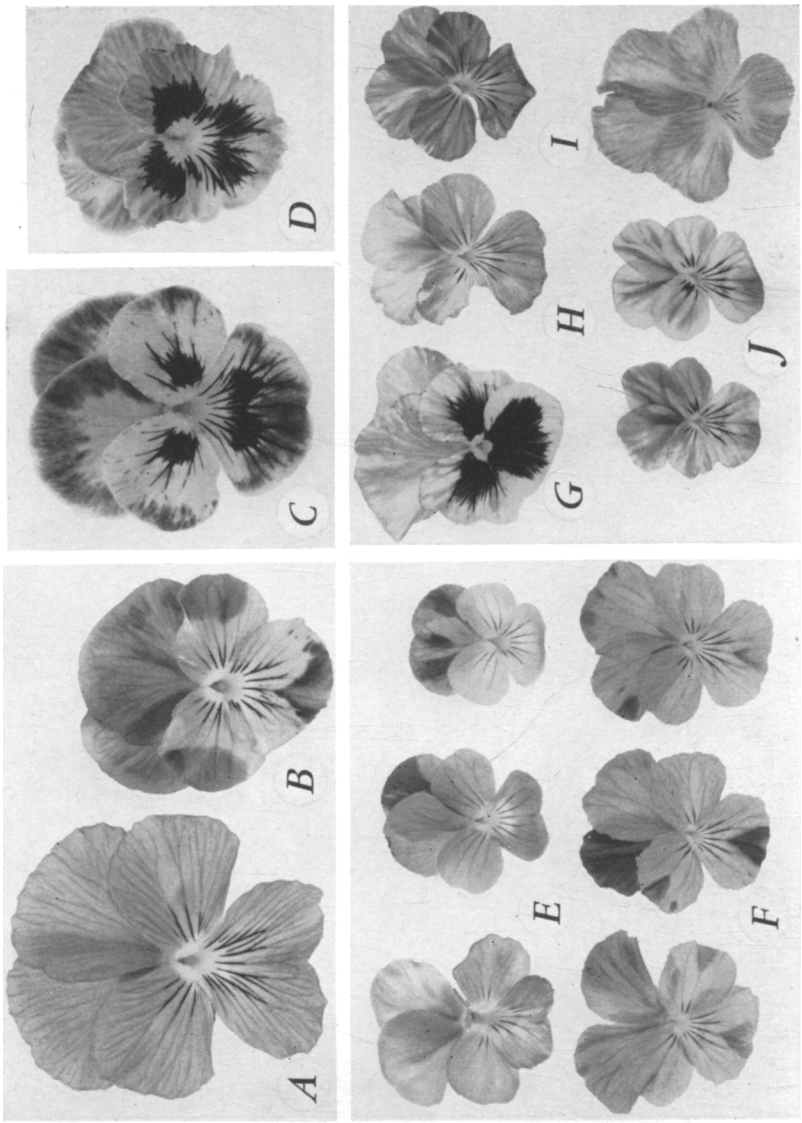
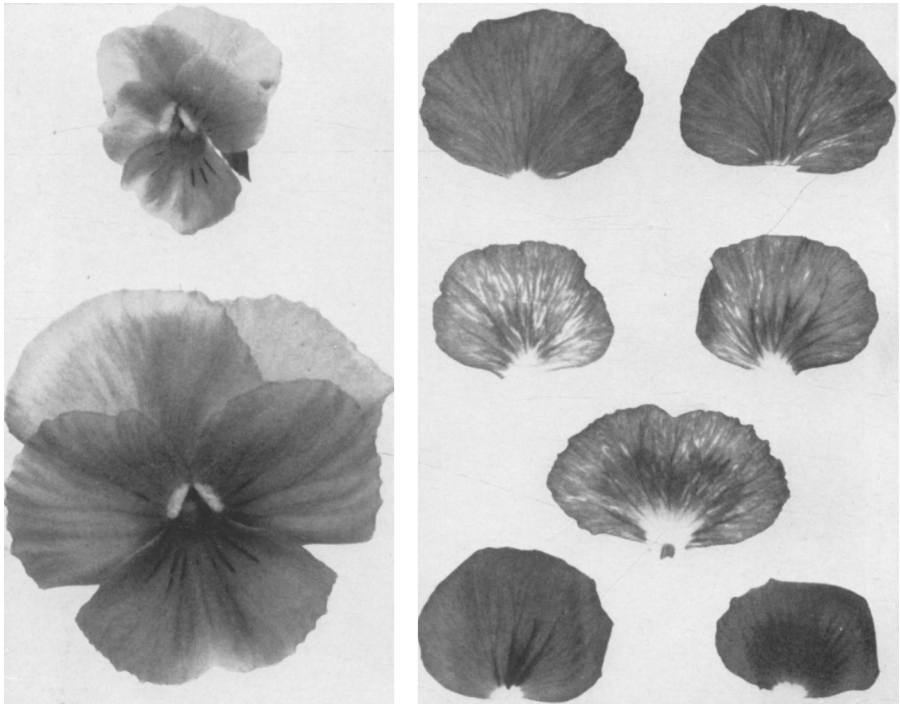


Plate 5. Tufted pansies or violas (*V. cornuta*) showing breaking in color of flower petals induced by western-cucumber-mosaic virus (*B, D, F, G, H, I*) and celery-calico virus (*E, J*). *A, B,* Heavenly Blue viola, *A* showing normal flower from healthy plant and *B,* a dwarfed flower from infected plant with normal, deep-blue color on upper petals and deep-blue blotches and pale-blue center on lateral and lowest petals; *C,* Tufted "Pansy Violet" showing normal flower from check or control plant; *D,* dwarfed flower with irregular margin showing numerous white streaks on petals; *E,* Lilac viola, flowers from plant inoculated with celery-calico virus; *F,* blossoms from plant inoculated with western-cucumber-mosaic virus showing dwarfing and stages of blanching of petals; *G,* Tufted "Pansy Violet" showing white streak and early blanching; *H,* Lake of Thun, or Ullswater pansy, dwarfed flower showing blanching; *I,* normal flower from check or control plant; *J* (lower row), Lilac viola, showing blanching and white streaks.

A *B*



C *D*

Plate 6. Pansy (*Viola tricolor* var. *hortensis*) and tufted pansy, or viola (*V. cornuta*) showing breaking in color of flower petals induced by common-cucumber-mosaic virus: *A*, *B*, Heavenly Blue viola, *A* showing normal flower from healthy check or control; and *B*, blanched petals with a few pale, blue blotches and streaks; *C*, Chantreyland viola, upper, dwarfed flower showing white blotches; lower, normal flower from healthy plant; *D*, Lake of Thun, or Ullswater, pansy, upper five petals showing short white streaks; lower, two petals from check or control plant.