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ADDITIONAL ORNAMENTAL FLOWERING PLANTS NATURALLY INFECTED WITH CALIFORNIA ASTER YELLOWS¹

HENRY H. P. SEVERIN² and JULIUS H. FREITAG³

INTRODUCTION

THE NATURAL infection of some ornamental flowering plants with California aster yellows has already been reported (Severin and Freitag, 1934).⁴ In California, such infection was found on 8 species in 7 genera belonging to 4 families.

Severin (1942a, 1942b) described the symptoms, determined the incubation period of the disease, and reported on vectors of the aster-yellows virus on perennial delphinium and annual larkspur. A later paper (Severin, 1943) dealt with the disease on annual phlox (*Phlox Drummondii*), apparently the first case of a leafhopper-transmitted virus inducing breaking in color of flowers. In a companion paper the symptoms of this disease on vegetable and seed crops have been described (Severin and Frazier, 1945).

Surveys were made from 1934 to 1943 to determine additional host plants. Field investigations were conducted on the ranches of seed companies; on the University Farm at Davis; and in the canyons of the Montara Mountains, where the production of cut flowers is an important industry.

METHODS

A detailed account on methods is given in the third paper of this series (Frazier and Severin, 1944).

HOST RANGE OF VIRUS

The host range of the aster-yellows virus among ornamental flowering plants naturally infected includes 45 species and 1 interspecific hybrid in 38 genera belonging to 17 families, including those previously reported (Severin, 1929, 1942a, 1942b, 1943, Severin and Freitag, 1934). The season's duration of each plant is given in the following list:

Boraginaceae:

Myosotis scorpioides L.,^{*5} true forget-me-not; annual or perennial

Caryophyllaceae:

Dianthus barbatus L., sweet william; perennial

Gypsophila paniculata L.,^{*} baby's-breath; perennial

¹ Received for publication June 12, 1944.

² Entomologist in the Experiment Station.

³ Assistant Professor of Entomology and Assistant Entomologist in the Experiment Station.

⁴ See "Literature Cited" at the end of this paper for complete data on citations, referred to in the text by author and date of publication.

⁵ Asterisk indicates overlapping host ranges of California and New York aster-yellows viruses.

Compositae:

- Chrysanthemum carinatum* L.,* tricolor chrysanthemum; annual; variety Dwarfed Golden Queen
Chrysanthemum segetum L., corn-marigold; annual; varieties Single Eldorado (Severin and Freitag, 1934) and Single Star
Chrysanthemum segetum L. \times *C. carinatum* L., single yellow daisy; annual
Chrysanthemum frutescens L.,* Marguerite; perennial
Rudbeckia hirta L.,* black-eyed Susan; annual or biennial
Helianthus annuus L., common garden sunflower; annual
Cosmos bipinnatus Cav.,* common cosmos; annual; varieties Giant Pink and White
Zinnia elegans Jacq., common zinnia, annual; varieties Dahlia-flowered mixed, Double Giant Pink, and Lilliput Scarlet Gem (Severin and Freitag, 1934)
Coreopsis Drummondii Torr. & Gray, golden wave coreopsis; annual
Coreopsis grandiflora Nutt., bigflower coreopsis; annual
Brachycome iberidifolia Benth.,* Swan River daisy; annual
Callistephus chinensis Nees,* China aster (Severin, 1929); annual
Tagetes erecta L.,* African marigold (Severin and Freitag, 1934); annual
Tagetes patula L., French marigold, dwarf type (Severin and Freitag, 1934); annual
Gaillardia pulchella Foug. var. *Picta* Gray, gaillardia or blanket-flower; annual
Calendula officinalis L.,* pot-marigold; annual; varieties Lemon Queen and Winter Queen
Helichrysum bracteatum Andr., strawflower (Severin and Freitag, 1934); annual
Centaurea americana Nutt., basket-flower; annual
Centaurea Cyanus L., cornflower or bachelor's button; annual

Cruciferae:

- Cheiranthus Cheiri* L., wallflower; perennial

Dipsaceae:

- Scabiosa atropurpurea* L.,* mourning bride or sweet scabious; annual

Labiateae:

- Salvia azurea* Lam. subsp. *Pitcheri* (Torr.) Epl., azure sage; perennial

Onagraceae:

- Clarkia elegans* Dougl.,* clarkia; annual
Godetia grandiflora Lindl., godetia; annual; varieties Double Fairy Lady, Double Rosy Morn, Duke of York, semidwarfed Kelvedon Glory, Sybil Sherwood (Severin and Freitag, 1934), semidwarfed Sherwood, and Tall Single White Swan
Gaura Lindheimeri Engelm. & Gray, white gaura; annual, biennial, or perennial

Papaveraceae:

- Eschscholtzia californica* Cham.,* California poppy (Severin and Freitag, 1934); annual or perennial

Plumbaginaceae:

- Limonium sinuatum* Mill., sea-lavender; biennial or perennial; variety Rose Superba

Polemoniaceae:

- Gilia capitata* Dougl., var. *achilleaeifolia* (Benth.) Mason, globe gilia; annual
Phlox Drummondii Hook.,* Drummond phlox (Severin, 1943); annual

Primulaceae:

- Primula polyantha* Mill., Polyanthus primrose; perennial

Ranunculaceae:

- Ranunculus asiaticus* L., Turban and Persian buttercups (Severin and Freitag, 1934); perennial
Anemone coronaria L., poppy-flowered anemone; perennial
Nigella damascena L., love-in-a-mist; annual
Delphinium cultorum Voss, perennial delphinium (Severin, 1942a); perennial
Delphinium Ajacis L., rocket larkspur (Severin, 1942b); annual

Rosaceae:

Geum chilöense Balb., geum; perennial

Serophulariaceae:

Linaria bipartita Willd., cloven-lip toadflax; annual

Mimulus cardinalis Dougl., crimson monkey-flower; perennial

Mimulus guttatus DC., common monkey-flower; annual or perennial

Solanaceae:

Petunia hybrida Vilm.,* petunia; annual; varieties Common, Dwarf Rose Bedder, Double Ruffled, Rosy Morn, Rosy Morn balcony-type

Salpiglossis sinuata Ruiz. & Pav., painted-glory; annual

Tropaeolaceae:

Tropaeolum majus L., garden nasturtium; annual

Umbelliferae:

Trachymene caerulea R. Graham,* blue lace-flower; annual

In California the virus overwinters in the biennials and perennials and in the adult leafhoppers.

Previously noninfective short-winged aster leafhoppers, *Macrosteles divisus* (Uhl.), and long-winged aster leafhoppers, a race of the same species (Severin, 1940), recovered the virus from naturally infected plants and transferred it to healthy aster or celery plants. The short-winged aster leafhopper was transferred to healthy celery. The long-winged forms were placed on aster, because on celery they often would have died before the so-called "virus-incubation period" could be completed in them.

SYMPTOMATOLOGY

The symptomatology of ornamental flowering plants naturally infected with aster yellows may vary according to the size of the plant when infected. Dwarfing is one noticeable symptom in which the degree of stunting depends upon the initial age of the plant. Shortening of the internodes is characteristic. One constant symptom is the production of axillary, leafy shoots from the bud normally dormant in the axil of each leaf. Another constant symptom is the upright or vertical position of the branches and leaves. Ornamental flowering plants naturally infected can be readily identified in the field by the compact, dense clusters of axillary, chlorotic shoots.

Among economic plants of the family Umbelliferae, curving, twisting, and intertwining of the petioles occur, as described for celery (Severin, 1929), celeriac (Severin and Frazier, 1944), carrots, parsley, and parsnips (Severin, 1932). Thus far these symptoms have not been found on any naturally infected ornamental flowering plant.

The foliage symptoms vary among different species of flowering ornamentals. The first symptom on aster, sea lavender, petunia, salpiglossis, mourning bride, and marigold is a clearing of the veins and veinlets, with a faint yellow vein-banding on the youngest leaves. In most ornamental flowering plants this does not appear. The leaves of infected plants may show an inward or outward rolling of the margin, an inward or outward cupping, a twist or spiral along the long axis, and malformation; often they are asymmetrical.

The most striking symptoms on the flowers of some ornamental plants are phyllody, the tendency of the floral organs to resemble leafy structures; virescence or the greening of the flowers; and proliferation of the flowers.

BORAGINACEAE, BORAGE FAMILY

True forget-me-not (*Myosotis scorpioides*): Infected plants produce numerous upright, axillary shoots with linear leaves. A noticeable symptom is the reddening of the lower leaves while the upper leaves are chlorotic. The flowers are abnormal, dwarfed, green, and densely clustered, sometimes on long pedicels (fig. 1, A, B).

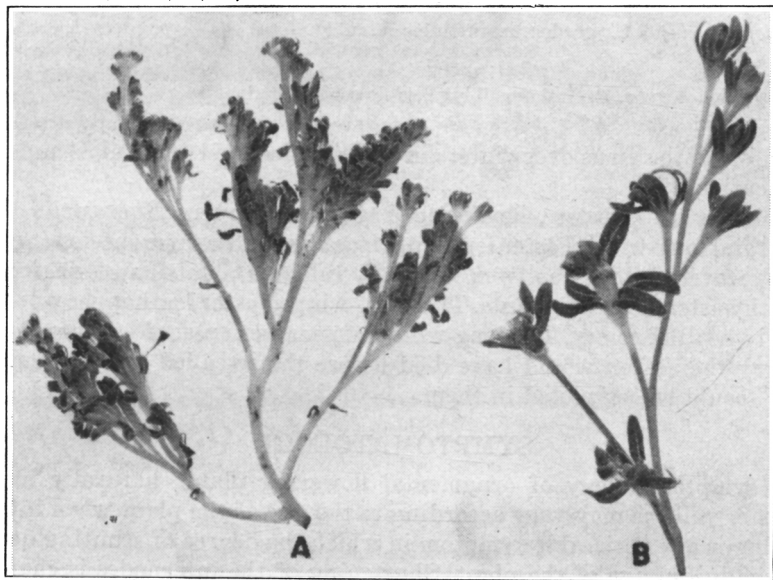


Fig. 1.—True forget-me-not (*Myosotis scorpioides*): A, apical shoot showing dense clusters of abnormal, dwarfed, virescent flowers; B, shoot showing flowers on long pedicels (Salinas, August 20, 1940).

CARYOPHYLLACEAE, PINK FAMILY

Sweet william (*Dianthus barbatus*): Plants are stunted; internodes shortened (plate 1, C); stems twisted and deformed; axillary shoots dwarfed, twisted, and chlorotic (plate 1, C). Young leaves are yellow and cupped inward toward the midrib (plate 1, C); flower buds are reduced; bracts are stiff and upright; sometimes the bud dries prematurely.

Baby's-breath (*Gypsophila paniculata*): Naturally infected plants are stunted, with numerous axillary shoots that form dense clusters (plate 2, C). Virescence, phyllody, and proliferation of the flowers occur (plate 2, B). The calyx is enlarged (plate 2, B), and the petals are reduced (plate 2, C).

COMPOSITAE, COMPOSITE FAMILY

Tricolor Chrysanthemum (*Chrysanthemum carinatum*): Infected plants of the Dwarf Golden Queen variety are stunted, with curved stems; the compact clusters of axillary shoots have dwarfed, green flower buds; flowers are

sessile and green, frequently have few or no rays, and are surrounded by a rosette of chlorotic leaves with curved petioles.

Corn-marigold (*Chrysanthemum segetum*): The symptoms on infected

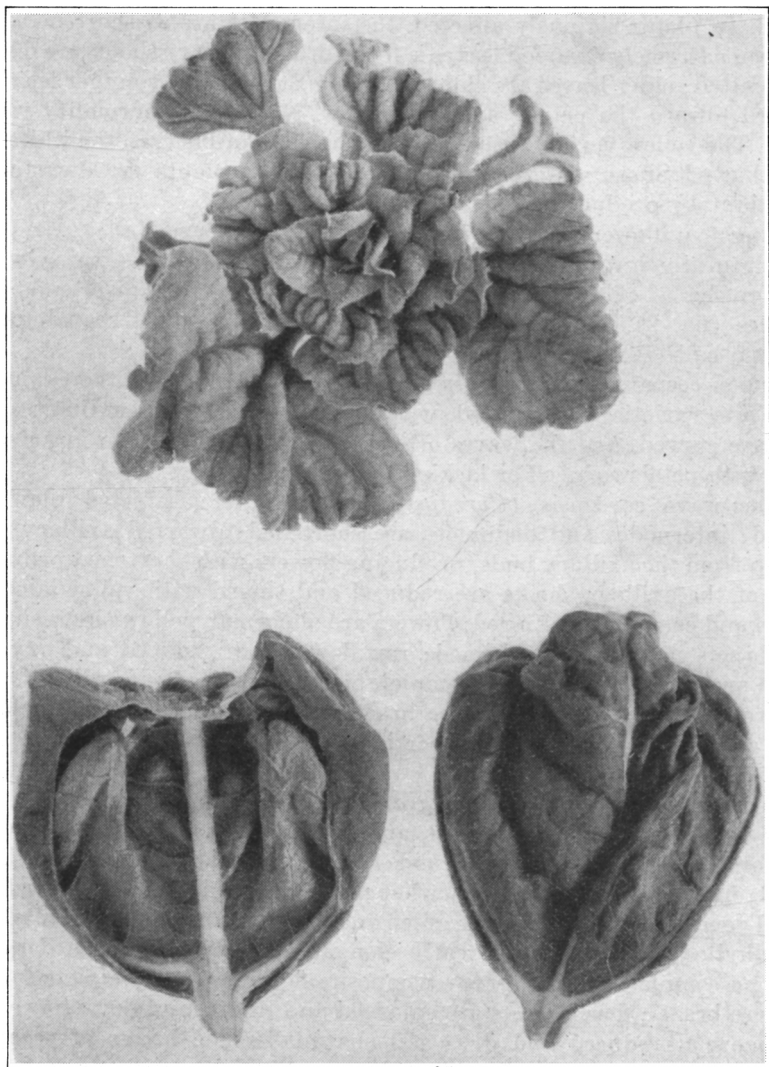


Fig. 2.—Common sunflower naturally infected with aster yellows: upper, cluster of chlorotic, outward-cupped leaves on the apical end of the branch; lower, extreme inward cupping of leaves, resembling a ball.

plants of the Single Eldorado and Single Star varieties are similar to those just described (plate 2, *D*).

Single yellow daisy, an interspecific hybrid with characters of *Chrysanthemum segetum* predominating, but with winged achenes of *C. carnatum*: The symptoms resemble those on tricolor chrysanthemum. Axillary flower buds

are sessile or they have short peduncles which are surrounded by curved or twisted leaves (plate 3, A).

Marguerite (*Chrysanthemum frutescens*) : Sometimes infected plants show symptoms on one branch or a portion of the plant and the remainder appears normal. In plants seriously affected, the internodes are so shortened that a rosette of extremely dwarfed leaves is formed. The axillary shoots are dwarfed and rosetted; older leaves are chlorotic along the margin; younger leaves roll outward toward the petiole and are yellow. No floral abnormality was observed. The yellow variety seemed to be more susceptible than the white.

Black-eyed Susan (*Rudbeckia hirta*) : Infected plants are dwarfed and chlorotic; they produce malformed, virescent flowers.

Common sunflower (*Helianthus annuus*) in the Castro Valley was proved to be naturally infected with aster yellows. Infected plants were dwarfed, with bunches of chlorotic, outward-cupped leaves on the apical ends of the branches (fig. 2). The cupping sometimes continues until each bunch resembles a ball (fig. 2).

Common cosmos (*Cosmos bipinnatus*) : Infected plants of the Giant Pink and White varieties are stunted, with chlorotic apical and axillary shoots; stems are curved, and the leaves often curl down; flowers are dwarfed and green, with petals reduced or lacking (plate 3, F).

Golden-wave coreopsis (*Coreopsis Drummondii*) : Infected plants are stunted; internodes and peduncles are shortened; dwarfed axillary shoots develop from the axillary buds, producing flowers with shortened peduncles; leaves of the axillary shoots are reduced and tinged with yellow along the margin and commonly with red; flowers are abnormal, yellowish green; involucre bracts usually are enlarged; ray flowers are reduced and dry; disk flowers are transformed into a complete new composite head, which is sometimes repeated to three series; the bracts of receptacle are much enlarged, green, and linear; and the achene portion of normal flower becomes elongated into a peduncle.

Bigflower coreopsis (*Coreopsis grandiflora*) : Axillary shoots of infected plants are dwarfed; stems, petioles, and young leaves are chlorotic; pedicels are chlorotic, somewhat shortened, and occasionally twisted, sometimes slightly curved; involucre bracts are somewhat reduced and flattened outward, with cleared venation; the involucre is green and loosely opened; individual flowers show phyllody; achenes are greatly elongated to form a flattened pedicel, bearing a complete minute, green, composite flower with a complete series of involucre bracts; floral bracts are enlarged and linear, and dry early; petals are somewhat reduced and dry; stamens unaffected; bracts of receptacle elongated, enlarged, and leaflike; ray flowers reduced, green, and leafy.

Swan River daisy (*Brachycome iberidifolia*) : Infected plants are stunted and chlorotic, with thin, axillary shoots; leaves are dwarfed, and flower buds yellowish.

Gaillardia, or blanket-flower (*Gaillardia pulchella* var. *picta*) : Healthy plants grow 12 to 20 inches high; but infected plants are dwarfed, with chlorotic, upright leaves. Virescence of the flowers occurs.

Pot-marigold (*Calendula officinalis*) : Plants shown to be naturally infected with aster yellows are stunted. On the Lemon Queen variety, veins and vein-

lets are clear, with yellow veinbanding on the youngest leaves (plate 4, *C*); flowers and flower buds are dwarfed and green (plate 2, *E*). On the Winter Queen variety the symptoms are short, chlorotic, axillary shoots having thick, dwarfed, curled leaves; flower buds are green.

Basket-flower (*Centaurea americana*): Infected plants are stunted, chlorotic, with numerous axillary shoots, which frequently have dwarfed, curved leaves; flowers are often reduced and fail to expand.

Cornflower, or bachelor's-button (*Centaurea Cyanus*): Infected plants are stunted, the stems spindling and upright; enormous numbers of axillary

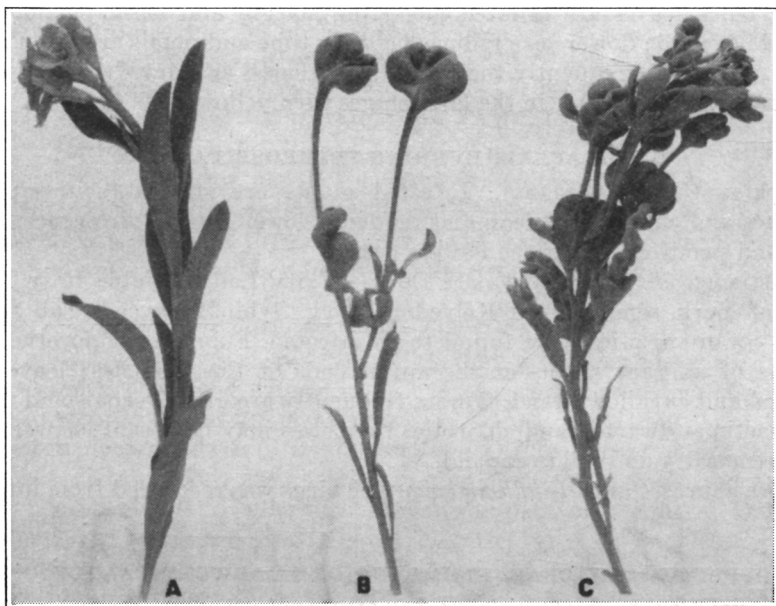


Fig. 3.—Wallflower (*Cheiranthus Cheiri*): *A*, shoot from a healthy plant showing normal flowers; *B*, *C*, shoots from naturally infected plants, showing flower organs replaced by green, leafy, orbicular structures, with long peduncles (Union Island, May 1, 1929).

shoots produce a broomlike appearance; flower production is inhibited; flower buds are very small, almost vestigial, and become dry and scarious before expanding.

CRUCIFERAE, MUSTARD FAMILY

Wallflower (*Cheiranthus Cheiri*): The most noticeable symptoms are virescence, phyllody (fig. 3, *B*, *C*), and proliferation of the flowers. Proliferated flowers often terminate in green, orbicular, leafy structures.

DIPSACEAE, TEASEL FAMILY

Mourning bride (*Scabiosa atropurpurea*): Plants are stunted (plate 5, *D*), with the main and floral stems and peduncles twisted and occasionally curling; the axillary shoots bear dwarfed, chlorotic leaves (plate 3, *D*); virescence and phyllody of the flowers occur; the calyx and corolla tube are elongated; enlargement of the flowers produces a long, loose flower head (plate 3, *C*, *E*).

LABIATAE, MINT FAMILY

Azure sage (*Salvia azurea* subsp. *Pitcheri*): The apical shoots are chlorotic; the axillary shoots bear linear, chlorotic leaves.

Petunia (*Petunia hybrida*): Dwarf Rose Bedder, Double Ruffled, Common, Rosy Morn, and Rosy Morn balcony-type, all were found to be naturally infected. Plants are stunted, with shortened internodes; axillary shoots are dwarfed and chlorotic, with twisted stems; young leaves are dwarfed, chlorotic, and cupped inward (plate 5, *C*), and show cleared venation banded with green; older leaves are bronzed along the margin and basal portion, and cupped outward; flowers are reduced, corolla tube and petals are often green (plate 5, *C*), and frequently the corolla is withered and dry. Infected plants are often deep green, but in the later stages turn yellow.

ONAGRACEAE, EVENING-PRIMROSE FAMILY

Clarkia (*Clarkia elegans*): Infected plants are stunted, with upright branches and chlorotic, apical, and reddened lower leaves; virescence, phyllody, and proliferation of the flowers occur.

Godetia (*Godetia grandiflora*): Double Fairy Lady, Double Rosy Morn, Duke of York, semidwarfed Kelvedon Glory, Sybil Sherwood, Tall Single White Swan varieties were found to be infected. Plants are chlorotic, with clusters of axillary shoots at the apical ends of the branches; leaves are dwarfed and curl downward; flowers frequently are green; sepals and petals are sometimes dwarfed and chlorotic; the petals may be absent; flower buds may become dry and fail to expand.

White gaura (*Gaura Lindheimeri*): The virus was recovered from infected plants.

PLUMBAGINACEAE, PLUMBAGO OR LEADWORT FAMILY

Sea-lavender (*Limonium sinuatum*): Infected plants of the variety Rose Superba are stunted, with upright leaves and numerous chlorotic axillary shoots (plate 5, *A*); youngest leaves show clearing of the veins (plate 4, *A*); the older leaves are reddened and cupped inward, with the petioles bent down (plate 5, *A*); the flowers are dwarfed, malformed, and virescent.

POLEMONIACEAE, PHLOX FAMILY

Globe gilia (*Gilia capitata* var. *achilleaefolia*): Naturally infected plants are chlorotic, with the axillary shoots dwarfed, curved, twisted, and spindling; the leaves reduced and chlorotic; the pinnules needlelike, tending to assume an upright position. Flowers are placed individually along a very loose umbel-like floral branch; they may have long peduncles instead of forming dense, globose, headlike clusters as in healthy plants; they are usually reduced and green, and often the buds dry prematurely.

PRIMULACEAE, PRIMROSE FAMILY

Polyanthus primrose (*Primula polyantha*): Infected plants are stunted, with numerous axillary shoots; leaves are yellow, and the youngest leaves linear; the flowers are green, with shortened peduncles (plate 4, *D*).

RANUNCULACEAE, CROWFOOT FAMILY

Poppy-flowered anemone (*Anemone coronaria*): Plants are stunted and chlorotic. The youngest leaves are dwarfed, with shortened petioles; sometimes the blades are reduced to small, curved, clublike expansions of the petioles. The older leaves are chlorotic and curl outward. Virescence (greening) of both single and double flowers is common, with a rosette of involucre bracts below the flowers (plate 4, B).

Love-in-a-mist (*Nigella damascena*): Infected plants develop dense clusters of axillary shoots (plate 5, B). The smaller plants have dwarfed, chlorotic leaflets; the larger ones bear a tuft of axillary shoots at the apical end of the branches, and often their flower buds fail to expand.

ROSACEAE, ROSE FAMILY

Geum (*Geum chilense*): Plants naturally infected with aster yellows develop dwarfed, chlorotic shoots from the crown, with spindling, chlorotic leaves that show slightly cleared venation. On affected blossom-bearing shoots the flowers are dwarfed, the petals green and leaflike, the stamens often reduced, the sepals enlarged and leafy, and the peduncles chlorotic.

SCROPHULARIACEAE, FIGWORT FAMILY

Cloven-lip toadflax (*Linaria bipartita*): The virus was recovered by previously noninfective long-winged aster leafhoppers and transferred to asters. No notes were taken on the symptoms.

Crimson monkey-flower (*Mimulus cardinalis*): The basal stems of the plant are affected; internodes are shortened; tips of affected stems and axillary shoots are stunted and chlorotic; the apical part of the plant shows no symptoms; the leaves are dwarfed and chlorotic.

Common monkey-flower (*Mimulus guttatus*): The virus was recovered from infected plants by short-winged and long-winged aster leafhoppers and transferred to healthy aster or celery. The symptoms were not recorded.

SOLANACEAE, NIGHTSHADE FAMILY

Painted-glory (*Salpiglossis sinuata*): Infected plants are dwarfed, with chlorotic, axillary shoots; petioles are often bent downward; leaves are cupped inward and sometimes show clear veins and veinlets.

TROPAEOLACEAE, TROPAEOLUM FAMILY

Garden nasturtium (*Tropaeolum majus*): Young infected plants assume an upright habit of growth, with cupped leaves; internodes of older plants are shortened; younger leaves and buds are minute near the apical end of the stems; axillary shoots are dwarfed and chlorotic, with curved or twisted stems; older leaves are reduced and cupped inward, with margins rolled inward; petioles are elongated; virescence and phyllody of the flowers occur (fig. 4); the calyx is sometimes reduced; the petals are cupped, leafy structures at the apical ends of flattened stalks (fig. 4); the stamens are often elongated, and are sometimes vestigial; and the gynoecium is enlarged and clublike (fig. 4).

UMBELLIFERAE, PARSLEY FAMILY

Blue lace-flower (*Trachymene caerulea*): Infected plants are stunted and chlorotic; peduncles are shortened and curved (plate 6, *B*), with apical stems bearing dwarfed green flowers; the axillary shoots (plate 6, *A*) have rosettes of leaves, often purple, below the virescent flowers (plate 6, *E*); pedicels are elongated, and the petals cupped inward (plate 6, *D*); often the flower buds become dry and fail to expand.

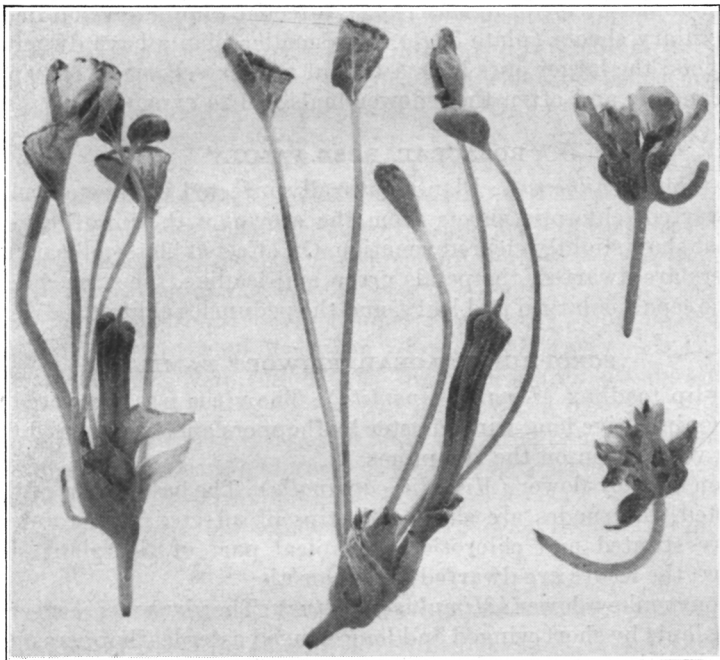


Fig. 4.—Garden nasturtium (*Tropaeolum majus*): flowers showing phyllody, the replacement of flower parts with leaflike structures; carpels greatly elongated, and flowers green (Salinas, August 16, 1939).

**HOST-RANGE DIFFERENCES OF CALIFORNIA AND
NEW YORK ASTER YELLOWS**

Garden nasturtium (*Tropaeolum majus*), of the family Tropaeolaceae, was naturally infected with California aster yellows. Neither this nor any other species of this family was listed by Kunkel (1931) as a host of the New York aster yellows. *Zinnia elegans* was shown to be naturally infected with the California aster-yellows virus, but according to Kunkel (1931) the New York aster-yellows virus was not transmitted to this species of flowering plant.

Kunkel (1926-1931) reported for the virus of New York aster yellows a host range including 184 species in 151 genera belonging to 38 families. Among ornamental flowering plants 168 species were experimentally infected, but only 6 species were found to be naturally attacked. The viruses of California and New York aster yellows have overlapping host ranges that include 15 species in 9 families, indicated by asterisks in the list (pages 599-601).

SUMMARY

Among ornamental flowering plants in California, 45 species and 1 inter-specific hybrid in 36 genera belonging to 17 families have been shown to be naturally infected with aster yellows. Previously noninfective short-winged and long-winged aster leafhoppers recovered the virus from the naturally infected plants and transferred it to healthy aster or celery.

The symptoms on flowering ornamentals naturally infected vary according to the size of the plant when infected. Noticeable symptoms include stunting; shortening of the internodes; production of axillary shoots from the bud normally dormant in the axil of each leaf; upright or vertical position of the leaves and stems; cleared venation; cupping, twisting, and chlorosis of the leaves. The most striking symptoms are phyllody, the tendency of the floral organs to resemble leafy structures; virescence of the flowers; and proliferation of the flowers.

ACKNOWLEDGMENT

We are indebted to Dr. H. L. Mason and the late Miss Ethel Crum, Botany Department, University of California, for determining the species and varieties of ornamental flowering plants.

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PLATES

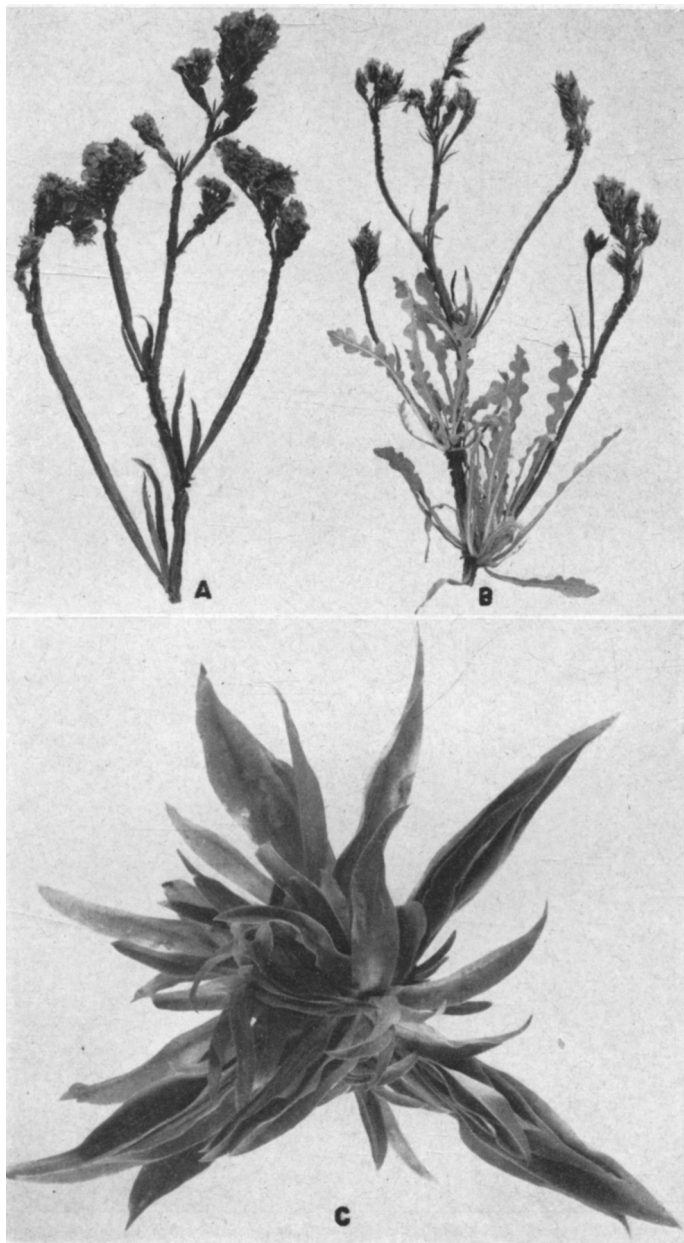


Plate 1.—A, B, Sea-lavender (*Limonium sinuatum*), Rose Superba variety: A, shoot from a healthy plant; B, shoot from a diseased plant, showing basal upright, chlorotic leaves and dwarfed, abnormal, green flowers. C, sweet william (*Dianthus barbatus*): apical branch showing shortened internodes, twisted stems, and deformed, twisted, chlorotic, axillary shoots bearing yellow leaves cupped inward toward the midrib (Montara, August 9, 1934).



Plate 2.—A—C, Baby's-breath (*Gypsophila paniculata*): A, shoots from healthy plant with normal flowers; B, shoots from infected plant, showing dwarfed green flowers with enlarged calyxes; C, stem from diseased plant with numerous axillary shoots bearing abnormal, green flowers and elongated sepals, petals, and pistils (Montara, October 13, 1936). D, Corn-marigold (*Chrysanthemum segetum*): center, normal flower; grouped around it, four dwarfed, green flowers, ray florets reduced or lacking (Montara, November 8, 1934). E, Pot-marigold (*Calendula officinalis*), Lemon Queen variety: center, normal flower; grouped around it, six dwarfed abnormal, green flowers (Montara, August 9, 1934).

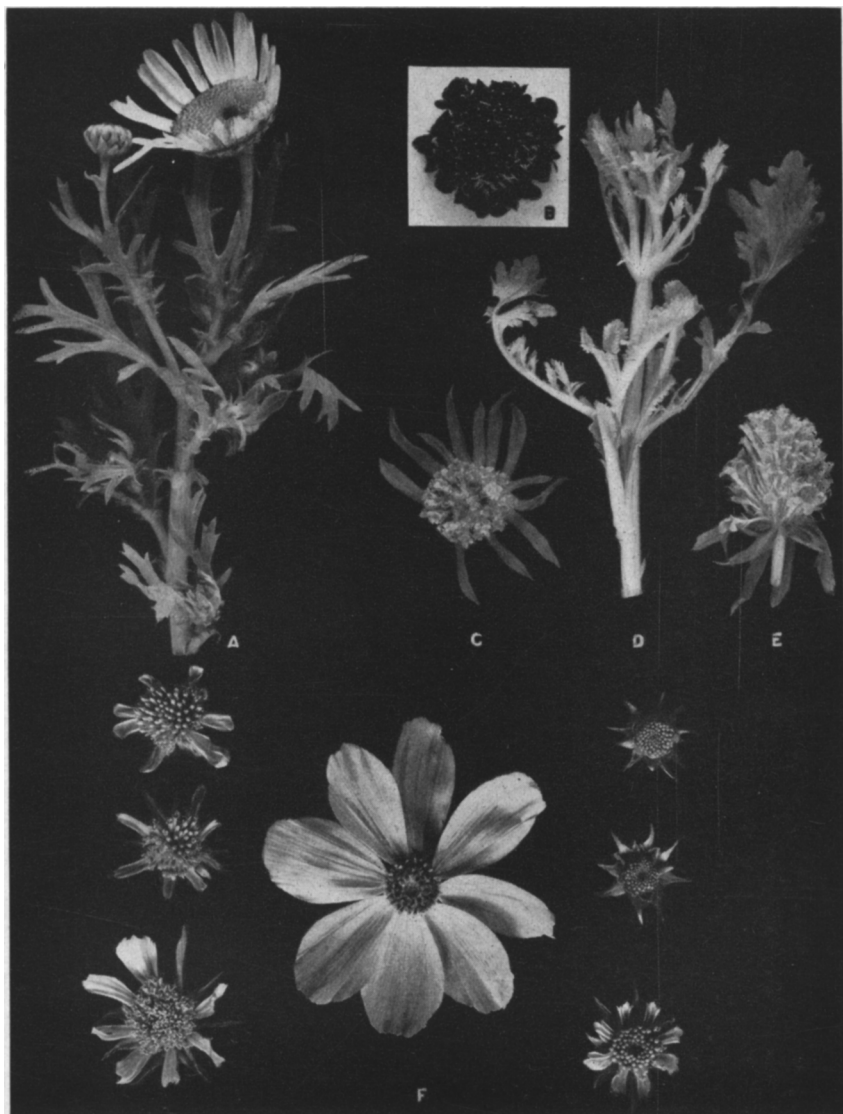


Plate 3.—A, Single yellow daisy (*Chrysanthemum segetum* \times *C. carinatum*): branch showing axillary, sessile flower buds, or short peduncles surrounded by curved or twisted leaves (Montara, November 8, 1934). B–E, Mourning bride (*Scabiosa atropurpurea*): B, normal flowers from healthy plant; C, E, abnormal flowers with pedicels elongated; D, apical, chlorotic branch showing axillary shoots and curved leaves, flower heads chlorotic or white, with elongated pedicels (Montara, September 24, 1935). F, Common cosmos (*Cosmos bipinnatus*), Giant Pink variety: center, normal flower from healthy plant; grouped around it, six dwarfed, green flowers with or without petals (Montara, July 31, 1934).

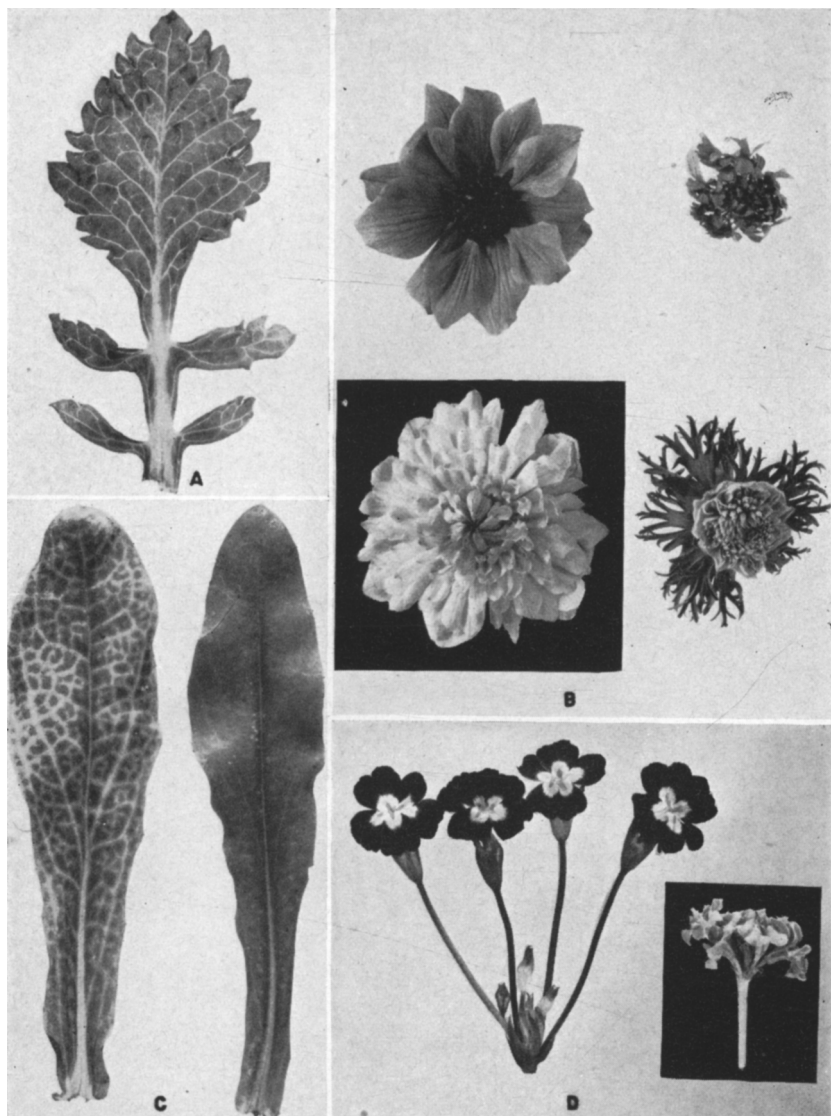


Plate 4.—A, Sea-lavender (*Limonium sinuatum*), Rose Superba variety: youngest leaf, showing clearing of the veins (San Bruno, April 19, 1944). B, Poppy-flowered anemone (*Anemone coronaria*): left, single and double flowers from healthy plants; right, virescence or greening of single and double flowers with rosettes of involucre bracts below the flowers (Half Moon Bay, November 8, 1934). C, Pot-marigold (*Calendula officinalis*), Lemon Queen variety: left, leaf showing cleared venation; right, leaf from healthy plant (Montara, August 9, 1934). D, Polyanthus primrose (*Primula polyantha*): left, cluster of flowers from a healthy plant; right, green flowers with shortened peduncles (Montara, October 13, 1936).

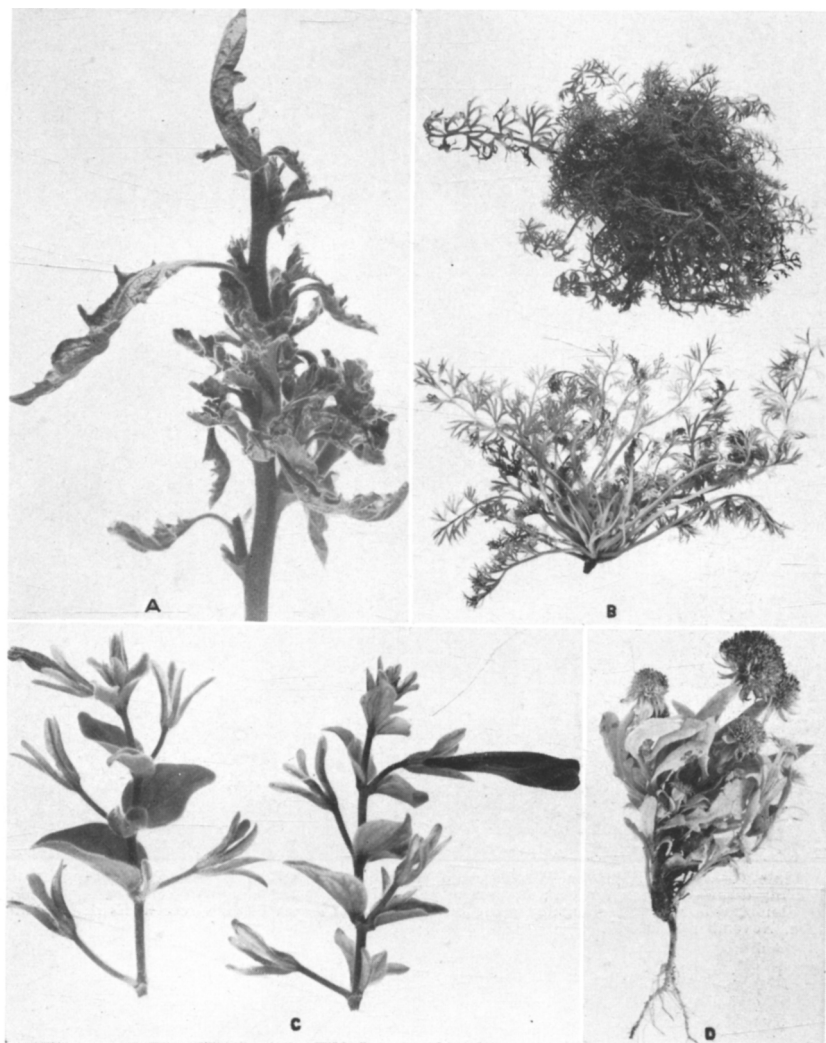


Plate 5.—*A*, Sea-lavender (*Limonium sinuatum*), Rose Superba variety: apical branch showing axillary shoots; older leaves cupped inward, and petioles bent down (Montara, September 24, 1935). *B*, Love-in-a-mist (*Nigella damascena*): two plants showing dense clusters of axillary shoots (Half Moon Bay, October 13, 1936). *C*, Petunia (*Petunia hybrida*), Rosy Morn balcony type: virescent flowers, mostly with sepals but no corolla tube (Salinas, July 28, 1943). *D*, Mourning bride (*Scabiosa atropurpurea*): stunted plant with apical and axillary chlorotic shoots (Montara, September 24, 1934).



Plate 6.—Blue lace-flower (*Trachymene caerulea*): A, apical stem with axillary shoots bearing dwarfed, green flowers; B, curved peduncles; C, normal flower from healthy plant; D, abnormal flower with elongated pedicels; E, rosette of leaves below virescent flowers (Montara, November 8, 1934).