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STUDIES ON HOST PLANTS OF THE LEAFHOPPERS OF THE GENUS EMPOASCA

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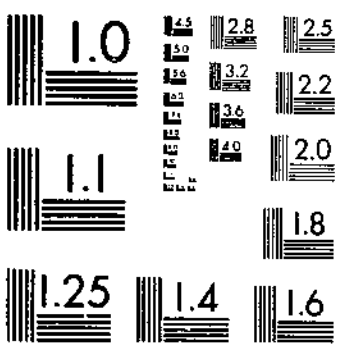

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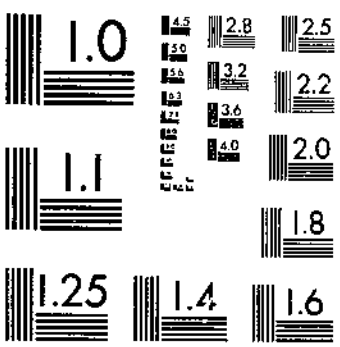

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Studies on Host Plants of the Leafhoppers of the Genus Empoasca[1]

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INTRODUCTION

The genus *Empoasca* contains a number of leafhoppers of much economic importance in the United States as pests of certain essential

[1] Submitted for publication June 15, 1942.

[2] The writers are greatly indebted to J. W. Scrivener for much assistance with details reported in this paper; also to S. F. Blake, C. O. Erlanson, and others of the Bureau of Plant Industry, Soils, and Agricultural Engineering, for identifying plants and verifying technical names. Acknowledgment is also made to the Divisions of Drug and Related Plants, Forage Crops and Diseases, and Fruit and Vegetable Crops and Diseases, of that Bureau, for permitting observation on a wide variety of available plant species grown at Arlington Experiment Farm.

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crops. Species belonging to this genus cause material losses of such staple forage crops as alfalfa, clover, cowpeas, and soybeans, and thus add to the difficulty of meeting our wartime needs for meat and dairy products. They are also important pests of such wartime essentials as potatoes, beans, fruits, cotton, and peanuts. Information on the identity, distribution, and host plants of these economically important insects is thus of direct aid in devising and applying measures for their control and in meeting the current demand for increased production of food, fiber, and oils.

In foreign countries at least 10 species of the genus *Empoasca* injure cotton and are listed as serious or major pests of this important crop. Four of these species are injurious to castor beans, the source of an important oil. One of these foreign species, easily confused with *E. fabae* and closely related species, is also considered a major pest of tea and is injurious to sugarcane, sugar beets, potatoes, orange and other fruit trees, and has caused a scarcity of mulberry leaves in sericulture. Most of these species breed on a number of plants, including wild host plants, and are found abundant on weeds.

Some species of this genus have been reported as vectors of plant diseases, and others have been suspected as potential vectors of certain virus diseases in various parts of the world. A knowledge of the distribution and host plants of the species of this genus, thus involved or suspected, is therefore of inestimable aid in the control of such diseases.

From an economic standpoint, the potato leafhopper, *Empoasca fabae* (Harris), is the most important species of the genus in the United States because of the severe damage it causes to many truck and garden crops, as well as to many forage-crop legumes and to a wide variety of nursery stock and other plants of economic importance. Several of the closely related congeneric species also have been observed to injure various kinds of plants under a wide variety of conditions.

Many host plants of the potato leafhopper are now being tested as cover crops in connection with soil conservation practices involving strip cropping and the use of suitable cover crops for various types of conditions. It is often of much aid in cropping methods to be able to locate certain crops at suitable distances from other susceptible crops which are host plants of species belonging to the genus *Empoasca*. Information on the distribution and host plants of the economically important potato leafhopper and other closely related species of the genus *Empoasca* is, therefore, of real practical value.

During the course of studies on the biology and control of the potato leafhopper on forage-crop legumes it became necessary to know

the identity of the various species of *Empoasca*[3] which closely resemble *fabae* and to study carefully their various host plants and the distribution of the different species of *Empoasca involved*. In this work much special technique had to be developed, because the species are so small and extremely active, and because most of them cannot be definitely differentiated by morphological characters except by examining structures within the abdomen of the male, more especially in the male genital chamber. The basic observations for this paper were made largely at the Arlington Experiment Farm, Arlington, Va., during the period 1929 to 1941, inclusive, and included the identification of more than 50,000 male specimens of *Empoasca*.

Prior to 1931 (*24*)[4] much confusion existed as to the identity of many of the common species of this genus, and therefore much of the earlier literature dealing with their host plants is of doubtful accuracy. A comprehensive search has been made, however, for all available references in the literature of *Empoasca*, and effort has been made to list only authentic records of occurrence or distribution of the various species. Wherever possible, particularly with the domestic species, these have been verified from specific identifications of material procured from various sources and collected by many individuals. Host plants from which the various species have been reared are distinguished from plants upon which adults of the various species of *Empoasca* were merely collected.

The plants upon which adults were collected are considered of importance only insofar as they may provide an indication as to host plants upon which the species may feed or may be reared. Such plants may be of no great significance for two reasons: (1) Adults of many species of *Empoasca* feed on or are collected on many plants in which they do not deposit their eggs; (2) in no instance have adults been observed causing any appreciable damage to plants unless eggs had also been deposited in such plants. It should not be inferred, however, that an extremely heavy population of adults may not severely injure a plant without the aid of nymphs.

The results presented in this bulletin have re-emphasized how very essential it is to know the correct identity of an insect in order to ascertain its definite economic status and its capacity for causing injury to its host plants. The wide variety and comparatively large number of host plants from which many of the species of *Empoasca* have been reared reaffirm the economic importance, both actual and potential, of members of this genus.

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[3] Order Homoptera, family Cicadellidae.

[4] Italic numbers in parentheses refer to Literature Cited, p. 44.

METHODS

Unless otherwise specified, the identity of host plants on which empoascan species were reared, as reported by the writers, was ascertained by collecting nymphs on the plants in the field and rearing these on the same host material to the adult stage, for specific identification by morphological characters within the abdomen of the male. Since only a preliminary study has been made (7) as to whether adequate valvular characters occur among the females of this genus, the problem was often complicated by the necessity of having male adults for specific identification. Not infrequently only females were reared from some collections, especially from those taken on uncommon hosts. The male genital characters used for specific identification are concealed and can best be revealed and examined by a preparation of the chitinous structures, involving the destruction of the softer parts by soaking gradually in a 10-percent solution of potassium hydroxide. Methods and apparatus used in identifying large numbers of leafhoppers have previously been described.[5]

Extreme care was exercised to collect nymphs only from plants sufficiently isolated from other species of possible hosts to make certain that the nymphs occurring there had hatched from eggs deposited in the plants on which the nymphs were found, and had not migrated from other plants. The smaller nymphs (first or second instars) have not been observed to move from plant to plant and are very difficult to dislodge from their natural host plants.

FOREIGN SPECIES OF EMPOASCA

Because of the economic importance of certain species of *Empoasca* that apparently occur only in foreign countries, foreign species that have been reported as damaging economic crops have also been listed. Approximately 118 foreign species and 7 foreign varieties of *Empoasca* are mentioned in the literature. Of these, 13 identified species and 5 additional forms unidentified as to species have been reported to be of economic importance. An annotated discussion, which includes the recorded host plants and localities of such reported economic species, treated in alphabetical order, is here presented. *Empoasca bipunctata* and *E. smaragdula*, which are both foreign and domestic species, will be discussed in their proper order among the latter.

In the lists of host plants as given by the various authors cited, the names given are those used by the writer of the article cited, if in Eng-

[5] POOS, F. W., WHEELER, N. H., and SCRIVENER, J. W. METHODS AND APPARATUS USED IN IDENTIFYING LARGE NUMBERS OF LEAFHOPPERS OF THE GENUS EMPOASCA. U. S. Bur. Ent. and Plant Quar., ET-72, 3 pp., illus. 1936. [Processed.]

lish. If from a publication in a foreign language, the names are given as accurately as they can be translated, unless it seems best to give the foreign-language name without translation. The technical names of the plants mentioned in this bulletin have been reviewed in the Division of Plant Exploration and Introduction of the Bureau of Plant Industry, Soils, and Agricultural Engineering and meet with the approval of the specialists of that Division.

EMPOASCA BENEDETTOI Paoli

Described in 1933 (*90*) from cotton in Italian Somaliland, Anglo-Egyptian Sudan, and Tanganyika, *Empoasca benedettoi* was reported by Harris (*54*) as infesting cotton in Tanganyika, and by Russo (*106*) as injuring cotton in Italian Somaliland, but not transmitting leaf-curl or leaf-crinkle. Hargreaves (*52*), in investigations in Uganda in 1934, observed reddening of the leaves of cotton on a plot attacked by three species of leafhoppers, of which *benedettoi* was the most abundant. Ballard (*8*) reported in 1937 that investigations were in progress in Palestine on the bionomics of this species and its possible relation to a virus disease of potato and eggplant.

EMPOASCA BIGUTTULA Matsumura

In a preliminary report on the studies of certain diseases of cotton in China, Teng (*119*) stated that cyrtosis of cotton was definitely known to be associated with *Empoasca biguttula* and might possibly be due to direct insect injury. This species, the original description of which has not been located, was included among the chief pests of cotton in China by Li and Chou (*72*), and was reported by Fukuda (*44*) and by Shiraki (*110*) as injurious to cotton in Formosa, and by Kuwayama (*69*) as attacking cotton in Manchuria.

EMPOASCA DECIPIENS Paoli

Empoasca decipiens was described in 1930 (*87*) from beet, eggplant, potato, and tomato in Italy, later (*89*) reported as occurring also on castor-oil plant, *Helianthus tuberosus*, herbs, kidney bean, oak, and vine in Italy, and (*91*) as occurring on barley, berseem clover (*Trifolium alexandrinum*), *Capparis* sp., castor-oil plant, cotton, kidney bean, lentil, maize, sugarcane, sweetpotato, tomato, and wheat in Egypt. Ribaut (*103*) reported it as occurring on plants, shrubs, and trees in France and western Europe.

EMPOASCA DEVASTANS Distant

The species *Empoasca devastans* was described in 1918 (*34*) as a serious pest of cotton in Nagpur, British India, and reported by

Fletcher (*43, p. 276*) as a bad pest of cotton in various localities in India, and by Vuillet (*122*) as among the most dangerous of the less-known cotton pests in British India. Husain (*58*) stated that *devastans* definitely causes leaf-crinkle of cotton in the Punjab, and Husain and Lal (*59*) reported this species as one of the most serious pests of the American cotton in that locality, with *Hibiscus esculentus*, *H. vitifolius*, *Solanum melongena*, *S. tuberosum*, and *Althaea rosea*, its alternate hosts, often damaged severely.

It was reported by Thomas and Krishnaswami (*120*) as a vector of a transmissible disease of brinjal, or eggplant (*Solanum melongena*), an important vegetable crop in southern India, this leafhopper being common in the brinjal fields in Coimbatore, where the disease was first observed.

EMPOASCA DOLICHI Paoli

Paoli, in 1930 (*87*), described the species *Empoasca dolichi* from *Dolichos lablab* in Italian Somaliland and later (*89*, *90*, and *91*) reported it as abundant in the Transvaal and Belgian Congo and at Ibadan, Nigeria, on cotton, pea, cowpea, bean (tepary, lima, and bonavist), peanut, and Indian corn. Russo (*106*) reported it as injurious to cotton in the Italian Somaliland.

EMPOASCA FACIALIS Jacobi

Empoasca facialis was described in 1912 (*5*) from Dutch East Africa on cotton. It is one of the major pests of cotton in India and northern, central, and southern Africa. It has been reported by many investigators as abundant on cotton and also occurring on *Hibiscus abelmoschus*, Bambara groundnuts (*Voandzeia subterranea*), cowpea, diverse cucurbits, *Dolichos*, field pea, *Hibiscus esculentus*, monkey nut, *Ricinus communis*, sword bean (*Canavalia ensiformis*), and tobacco. Bebbington and Allan (*12*) reported *Thespesia* to be a wild host plant and reared nymphs from cotton on leaves of *Thespesia* and those from *Thespesia* on cotton, their developmental period comparing well with that of nymphs from cotton reared normally on cotton.

Heavy infestation by *Empoasca facialis* has been associated with premature reddening of cotton foliage, but Jack (*60*) reported experiments in this connection to indicate that although this reddening is probably induced by leafhoppers, it is probably a characteristic reaction of a variety rather than a result of attack. Vuillet (*122*) observed a close relationship between the spread of bacterial rust of cotton and of mosaic disease and the increase of *E. facialis*. Monteil (*78*) described the injury to cotton in French Equatorial Africa by a leafhopper (identified as possibly *E. facialis*) which appears when cotton comes into flower and is found throughout the season on the

leaves and young shoots. The injury consists of a crinkling of the foliage and withering of the extremities. Monteil stated that as a potential vector of diseases the insect deserves further study. Kirkpatrick (*65*) stated that the disease could be conveyed experimentally by aleurodids or by *E. facialis*, but that the latter was certainly not mainly responsible. Golding (*48*) and Johnston (*63*) procured only negative evidence, however, in experiments to prove it a vector of leaf-crinkle or leaf-curl. Likewise, in experiments to transmit tobacco mosaic in Rhodesia, Roberts (*104*) was unsuccessful with *facialis*. Paoli (*88*) observed that crinkling of leaves of cotton occurred only in the presence of *facialis;* but he attributed this to the effect of the insect's saliva and not to the transmission of a virus capable of development after inoculation; and stated that the decrease in symptoms at the end of the season was not due, as usually thought, to the advent of rains but in Italian Somaliland to a mymarid parasite, *Anagrus scassellatii* Paoli, which attacks the leafhopper's eggs.

Hargreaves (*51*) observed a close connection between hairiness of the foliage and resistance to infestation by *facialis*, and Jack (*61*) recommended breeding of plant strains of high resistance to leafhoppers as one of the primary considerations in the selection and breeding work.

The abundance of *facialis* on cowpea, groundnut, and pea in South Africa has been noted by several investigators, and Parsons (*93*) in Natal reported its attack on Bambara groundnuts (commonly called "jugo beans"), an infested crop being difficult to harvest owing to the breaking of the slender peduncles when the plants were lifted, with the result that most of the nuts were left in the soil. Soyer (*116*) included *E. facialis* among the insects occurring on peanuts in the Belgian Congo, but reported negatively on this species as a vector of "rosette."

Myers,[6] in a compilation of literature on the insects of the castor bean, stated that *facialis* sometimes causes considerable injury in the Niger Valley of Africa, in Italian Somaliland, and in the Khartoum district of the Anglo-Egyptian Sudan.

EMPOASCA FLAVESCENS (Fabricius)

Fabricius (*40, p. 46*) described *Cicada flavescens* from Germany in 1794. It was later reported by other investigators as occurring generally throughout Europe and northern Africa on *Atriplex*, *Chenopodium*, *Clematis*, hop, potato, raspberry, sugar beet, and vines, and on many herbaceous plants and deciduous and coniferous trees. Melichar (*75*) reported *flavescens* from Ceylon, and Distant (*33*)

[6] MYERS, G. INSECTS OF THE CASTOR-BEAN. U. S. Bur. Ent. and Plant Quar., E-169, 19 pp. 1939. [Processed.]

found this species in India in tea gardens. It is now commonly known as the tea green-fly and is one of the most widely distributed of the major pests of tea in northeastern India. It has been generally accused of producing a stunted growth on the plants attacked in India, but cage experiments by Andrews (*1*) gave negative results, and the appearance of the stunting effect at the time when the insects are most active is thought to be merely coincidental and due to some cause independent of *Empoasca flavescens*. Shiraki (*109*) reported *flavescens* as a pest of tea in Formosa and also injurious to orange trees and sugarcane, and its injury to mulberry as causing a scarcity of leaves for sericulturists. DuPasquier (*36*) reported *flavescens* as a pest of tea, feeding on the young shoots in Indo-China, India (Assam, Darjeeling), Formosa, and Japan. It was also reported as injurious to peach and plum trees in Formosa by Kayashima (*64*), and included by Kuwayama (*68*) among the more injurious pests of apple in Japan.

Both in India and Egypt *flavescens* attacks the castor bean (*Ricinus communis*) and has been reported as particularly injurious when the plants are young, sucking the juices to such an extent that the plants fade, curl, and eventually die.

Blattný (*17*) listed *Empoasca flavescens* as injurious to *Mentha crispa* L. in Czechoslovakia, and reported (*18*) that this species occurred in great numbers on celery in hotbeds in Bohemia and was associated with a severe outbreak of mosaic, previously unrecorded in Czechoslovakia.

Otanes and Butac (*86*) mentioned *flavescens* among the more injurious of the sucking insects on cotton in the Philippines. It caused the leaves to curl and contributed to the failure of an extensive cotton planting. It also occurred there on eggplant and potato.

Investigations in Germany by Heinze (*57*) showed *flavescens* to be common on potato, but unable to transmit the potato virus, although its attack caused a rolling of the leaves similar in appearance to that due to the virus of leaf-roll.

Esaki and Hashimoto (*38*) reported *flavescens* abundant on rice in Oita, Kyushu, Japan.

Empoasca flavescens is among the insects listed as attacking sugar beet in Czechoslovakia, Germany, and Sweden. According to Schneider (*108*), it injures the palisade and parenchyma tissues and vascular bundles. Rambousek (*101*) observed one instance in Czechoslovakia where the beet leaves were infected by this species with what appeared to be mosaic disease.

Although *flavescens* has been reported upon several occasions from the United States, Cuba, Puerto Rico, and Bolivia, all these reports resulted from studies made before the use of genital structures in

identification work became common. Since this species is easily confused with *fabae* and closely related species, no authentic records of its occurrence in these localities have thus far been obtained. Although Osborn (*81*) reported *flavescens* in his survey of Cuban Homoptera as having a wide range in Cuba but "not known to occur on cane or grasses," and as occurring in Bolivia (*82*) and in Puerto Rico (*83*), he later (*84*) listed the Puerto Rico record of *flavescens* under *fabalis*.

Empoasca lybica (Bergevin)

Bergevin and Zanon (*15*) included the description of *Empoasca lybica* in 1922 as *Chlorita lybica* from grape in Africa. Kruger (*67*) reported it as having increased to dangerous proportions on vines in the district of Benghazi and the plain of Barce (Africa), damaging the foliage by causing it to become dark and to fall, the grapes not to ripen well, the young shoots to develop with short internodes, and the leaves to curl up. Ruiz and Mendizábal (*105*) reported grapevines in Almeria, Spain, to be seriously injured by the insect, it causing a discoloration ("colored rust") and crinkling of the leaves, with grapes stunted and ripening late.

Bedford [7] reported the abundance of *lybica* on cotton in the Sudan as causing noticeable damage to the older leaves, particularly in the case of American cotton. A later report (*13*) stated that hopperburn was observed on cotton plants in cages into which *lybica* had been introduced a month earlier. In his report for 1937–38, Bedford (*14*) stated that *lybica* was abundant and responsible for the usual hopperburn. He also noted the breeding of this species on "weika" (*Hibiscus esculentus*), its abundance on "lubia" (*Dolichos lablab*), and its presence on *Cajanus cajan*, *Rhynchosia memnonia*, "berseem" (*Medicago sativa*), "dura" (sorghum), *Withania somnifera*, and *Ocimum basilicum*.

Empoasca notata Melichar

The species *Empoasca notata* was described in 1903 (*75*) from Ceylon. Misra (*76*) reported the appearance in North Bihar, India, of enormous swarms of *E. notata* on cotton, sucking away the sap which would have gone to mature the plants, and causing the leaves to curl badly, to become pale and seared, and to drop off prematurely. Vuillet (*122*) lists *E. notata* among the most dangerous of the less-known cotton pests in British India. Grunwald (*49*) records *notata* as injurious to castor-oil plant (*Ricinus communis*) in India.

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[7] Bedford, H. W. Entomological Section Agricultural Research Service. Report on work carried out by the staff of the section during the season 1934/35. Sudan Agr. Res. Serv. Ann. Rpt. 1935: 63–96, illus. 1936. [Processed.]

EMPOASCA SIGNATA Haupt

Empoasca signata was described in 1927 from Palestine (*56*). Bodenheimer and Klein (*19*) reported considerable damage by this species to eggplant (*Solanum melongena*) in Palestine, pepper and tomato also being attacked. Young plants are most severely attacked, the leafhoppers occurring on the lower surface of the leaves, which become discolored and curl at the edges.

EMPOASCA TERRA-REGINAE Paoli

Described in 1936 (*92*) from cotton at Biloela, Queensland, Australia. Reported in 1939 by Smith (*114*) as a cotton pest in Queensland, where it was proving itself more serious than for some time past, many areas being heavily infested late in the season. Evans (*39*) included this species among the Queensland leafhoppers that attack alfalfa, saying:

> * * * It would appear that *E. terra-reginae* is of considerable economic importance, since in addition to being recorded from lucerne (Darling Downs) and tomatoes (Dimbulah), specimens have been received from Moree, New South Wales, accompanied by a report that they were abundant on vegetables and weeds.

EMPOASCA spp. (undetermined)

Mo (*77*) reported an *Empoasca* that caused leaf-curl on *Hibiscus sabdariffa* in the Netherlands Indies. Incidentally, *E. fabae* was reared from *H. sabdariffa* L. at Arlington, Va., in 1929.

Dulzetto and Muscatello (*35*) described a type of lesion becoming increasingly common on oranges and mandarins in orchards in Sicily that are heavily infested by an empoascan species, and suggested that the punctures caused by the feeding of the insects might be responsible for the injury. Russo (*107*) reported a species of *Empoasca* attacking oranges in Sicily and causing what is called fetola, an injury similar to the fruit-spotting in California caused by *fabae* (*71*).

Baker (*6*) reported a species of *Empoasca*, abundant on papaw in Trinidad, that caused symptoms similar to those described by other authors as curly leaf, but constituting a "stigmonose" effect owing to the large numbers of insects feeding on the plants.

Lever (*70*) reported an undescribed species of *Empoasca* occurring as a pest of cotton in Fiji.

Wille (*128*) gave a brief account of investigations showing that a leaf-curl of cotton, first observed in the Huaura Valley, Peru, in 1938, was most probably caused by the feeding of an undescribed species of *Empoasca* that had not previously been observed to cause economic injury.

DOMESTIC SPECIES OF EMPOASCA

Approximately 181 domestic species of *Empoasca* have been described, of which at least 15 have injured plants enough to be considered economically important. Twenty-three species have been reared at Arlington, Va., in the manner described under Methods. The number of host plants from which the species of *Empoasca* have been reared ranged from 1 for the less abundant species to 108 different host plants for the more abundant *fabae*. Thirty-nine species of host plants had more than 1 species of *Empoasca* reared from each of them, as shown in table 1. The maximum number of species reared from a single species of host plant was 7, as in the case of both potato and sweetpotato. A single collection of nymphs from 1 host plant, such as sunflower, sometimes yielded 4 species of *Empoasca*. Thirty-one of the species involved in these studies are discussed, in alphabetical order.

TABLE 1.—*Host plants from which more than 1 species of Empoasca were reared*

Host plant	Species of *Empoasca*: *abrupta*	*albovaria*	*bolatae*	*bifurcata*	*birdi*	*chelata*	*delongi*	*diffisa*	*distracta*	*ditata*	*erigeron*	*fabae*	*filamenta*	*maligna*	*pergandei*	*plebeia*	*radiata*	*recurvata*	*saliela*	*salivae*	*solana*
Alfalfa (*Medicago sativa* L.)	+			+							+	+	+							+	
Apple (*Malus* sp.)												+		+							
Artichoke, Jerusalem (*Helianthus tuberosus* L.)				+							+	+									
Aster (*Aster* sp.)	+			+							+							+			+
Belladonna (*Atropa belladonna* L.)												+						+			
Boneset (*Eupatorium perfoliatum* L.)				+						+		+									
Broadbean (*Vicia faba* L.)												+						+			
Castor-bean (*Ricinus communis* L.)											+	+						+			
Cestrum (*Cestrum* sp.)																+					+
Clover, red (*Trifolium pratense* L.)	+											+									
Coltsfoot (*Tussilago farfara* L.)				+							+										
Cowpea (*Vigna sinensis* (L.) Endl.)												+									
Dahlia (*Dahlia* sp.)	+			+							+	+						+			
Dock (*Rumex* sp.)											+	+									
False loosestrife (*Steironema ciliatum* (L.) Raf.)				+							+										
Goldenrod (*Solidago* sp.)	+			+							+										
Hemp (*Cannabis sativa* L.)												+									
Horsemint (*Monarda didyma* L.)				+														+			
Horsemint (*Monarda mollis* L.)				+														+			
Horsenettle (*Solanum carolinense* L.)				+			+				+										
Inula (*Inula helenium* L.)											+	+									
Ironweed (*Vernonia altissima* Nutt.)				+					+		+										
Locust (*Robinia pseudoacacia* L.)												+				+					
Mint (*Mentha crispa* L.)																	+	+			
Papaya (*Carica papaya* L.)								+			+	+				+					+
Perilla (*Perilla ocymoides* L.)											+							+			
Pigweed (*Amaranthus retroflexus* L.)											+										+
Pokeweed (*Phytolacca* sp.)											+										+
Potato (*Solanum tuberosum* L.)	+			+			+				+	+						+			+
Ragweed (*Ambrosia artemisiifolia* L.)		+		+							+										
Sage (*Salvia hispanica* L.)				+							+							+			
Strawflower (*Helichrysum* sp.)											+							+			
Sumac (*Rhus copallina* L.)											+							+			
Sunflower (*Helianthus annuus* L.)				+						+	+	+						+			
Sweetpotato (*Ipomoea batatas* Poir.)	+		+	+	+						+							+			+
Tansy (*Tanacetum vulgare* L.)				+							+										
Valerian (*Valeriana officinalis* L.)				+													+				
Willow (*Salix* sp.)											+								+		
Wormwood (*Artemisia absinthium* L.)				+							+	+									

EMPOASCA ABRUPTA DeLong

DeLong described *Empoasca abrupta* in 1931 (*24, p. 48*) and gave it the common name western potato leafhopper. This species has not been found east of Missouri. It was reported in 1933 from New Mexico (*1*) as a pest of potato, producing etiolation and hopperburn. In 1939 McKinney (*74*) reported it as injuring Irish potato to an important degree in the Salt River Valley, Ariz. Records have been obtained, from material identified from miscellaneous collections, of its occurrence in the following States: Arizona, California, Colorado, Kansas, Missouri, New Mexico, Oregon, and Texas. It is mainly a truck-crop pest, and, according to various published reports too numerous to be cited, it has been collected from the following plants: Alfalfa, artichoke, *Aster* sp., bean, beet, calendula, cantaloupe, cassaba, celery, corn, cotton, cucumber, cucurbits, dahlia, eggplant, gherkin, lettuce, melon, okra, parsnip, pepper, potato, red clover, *Solidago* sp., squash, sunflower, sweetpotato, tomato, turnip, and watermelon. It has also been identified from collections taken in trap lights in Kansas.

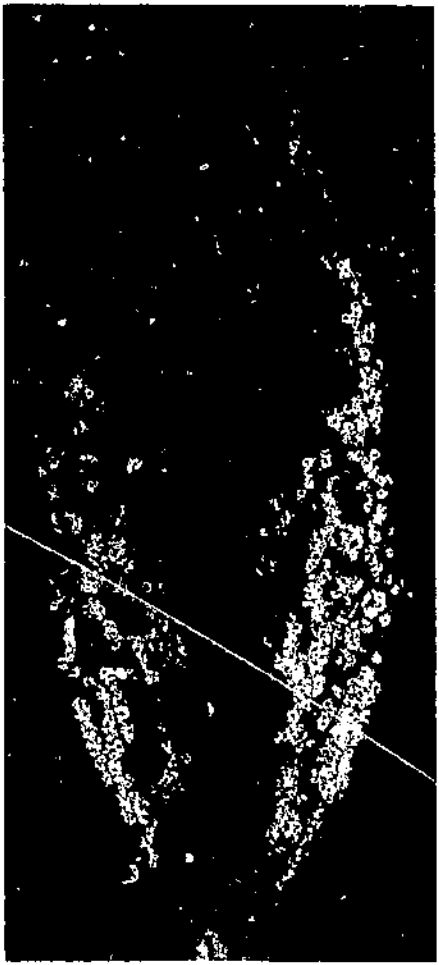

FIGURE 1.—Typical stippling produced by *Empoasca abrupta* on *Aster* sp. when confined to this host in a celluloid cage.

DeLong (*29*) reared *abrupta* from material collected on potatoes in California, females of which oviposited on sugar beets en route to Columbus, Ohio. Comparisons of the type of injury produced by *abrupta* with that produced by *fabae* have shown that no hopperburn is produced on potato plants infested by *abrupta*, but the result of infestation is a speckled-white appearance or stippling which is entirely different, and readily distinguishable from the injury

caused by *fabae*. The same difference has been noted on bean plants.

During 1931 *abrupta* was reared at Arlington Experiment Farm from material collected by R. A. Blanchard on potato and alfalfa in California. It was also reared from nymphs collected on calendula which was being severely injured at Leavenworth, Kans., and from nymphs collected on dahlias both at Leavenworth and at Beverly Station, Mo. It was bred on alfalfa, *Aster* sp., bean (*Phaseolus vulgaris* L.), red clover, *Solidago* sp., and sweetpotato in confinement, but seemed to prefer potato. From records on oviposition and nymphal development obtained at Arlington Experiment Farm from 1931 to 1932, *abrupta* appeared to be very prolific, ranking probably second to *fabae*.

From a comparison of the feeding habits of *abrupta* with *fabae*, it was found by Smith and Poos (*113*) that *abrupta* belonged to a group characterized by a habit of feeding on the mesophyll tissue of the leaves (fig. 1), while *fabae* evidently fed by preference on the phloem, or water-conducting tissue; and that the differences in feeding habits seemed to be correlated with the physiology of the species.

EMPOASCA ALBONEURA Gillette

The species *Empoasca alboneura* is widely distributed throughout the United States and was originally described (*45*) from specimens from Colorado, Mississippi, and Virginia. More recently this species has been identified in miscellaneous collections from Alabama, California, Connecticut, the District of Columbia, Kansas, Kentucky, Maryland, Missouri, Montana, Nevada, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, and Wyoming. It was originally reported from "native plants" and from plum in Colorado and has also been recorded (*127*) as occurring on alfalfa, *Artemisia*, artichoke, aster, *Chrysothamnus*, giant ragweed, and white pine. This species has been collected both as nymphs and as adults on dogfennel (*Anthemis cotula* L.) and on ragweed (*Ambrosia artemisiifolia* L.), and has been taken in trap lights and in a wind trap at Arlington, Va.; and in trap lights at Clemson, S. C., Knoxville, Tenn., and Richfield, Utah.

EMPOASCA ARIDA DeLong

Empoasca arida has been collected only in Arizona, California, and Utah. It was described in 1931 (*24, p. 49*) from a large series taken chiefly from sugar beet and alfalfa. It has been taken abundantly from sugar beet and potato; also collected on alfalfa, bean, carrot, celery, Chinese cabbage, cucumber, eggplant, lettuce, parsnip,

squash, Swiss chard, and tomato. Reports of field observations (*35*) indicate that where this species is abundant the leaves of the infested plants show a conspicuous injury—white spotting, or white stippled injury—owing to a loss of chlorophyll.

EMPOASCA BATATAE POOS

The senior author (*25*) in 1933 described a leafhopper from a large series of specimens reared on sweetpotato at Arlington, Va., and from

FIGURE 2.—Typical stippling produced by *Empoasca batatae* on sweetpotato, one of its preferred host plants.

specimens collected as nymphs from the same host plant at Fort Myers, Fla., in 1931 and 1932, giving it the name *Empoasca batatae*. Specimens were also received from Brazil, collected on cotton, grahoma, legumes, and sweetpotato. It injures the foliage of sweetpotato by

feeding on the leaves and produces a distinct and prominent stippling (fig. 2). This species has also been identified from specimens taken in 1934 at Philadelphia, Pa., in a cargo originating in Honduras.

EMPOASCA BIFURCATA DeLong

DeLong described *Empoasca bifurcata* in 1931 (*24, p. 40*), reporting it as apparently very common throughout the eastern part of the United States. It has been identified from specimens collected in Alabama, the District of Columbia, Connecticut, Florida, Georgia, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia, and Wisconsin. Adults of *bifurcata* have been collected from a variety of plants, such as alfalfa, aster, *Coreopsis* sp., corn, crapemyrtle (*Lagerstroemia indica* L.), dock, dogfennel (*Anthemis cotula* L.), endive, *Erigeron* spp., false nettle (*Boehmeria cylindrica* (L.) Swartz), goldenrod (*Solidago* sp.), *Laburnum* sp., *Polygonum* sp., rhubarb, rye, spearmint (*Mentha spicata* L.), sweetclover, and willow. It has been identified from a collection swept from weeds at Vineland Station, Ontario, and from specimens taken at Philadelphia, Pa., in 1936 from a cargo of bananas from Guatemala. This species was listed (*46*) among the insects taken at altitudes of 200 and 500 feet in an airplane trap in Louisiana. It has also been identified in collections from trap lights in operation at Arlington, Va., and at Knoxville, Tenn., and from a wind trap at Arlington.

Host plants from which *Empoasca bifurcata* has been reared at Arlington Experiment Farm are as follows:

Aconite (*Aconitum napellus* L.)
Artichoke, Jerusalem (*Helianthus tuberosus* L.)
Aster (*Aster* sp.)
Boneset (*Eupatorium perfoliatum* L.)
Coltsfoot (*Tussilago farfara* L.)
Dahlia (*Dahlia* sp.)
False loosestrife (*Steironema ciliatum* (L.) Raf.)
Goldenrod (*Solidago* sp.)
Horsemints:
Monarda didyma L.
Monarda mollis L.
Horsenettle (*Solanum carolinense* L.)
Ironweed (*Vernonia altissima* Nutt.)
Lettuce:
prickly (*Lactuca serriola* L.)
wild (*Lactuca canadensis* L.)
Mints:
peppermint (*Mentha piperita* L.)
water mint (*Mentha aquatica* L.)
Potato (*Solanum tuberosum* L.)
Ragweed (*Ambrosia artemisiifolia* L.)
Sage (*Salvia hispanica* L.)
Sunflower (*Helianthus annuus* L.)
Sweetpotato (*Ipomoea batatas* Poir.)
Tansy (*Tanacetum vulgare* L.)
Wormwood (*Artemisia absinthium* L.)

This species feeds on mesophyll tissue of leaves and produces definite spotting, or stippling, on the upper surface (fig. 3) as described by Smith and Poos (*113*).

EMPOASCA BIPUNCTATA (Oshanin)

A foreign species, probably introduced into the United States, was originally described by Oshanin in 1870 (*85, p. 212*) as *Chlorita bipunctata*, from Samarkand, Russia. Haupt (*55*) described this species as *Empoasca punctum*, from Germany, and later Ribaut (*102*) gave to *punctum* the new name *haupti*. Paoli (*92*), placing *Chlorita bipunctata* Osh., *Empoasca punctum* Hpt., and *Empoasca haupti* Ribaut as synonyms of *Empoasca bipunctata* Osh., redescribed this species and illustrated the internal male genitalia.

FIGURE 3.—Typical stippling produced by *Empoasca bifurcata* on *Solidago* sp., one of its preferred host plants.

This species has been reported as occurring on cotton in Asiatic Russia, on elm in middle Europe, and on hemp in Italy. It has been identified from material collected in 1930 by F. F. Smith on European elm in Pennsylvania, and more recently has been reported by G. F. Knowlton as being very abundant on Siberian elm in Utah. Specimens of this species have also been identified from Winona, Ontario, where William L. Putman reported it as very injurious on Chinese elm (*Ulmus pumila*).

EMPOASCA BIRDII Goding

Goding (*47*) described *Empoasca birdii* in 1890 from many specimens taken in Illinois from leaves of apple, bean, hop, walnut, and some weeds, adding it to the long list of apple pests, from observations

repeated during two seasons. He described the injury to the apple leaves as "plainly to be seen, the leaves being discolored wherever a puncture had been made."

Owing to confusion in the type series and a superficial resemblance among several species of this genus, the specimen redescribed and illustrated by DeLong (*24, p. 41*) as *Empoasca birdii* proved (*126*) to be identical with the species later described by DeLong and Caldwell (*30*) as *vergena*, and the specimen designated (*126*) lectotype of *E. birdii* Goding proved to be identical with that described by DeLong (*28*) as *infusca*. As a result of this confusion in identity, host and locality records appearing previously in the literature may likewise have been confused and are, therefore, not considered authentic.

This species has been collected both as nymphs and as adults on sweetpotato at Arlington, Va., and other places in the vicinity of Washington, D. C., and has been identified from collections taken in a wind trap at Arlington Experiment Farm and from collections taken in trap lights in Virginia, Tennessee, and Kansas. It has also been identified from material collected on alfalfa in Ohio and Indiana, on bindweed and red clover in Ohio, on hops in Canada, and from miscellaneous collections from Iowa and the State of Washington. In 1938 Gilbert[8] reported injury to hops at Fournier, Ontario, by *Empoasca birdii*, stating that the lower leaves of the vines were so badly "hopper burnt" in many cases that this injury undoubtedly would have some effect on the crop.

Empoasca chelata DeLong and Davidson

Empoasca chelata was described in 1936 (*32*) from two specimens collected at Okolona, Miss., from *Crataegus*. It has been identified from collections made in Florida and from collections taken in trap lights at Arlington, Va., and Knoxville, Tenn., and has also been reared from nymphs collected on shining sumac (*Rhus copallina* L.) at Hanover, Ivor, and Suffolk, Va.

Empoasca delongi Poos

Empoasca delongi was described in 1933 (*95*) from a large series of adult specimens collected as nymphs near Occoquan, Va., from horsenettle (*Solanum carolinense* L.). It was also reared from nymphs collected on horsenettle at Arlington, Va., and reared on potato in

[8] Reported by H. A. Gilbert in Field Crop and Garden Insects, Canada Dept. Agr., Canad. Insect Pest Rev. 16: 243–282, 1938. [Processed.] See p. 277.

life-history studies in an insectary. Adults were collected on alfalfa at Luray, Va., and in trap lights at Arlington, Va., and Knoxville, Tenn.

EMPOASCA DILITARA DeLong and Davidson

Empoasca dilitara was described in 1935 (*31*) from New Mexico, but no host plant was recorded. It has been identified at Arlington, Va., from a large series of males from nymphs collected in 1937 by G. W. Barber from papaya (*Carica papaya* L.) at Redlands, Fla., and sent to the authors for rearing.

EMPOASCA DISTRACTA DeLong and Caldwell

Empoasca distracta was described in 1934 (*30*) from two specimens collected at Attica, Ohio. It has been reared at Arlington, Va., from boneset (*Eupatorium perfoliatum* L.), ironweed (*Vernonia altissima* Nutt.), and snowball (*Viburnum opulus* var. *roseum* L.), and was collected on ironweed at Kingman, Kans., in 1930.

EMPOASCA DITATA DeLong and Caldwell

Empoasca ditata was described in 1934 (*30*) from two specimens collected at Cedar Swamp, Ohio. It has been reared at Arlington, Va., from nymphs collected on sunflower and has been identified from collections taken in trap lights at Arlington, Va., Manhattan, Kans., and Knoxville, Tenn.

EMPOASCA ERIGERON DeLong

DeLong described *Empoasca erigeron* in 1931 (*24, p. 48*) as resembling *fabae* and undoubtedly mistaken by previous workers for that species on wild host plants in early spring. It occurs commonly on *Erigeron* spp. and similar wild host plants, overwintering in the egg stage in the old plant stems and, at Arlington, Va., hatching early in the spring. In northern Virginia it appears to be, next to *fabae*, the most abundant species of *Empoasca*, and it has been recorded from the following other States: Connecticut, the District of Columbia, Florida, Illinois, Indiana, Louisiana, Kansas, Maryland, Michigan, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, and Wisconsin.

Records have been obtained of the occurrence of *Empoasca erigeron* on the following plants: Bean, blackberry, chard, chickweed, clover, corn, dahlia, endive, false nettle (*Boehmeria cylindrica* (L.) Swartz), grasses, hollyhock, marigold, narcissus, potato, and sweetpotato. This species has also been identified in collections from Vineland Sta-

tion, Ontario, where it was reared by William L. Putman from *Prunella vulgaris*, *Arctium minus*, *Aster* spp., and *Solidago* spp.

Identifications of this species have been made from adults collected as nymphs and reared at Arlington, Va., from the following host plants:

Actinomeris alternifolia (L.) DC.
Alfalfa (*Medicago sativa* L.)
Artichoke, Jerusalem (*Helianthus tuberosus* L.)
Aster (*Aster* sp.)
Boneset:
Eupatorium perfoliatum L.
Eupatorium sessilifolium var. *vaseyi* (Porter) Fern. and Grisc.
Burdock (*Arctium* sp.)
Carrot, wild (*Daucus carota* L.)
Castor-bean (*Ricinus communis* L.)
Catnip (*Nepeta cataria* L.)
Chrysanthemum (*Chrysanthemum* sp.)
Cocklebur (*Xanthium* sp.)
Coltsfoot (*Tussilago farfara* L.)
Coneflower, purple (*Echinacea purpurea* (L.) Moench.)
Dahlia (*Dahlia* sp.)
Dock (*Rumex* sp.)
False loosestrife (*Steironema ciliatum* (L.) Raf.)
Fleabane (*Erigeron* spp.)
Goldenrod:
white (*Solidago bicolor* L.)
wreath (*Solidago caesia* L.)
pinebarren (*Solidago fistulosa* Mill.)
Ground ivy (*Nepeta hederacea* (L.) Trevisan)
Inula (*Inula helenium* L.)
Ironweed (*Vernonia altissima* Nutt.)
Milfoil (*Achillea millefolium* L.)
Perilla (*Perilla ocymoides* L.)
Ragweed (*Ambrosia artemisiifolia* L.)
Ragweed, giant (*Ambrosia trifida* L.)
Sage (*Salvia hispanica* L.)
Sunflower (*Helianthus annuus* L.)
Tansy (*Tanacetum vulgare* L.)
Wormwood (*Artemisia absinthium* L.)
Zinnia (*Zinnia* sp.)

This species has also been identified from material taken in trap lights in Kansas, South Carolina, Tennessee, and Virginia; in wind traps at Columbus, Ohio, and Arlington, Va.; and from airplane traps at altitudes up to 6,000 feet in Louisana (*46*). The injury produced by this species is the typical stippling (figs. 4 and 5) characteristic of the species of this genus that appear to feed largely, if not entirely on the mesophyll tissue.

Empoasca fabae (Harris)

The species *Empoasca fabae* was originally described by Harris (*53*) in 1841 as *Tettigonia fabae*, injurious to Windsor bean in Massachusetts. It is commonly known as the potato leafhopper and is one of the more important pests of forage-crop legumes and certain truck crops. It occurs over a wide area and is often particularly abundant and injurious in the eastern half of the United States. It has been reported from the following States: Alabama, Arizona, Arkansas, California, Connecticut, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia, Washington, and

Wisconsin, and also from collections in trap lights on lighthouses in Delaware Bay (*117*) and in an airplane trap in Louisiana at elevations from 20 feet to 7,000 feet (*46*). Approximately 20,000 specimens of *fabae* have been identified by the writers from collections in trap lights operated in Kansas, South Carolina, Tennessee, and Virginia, and in

FIGURE 4.—Typical stippling produced by *Empoasca erigeron* on *Solidago* sp., one of its preferred host plants. The dark area near the tip of the leaf was produced by infection of mildew.

wind traps in Ohio and Virginia. Outside of the United States it has been reported from Argentina, Bermuda, Bolivia, Brazil, British Columbia, Costa Rica, Cuba, Mexico, Nova Scotia, Ontario, and Puerto Rico and it has been identified from specimens taken at Philadelphia, Pa., from a cargo of bananas from Guatemala.

FIGURE 5.—Stippling produced by *Empoasca erigeron* on Michigan red clover.

The following lists of its host plants show the wide scope of its capacity for causing injury:

COLLECTED ON—
- Bindweed
- Corn
- Cottonwood (*Populus deltoides* Marsh.)
- Cucumber
- Giant ragweed
- Gladiolus
- Grape
- *Grotalaria*
- Jimsonweed
- *Morning glory*
- Narcissus
- Oats
- Orange
- Pine (white)
- Plum
- Poplar (nursery stock)
- Raspberry
- Rue-weed cassia (*Cassia obtusifolia* L.)

COLLECTED ON—Continued.
- Rye
- Sainfoin
- Shrubs
- Sugarcane
- Sweetclover (*Melilotus indica* (L.) All.)
- Tansy
- Watermelon
- Wayfaring-tree (*Viburnum lantana* L.)
- Wheat

REARED FROM
- Alfalfa (*Medicago sativa* L.)
- Apple (*Malus* spp.)
- Artichoke, Jerusalem (*Helianthus tuberosus* L.)
- Barberry (*Berberis aquifolium* Pursh)
- Belladonna (*Atropa belladonna* L.)

REARED FROM—Continued.

Beans:
- garden, various varieties (*Phaseolus vulgaris* L.)
- lima, several garden varieties (*Phaseolus lunatus* var. *macrocarpus* Benth.)
- mung (*Phaseolus aureus* Roxb.)
- rice (*Phaseolus calcaratus* Roxb.)

Beet, sugar (*Beta vulgaris* L.)
Birch (*Betula* sp.)
Blackberry (*Rubus* sp.)
Bonavist bean (*Dolichos lablab* L.)
Boxelder (*Acer negundo* L.)
Broadbean (*Vicia faba* L.)
Buckthorn, alder (*Rhamnus frangula* L.)
Butterfly-pea (*Centrosema* sp.)
Castor-bean (*Ricinus communis* L.)
Cherry:
- flowering oriental (*Prunus* sp.)
- sour (*Prunus cerasus* L.)

Chestnut (*Castanea dentata* (Marsh.) Borkh.)
Chinese chestnut (*Castanea* sp.)
Chinquapin (*Castanea pumila* (L.) Mill.)
Clovers:
- alsike (*Trifolium hybridum* L.)
- bush (*Lespedeza cuneata* (Dumont) G. Don)
- bush (*Lespedeza* sp.)
- red (*Trifolium pratense* L.)
- strawberry (*Trifolium resupinatum* L.)
- sweet (*Melilotus alba* Desr.)
- sweet (*Melilotus officinalis* (L.) Lam.)
- white (*Trifolium repens*, L.)
- zigzag (*Trifolium medium* L.)

Cocklebur (*Xanthium* sp.)
Cotton (*Gossypium* sp.)
Cowpea (*Vigna sinensis* (L.) Endl.)
Cow vetch (*Vicia cracca* L.)
Cracca (*Tephrosia toxicaria* (L.) Pers.)[9]

REARED FROM—Continued.

Cracca (*Tephrosia virginiana* (L.) Pers.)
Crown vetch (*Coronilla varia* L.)
Cucumber (*Cucumis sativus* L.)
Dahlia (*Dahlia* sp.)
Dock:
- broad leaf (*Rumex obtusifolius* L.)
- narrow leaf (*Rumex crispus* L.)

Eggplant (*Solanum melongena* L.)
Elm:
- American (*Ulmus americana* L.)
- dwarf (*Ulmus pumila* L.)

False indigo (*Amorpha glabra* Poir.)
Guizotia abyssinica (L. f.) Cass.
Hackberry (*Celtis occidentalis* L.)
Hemp (*Cannabis sativa* L.)
Hickory (*Carya* sp.)
Hollyhock (*Althaea* sp.)
Horsenettle (*Solanum carolinense* L.)
Indigo (*Indigofera* sp.)
Inula (*Inula helenium* L.)
Japanese pagoda-tree (*Sophora japonica* L.)
Knotweed (*Polygonum pensylvanicum* L.)
Kudzu (*Pueraria thunbergiana* Benth.)
Laburnum sp.
Lallemantia iberica Fisch. and Mey.
Lespedeza (see clover, bush)
Licorice:
- *Glycyrrhiza glabra* L.
- *Glycyrrhiza lepidota* (Nutt.) Pursh

Locust, black (*Robinia pseudoacacia* L.)
Lupine (*Lupinus nanus* Dougl.)
Mallow (*Malva* sp.)
Marigold, African (*Tagetes erecta* L.)
Marshmallow (*Althaea officinalis* L.)
Maple (*Acer* sp.)

[9] Nymphs collected on this host and reared only to the second instar. They were matured on Whippoorwill cowpea.

REARED FROM—Continued.

Mexican solanum (*Solanum torvum* Swartz)
Milk vetch (*Astragalus falcatus* Lam.)
Milk vetch (*Astragalus glycyphylla* L.)
Mimosa sp.
Oak:
blackjack (*Quercus marilandica* Muench.)
northern red (*Quercus maxima* (Marsh.) Ashe)
post (*Quercus stellata* Wang.)
scrub (*Quercus ilicifolia* Wang.)
white (*Quercus alba* L.)
willow (*Quercus phellos* L.)
yellow chestnut (*Quercus muhlenbergii* Engelm.)
Onobrychis arenaria DC.
Papaya (*Carica papaya* L.)
Peanut (*Arachis hypogaea* L.)
Pigweed (*Amaranthus retroflexus* L.)
Plum (*Prunus americana* Marsh.)
Pokeweed (*Phytolacca* sp.)
Potato (*Solanum tuberosum* L.)
Rattlebox:
Crotalaria incana L.
Crotalaria intermedia Kotschy
Crotalaria lanceolata E. Mey.
Crotalaria usaramoensis Baker f.

REARED FROM—Continued.

Redbud (*Cercis canadensis* L.)
Rhubarb (*Rheum rhaponticum* L.)
Rose (*Rosa* spp.)
Roselle (*Hibiscus sabdariffa* L.)[10]
Rose-mallow (*Hibiscus cannabinus* L.)
Soybean (*Glycine soja* Sieb. and Zucc.)
Strawberry (*Fragaria* sp.)
Strawflower (*Helichrysum* sp.)
Sumac:
shining (*Rhus copallina* L.)
smooth (*Rhus glabra* L.)
staghorn (*Rhus typhina* L.)
Sunflower (*Helianthus annuus* L.)
Sweetpotato (*Ipomoea batatas* Poir.)
Walnut, English (*Juglans regia* L.)
Willow (*Salix* sp.)
Wisteria:
American (*Wisteria floribunda* f. *rosea* (Bean) Rehd. and Wils.)
Chinese (*Wisteria sinensis* (Sims) Sweet)
Wormwood (*Artemisia absinthium* L.)
Yellow-wood (*Cladrastis lutea* (Michx.) K. Koch)
Zinnia (*Zinnia* sp.)

GENERAL CONSIDERATION OF THE HOST PLANTS OF EMPOASCA FABAE

From the list of host plants presented here from which *E. fabae* has been reared, it seems evident that this species is not eccentric in its food-plant reactions. The number of distinct species (when botanical varieties and the more important horicultural varieties are disregarded) from which nymphs were collected and reared to adult for identification is well over 100. The insect is sometimes a pest of economic importance on plants other than fruit, vegetable, and forage-crop plants. Usually only the leaves and stems are attacked, the larger leaf veins and the more tender stems and petioles being most frequently infested, but orange fruits have been reported injured by adults.

[10] Tjoa Tjien Mo (77) reported an unidentified species of *Empoasca* injurious to *Hibiscus sabdariffa* in the Netherlands Indies, attacking young parts of the plants and causing leaf-curl.

Many factors undoubtedly affect the infestation of certain host plants such as their seasonal development, characteristics, environment, frequency of occurrence, and distribution. Although the study of the host plants of this leafhopper is not entirely complete, and the consideration of some of the problems has had to be regarded as only a supplementary investigation, there are certain facts relevant to the environment of the plants concerned which obviously affect their status as hosts of this insect. Because of the concentrations of populations on such favored hosts as alfalfa, bean, cowpea, and potato, the proximity of certain other hosts to such crops has at times markedly influenced the extent of infestation in the latter. Most of the rarely infested hosts, however, have not been found immediately adjacent to such sources of infestation, but occurred in areas which were apparently affected only by fluctuations in the general seasonal abundance. While fluctuation in the number of insects from generation to generation probably does not greatly affect the relative frequency of infestation in the more favored and commonly occurring host plants of this insect, it doubtless has the effect of limiting many of the less favored or rarely occurring ones in seasons when these insects are less abundant than usual.

EFFECT OF SEASONAL DEVELOPMENT, CONDITION, AND CHARACTERISTICS OF THE PLANT ON INFESTATION BY EMPOASCA FABAE

Some plants, such as oak and hickory, are apparently of most significance as first-generation hosts, whereas others, such as alfalfa, are suitable for attack almost continuously throughout the season. Tender shoots of oak and hickory, as well as those of the usually less abundant boxelder and black locust, are suitable host plants of this species throughout the summer, but in the Atlantic Coastal Plain at least it appears that oak and hickory are of special significance in that they are the principal hosts by which this insect migrates northward at the beginning of each season (*96*). *Empoasca fabae* has not been found breeding on mature leaves and stems of oak and hickory, but a large brood of adults of this species matures on these hosts about June 15 at Arlington, Va., just prior to the time the leaves of these trees become full-grown. These plants are therefore important as hosts for feeding and building up the populations of this insect during its northward migration each spring and previous to its appearance in destructive numbers on commercial crops. These hosts, as well as other tree and shrub hosts, are also important in producing a constant supply of adults of *E. fabae* for the reinfestation of such crops as alfalfa, bean, and potato which are mature or ready for harvesting at various intervals during the growing season each year.

It is also obvious that the development and condition of plants at the time of egg laying and subsequent nymphal feeding may influence the frequency and intensity of infestation on them. It is equally true that the inherent characteristics of these plants may affect their susceptibility to injury by the insects. This has been shown in studies with various selections of alfalfa which exhibited different degrees of resistance to injury. That the condition as well as the development of plants affects the rate of oviposition and nymphal development on them is shown by records on oviposition and nymphal development on peanut plants in different stages of development (tables 2 and 3). The data presented in table 2 show a 110-percent increase in the number of eggs deposited in the younger plants, although the older plants were comparable in size and appeared to be in a succulent condition and, therefore, apparently suitable for oviposition. In table 3 it is indicated that approximately 15 percent less nymphs developed to adults on old plants, which were apparently comparable except for age, than on the younger plants. This is of much practical importance in the peanut-growing area of southeastern Virginia, where in normal seasons no insecticides for the control of this insect need be applied after about August 15 unless abnormal weather conditions make the peanut vines more succulent than usual. The abundance and continuity of favored host-plant species are important factors in determining the intensity and relative frequency of their infestation, although favorable weather conditions are at least equally important for the building up of heavy populations of this insect.

TABLE 2.—*Oviposition tests with Empoasca fabae*[1] *on peanuts. Arlington, Va., 1938*

Average age of plants (days)	Plants tested	Average trifoliate leaves	Average leaves injured at end of oviposition period	Average nymphs appearing
	Number	*Number*	*Number*	*Number*
79.8	15	25.6	1.03	62.0
109.1	15	23.1	.6	29.5

[1] Four females and 1 male of *Empoasca fabae* were confined by means of a celluloid cage to each plant for 6 days.

TABLE 3.—*Nymphal development of Empoasca fabae on peanut plants of different ages. Arlington, Va., 1938*

Age of plants	Plants used	Total nymphs used	Total nymphs developed to adults	
	Number	*Number*	*Number*	*Percent*
Medium	4	111	87	78.3
Old	3	118	74	62.7

During 1929 and 1930 (*90*) a number of forage-crop and other plants were used in comparative tests to ascertain which plants *fabæ* chose for oviposition, and also the relative number of nymphs developing to the adult stage on these plants. In studying the physical characteristics of certain preferred host plants as correlated

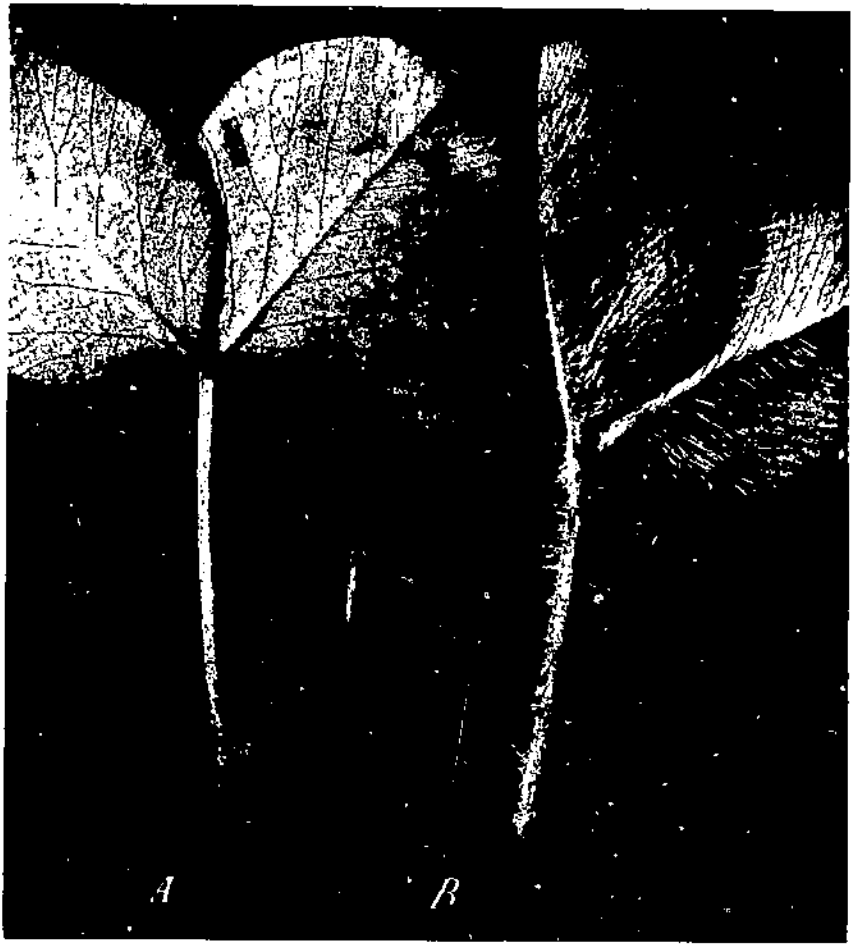

FIGURE 6.—*Empoasca fabæ*, enlarged 3 diameters, with Russian red clover (*A*), and Tennessee red clover (*B*) to show comparative pubescence with relation to the size of the adult leafhopper.

with oviposition, nymphal development, and injury caused by this species, the amount of injury present on several of these host plants seemed to be correlated in some way with the amount and type of the pubescence borne by these plants. In general, the rough-hairy pubescent varieties, *within a species*, usually were much less injured by this leafhopper than the nonpubescent or appressed-pubescent

varieties (fig. 6). More nymphs of *fabae* hatched from certain hosts than from others, regardless of whether such hosts were very hairy or only slightly pubescent. The number of nymphs of *fabae* that developed to adults on the different species and varieties of plants tested was not inversely proportional to the amount and type of pubescence on these host plants. It seems probable, therefore, that factors other than the amount and type of pubescence are at least in part responsible for the resistance to the injury by *fabae* observed in some of the strongly pubescent varieties.

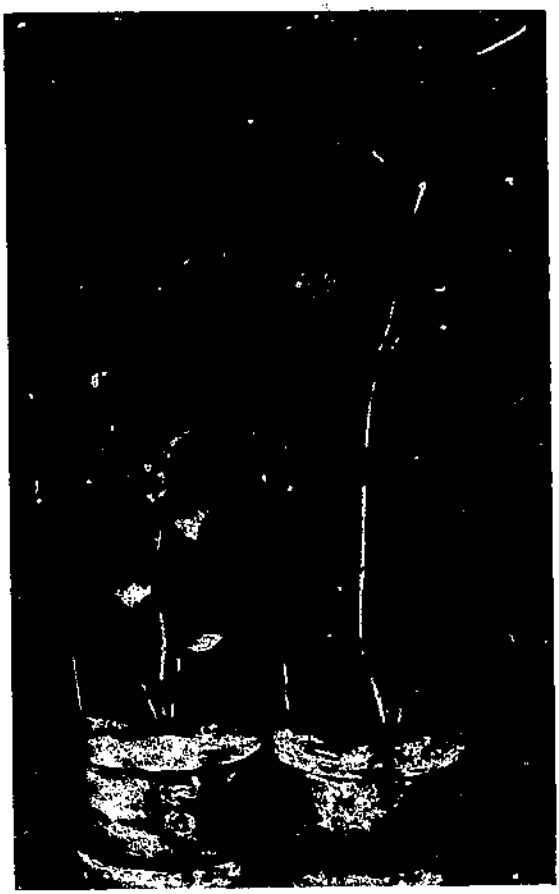

FIGURE 7.—Injury to broadbean by *Empoasca fabae;* infested plant at left.

According to the results of the tests in 1929 and 1930 on choice of plants for oviposition (*99*) it appeared that *fabae* preferred potato and therefore was one of the few insects bearing the correct common name. Since that time, however, broadbean (*Vicia faba* L.) has been found to be much preferred to potato by *fabae*, both for oviposition and for nymphal development (fig. 7). During the period September 1938 to January 1941, inclusive, *fabae* developed through 26 generations on broadbean, whereas only 20 generations of a similar strain developed on potato. Adults developing on broadbean appeared to be larger and more vigorous than those developing on potato.

DISEASELIKE INJURIES CAUSED BY EMPOASCA FABAE

The injury caused by *Empoasca fabae* is usually characteristic for each species of plant injured (figs. 8, 9, 10, 11) and often results in

the partial, sometimes in the total, destruction of the plant. That the amount of injury which *fabae* causes to its host plants is directly proportional to the number of insects present on these plants was shown (*98*) with hairy Peruvian alfalfa and with Kansas common alfalfa in 1931 (fig. 12). That the diseaselike injury produced on alfalfa by *fabae* is not systemic was shown by a test illustrated in figure 13. Adults of the potato leafhopper confined to one half of an alfalfa plant caused no injurious effects upon the remainder of the plant. The early stages of the injury to an individual leaf are illustrated in figure 14. This injury usually begins with discoloration along the midrib of the leaflet. As the injury progresses the distal end of the leaflet is the first to die.

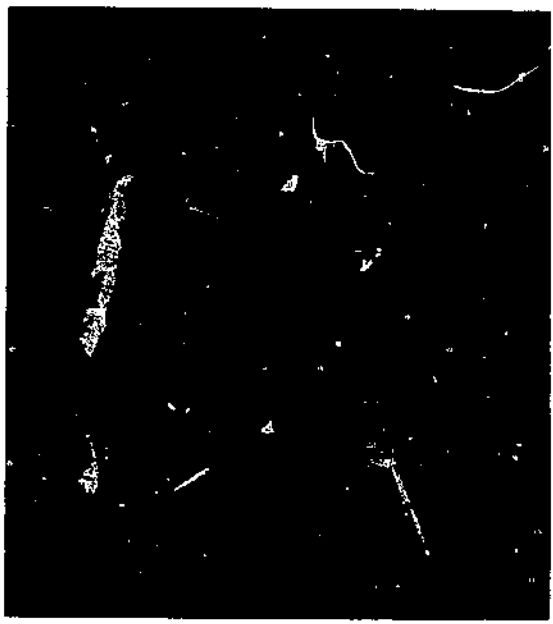

FIGURE 8.—Injury to cowpea by *Empoasca fabae;* infested leaf at left.

From a study of the feeding habits of *Empoasca fabae* (*113*) it was shown that this insect feeds on the phloem tissue or xylem vessels, which results in a more serious injury to the host plant than that caused by other species that feed only on the mesophyll tissue. This species is therefore the most injurious domestic empoascan species as well as the most generally known because it has been proved to be responsible for certain striking types of diseaselike injury, resulting from physiological disturbance, on many plants of economic importance.

In addition to the more destructive type of injury caused by this method of feeding, the wide range of host plants of *Empoasca fabae* and the additional number of generations (*94*) which it develops each season are extremely significant in explaining its extreme abundance and therefore its importance in comparison with its close congeneric relatives.

On alfalfa the diseaselike injury caused by *Empoasca fabae* has been commonly known as "yellows," "yellow-top," or "leafhopper

yellowing." It is preferable to refer to this as potato-leafhopper-injury (*100*), since the term "yellows" or "yellow-top" usually carries the inference that a virus or bacterial disease is involved, and because various shades of pink, red, and purple, as well as yellow, are usually present. On potatoes the injury is known as hopperburn, leafroll, or tipburn. On peanut it has produced a condition sometimes called pouts, which is known to be more commonly caused by thrips (*97*). The common symptoms of the diseaselike injury to peanuts (*9*) caused by *fabae* are a burning of the tips and the margins of the leaves and a yellowing and dwarfing of the foliage.

FIGURE 9.—Injury to eggplant by *Empoasca fabae*: infested plant at right.

This species has been reported as causing serious damage to dahlias (*73*, *121*), resulting in tip burning of leaves and dwarfing of growth, and as causing a condition similar to potato hopperburn on hollyhock, marigold (*111*), and zinnia. It has also been reported from Bermuda by Waterston (*124*) as causing hopperburn on watermelon and as doing considerable damage to foliage on gladioli early in the season (*125*). From California, Lewis (*71*) reported *Empoasca fabae* as causing a fruit-spotting injury to navel and Valencia oranges, which Russo (*107*) compared with a serious disease of the orange known in Sicily as fetola, and stated that it was probably due to some species of *Empoasca* there. Severe burning of tips of *Wisteria floribunda* f. *rosea* (Bean) Rehd. and Wils. by *fabae* was observed in 1939 at Arlington, Va., and symptoms of tip-killing and leaf-wilting were recorded in 1940 (*112*) from field observations on young seedlings of *Rosa multiflora* at Arlington Experiment Farm.

In a test conducted during 1933 no immunity to the diseaselike injury caused by this leafhopper was developed in Italian red clover. On July 25 a severely injured plant (fig. 15) was protected from the insect and on October 19, after it had recovered its normal growth (fig. 16), it was reinfested. On November 2 it was again severely injured (fig. 17).

TRANSMISSION OF PLANT DISEASES BY EMPOASCA FABAE

From time to time *Empoasca fabae* has been suspected of transmitting various plant diseases, but most of the experimental evidence

FIGURE 10.—Injury to peanut by *Empoasca fabae*; infested plant at right.

has proved negative. As positive evidence, Muncie (*39*) reported, from experiments in Michigan, that inoculation tests showed that yellow dwarf disease of potatoes was caused by a virus transmitted by means of tuber grafts and by the potato leafhopper (*E. fabae*) and the potato aphid (*Macrosiphum solanifolii*), the former being the better carrier, but Black's experiments (*16*) to transmit the virus of this disease with *fabae* gave negative evidence. Fajardo (*17*) reported that trials with *fabae* in the transmission of mosaic disease of the bean gave negative results. Brierley (*5*), in experiments in the transmission of mosaic of dahlias, found that it was not transmitted by *fabae*. Johnson (*25*) stated that all available evidence indicated

that the pathological symptoms caused by *fabae* on forage legumes were not due to the transmission of a virus by this insect. Tate (*118*), from transmission tests with *fabae*, concluded that this species was not capable of transmitting the virus of onion yellow dwarf.

EMPOASCA FABALIS DeLong

In 1930, Smith and Barker (*115*), from observations on the "yellows" disease of beans and related plants in Haiti, found this very severe bean disease to be caused by the feeding of a small green leaf-

FIGURE 11.—Injury to Japanese pagoda-tree (*Sophora japonica*) by *Empoasca fabae*: injured twig at left.

hopper of the genus *Empoasca* and stated "It appeared likely that a yellow condition of adjacent peanuts infested with the same leaf hoppers was related to the bean yellows." This leafhopper, described by Delong (*23*) as *Empoasca fabalis*, was reported as "extremely abundant upon beans and sweetpotatoes and the most important species of economic leaf hopper in Haiti upon truck crops." This species has been identified from specimens collected by F. M. Wadley in 1936 on bean in Mayaguez, P. R. It was recorded by Wolcott (*129*) in the list of insects of Puerto Rico as occurring also on *Sesbania grandiflora*, beet, carrot, cowpea, malojillo, melon, morning-

glory, potato, tobacco, and tomato. In the report of the Puerto Rico Experiment Station for 1939 (*4*) *E. fabalis* was recorded as injuring the leaves of small-seeded varieties of lima beans, while those of large-

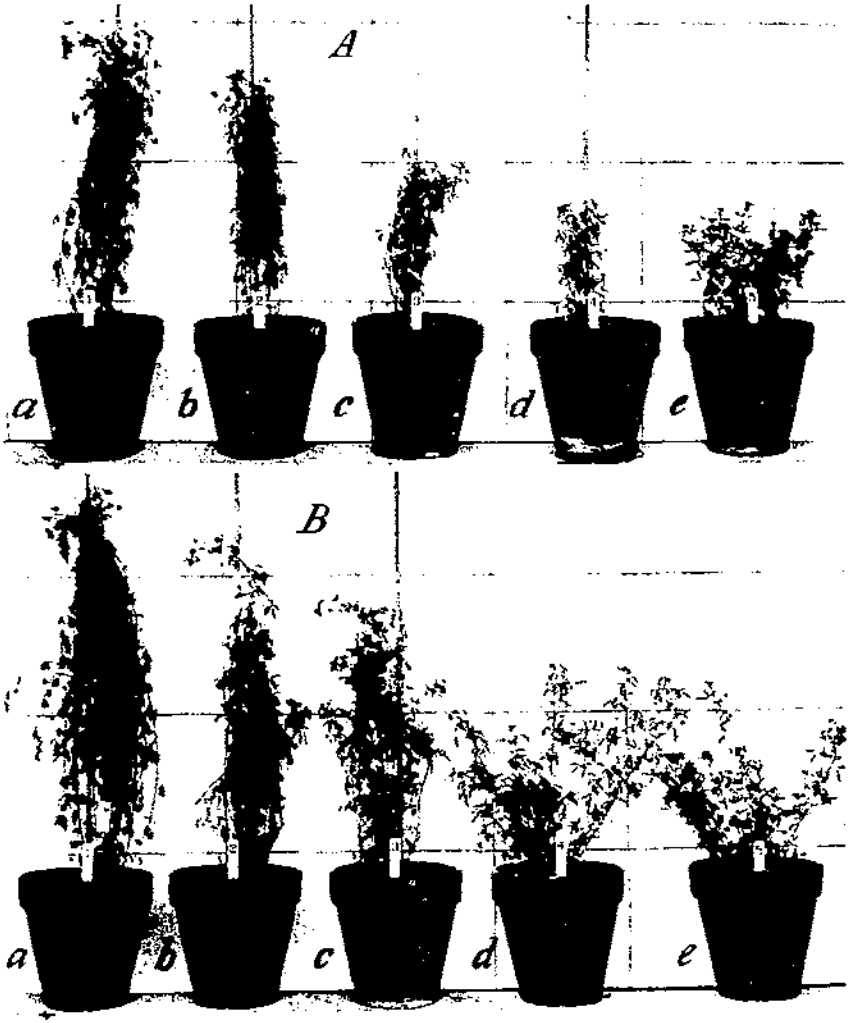

FIGURE 12.—Effect of infestation by *Empoasca fabae* on vegetatively propagated plants of hairy Peruvian alfalfa (*A*) and Kansas common alfalfa (*B*) in 1931: *a*, Uninfested; *b*, 10 adults; *c*, 80 adults; *d*, 160 adults; *e*, uncaged plant, natural infestation. The plants were transferred from field cages to 10-inch flowerpots for photographing against a background ruled into 1-foot squares. (After Doos and Johnson.)

seeded varieties were infested but not injured. It was also reported that the yellowing and mottling of the leaves appeared to be caused by the feeding of this leafhopper and not by a virus.

EMPOASCA FILAMENTA DeLong

DeLong (*24, p. 43*) described *Empoasca filamenta* from specimens collected in Oregon and Washington. It was later designated by DeLong as a high-altitude species, occurring abundantly on crops growing at 4,000 to 6,000 feet elevation, but seeming to be scarce at altitudes of less than 1,000 feet. It has also been identified by the authors in collections from Canada and from the following Western States: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. It has been reported as abundant on potato, bean, and sugar beet especially, and as occurring also on alfalfa, artichoke, carrot, cucumber, eggplant, herbs, parsnip (Japanese), squash, sweetpotato, and tomato. It has also been identified from specimens collected by E. J. Hambleton in Brazil on bean foliage, cotton plants, Leguminosae, grasses and weeds, and "sweetpotato or soybean."

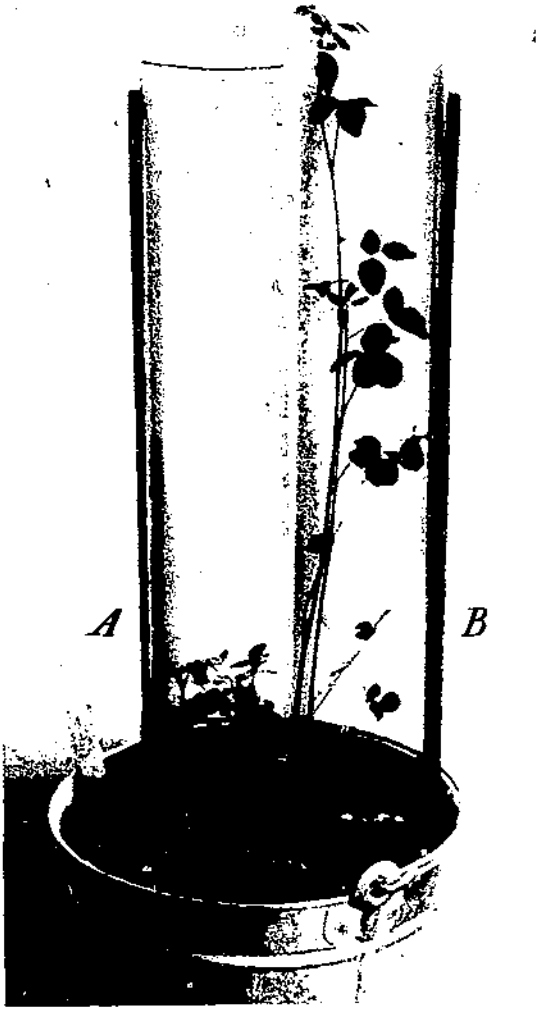

FIGURE 13.—Diseaselike injury to alfalfa by *Empoasca fabae* not systemic. Cages over shoots of the same plant: *A*, Infested; *B*, uninfested.

Zaumeyer and Kearns (*130*) reported negative results in attempts to transmit bean mosaic with *filamenta*, as did also Dykstra and Whitaker (*37*) in attempts to transmit various potato viruses.

This species was reared on potato and alfalfa at Arlington, Va., from material imported from California and studied in comparison of feeding habits on alfalfa and cowpea. It belongs to the group of which each species produces a definite spotting or stippling on the upper surface (fig. 18), characteristic of the species which feed on mesophyll tissue.

EMPOASCA GOSSYPII DeLong

Empoasca gossypii was described in 1932 (*27*) from specimens collected from cotton at Hinche, Haiti. It has been identified by the authors from specimens collected by E. J. Hambleton in 1934

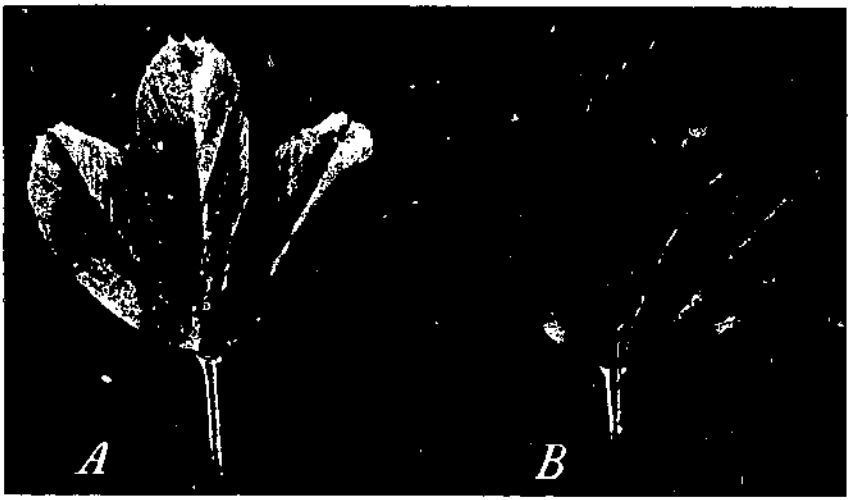

FIGURE 14.—Leaves of alfalfa showing (A) early stages of injury by *Empoasca fabae* compared with (*B*) normal leaf

on cotton plants in Vicosa, Minas-Geraes, Brazil; also from a single specimen collected by R. H. Beamer in 1934 at Mobile Bay, Ala. Osborn (*87*) reported *gossypii* as occurring on cotton in Puerto Rico. Hambleton and Sauer (*50*) reported it as a pest of minor importance on cotton in northeastern and southern Brazil.

EMPOASCA MALIGNA (Walsh)

Empoasca maligna was originally described by Walsh in 1862 (*123*) as *Chlorotettix maligna* in connection with a discussion of fire blight of apple and pear and its probable causes. This species is an apple leafhopper for which the common name green apple leafhopper was proposed by DeLong (*30*). It overwinters in the egg stage in the apple twigs and hatches in the spring. It has been

reported as abundant and destructive on cultivated and wild *Crataegus* and as occurring on pear, prune, and plum in various localities. It has been identified in collections from Arkansas, California, Colorado, Idaho, Illinois, Iowa, Maryland, New Hampshire, New York, Ohio, Oregon, Pennsylvania, South Dakota, Utah, Virginia, and Wisconsin and has been reported in conspicuous numbers on apple trees in inadequately sprayed orchards in Canada.[11]

This species has been collected in the trap lights at Arlington, Va., and has been reared from nymphs collected on apple. It has also been identified in collections from trap lights at Knoxville, Tenn. It was reported by F. F. Smith (*112*) to be breeding in large numbers on rambler rose at West Grove, Pa., and adults were reared by him in small numbers on butterfly rose. From studies made of comparative feeding habits it was found (*113*) that *maligna* feeds primarily on mesophyll tissue and causes a very finely peppered stippling on the leaves. Observations made over several years on hatching of *maligna* on apple established May 1 as the earliest hatching date at Arlington, Va., only one generation a year being noted.

FIGURE 15.—Italian red clover plant severely injured by *Empoasca fabae;* photographed July 26, 1933.

EMPOASCA OBTUSA Walsh

The species described as *Empoasca obtusa* by Walsh in 1862 (*123*), in connection with fire blight investigations, is a relatively large, broadheaded species that is apparently very common on willow and poplar. It has been recorded also from alfalfa, apple, birch (*Betula*

[11] ROSS, W. A. FRUIT INSECTS OF THE SEASON 1938 IN ONTARIO. Canada Dept. Agr., Canad. Insect Pest Rev. 17: 44–52. 1939. [Processed.] See p. 46.

latus Mich.), cottonwood, grasses, sheep-laurel (*Kalmia angustifolia* L.), and Virginia creeper; and reported from Quebec and from the following States: Alabama, California, Colorado, Connecticut, District of Columbia, Illinois, Iowa, Kansas, Maine, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and Wisconsin. This species has been identified from material taken in trap lights at Arlington, Va., at Manhattan and Hays, Kans., and at Knoxville, Tenn., and from wind traps at Arlington, Va., and Columbus, Ohio.

FIGURE 16.—Same Dalbit red clover plant as shown in figure 15, fully recovered; photographed October 19, 1933.

EMPOASCA PAPAYAE Oman

Empoasca papayae was described in 1937 (*80*) from specimens collected on *Carica papaya* L. at Mayaguez, P. R., and reported to be associated with the "bunchy-top disease" of papaya. In cage experiments (*79*) at the Puerto Rico Agricultural Experiment Station *papayae* produced stunting of papaya plants, and later symptoms resembling those of bunchy top developed.

EMPOASCA PATULA DeLong

DeLong described *Empoasca patula* in 1931 (*24, p. 77*) from specimens collected in Maine, Pennsylvania, and Tennessee, but no host

plant was mentioned. In 1931 it was reared from nymphs collected by M. V. Anthony on *Populus deltoides* Marsh. at Columbus, Ohio. Later it was recorded by Knowlton (1935) from Utah, and by Davidson and Landis (1942) from the cells of a wasp, *Crabro davidsoni* Sandh., in Ohio. This species has been identified by the authors in miscellaneous collections from Colorado, Iowa, and Kansas; from collections on willow from Arlington, Va., Scotia, N. Y., Wisconsin Rapids, Wis., and Vineland Station, Ontario, and from collections of trap light

FIGURE 17.—Same Italian red clover plant as shown in figures 15 and 16, pen-tested by *Empoasca fabae* on October 19, 1933, and again severely injured; photographed November 2, 1933

material taken at Arlington, Va., Knoxville, Tenn., and Cherryvale, Garden City, Hays, and Manhattan, Kans.

EMPOASCA PERGANDEI Gillette

Empoasca pergandei was described in 1898 (45) from a single female from Forest Hills, Mass. It has since been recorded from herbaceous vegetation in Connecticut, from black locust in New Hampshire, and from alfalfa and artichoke in Virginia. It has been identified from collections of trap light material from Kansas and Virginia; also from miscellaneous collections from other States, as follows: Arkansas, Colorado, the District of Columbia, Maine, Massa-

chusetts, New Hampshire, Pennsylvania, Tennessee, and West Virginia. This species has been reared at Arlington Experiment Farm from nymphs collected on black locust (*Robinia pseudoacacia* L.) in Pennsylvania and Virginia, and reported as reared from *R. pseudoacacia* by William L. Putman at Vineland Station, Ontario.

EMPOASCA PLEBEIA DeLong and Davidson

DeLong and Davidson (*31*) recorded *Empoasca plebeia* in the original description, in 1935, from Arizona, Florida, and Haiti, but no host plant was mentioned. In 1937 it was reared and identified at Arlington, Va., from nymphs collected on papaya (*Carica papaya* L.) and on *Cestrum* sp. in Florida by G. W. Barber.

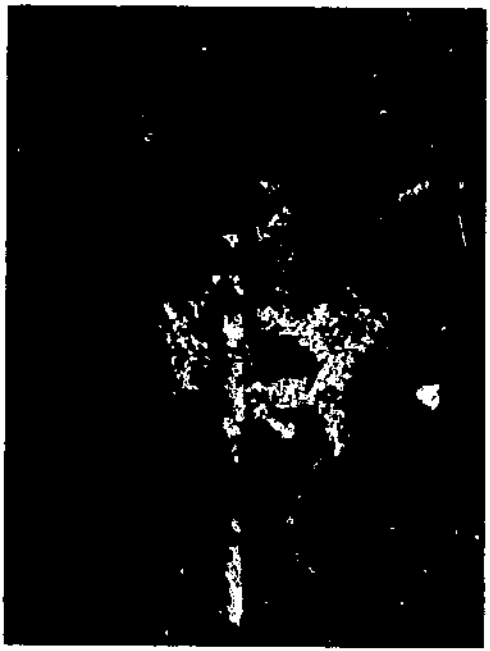

FIGURE 18.—Stippling produced on alfalfa leaflet by *Empoasca filamenta* during 24 hours of feeding.

EMPOASCA RADIATA Gillette

Empoasca radiata was originally described in 1898 (*45*) from specimens collected in Colorado. It was later recorded from the District of Columbia, Maryland, Missouri, Tennessee, and Texas, collected from grasses and herbaceous vegetation, with no definite records of host plants until recently, when this species was reared, in 1939, at Arlington, Va., from nymphs collected on mint (*Mentha crispa* L.), horsemints (*Monarda didyma* L., *M. mollis* L., and *M. punctata* L.), sage (*Salvia officinalis* L.), and valerian (*Valeriana officinalis* L.). In 1941 two specimens of *radiata* were taken in the trap lights at Arlington Experiment Farm, Va.

EMPOASCA RECURVATA DeLong

The original description of *Empoasca recurvata* in 1931 (*24, p. 38*) recorded two male specimens collected at Clarksville, Tenn., but no host plant was mentioned. This species has been identified from collections made in California, Florida, Illinois, Kansas, Kentucky,

Minnesota, Missouri, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Virginia, and Washington, D. C. It has been collected on alfalfa, bean, chickweed, cotton, dock, nettle, skunk cabbage, sweetclover, and wild cherry, and was found at Arlington, Va., during warm periods in winter and early spring, feeding on tender shoots of wild honeysuckle (*Lonicera japonica* Thunb.) which was partly covered by dried leaves. It has been found abundant late in the autumn in Virginia on chrysanthemum, on which it was causing a mottling of the leaves. It has also been collected in the trap lights and in a wind trap at Arlington, Va., and in a trap light at Knoxville, Tenn. It has been reared from the following hosts: American spikenard (*Aralia racemosa* L.), *Aster* spp., belladonna (*Atropa belladonna* L.), bindweed (*Convolvulus sepium* L.), castorbean (*Ricinus communis* L.), cowpea, dahlia, hemp (*Cannabis sativa* L.), Indian hemp (*Apocynum cannabinum* L.), mint (*Mentha crispa* L.), *Perilla ocymoides* L., potato, sage (*Salvia hispanica* L.), squash (*Cucurbita maxima* Duchesne), strawflower (*Helichrysum* sp.), sunflower (*Helianthus annuus* L.), sweetpotato, and wintergreen (*Gaultheria procumbens* L.).

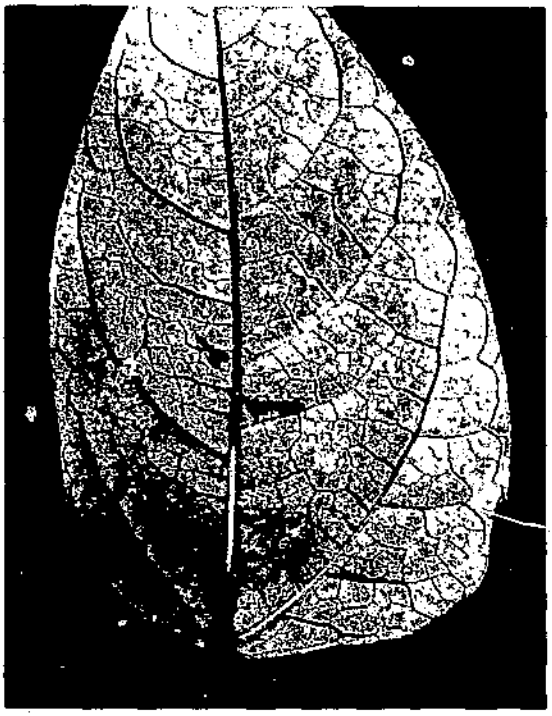

FIGURE 19.—Injury caused by *Empoasca recurvata* to the midrib of a cowpea leaf when confined to this host plant.

It was also reared on broadbean (*Vicia faba* L.) from eggs from a female adult collected on alfalfa near Fredericksburg, Va., May 6, 1940, in an attempt to record the earliest seasonal occurrence of *Empoasca fabae*. The injury caused by this species to the midrib of a cowpea leaf when confined to this host plant is illustrated in figure 19. The injury caused when confined to potato (fig. 20) would appear to justify further study. This species, like *E. fabae*, apparently feeds on the phloem of its host plants.

EMPOASCA SALICIS Wheeler

The species *Empoasca salicis*, which was described in 1937 (*126*), has been reared from nymphs collected on willow at Arlington, Va., and has been taken in trap lights both at Arlington, Va., and Knoxville, Tenn.

EMPOASCA SATIVAE Poos

Poos (*95*) described *Empoasca sativae* in 1933 from specimens collected in large numbers on alfalfa in Kansas and Louisiana. It has since been identified from collections on alfalfa in North Carolina, Ohio, and Virginia; from sweeping in an apple orchard and from collections on grape at Arlington, Va.; from *Melilotus indica* (L.) All. at Baton Rouge, La.; on banana debris at Philadelphia, Pa., originally from Honduras; from *Centrosema* sp. and indigo (*Indigofera* sp.) in Puerto Rico; from cotton plants in Brazil; and from miscellaneous collections (no host plants recorded) from Arizona, California, and Texas. This species has also been taken in trap lights at Arlington, Va., and at Knoxville, Tenn., and was tentatively identified by P. W. Oman as *Empoasca* n. sp. near *abrupta* from specimens taken in an airplane trap at elevations of 500 and 1,000 feet at Tallulah, La. (*46*). Adults of *sativae* have been reared and identified at Arlington, Va., from nymphs collected on alfalfa by Norman Allen at Baton Rouge, La.

FIGURE 20.—Injury to potato leaflet by *Empoasca recurrata* in a cage.

EMPOASCA SMARAGDULA (Fallén)

The species originally described from Sweden by Fallén in 1806 (*42*) as *Cicada smaragdula* was later described as *Empoasca smaragdula* (Fallén) by Gillette (*45*). This is a species of wide distribution throughout Europe as well as in Canada and throughout the United

States, where it has been recorded from California, Colorado, Connecticut, Maine, Michigan, Missouri, New Hampshire, New York, Oregon, Pennsylvania, Tennessee, Virginia, and Wisconsin. It is common on willow and occurs also on alder, birch, *Crataegus rivularis* Nutt., linden, poplar, and sallow. It has been taken at Arlington Experiment Farm, Va., both on willow and in the trap lights, and has been identified in a collection from trap lights at Knoxville, Tenn. This species has recently been identified in a collection received from William L. Putman, who reported finding it, both as nymphs and as adults, on an unidentified willow species grown as an ornamental at Vineland Station, Ontario.

Empoasca solana DeLong

Empoasca solana was described in 1931 (*24, p 50*) from two male adults collected on potato in Louisiana. It breeds abundantly on potato and pigweed (*Amaranthus retroflexus* L.) at Arlington, Va., and has also been reared from nymphs collected on the following hosts: *Aster* sp., black nightshade (*Solanum nigrum* L.), *Cestrum* sp., chayote (*Sechium edule* (Jacq.) Swartz), Mexican tea (*Chenopodium ambrosioides* L.), papaya (*Carica papaya* L.), pokeweed (*Phytolacca* sp.), and sweetpotato. It was reported as abundant on cotton in Louisiana in 1937. It has been identified from collections taken from alfalfa, castor-bean, chickweed, dahlia, lemon trees, nightshade leaves, sugar beet, willow, and weeds. This species was also identified from specimens taken in 1936 at Philadelphia, Pa., in a cargo of bananas originally from Guatemala. It was also taken in an airplane trap, at elevations of 200 to 1,000 feet, in Louisiana, and from trap lights in Kansas, Tennessee, and Virginia. Other records on the distribution of this species include Arizona, California, Florida, Georgia, Kentucky, Illinois, Missouri, South Carolina, Texas, and also the Bahamas, Honduras, Mexico, Panama, and Santo Domingo. It was reported in Hawaii (*21*) as causing considerable injury ("leafhopper burn") to potato, watermelon, and castor-bean and "stippling of chlorotic spots" on *Amaranthus*. New host records recently reported (*11*) for Hawaii included *solana* in abundance on lettuce and on peanuts; and also as most abundant and causing "hopperburn" on beans in hot, dry sections such as Lualualei.

Some evidence of feeding injury to potato by this species (fig. 21) in confinement was observed at Arlington Experiment Farm. Further studies of the feeding habits of this species seem justified since it has appeared to be more abundant than *fabae* on potato in early May in the vicinity of Charleston, S. C. This species, as well as *fabae* and *recurrata*, apparently is a phloem feeder.

In transmission experiments conducted in Hawaii (*10*), *solana* collected on papaya gave negative results as a possible vector of a virus disease of papaya.

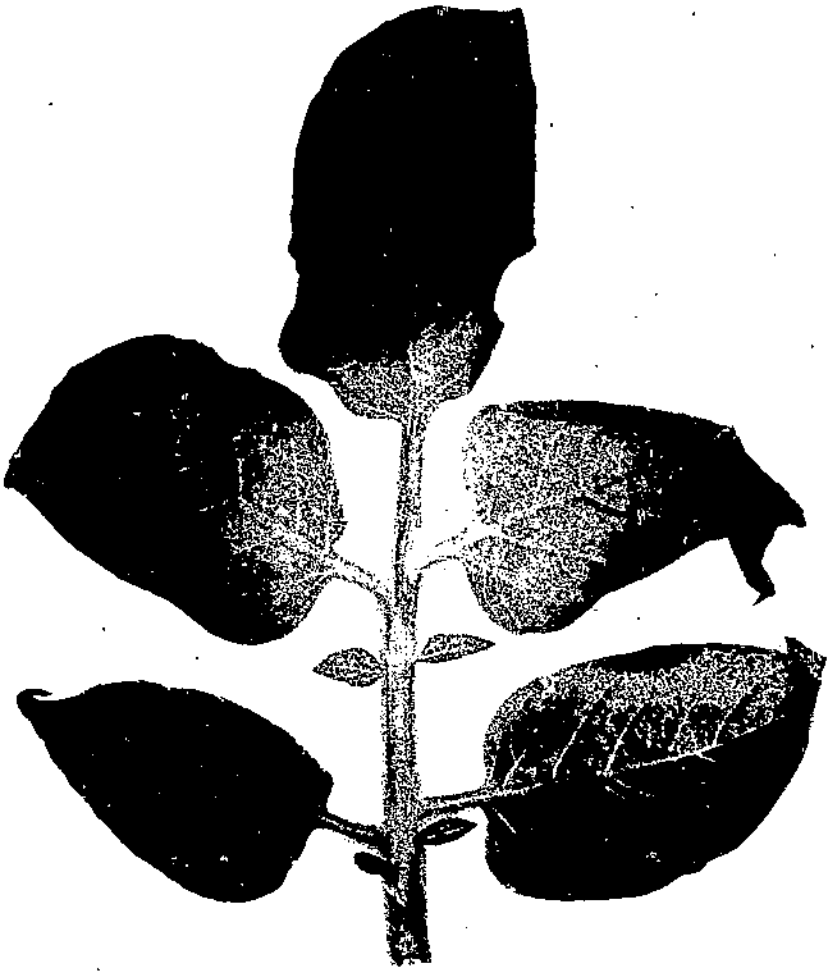

FIGURE 21.—Injury caused by *Empoasca solana* to potato when confined in a cage.

EMPOASCA TRIFASCIATA Gillette

Empoasca trifasciata is a common species on cottonwood (*Populus deltoides* Marsh.) and Lombardy poplar (*Populus nigra italica* Muench.). It was described in 1898 (*5*) from specimens from Kansas, Illinois, and Iowa. It has been recorded also from Arizona, Colorado, Connecticut, Massachusetts, Missouri, New Jersey, New

York, Ohio, Pennsylvania, and Tennessee and has been identified from a collection taken in the trap light at Arlington, Va.

EMPOASCA VERGENA DeLong and Caldwell

DeLong and Caldwell (*30*) described *Empoasca vergena* in 1934 from specimens collected in Ohio and Illinois. It has been reared on stinging nettle (*Urtica gracilis* Ait.) in life-history studies at Arlington, Va., and has been identified from collections taken in trap lights operated in Kansas, Tennessee, and Virginia, and from a miscellaneous collection taken in Pennsylvania.

EMPOASCA spp.

Since males are necessary for most specific identifications in the genus *Empoasca*, the plants from which only indeterminate females were reared from the nymphs collected on them are not listed under any definite species, but are considered, for the time being, as host plants of *Empoasca* spp. They were *Parietaria officinalis* L. and *Salvia austriaca* Jacq. Host plants from which nymphs were collected, but not successfully reared to adult, are rose geranium (*Pelargonium graveolens* (Thunb.) L'Her.) and crapemyrtle (*Lagerstroemia indica* L.).

SUMMARY

Many species of *Empoasca* cannot be definitely differentiated by external morphological characters but must be identified by structures within the abdomen of the male, particularly the genital chamber. Correct identity of these species, based on a special technique, is essential in ascertaining their economic status and capacity for causing injury to their host plants. The study of the relative seasonal abundance, host plants, biology, and feeding habits of the species investigated at the Arlington Experiment Farm, Arlington, Va., included the specific identification of more than 50,000 male specimens of *Empoasca*.

Records of occurrence and host plants of 13 foreign species are compiled from the literature because of their reported economic importance. Thirty-one domestic species of which at least 15 have injured plants enough to be considered economically important are similarly treated. Twenty-three of these species were reared at the Arlington Experiment Farm. The number of different host plants from which these species were reared ranged from 1, for the less abundant empoascan species, to 108 host plants for *fabae*, the potato leafhopper. Thirty-nine species of host plants had more than 1 species of *Empoasca* reared from each of them. Potato and sweetpotato each had

the maximum of 7 species reared from them. The wide variety and comparatively large number of host plants from which many of the species of *Empoasca* have been reared re-emphasize the economic importance, both actual and potential, of members of this genus.

The most important domestic species of *Empoasca* is undoubtedly *fabae*, which is one of the very injurious pests of forage-crop legumes and certain truck crops. It occurs over a wide area and is often particularly abundant in the eastern half of the United States. It is apparently the most injurious domestic species of *Empoasca* because of the large variety of host plants on which it feeds, because of its ability to build up its populations rapidly under favorable conditions through a number of generations, and because of its peculiar habit of taking its food from the phloem and xylem rather than the mesophyll of the host plant. At least two domestic species (*recurvata* and *solana*) have shown evidence of having feeding habits similar to those of *fabae*. The diseaselike injury caused by *fabae* is usually characteristic for each species of plant injured and is, accordingly, known by various names. *E. fabae* has been suspected from time to time of transmitting various plant diseases, but most of the experimental evidence has been in the negative.

LITERATURE CITED

(1) ANONYMOUS
1933. BIOLOGY. N. Mex., Agr. Expt. Sta. Ann. Rpt. (1931–32) 43: 38–40, illus.

(2) ——
1939. PLANT-DISEASE INVESTIGATIONS. PAPAYA BUNCHY TOP STUDIES. Puerto Rico Agr. Expt. Sta. Rpt. 1938: 121–125, illus.

(3) ——
1940. VEGETABLE CROP INVESTIGATIONS. Puerto Rico Agr. Expt. Sta. Rpt. 1939: 45–62, illus.

(4) ANDREWS, E. A.
1927. TEA GREEN FLY (EMPOASCA FLAVESCENS-FABR.). Indian Tea Assoc., Sci. Dept. Quart. Jour. 1927: [61]–68.

(5) AUTMANN, G.
1912. MITTEILUNG ÜBER DIE OSTAFRIKANISCHE BAUMWOLLCICADE, CHLOROITA FACIALIS JAC. N. SP. Ent. Rundschau 29: 69.

(6) BAKER, R. E. D.
1939. PAPAW MOSAIC DISEASE. Trop. Agr. [Trinidad] 16: 159–163, illus.

(7) BALDUF, W. V.
1934. THE TAXONOMIC VALUE OF OVIPOSITORS IN SOME EMPOASCA SPECIES (HOMOPTERA, CICADELLIDAE). Ent. Soc. Amer. Ann. 27: 293–310, illus.

(8) BALLARD, E.
1937. REPORT OF THE GOVERNMENT ENTOMOLOGIST FOR THE YEAR 1ST APRIL, 1935 TO 31ST MARCH 1936. Palestine Dept. Agr. and Forests Ann. Rpt. 1935–36: 202–205.

(9) BATTEN, E. T., and POOS, F. W.
1928. SPRAYING AND DUSTING TO CONTROL THE POTATO LEAFHOPPER ON PEANUTS IN VIRGINIA. Va. Agr. Expt. Sta. Bul. 316, 20 pp., illus.

(10) [BEAUMONT, J. H.]
1940. ENTOMOLOGY. Hawaii Agr. Expt. Sta. Rpt. 1939: [36]–42.

(11) ——
1941. ENTOMOLOGY. Hawaii Agr. Expt. Sta. Rpt. 1940: [38]–45, illus.

(12) BERRINGTON, A. G., and ALLAN, W.
1930. RESEARCH STATION, MAZABUKA. REPORT ON WORK ON COTTON, SEASON 1928–29 (NORTHERN RHODESIA). Empire Cotton Growing Corp., Expt. Stas. Rpts. 1928–29: 131–145, illus.

(13) BEDFORD, H. W.
1936. ENTOMOLOGICAL SECTION, AGRICULTURAL RESEARCH SERVICE. REPORT ON WORK CARRIED OUT BY THE STAFF OF THE SECTION DURING THE SEASON 1935/36. Sudan Agr. Res. Serv. Ann. Rpt. 1936 (Pt. 2): 38–52.

(14) ———
1938. ENTOMOLOGICAL SECTION, AGRICULTURAL RESEARCH SERVICE. REPORT ON WORK CARRIED OUT BY THE STAFF OF THE SECTION DURING THE SEASON 1937/38. Sudan Agr. Res. Serv. Ann. Rpt. 1938 (Pt. 2): 50–71.

(15) BERGEVIN, E., and ZANON, D. V.
1922. DANNI ALLA VITE IN CIRENAICA E TRIPOLITANIA DOVUTI AD UN NUOVO OMOTTERO (CHLOROTA LYBICA SP. N.). Agr. Colon. [Italy] 16: 58–64.

(16) BLACK, L. M.
1937. A STUDY OF POTATO YELLOW DWARF IN NEW YORK. N. Y. (Cornell) Agr. Expt. Sta. Mem. 209, 23 pp., illus.

(17) BLATTNÝ, C.
1924. ŠKODOVÉ A NĚKTERÉ CHOROBY ROSTLIN LÉČIVÝCH ROCE 1923. (INJURY AND SOME DISEASES OF MEDICINAL PLANTS IN 1923.) Ochrana Rostlin 4 (1): 10–12.

(18) ———.
1933. MOSAIKA NA CELERU (APIUM GRAVEOLENS) NEBYLA U NÁS DOSUD POPSÁNA. (Miscellaneous Notes) Ochrana Rostlin 13 (3/4): 145–146.

(19) BODENHEIMER, F. S., and KLEIN, H. Z
1929. THE GREEN CICADA—A NEW INSECT PEST OF EGGPLANTS. Zionist Agr. Expt. Sta. Yedeoth (Proc.) 2, Nos. 1–2 (11–32): 524–527, illus. (English summary, p. 558.)

(20) BRIERLEY, P.
1933. STUDIES ON MOSAIC AND RELATED DISEASES OF DAHLIA. Boyce Thompson Inst. Contrib. 5: 235–288, illus.

(21) CARTER, W.
1936. INSECTS AND PLANT DISEASES. Hawaii. Ent. Soc. Proc. (1935) 9: [159]–170, illus.

(22) DAVIDSON, R. H., and LANDIS, B. J.
1938. CRABRO DAVIDSONI SANDH., A WASP PREDACIOUS ON ADULT LEAFHOPPERS. Ent. Soc. Amer. Ann. 31: 5–8, illus.

(23) DELONG, D. M.
1930. A NEW SPECIES OF BEAN LEAFHOPPER FROM HAITI. Canad. Ent. 62: 92–94, illus.

(24) ——— —
1931. A REVISION OF THE AMERICAN SPECIES OF EMPOASCA KNOWN TO OCCUR NORTH OF MEXICO. U. S. Dept. Agr. Tech. Bul. 231, 60 pp., illus.

(25) ———
1931. DISTRIBUTION OF THE POTATO LEAFHOPPER (EMPOASCA FABAE HARRIS) AND ITS CLOSE RELATIVES OF EMPOASCA. Jour. Econ. Ent. 24: 475–479, illus.

(26) ———
1931. THE MORE IMPORTANT SPECIES OF LEAFHOPPERS AFFECTING THE APPLE. Jour. Econ. Ent. 24: 1214–1222, illus.

(27) ———
1932. THREE SPECIES OF EMPOASCA LEAFHOPPERS KNOWN TO AFFECT ECONOMIC PLANTS IN HAITI (INCLUDING THE DESCRIPTION OF TWO NEW SPECIES). Puerto Rico Dept. Agr. Jour. 16: 113–115, illus.

(28) ———
1932. FURTHER STUDIES OF THE GENUS EMPOASCA (HOMOPTERA, CICADELLIDAE). PART I, NINE NEW SPECIES OF EMPOASCA. Ohio Jour. Sci. 32: 393–401, illus.

(29) ———
1938. BIOLOGICAL STUDIES ON THE LEAFHOPPER EMPOASCA FABAE AS A BEAN PEST. U. S. Dept. Agr. Tech. Bul. 618, 60 pp., illus.

(30) DeLong, D. M., and Caldwell, J. S.
1934. STUDIES OF THE GENUS EMPOASCA. PART II. NINE NEW SPECIES OF EMPOASCA. Ent. Soc. Amer. Ann. 27: 604–609, illus.
(31) ——— and Davidson, R. H.
1935. FURTHER STUDIES OF THE GENUS EMPOASCA (HOMOPTERA, CICADELLIDAE). PART III. SEVENTEEN NEW SPECIES OF EMPOASCA FROM THE UNITED STATES AND CANADA. Ohio Jour. Sci. 35: 29–39, illus.
(32) ——— and Davidson, R. H.
1936. FURTHER STUDIES OF THE GENUS EMPOASCA (HOMOPTERA, CICADELLIDAE). PART IV. ELEVEN NEW SPECIES OF EMPOASCA FROM THE UNITED STATES. Ohio Jour. Sci. 36: 225–230, illus.
(33) Distant, W. L.
1910. DESCRIPTIONS OF THREE NEW SPECIES OF INDIAN RHYNCHOTA. Entomologist 43: 195–196.
(34) ———
1918. THE FAUNA OF BRITISH INDIA, INCLUDING CEYLON AND BURMA. Rhynchota 7, 210 pp., illus. London.
(35) Dulzetto, F., and Muscatello, G.
1939. SU LA "PETOLA" DELLE ARANCE E SULLE PROBABILI CAUSE CHE LA DETERMINANO (NOTA PREVENTIVA). ["DECAY" OF ORANGES AND ITS PROBABLE CAUSES (PRELIMINARY NOTE).] Accad. Gioenia di Sci. Nat. Atti 3 (2): 23–27, illus. [Abstract in Rev. Appl. Ent. (A) 28: 328. 1940.]
(36) Du Pasquier, R.
1932. PRINCIPALES MALADIES PARASITAIRES DU THÉIER ET DU CAFÉIER EN EXTRÊME-ORIENT. Bul. Écon. de l'Indochine, Sect. B, 35: [367 B]–415 B, [589 B]–618 B, illus.
(37) Dykstra, T. P., and Whitaker, W. C.
1938. EXPERIMENTS ON THE TRANSMISSION OF POTATO VIRUSES BY VECTORS. Jour. Agr. Res. 57: 319–334, illus.
(38) Esaki, T., and Hashimoto, S.
1936. REPORT ON THE LEAF-HOPPERS INJURIOUS TO THE RICE PLANT AND THEIR NATURAL ENEMIES, NO. 7 (FOR THE YEAR 1935). Kyushu Imp. Univ., Dept. Agr. Ent. Lab., 31 pp., illus. [In Japanese.]
(39) Evans, J. W.
1941. SOME QUEENSLAND LEAF-HOPPERS (JASSOIDEA, HOMOPTERA) THAT ATTACK LUCERNE. Roy. Soc. Queensland, Proc. (1941) 52 (1): 10–13, illus.
(40) Fabricius, J. C.
1792–94. ENTOMOLOGIA SYSTEMATICA EMENDATA ET AUCTA. SECUNDUM CLASSES, ORDINES, GENERA, SPECIES, ADJECTIS SYNONIMIS, LOCIS, OBSERVATIONIBUS, DESCRIPTIONIBUS. 4 v. Hafniae.
(41) Fajardo, T. G.
1930. STUDIES ON THE MOSAIC DISEASE OF THE BEAN (PHASEOLUS VULGARIS L.). Phytopathology 20: 469–494, illus.
(42) Fallén, C. F.
1806. FÖRSÖK TILL DE SVENSKA CICAD-ARTERNAS UPPSTÄLLNING OCH BESKRIFNING. Svenska Vetensk. Akad. Handl. 27: 6–43.
(43) Fletcher, T. B.
1920. ANNOTATED LIST OF INDIAN CROP-PESTS. Pusa 3d Ent. Meeting (1919), Proc. 1: 33–374, illus.
(44) Fukuda, K.
1937. [CONTROL EXPERIMENTS WITH INSECT PESTS OF COTTON.] Formosan Agr. Rev. 33 (367): 483–519. [In Japanese. Abstract in Rev. Appl. Ent. (A) 25: 744. 1937.]
(45) Gillette, C. P.
1898. AMERICAN LEAF-HOPPERS OF THE SUBFAMILY TYPHLOCYBINAE. U. S. Natl. Mus. Proc. 20: 709–773, illus.
(46) Glick, P. A.
1939. THE DISTRIBUTION OF INSECTS, SPIDERS, AND MITES IN THE AIR. U. S. Dept. Agr. Tech. Bul. 673, 151 pp., illus.
(47) Goding, F. W.
1890. A NEW APPLE PEST. Ent. News 1: 123–124.
(48) Golding, F. D.
1930. A VECTOR OF LEAF CURL OF COTTON IN SOUTHERN NIGERIA. Empire Cotton Growing Rev. 7: 120–126.

(49) GRUNWALD, H.
1930. RIZINUS. [THE CASTOR OIL PLANT.] Tropenpflanz. Beih. 27 (1), 58 pp., illus.

(50) HAMBLETON, E. J., and SAUER, H. F. G.
1938. OBSERVAÇÕES SOBRE AS PRÁGAS DA CULTURA ALGODOEIRA NO NORDESTE E NORTE DO BRASIL. [OBSERVATIONS ON COTTON PESTS IN NORTHEASTERN AND NORTHERN BRAZIL.] Inst. Biol. [São Paulo] Arq. 9: [319]–330. [English abstract, p. 330.]

(51) HARGREAVES, H.
1934. CLIMATIC AND SOIL FACTORS IN RELATION TO PREVALENCE OF, AND DAMAGE BY, INSECTS; POSSIBILITIES OF REDUCTION OF LOSS OF CROP DUE TO INSECTS, BY THE SELECTION AND RESTRICTION OF SOWING PERIODS AND BY THE PROPAGATION OF COTTON STRAINS BETTER ADAPTED TO LOCAL CONDITIONS. Empire Cotton Growing Corp., 2d Conf. Cotton Growing Prob., Rpt., pp. 125–131.

(52) ———
1936. REPORT OF THE GOVERNMENT ENTOMOLOGIST FOR 1934. Uganda Dept. Agr. Ann. Rpt. 1934. (Pt. 2): 62–72.

(53) HARRIS, T. W.
1841. A REPORT ON THE INSECTS OF MASSACHUSETTS, INJURIOUS TO VEGETATION. 459 pp. Cambridge, Mass.

(54) HARRIS, W. V.
1933. REPORT OF THE ASSISTANT ENTOMOLOGIST, 1932. Tanganyika Dept. Agr. Ann. Rpt. 1932: 73–75.

(55) HAUPT, H.
1912. NEUES UND KRITISCHES ÜBER ARTEN UND VARIETÄTEN EINHEIMISCHER HOMOPTERA. Berlin. Ent. Ztschr. (1911) 56: 177–196, illus.

(56) ———
1927. HOMOPTERA PALESTINAE I. Zion. Organ. Inst. Agr. Nat. Hist. Bul. 8, 43 pp., illus.

(57) HEINZE, K.
1937. ZUR FRAGE DER UEBERTRAGUNG DER KARTOFFELVIROSEN DURCH JASSIDEN. [ON THE QUESTION OF THE TRANSMISSION OF POTATO VIRUSES BY JASSIDS.] Phytopath. Ztschr. 10: 606–613, illus.

(58) HUSAIN, M. A.
1930. LEAF-CURL IN COTTON. (Letters to the Editor) Nature [London] 126: 958.

(59) ——— and LAL, K. B.
1939. THE COTTON JASSID, EMPOASCA DEVASTANS DISTANT. (Abstract) Indian Sci. Cong. Proc. (1938) 25: 183.

(60) JACK, R. W.
1928. REPORT OF THE CHIEF ENTOMOLOGIST FOR THE YEAR 1927. Rhodesia, South., Dept. Agr. Rpt. Sec. 1927: 25–29.

(61) ———
1938. ANNUAL REPORT OF THE DIVISION OF ENTOMOLOGY FOR THE YEAR ENDED 31ST DECEMBER, 1937. Rhodesia Agr. Jour. 35: 652–676; also Rhodesia, South., Dept. Agr. and Lands Bul. 1080, 25 pp.

(62) JOHNSON, H. W.
1934. NATURE OF INJURY TO FORAGE LEGUMES BY THE POTATO LEAF HOPPER. Jour. Agr. Res. 49: 379–406, illus.

(63) JOHNSTON, H. B.
1930. SUMMARY REPORT ON THE ENTOMOLOGICAL WORK OF THE GEZIRA LABORATORY FOR THE YEAR 1929. Sudan Govt. Wellcome Trop. Res. Lab., Ent. Sect. Bul. 31: [42]–47.

(64) KAYASHIMA, I.
1934. [ON THE DAMAGE CAUSED BY LEAFHOPPERS TO USEFUL TREES IN FORMOSA.] Taiwan no Sanrin 94: 31–34. [In Japanese. Abstract in Rev. Appl. Ent. (A) 22: 376. 1934.]

(65) KIRKPATRICK, T. W.
1930. PRELIMINARY NOTE ON LEAF-CRINKLE OF COTTON IN THE GEZIRA AREA, SUDAN. Bul. Ent. Res. 21: 127–137.

(66) KNOWLTON, G. F.
1934. SOME UTAH LEAFHOPPERS. Canad. Ent. 66: 164–168.

(67) KRUGER, G.
1934. CYRENAICA; PLANT PESTS. (Communication) Internatl. Inst. Agr. Internatl. Bul. Plant Protect. 8(11): M243–M244.

(68) KUWAYAMA, S.
1936. [INSECT PESTS OF APPLE IN HOKKAIDO.] Sapporo, Abs. Lect. Hort. Lect.-Meet. 4: 87–118. [In Japanese. Abstract in Rev. Appl. Ent. (A) 25: 226. 1937.]

(69) ———
1938. [REPORT ON THE DISTRIBUTION OF AND THE CONDITIONS OF INJURIES BY INSECT PESTS OF IMPORTANT AGRICULTURAL CROPS IN MANCHUKUO.] Manchukuo Bur. Indus. Sangyobu Shiryo 33, 112 pp., illus. [In Japanese. Abstract in Rev. Appl. Ent. (A) 27: 340. 1939.]

(70) LEVER, R. J. A. W.
1940. THE JASSID LEAF-HOPPER OF COTTON. Fiji Dept. Agr., Agr. Jour. 11: 16–17.

(71) LEWIS, H. C.
1939. FRUIT SPOTTING CAUSED BY THE GREEN LEAFHOPPER. Calif. Citrog. 24: 108–109, illus.

(72) LI, F.-S., and CHOU, S.-M.
1937. THE DISTRIBUTION OF IMPORTANT COTTON INSECTS RECORDED IN CHINESE LITERATURE. Ent. and Phytopath. 5(15–16): 282–302, illus. [English summary, p. 294.]

(73) MCDANIEL, E. I.
1936. CONTROL OF THE POTATO LEAFHOPPER EMPOASCA FABAE ON DAHLIA WITH FLOUR, TALC AND INFUSORIAL EARTH. (Scientific Notes) Jour. Econ. Ent. 29: 404.

(74) MCKINNEY, K. B.
1939. COMMON INSECTS ATTACKING SUGAR BEETS AND VEGETABLE CROPS IN THE SALT RIVER VALLEY OF ARIZONA. Jour. Econ. Ent. 32: 808–810.

(75) MELICHAR, L.
1903. HOMOPTEREN-FAUNA VON CEYLON. 248 pp., illus. Berlin.

(76) MISRA, C. S.
1920. SOME PESTS OF COTTON IN NORTH BIHAR. Pusa, 3d Ent. Meeting, (1919) Proc. 2: 547–561, illus.

(77) MO, T. T.
1937. AANTEEKENINGEN OVER EENIGE SCHADELIJKE INSECTEN OP HIBISCUS SABDARIFFA (ROSELLE). [NOTES ON SOME INJURIOUS INSECTS ON H. SABDARIFFA.] Bergcultures 11: 1850–1852, illus.

(78) MONTEIL, L.
1934. LES INSECTES NUISIBLES AU COTONNIER EN AFRIQUE ÉQUATORIALE FRANÇAISE. Agron. Colon. 23: 11–18.

(79) MUNCIE, J. H.
1935. YELLOW DWARF DISEASE OF POTATOES. Mich. Agr. Expt. Sta. Spec. Bul. 260, 78 pp., illus.

(80) OMAN, P. W.
1937. NEW EUPTERYGINE LEAFHOPPERS FROM PUERTO RICO (HOMOPTERA—CICADELLIDAE). Puerto Rico Univ. Jour. Agr. 21: 567–572, illus.

(81) OSBORN, H.
1926. FAUNISTIC AND ECOLOGIC NOTES ON CUBAN HOMOPTERA. Ent. Soc. Amer. Ann. 19: 335–366, illus.

(82) ———
1928. NEOTROPICAL HOMOPTERA OF THE CARNEGIE MUSEUM. PART 6. REPORT ON THE SUBFAMILY TYPHLOCYBINAE, WITH DESCRIPTIONS OF NEW SPECIES. Carnegie Mus. Ann. 18: 253–298, illus.

(83) ———
1929. NOTES ON PORTO RICAN HOMOPTERA. Porto Rico Dept. Agr. Jour. 13: 81–112, illus.

(84) ———
1935. INSECTS OF PORTO RICO AND THE VIRGIN ISLANDS. HOMOPTERA (EXCLUSIVE OF STERNORHYNCHII). N. Y. Acad. Sci. Sci. Survey Porto Rico and the Virgin Isl. 14: 111–260, illus. New York.

(85) OSHANIN, B.
1870. [SUGLI EMITTERI DELLA VALLE DEL ZERAVSHAN.] Moscov. Obshch. Liubit. Est. Ant. Etnog. Izv. 8: 194–214. [In Russian. Not seen.]

(86) OTANES, F. Q., and BUTAC, F. L.
1935. A PRELIMINARY STUDY OF THE INSECT PESTS OF COTTON IN THE PHILIPPINES WITH SUGGESTIONS FOR THEIR CONTROL. Philippine Jour. Agr. 6: 147–174, illus.

(87) PAOLI, G.
1930. CARATTERI DIAGNOSTICI DELLE EMPOASCA E DESCRIZIONE DI NUOVE SPECIE. [DIAGNOSTIC CHARACTERS OF EMPOASCA AND DESCRIPTION OF NEW SPECIES.] Toscana Soc. di Sci. Nat. Atti 39(5): 64–75, illus. (Rev. Appl. Ent. (A) 19: 201. 1931.)

(88) ———
1930. NOTIZIE SULL'ARRICCIAMENTO DEL COTONE NELLA SOMALIA ITALIANA. [NOTES ON LEAF-CRINKLING IN COTTON IN ITALIAN SOMALILAND.] Russ. Econ. Colon. 18: 324–336.

(89) ———
1932. CARATTERI DIAGNOSTICI DELLE EMPOASCA E DESCRIZIONE DI NUOVE SPECIE. Arch Zool. Ital. 16 (3–4): [1046]–1054, illus.

(90) ———
1933. SPECIE NUOVE DI EMPOASCA (HEMIPTERA-HOMOPTERA) E APPUNTI DI COROLOGIA. [NEW SPECIES OF EMPOASCA AND NOTES ON THE DISTRIBUTION AND FOOD-PLANTS OF SOME JASSIDS.] Soc. Ent. Ital. Mem. (1932) 11: 109–122, illus.

(91) ———
1936. ALCUNE SPECIE DI EMPOASCA VIVENTI IN EGITTO (HEMIPTERA-HOMOPTERA). Soc. Roy. Ent. d'Égypte Bul. (Séance du 25 Mai 1936), pp. 144–151, illus.

(92) ———
1936. DESCRIZIONE DI ALCUNE NUOVE SPECIE DI EMPOASCA (HEMIPT. HOMOPT.) E OSSERVAZIONI SU SPECIE NOTE. Soc. Ent. Ital. Mem. 15: 5–24, illus.

(93) PARSONS, F. S.
1929. REPORT ON THE WORK OF THE COTTON EXPERIMENT STATION, CANDOVER, MAGUT, NATAL, FOR THE SEASON 1927-1928. Empire Cotton Growing Corp., Expt. Stns. Rpts. 1927–28: 55–89, illus.

(94) POOS, F. W.
1932. BIOLOGY OF THE POTATO LEAFHOPPER, EMPOASCA FABAE (HARRIS), AND SOME CLOSELY RELATED SPECIES OF EMPOASCA. Jour. Econ. Ent. 25: 639–646.

(95) ———
1933. FOUR NEW SPECIES OF EMPOASCA (HOMOPTERA: CICADELLIDAE). Wash. Ent. Soc. Proc. 35: 174–179, illus.

(96) ———
1935. NEW HOST PLANTS OF THE POTATO LEAFHOPPER, EMPOASCA FABAE (HARRIS), AND THEIR PROBABLE SIGNIFICANCE. (Scientific Notes) Jour. Econ. Ent. 28: 1072–1073.

(97) ———
1941. ON THE CAUSES OF PEANUT "POUTS." (Scientific Notes) Jour. Econ. Ent. 34: 727–728. illus.

(98) ———
1936. INJURY TO ALFALFA AND RED CLOVER BY THE POTATO LEAFHOPPER. Jour. Econ. Ent. 29: 325–331. illus.

(99) ———
1931. A COMPARISON OF OVIPOSITION AND NYMPHAL DEVELOPMENT OF EMPOASCA FABAE (HARRIS) ON DIFFERENT HOST PLANTS. Jour. Econ. Ent. 24: 361–371, illus.

(100) ——— and WESTOVER, H. L.
1934. "ALFALFA YELLOWS." Science 79: 319.

(101) RAMBOUSEK, F.
1931. SCHÄDLINGE UND KRANKHEITEN DER ZUCKERRÜBE IM JAHRE 1930. [PESTS AND DISEASES OF THE SUGAR-BEET IN CZECHOSLOVAKIA IN 1930.] Ztschr. f. die Zuckerindus. Čechoslovak Repub. 1930–31, 55: [539]–551, illus.; also Ber. Forschsinst. der Čechoslovak Zuckerindus. in Prag. Ber. 37: 59–71. illus. 1932.

(102) RIBAUT, H.
1933. SUR QUELQUES ESPÈCES DU GENRE EMPOASCA. [Toulouse] Soc. d'Hist. Nat. Bul. 65: 150–161, illus.

(103) ———
1936. HOMOPTÈRES APHÉNORHYNQUES *I.* (TYPHLOCYBIDAE). 228 pp., illus. Paris. (Faune de France, v. 31.)

(104) ROBERTS, J. I.
1930. THE TOBACCO CAPSID (ENGYTATUS VOLUCER, KIRK.) IN RHODESIA. Bul. Ent. Res. 21: 169–183, illus.

(105) RUIZ CASTRO, A., and MENDIZÁBAL, M.
1936–1937. LA "ROYA COLORADO," PRODUCIDA POR EMPOASCA LIBYCA DE "BERGEVIN (HEM. HOM.), EN LOS PARRALES DE ALMERÍA. [THE "COLOURED RUST" PRODUCED BY E. LIBYCA IN VINEYARDS IN ALMERIA.] Bol. de Patol. Veg. y Ent. Agr. 8: 150–161, illus.

(106) RUSSO, G.
1935. IL RAGGRINZIMENTO O ARRICCIAMENTO DEL COTONE NELLA SOMALIA ITALIANA. [THE CRINKLING OR CURLING OF COTTON IN ITALIAN SOMALILAND.] Agr. Colon [Italy] 29: 78–95, 133–143, 188–199, illus.

(107) ———
1939. THE 'FETOLA' OR YELLOW SPOT OF CITRUS IN SICILY. (Communication) Internatl. Inst. Agr. Internatl. Bul. Plant Protect. 13: 106M–108M, illus.

(108) SCHNEIDER, H.
1933. UNTERSUCHUNGEN ÜBER DIE AN DER ZUCKERRÜBE SAUGENDEN INSEKTEN UND DEREN SCHADWIRKUNG UNTER BESONDERER BERÜCKSICHTIGUNG DER BÜBENBLATTWANZE (PIESMA QUADRATA FIEB.). Landw. Hochsch. Berl., Inaug. Diss., pp. 717–790, illus. [Abstract, Rev. Appl. Ent. (A) 22: 667, 1934.]

(109) SHIRAKI, T.
1920. INSECT PESTS OF THE TEA-PLANT IN FORMOSA. (PRELIMINARY REPORT.) Pusa 3d Ent. Meeting, Proc. (1919) 2: 629–669.

(110) ———
1937. [COTTON INSECTS. COMPENDIUM OF INSECTS AND FUNGOUS PESTS OF AGRICULTURAL CROPS IN FORMOSA, NO. 4.] Pub. Bur. Indus. Formosa 801, 166 pp., illus. [Abstract in Rev. Appl. Ent. (A) 26: 306. 1938.]

(111) SMITH, F. F.
1932. INJURY TO HOLLYHOCK AND MARIGOLD BY THE POTATO LEAF HOPPER, EMPOASCA FABAE (HARRIS). Jour. Econ. Ent. 25: 318–321, illus.

(112) ———
1940. CERTAIN SUCKING INSECTS CAUSING INJURY TO ROSE. Jour. Econ. Ent. 33: 658–662, illus.

(113) ——— and POOS, F. W.
1931. THE FEEDING HABITS OF SOME LEAF HOPPERS OF THE GENUS EMPOASCA. Jour. Agr. Res. 43: 267–285, illus.

(114) SMITH, J. H.
1939. REPORT OF THE ENTOMOLOGICAL SECTION. Queensland Dept. Agr. and Stock. Ann. Rpt. 1938–39: 32–35.

(115) SMITH, R. C., and BARKER, H. D.
1930. OBSERVATIONS ON THE "YELLOWS" DISEASE OF BEANS AND RELATED PLANTS IN HAITI. Jour. Econ. Ent. 23: 842–847, illus.

(116) SOYER, D.
1933. LA "ROSETTE" DE L'ARACHIDE. RECHERCHES SUR LES VECTEURS POSSIBLES DE LA MALADIE. Inst. Natl. pour l'Étude Agron. Congo Belge Pubs., Sér. Sci. 21, 23 pp., illus.

(117) STEARNS, L. A., and MACCREARY, D.
1938. LEAFHOPPER MIGRATION ACROSS DELAWARE BAY. Jour. Econ. Ent. 31: 226–229.

(118) TATE, H. D.
1940. INSECTS AS VECTORS OF YELLOW DWARF, A VIRUS DISEASE OF ONIONS. Iowa State Col. Jour. Sci. 14: 267–294.

(119) TENG, S. C.
1931. A PRELIMINARY REPORT ON THE STUDIES OF CERTAIN DISEASES OF COTTON. I. STUDIES OF THE CYTOSIS. Sci. Soc. China, Biol. Lab. Contrib., Bot. Ser. 6: 117–126.

(120) THOMAS, K. M., and KRISHNASWAMI, C. S.
1939. LITTLE LEAF—A TRANSMISSIBLE DISEASE OF BRINJAL. Indian Acad. Sci. Proc., Sect. B. 10: 201–212, illus.

(121) TURNER, N.
1937. CONTROL OF LEAFHOPPERS ON BAHIAS. Conn. Agr. Expt. Sta., 36th Rpt. State Ent. 1936 (Bul. 396): 370–371, illus.

(122) VUILLET, J.
1924. LA LUTTE CONTRE LES JASSIDES PARASITES DU COTONNIER AU SOUDAN FRANÇAIS. Rev. de Bot. Appl. et d'Agr. Colon. 4, (Bul. 39) : 757–759.
(123) WALSH, B. D.
1862. FIRE-BLIGHT, TWO NEW FOES OF THE APPLE AND PEAR. (Ent. note, pp. 148–149, appended.) Prairie Farmer (n. s.) 10 : 147–149, illus.
(124) WATERSTON, J. M.
1938. REPORT OF THE PLANT PATHOLOGIST, 1937. Bermuda Dept. Agr. Rpt. 1937 : 24–37.
(125) ———
1939. REPORT OF THE PLANT PATHOLOGIST, 1938. Bermuda Dept. Agr. Rpt. 1938 : 22–34.
(126) WHEELER, N. H.
1937. TRAP-LIGHT STUDIES ON LEAFHOPPERS BELONGING TO THE GENUS EMPOASCA (HOMOPTERA : CICADELLIDAE), WITH THE DESCRIPTION OF TWO NEW SPECIES. Wash. Ent. Soc. Proc. 39 : 141–156, illus.
(127) ———
1940. THE NORTH AMERICAN EMPOASCAN LEAFHOPPERS OF THE ALBONEURA GROUP (HOMOPTERA–CICADELLIDAE). Wash. Acad. Sci. Jour. 30 : 478–483, illus.
(128) WILLE, J. E.
1940. DEPARTAMENTO DE ENTOMOLOGÍA. MEMORIA DEL JEFE DEL DEPARTAMENTO. Lima, Peru, Estac. Expt. Agr. de La Molina Mem. (1939) 12 : 177–210, illus.
(129) WOLCOTT, G. N.
1936. "INSECTAE BORINQUENSES." A REVISION OF "'INSECTAE PORTORICENSIS,' A PRELIMINARY ANNOTATED CHECK-LIST OF THE INSECTS OF PORTO RICO, WITH DESCRIPTIONS OF SOME NEW SPECIES." Puerto Rico Univ. Jour. Agr. 20 : [1]–627, illus.
(130) ZAUMEYER, W. J., and KEARNS, C. W.
1936. THE RELATION OF APHIDS TO THE TRANSMISSION OF BEAN MOSAIC. Phytopathology 26 : 614–629.

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