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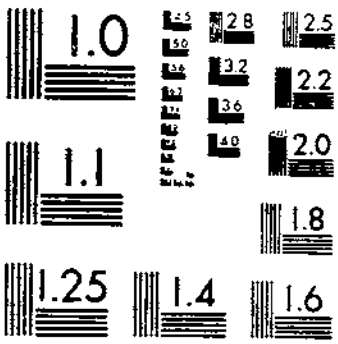

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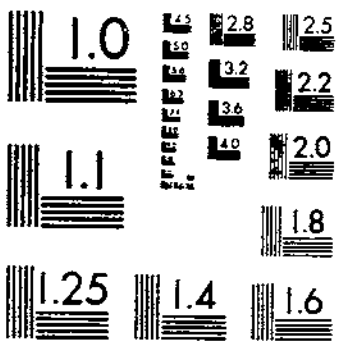

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Biological Control of the CITRUS BLACKFLY in Mexico

Agricultural Research Service
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Contents

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BIOLOGICAL CONTROL OF THE CITRUS BLACKFLY IN MEXICO

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Biological control of the citrus blackfly (*Aleurocanthus woglumi* Ashby) in Mexico is an outstanding example of the successful domination of an economically important insect pest by introduced natural enemies.

The harmonious cooperation between the Mexican Defensa Agrícola and the U.S. Agricultural Research Service has largely contributed to the success of the citrus blackfly program. This cooperative effort between the two countries antedates the blackfly program and continues in the mutual interest of exclusion, containment, control, and eradication of several insect pests on both sides of the international border.

The citrus blackfly is native to south Asia. It was first discovered in the New World on Jamaica, West Indies, in 1913 (Ashby *1915*). [3] Dietz and Zetek (*1920*) discussed its subsequent discovery in Cuba and the Bahama Islands in 1916, in the Republic of Panama and the Canal Zone in 1917, and in Costa Rica in 1919. Newell and Brown (*1939*) described the infestation discovered at Key West, Fla., in 1934; it was eradicated there in 1937. The citrus blackfly also has been recorded from Mexico in 1935 (Baker and Dampf *1937*), from the Republic of Ecuador more recently (Yust and Cevallos *1954–55*), and from Texas in 1955. The Texas infestation was eradicated in 1956.

HISTORY OF SPREAD IN MEXICO

The citrus blackfly was first recorded in Mexico at El Dorado, Sinaloa. It is not known how it entered the country, but it may have been introduced on shipments of mango cuttings from India or from fruit boats from Central America.

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[1] Deceased 1958.

[2] C. P. Clausen, in charge of the former Division of Foreign Parasite Introduction, U.S. Bureau of Entomology and Plant Quarantine, planned and initiated the biological control program against the citrus blackfly in Mexico. Herbert D. Smith developed and largely carried out this work. He began but did not complete this written history of the program. E. R. Gardner and Paul W. Oman, Entomology Research Division, compiled his field notes, correspondence, and other unpublished material, and it is on much of this material that this publication is based. H. L. Maltby, who succeeded Mr. Smith, brought this information up to date and completed this bulletin.

Eduardo Merino, formerly with Defensa Agrícola, did the illustrations for figures 2, 4, 9, 10, and 11.

[3] The years in italics after the authors' names are the key to the references listed on p. 29.

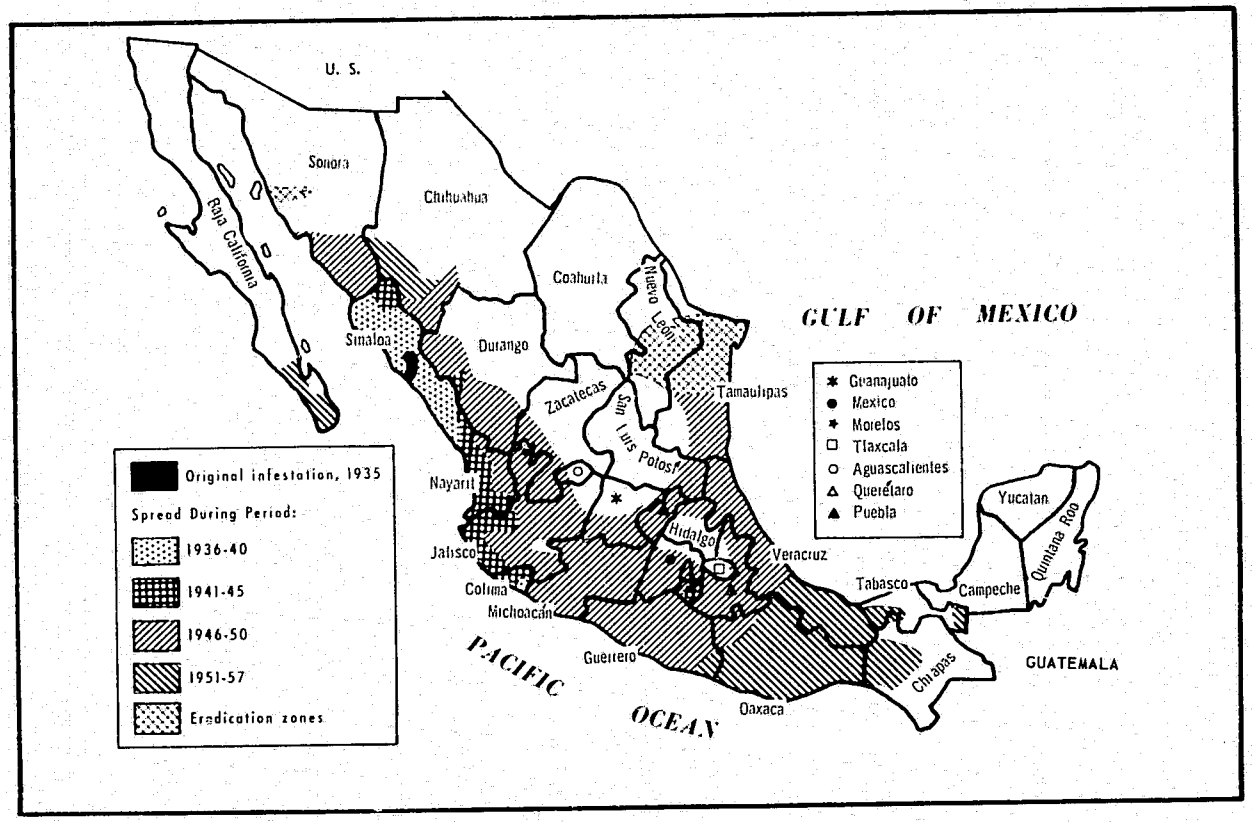

FIGURE 1.—Spread of the citrus blackfly in Mexico, 1935–57.

From the original infestation in Sinaloa, the blackfly spread north and south along the coastal plain and by 1940 had become a serious pest of citrus in that region. In the same year a small infestation was found in a lime grove in the State of Colima, several hundred miles south of the nearest infestation in Sinaloa. By 1943 all citrus-growing areas in Sinaloa and the coastal areas of the States of Nayarit, Jalisco, and Colima were infested.

During the next 2 years infestations multiplied to cover approximately half of coastal Nayarit and all of Colima, and the fly was found farther inland in Jalisco. In addition, small infestations were found in the States of Durango and Morelos; the latter, at Cuernavaca, resulted from infested nursery stock introduced from the west coast in 1944.

By 1948 the blackfly had spread north to the State of Sonora, south to the States of Michoacán and Guerrero, east to the States of Zacatecas and Aguascalientes, and west to Baja California. In eastern Mexico small infestations were discovered in the central part of the State of Veracruz and in southern San Luis Potosí.

During the next 2 years infestations were found farther to the east and southeast and to the north and northeast. Areas newly infested included the States of Guanajuato, Hidalgo, Puebla, Oaxaca, Chihuahua, Querétaro, Nuevo León, and the northeastern section of Tamaulipas, close to the U.S. border. By 1952 the far-southern States of Chiapas and Tabasco also had been invaded. The most recent invasion of a previously uninfested area was reported in the State of Campeche in November 1960. As of this date the citrus blackfly had infested practically all the regions where citrus is grown on a commercial scale in Mexico.

Figure 1 shows the spread of the blackfly from the original infestation in the State of Sinaloa in 1935 through 1957. Since the blackfly is unable to survive at temperatures as low as 24° F. for any length of time, it does not occur on host plants at high elevations on the central plateau or Sierra Madre range. However, of those regions that are climatically adaptable to citriculture, only the State of Yucatán, northern Baja California, and the Territory of Quintana Roo remained uninfested in 1957. In January 1963 the State of Yucatán became infested.

HOST PLANTS IN MEXICO

Hosts of the citrus blackfly in Mexico are much more numerous than those reported in the Orient. Clausen and Berry (*1932*) reported that citrus was nearly the sole host in several countries of Asia. In all regions of Mexico citrus is the preferred and most important host. Other favorite food plants in Mexico are mango, persimmon, pear, quince, coffee, myrtle, cherimoya, and sapote. The blackfly develops on numerous other plants, but infestations are usually light or moderate. Oviposition occurs on a large number of plants, but development to the adult stage is never completed. Shaw (*1950a*) listed 75 plant species, belonging to 38 families, on which complete development of the blackfly had been observed in Mexico. In addition, he listed 56 plants on which the blackfly had been observed to oviposit but on

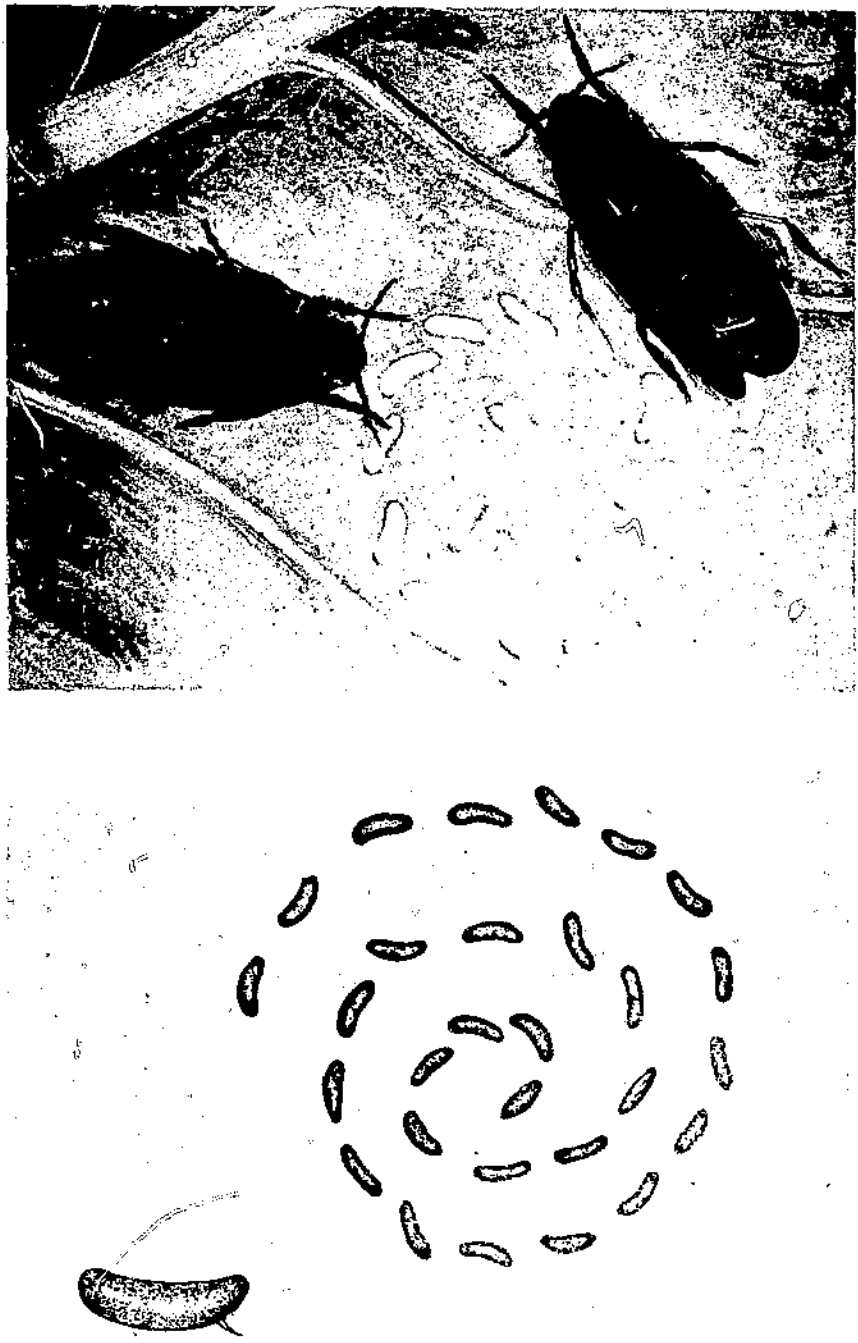

FIGURE 2. Oviposition and eggs of the citrus blackfly. Note the spiral pattern and the egg with the pedicel.

which eggs failed to hatch or complete development did not take place.

Heavy infestations of the citrus blackfly occur on such hosts as mango, pear, and coffee in Mexico when these plants are near heavily infested citrus trees. When the blackfly is well controlled and infestations are light on citrus, very few other host plants are found to be infested.

LIFE HISTORY

The citrus blackfly completes its life cycle in 2 to 4 months in Mexico. Usually there is a slight overlapping of generations. Mating takes place soon after emergence, and oviposition occurs several days later. Eggs commonly are deposited in a typical spiral pattern on the underside of leaves of the host plant (fig. 2); spirals average about 40 eggs each. A female deposits more than 100 eggs during an adult life of approximately 10 days. Eggs hatch in 9 to 25 days. The duration of the first larval stage is 8 to 17 days, the second 7 to 16 days, and the third 7 to 22 days. The pupal stage lasts for 21 to 45 days. Figure 3 shows a life cycle under specific conditions of temperature.

During the larval and pupal stages the blackfly excretes copious amounts of honeydew through a vasiform orifice.

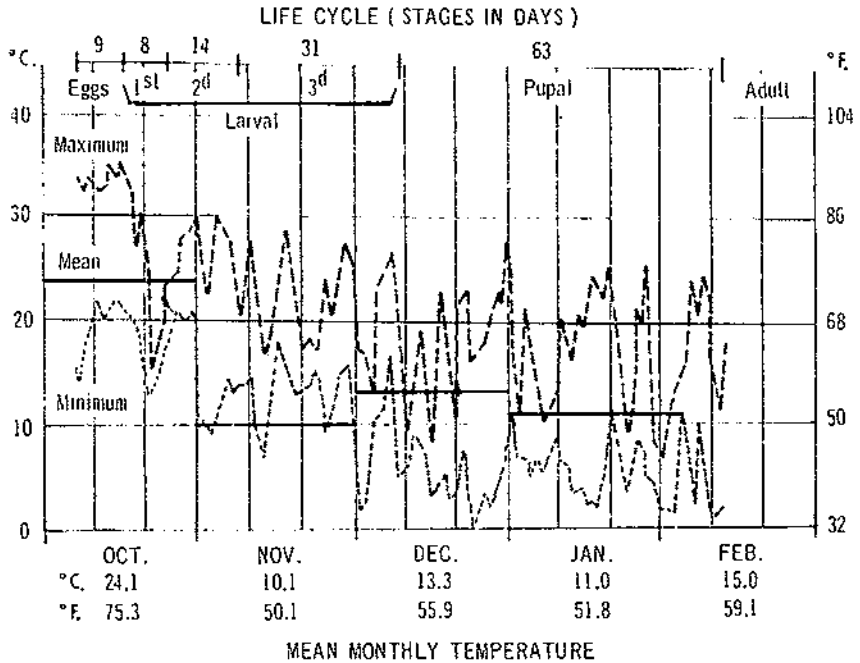

FIGURE 3.—Life cycle of the citrus blackfly under specific conditions of temperature. (Courtesy of Departamento de Control Biológico, Dirección General de Defensa Agrícola.)

DESCRIPTION OF STAGES

The adult citrus blackfly (fig. 4) has slaty-blue wings, red abdomen, reddish-brown eyes, and whitish antennae tinged with pale yellow. When the insect is at rest, colorless spots on the wings form what appears to be a white band across the middle of the abdomen. Adult females average 1.66 and males 1.33 mm. in length.

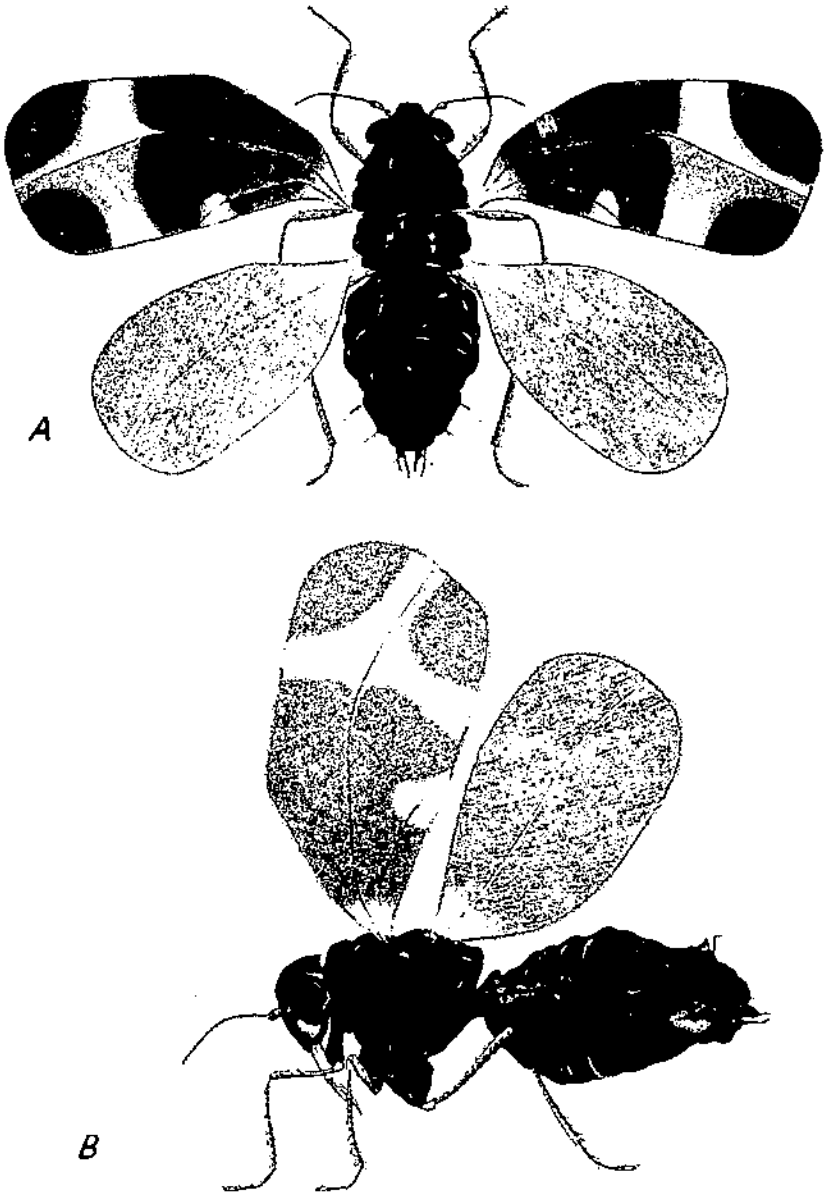

FIGURE 4.—Adult citrus blackfly. *A*, Dorsal view; *B*, side view.

The curved, elliptical egg is attached to the leaf of the host plant by a short pedicel near its posterior end (fig. 2). When first laid, the egg is yellowish white but soon turns light brown.

The first-stage larva (fig. 5, *A*) is elongate-ovate, averages about 0.300 by 0.150 mm., and is dusky in color. On each side of a pronounced median ridge are two long dorsal spines and numerous shorter spines. The second-stage larva (fig. 5, *B*) is more ovate and convex than the first stage and measures approximately 0.400 by 0.200 mm. It is dark brown or dull black, with patches of yellow. Numerous prominent spines cover the body. The ovate third stage (fig. 5, *C*) is more convex and much larger than the second stage, averaging 0.870 by 0.740 mm. Its body is shiny black, with a hemispherical dull-green spot on the anterior part of the abdomen. The spines are stouter and more numerous than those in the second stage.

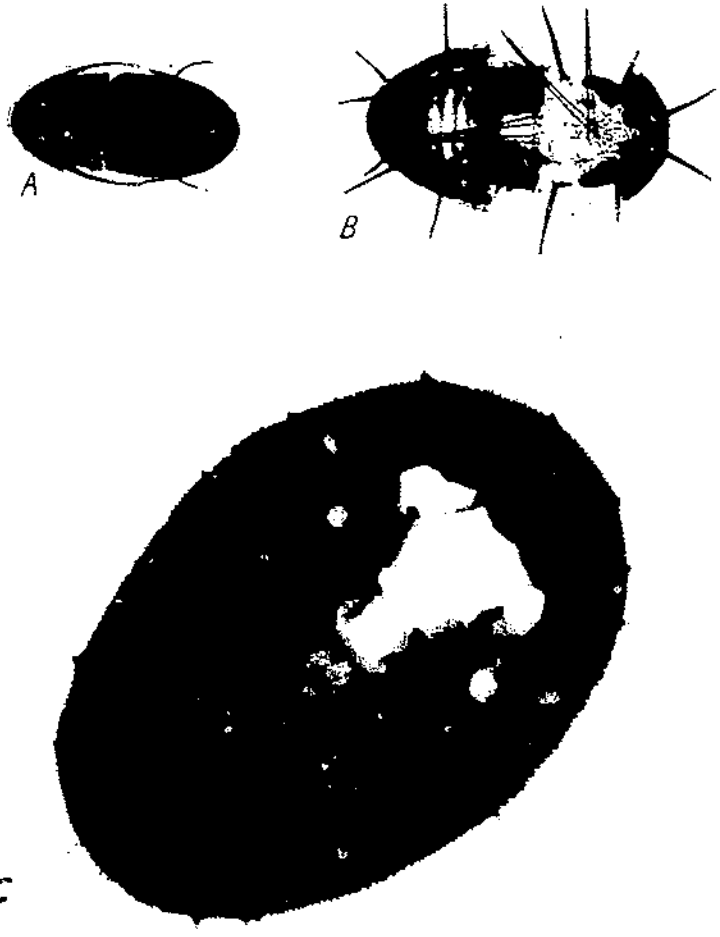

FIGURE 5.—Citrus blackfly larvae (dorsal view): *A*, First stage; *B*, second stage; *C*, third stage.

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In the pupal stage it is possible to distinguish the sexes. Female pupae are conspicuously larger than males, the former averaging 1.25 and the latter 1.00 mm. in length. The pupae (fig. 6) are ovate and shiny black, with a marginal band of white waxy secretion. Several long, tapering, conspicuous spines extend from the convex dorsal surface of the body.

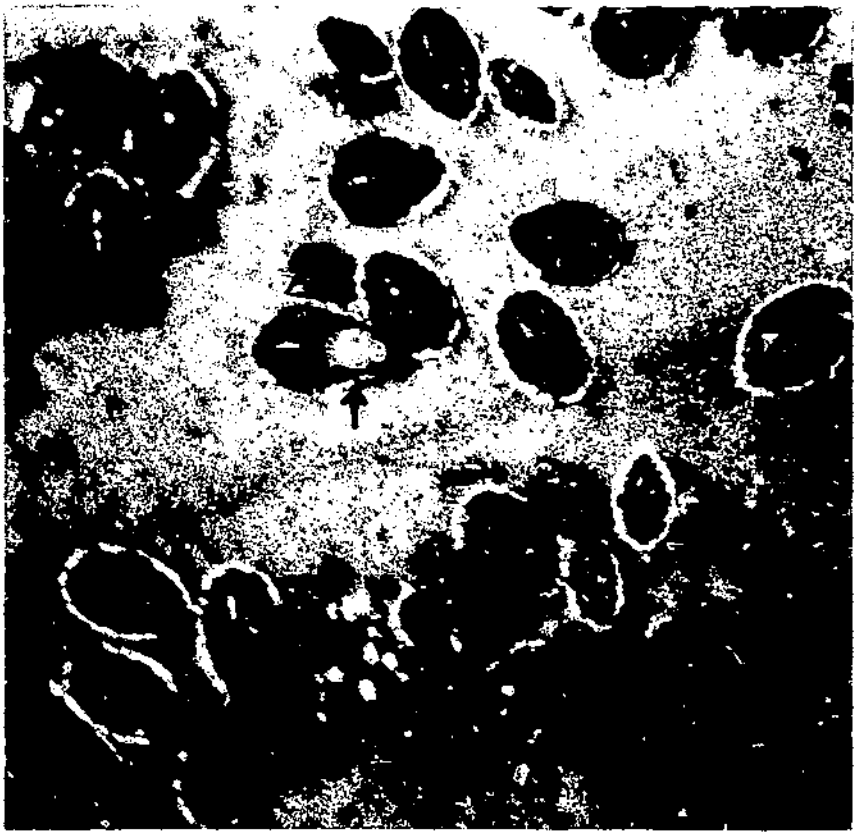

FIGURE 6.--Pupae of the citrus blackfly. Note emerging adult.

DAMAGE

Damage caused by the citrus blackfly results from its feeding, particularly on new growth of the host plant, and from deposition of honeydew on which sooty mold fungus develops. The fungus growth interferes with the normal function of the plant's leaves, reducing respiration and photosynthesis. In Mexico there is almost a complete crop failure when heavy infestations of the blackfly last longer than 1 year on citrus trees. Infestations of shorter duration may reduce production as much as 50 percent, as well as depreciate fruit quality. In general, growers report approximately 80-percent production losses in areas of heavy infestation.

CHEMICAL CONTROL

The first attempts to control the blackfly in Mexico were made with insecticides. Previous to its invasion there, little was known of chemical measures for its control. Kerosene emulsions had been tried in Jamaica by Ashby (*1915*) and in the Panama Canal Zone by Dietz and Zetek (*1920*). Oil emulsions were tested in Cuba by Bruner (*1931*). Later the blackfly was eradicated with repeated oil spray applications at Key West (Newell and Brown *1930*).

By 1947 considerable improvement had been made in formulations of insecticides used in the control of the blackfly, and in April of that year the cube in oil formula was recommended to the Mexican authorities for control of the blackfly at Ciudad Valles, San Luis Potosí (Cooper and Plummer *1950*). This formula was used successfully by Woglum (*1948*) and his Mexican cooperators in blackfly control in the Guaymas-Empalme area of the State of Sonora in 1947–48.

In 1956 the Mexican Department of Agriculture changed from the cube in oil spray formulation to one containing 3 pounds of 25-percent malathion wettable powder per 100 gallons of water. It was used in a series of three to four applications at 21-day intervals. Late in 1961 in the State of Nuevo León the Mexican Department of Agriculture changed to a spray formulation of 1 gallon of carbophenothion, containing 4 pounds of actual chemical, per 800 gallons of water. It was used in a series of three applications at 30-day intervals. Apparently this treatment was more effective than a larger number of malathion applications.

Spray formulations are used in Mexico in those areas designated as chemical control zones of the blackfly (fig. 7). These are north of the generally infested areas where biological control measures are effectively preventing commercial damage to citrus. The objective in the chemical control zones in Mexico is to keep these areas entirely free of the citrus blackfly. When infestations of blackfly are located in these zones, based on intensive surveys that are continuously being made there, insecticide applications are promptly made to eradicate this pest.

The advantage of maintaining blackfly-free zones in northern Mexico is twofold. First, these zones provide a protective barrier against the introduction of the blackfly into adjacent citrus areas of the United States. Second, they enable the growers in these important citrus areas to produce fruit under conditions relatively free of the blackfly.

BIOLOGICAL CONTROL

Early Work

Early in the history of citrus blackfly infestation in Mexico, it was suspected that chemical control of the pest would prove to be very difficult and prohibitively expensive. As infestations became more numerous and widespread and the host list became longer, these early suspicions were justified, and an attempt was made to control the blackfly biologically.

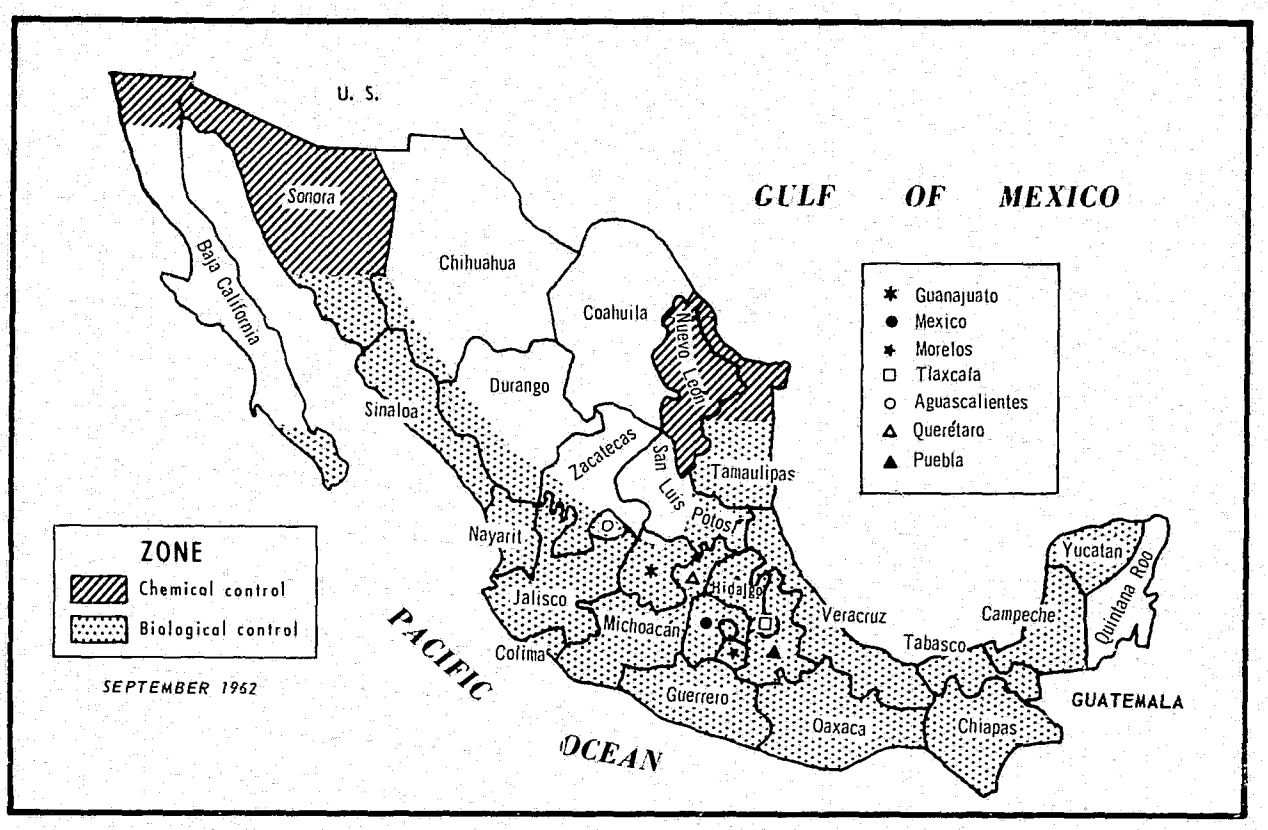

FIGURE 7.—Biological and chemical control zones of the citrus blackfly in Mexico, September 1962.

In 1938 the Mexican Department of Agriculture requested the importation of the parasite *Eretmocerus serius* Silvestri, which had controlled the blackfly in Cuba (Smith *1945*). Arrangements were made with the former Bureau of Entomology and Plant Quarantine of the U.S. Department of Agriculture to obtain this species from the Bureau's laboratory at Balboa in the Canal Zone.

In July 1938 three shipments of *E. serius* were sent to the Bureau's laboratory in Mexico City by air express. The parasites were turned over to the Mexican authorities and were released as adults in infested lime groves in Culiacán, Sinaloa, but they did not become established.

As the blackfly continued to spread, it became an increasing potential threat to citrus-growing areas in California and other border States in the United States, as well as an actual threat to the production of citrus in Mexico. Thus, in 1943 a working agreement was negotiated by the Governments of Mexico and the United States relative to biological, chemical, and quarantine measures to control the blackfly.

When Mexico requested *E. serius* again in 1943, parasitized material was shipped from the Bureau's Balboa laboratory, and Herbert D. Smith was sent to the west coast of Mexico to supervise receiving and colonizing the parasite.

Twelve shipments of parasitized material were made during May and June of 1943 from Balboa to Mexico City by plane in custody of a courier. The material was processed at the Bureau's laboratory and forwarded to several locations on Mexico's west coast. From these shipments 8,867 *E. serius* parasites emerged and were released at 60 localities in the States of Colima, Nayarit, and Sinaloa. Establishment of the parasite was successful in at least three colonization sites.

During 1944 and 1945 extensive field collections of *E. serius* were made at the colony site of La Albarrada in Colima by J. G. Shaw of the U.S. Department of Agriculture and by Alfonso Delgado and other members of the Mexican Department of Agriculture (Shaw *1950b*). These parasites were released in other infested areas in Colima and in the States of Nayarit, Jalisco, Sinaloa, and Morelos. Later many liberations were made in infested groves in other States.

Although *E. serius* is an effective parasite in Cuba and other islands of the West Indies, it was unable to bring the citrus blackfly under satisfactory control on the west coast of Mexico except in restricted areas of persisting high humidity. At Cuernavaca, Morelos, Shaw (*1950b*) observed that parasitization by *E. serius* reached 85 percent at the end of the rainy season in the fall, but that it dropped to 8 percent at the end of the dry season in May. Similar observations of extreme oscillations in parasitization have been made in other areas where the parasite has become established. Apparently *E. serius* requires almost continuous moist conditions to be effective. Although Cuba has a rainless period similar to that in many areas of Mexico, it has heavy nocturnal dews during this period with sufficient moisture to maintain a constant, effective parasite population.

Consideration was given also to the introduction of the coccinellid *Catana clauseni* Chapin from Cuba, where it had been effective in reducing heavy infestations of the blackfly soon after its introduction

from Malaya (Clausen and Berry *1932*). In 1947 a careful search for this predator was made in Cuba, but it was not found. Subsequent surveys in 1948 and 1951 also failed to reveal its presence.

The failure of *E. serius* to control the blackfly in Mexico made further searches for natural enemies necessary. Smith went to Malaya in the fall of 1948 to collect several species of citrus blackfly parasites reported by Clausen as occurring there (Clausen and Berry *1932*). He sent the first shipments of natural enemies of the citrus blackfly from Malaya to Mexico in 1948. These consisted of infested citrus plants in nine Wardian cages and an airmail shipment of infested leaves. No parasites were reared from the material in the Wardian cages, but a few adults of *Prospaltella divergens* Silvestri and *P. smithi* Silvestri emerged from the air shipment. These were released in the field but failed to become established.

Aleurocanthus in India and Pakistan

In 1949 and 1950 Smith spent 8 months exploring the citrus regions of India and Pakistan for natural enemies of the citrus blackfly that might adapt to the dry climate of certain areas of Mexico. Figure 8 shows these locations in India and Pakistan and the *Aleurocanthus* species found there. Previous to this exploration little was known about the citrus blackfly or its parasites in these two countries, nor did the limited time spent there by Smith permit a detailed study of the biology and life history of parasites and predators of this insect.

The citrus blackfly was present in most of the citrus areas of India and Pakistan, but infestations were light or negligible. In areas of persisting high temperatures, such as at Lyallpur in West Pakistan and Agra and Nagpur in India, where maximum temperatures in May and June fluctuated between 110° and 118° F., this blackfly was not found. However, in those areas where it did not occur, considerable damage was caused to citrus by a closely allied species, *Aleurocanthus husaini* Corbett. Although the citrus blackfly and *A. husaini* are similar and occur together on the same leaves, the parasites of neither host were observed to attack the other.

Two other *Aleurocanthus* species were found on citrus in India and Pakistan, but only in negligible numbers. *Aleurocanthus citriperdus* Quaintance and Baker was found only at Shillong in Assam. It was heavily parasitized by an *Amitus* species, not *A. hesperidum*. *Aleurocanthus spiniferus* (Quaintance) was seen on citrus occasionally and damaged roses in some regions. It was parasitized by *P. smithi*, but parasitization was never observed to exceed 20 percent.

Climate in Mexico, India, and Pakistan

There are two distinct seasons in India and Pakistan as there are in Mexico. In general, the dry season extends from October to May and the wet season from May to October. Table 1 indicates the seasonal rainfall distribution at several citrus localities in these three countries. The annual rainfall varies considerably in different regions of India and Pakistan. Areas on the west coast receive more than 70 inches and east coast areas from 35 to more than 60 inches. In the Ganges Valley and in most of the central plateau area the yearly average is 25 to 50 inches. In the southern Punjab and in Pakistan

10 to 20 inches fall annually, and in the entire Thar or Indian Desert less than 10 inches annually are recorded. Farther north in the foothills of the Himalayas rainfall is generally moderate but sufficient for agricultural purposes.

Citrus is grown in India and Pakistan in a rather wide range of temperatures, as shown at representative areas in table 2. In north-central and south-central India (Allahabad and Hyderabad) and in West Pakistan (Lahore) there is a pronounced opposition between summer and winter temperatures. In Mexico similar but less pronounced recorded differences occur in the northwest, for example, at Ciudad Obregón and Los Mochis, and in the northeast at Ciudad Victoria. Mean temperatures of the warmest month are generally higher in India and Pakistan than in Mexico. Mean temperatures annually and for the coldest month at most localities are similar in the three countries.

FIGURE 8.—*Aleurocanthus* species found in India and Pakistan.

TABLE 1.—*Seasonal mean rainfall in several citrus localities in Mexico, India, and Pakistan*

Locality	Annual rainfall		Distribution[1]												Length of time recorded
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
	Inches	*Mm.*													*Years*
4–6 MONTHS WITH LESS THAN 2-INCH PRECIPITATION															
Mexico:															
Ciudad Victoria	35.5	902					+	+	+	+	+	+			17
Tampico	49.3	1,252					+	+	+	+	+	+	+		
India:															
Bangalore	34.6	879				+	+	+	+	+	+	+			
Calcutta	63.0	1,600					+	+	+	+	+	+	+		60
7–9 MONTHS WITH LESS THAN 2-INCH PRECIPITATION															
Mexico:															
Apatzingán	28.1	714						+	+	+	+	+			17
Colima	34.5	876						+	+	+	+	+			17
Los Mochis	14.3	361							+	+	+	+			
India:															
Allahabad	41.8	1,062						+	+	+	+	+			60
Bombay	71.2	1,808						+	+	+	+				60
Pakistan, Lahore	19.8	503							+	+	+				23
10 OR MORE MONTHS WITH LESS THAN 2-INCH PRECIPITATION															
Mexico, Ciudad Obregón	8.3	212							+	+					17
India, Hyderabad	7.4	188					+	+							45

[1] + = about 2 inches, or 50 mm., or more of precipitation.

TABLE 2.—*Mean temperatures in several citrus localities in Mexico, India, and Pakistan*

Locality	Annual		Warmest month		Coldest month		Difference	
	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.
Mexico:								
Apatzingán	28.2	82.8	31.2	88.2	24.5	76.2	6.7	12.0
Ciudad Obregón	26.5	79.6	33.6	92.6	18.2	64.7	15.4	27.9
Ciudad Victoria	23.2	73.6	29.4	84.9	15.9	60.6	13.5	24.3
Colima	24.5	76.2	26.5	79.8	22.5	72.5	4.0	7.3
Jalapa	17.4	63.7	19.4	66.9	15.2	59.3	4.2	7.6
Los Mochis	24.3	75.8	31.0	87.8	15.7	60.2	15.3	27.6
India:								
Allahabad	25.7	78.4	33.5	92.5	17.2	63.0	16.3	29.5
Bangalore	23.4	74.0	27.4	81.4	20.3	68.7	7.1	12.7
Bombay	26.8	80.2	29.7	85.4	24.0	75.2	5.7	10.2
Calcutta	25.2	77.4	29.9	85.8	19.1	66.3	10.8	19.5
Hyderabad	26.9	80.4	33.7	92.7	17.5	63.6	16.2	29.1
Pakistan, Lahore	24.3	75.8	34.1	93.4	12.8	55.0	21.3	38.4

Natural Enemies of the Citrus Blackfly in India and Pakistan

In most of India and Pakistan the citrus blackfly was found to be well controlled by three of its several parasites. In order of their effectiveness they were *Prospaltella clypealis* Silvestri (fig. 9), *Amitus hesperidum* Silvestri (fig. 10), and *Prospaltella opulenta* Silvestri (fig. 11). Other parasites reared from this blackfly were *P. divergens*, *Encarsia merceti* Silvestri, *Eretmocerus serius*, and *P. smithi*. Of these parasites, *P. divergens* occurred only in Assam, which has a very wet climate. *E. merceti* was found only in Assam and near Delhi. *E. serius* was reared from the citrus blackfly only in one locality in Assam. *P. smithi* rarely was reared from this host and was found only in southern India.

All the parasites of the citrus blackfly are attacked by a secondary parasite, *Alloxysta macrochaeta inquirenda* Silvestri. It does not occur in Pakistan nor in many areas of India.

Predators found to attack the citrus blackfly in India and Pakistan generally were ineffective, only occasionally exerting any marked degree of control. In order of effectiveness they were *Acletoxenus* spp., *Catana parcesetosa* (Sicard), and *Delphastus* spp.

Prospaltella clypealis Silvestri

P. clypealis was the most effective parasite of the citrus blackfly in India. Although it may occur in Pakistan, it was not observed there. In the Poona area 80 to 90 percent of the hosts observed were parasitized. The mortality of its immature stages was very little as compared with that of *A. hesperidum*, an indication that *P. clypealis* was more adaptable than *A. hesperidum* to the high daily temperatures in the area. The length of life of females under favorable conditions in the field averaged about 1 month, with a maximum of 6 weeks.

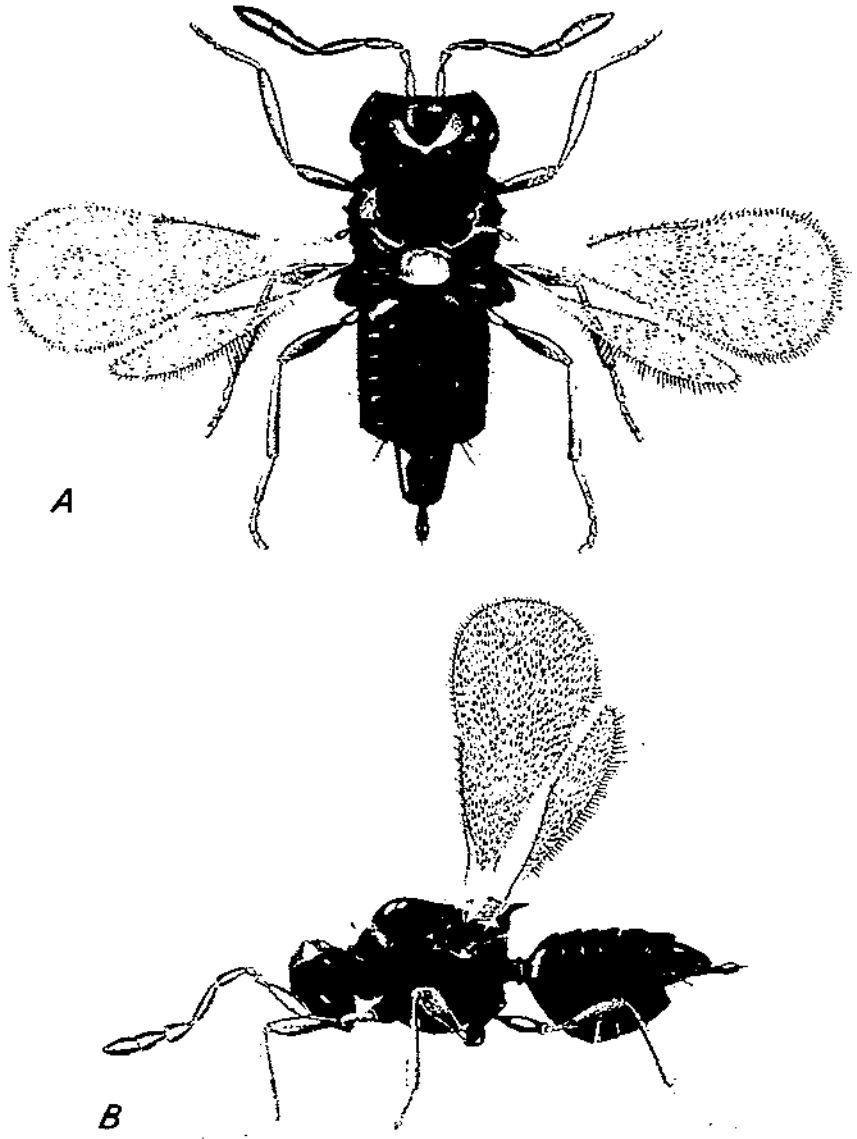

FIGURE 9.—*Prospaltella clypealis* Silvestri female: *A*, Dorsal view; *B*, side view.

P. clypealis is probably parthenogenetic, as mating was rarely observed. Oviposition takes place in the three larval stages and in the pupal stage of the host, with a preference for the second stage. Eggs deposited in the primary stage are carried over to the second stage before hatching. The female deposits its male eggs in host pupae containing the larva of a primary parasite, which may be *P. clypealis* or some other eulophid species. This is accomplished by thrusting the ovipositor into the host body through the upper surface of the leaf. The hatched larva acts as a secondary parasite and feeds on

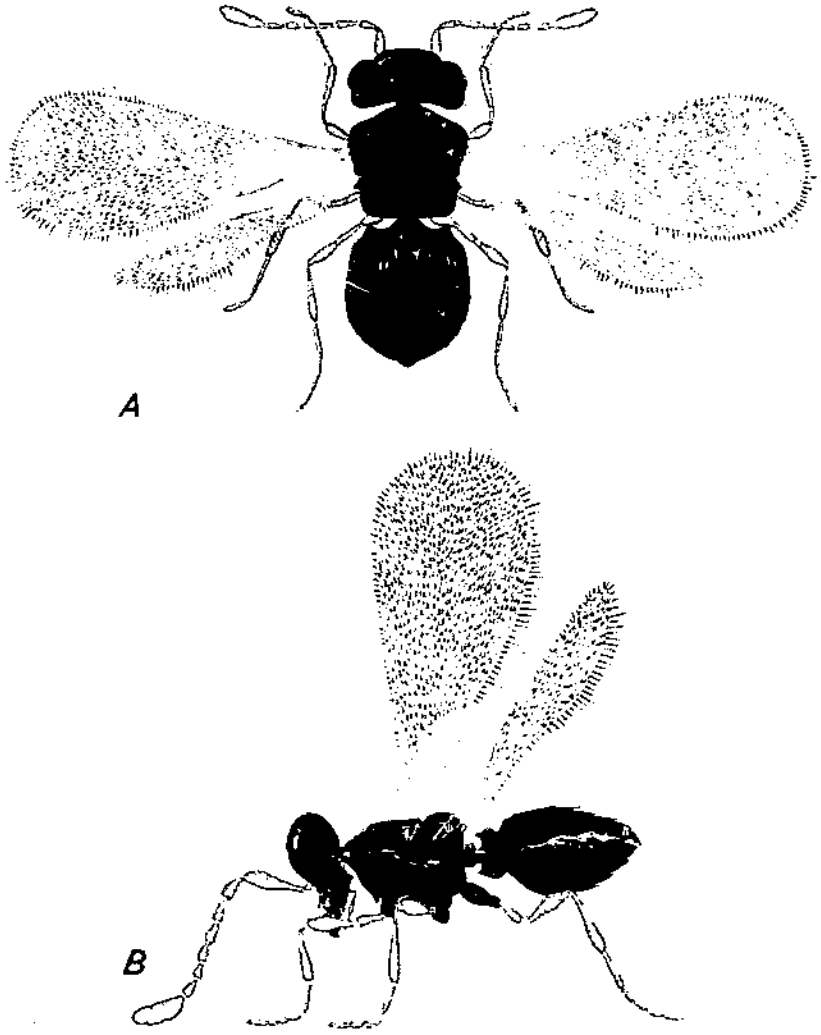

FIGURE 10.—*Amitus hesperidum* Silvestri female: *A*, Dorsal view; *B*, side view.

the primary larva. Female eggs are deposited directly into the host body on the underside of the leaf. The sex ratio of *P. clypealis* is approximately 1 to 7, with females predominating. There is a single generation to each one of the host's, with many of the female parasites emerging before the unparasitized hosts appear. A host pupa from which *P. clypealis* has issued shows a very small emergence hole and contains a rose-colored meconium.

Amitus hesperidum Silvestri

A. hesperidum was described originally by Silvestri (*1928*) from pupae of *A. citriperdus*. Previous to its having been found on the citrus blackfly in Pakistan, it never had been recorded as a parasite of this species, but only as a parasite of *A. citriperdus* and *A. spiniferus*.

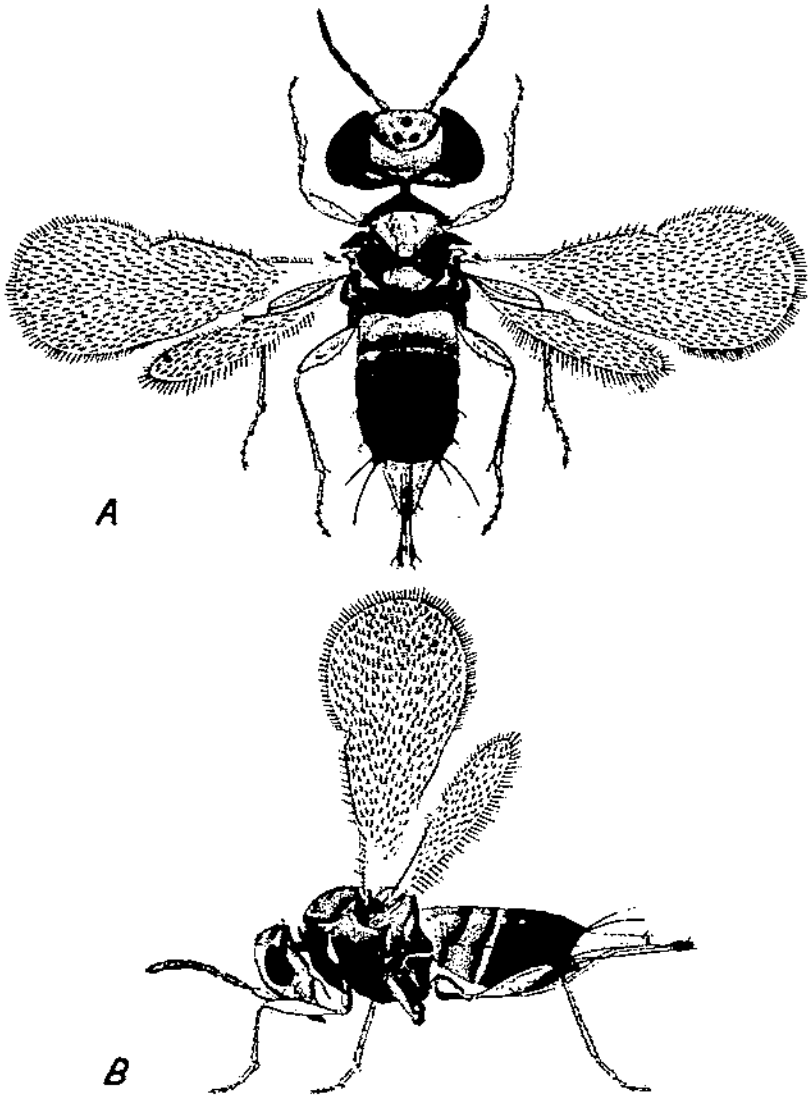

FIGURE 11.—*Prospaltella opulenta* Silvestri female: *A*, Dorsal view; *B*, side view.

A. hesperidum was the only parasite found attacking the citrus blackfly in Pakistan. It was generally distributed there, occurring wherever the blackfly was found. Its greatest parasitization was observed at Lahore and Gujranwala, where in some groves it reached 90 percent. During the fall generation of 1949 approximately 30-percent mortality of *A. hesperidum* larvae and pupae was observed to occur inside the host pupae. Apparently this mortality was due to dry weather.

In India *A. hesperidum* was well distributed, but appeared to be less common in the southern part of the country. In the north, near Saharanpur, parasitization of 70 percent was recorded in one grove. In other regions of the country parasitization was usually less than 30

percent. In general, *A. hesperidum* appeared to be much less effective than *P. clypealis* in India.

Oviposition by *A. hesperidum* occurs in the three larval stages of the host, with an apparent preference for the first stage. Female host pupae commonly produce two and occasionally three parasites, whereas male host pupae produce only one. Whenever *A. hesperidum* is present in the host, both male and female host pupae usually widen perceptibly, and this takes place while *A. hesperidum* is still in the minute first stage. This characteristic is of considerable value, in that it makes possible rapid estimation of parasitization in the field before parasite emergence from the host.

Adult female parasites have a life span of approximately 6 days; males live 4 or 5 days. The ratio of males to females is about 1 to 1. There is a generation to each generation of the host.

Prospaltella opulenta Silvestri

P. opulenta was described originally by Silvestri (*1928*) from specimens reared from pupae of *Aleurocanthus inceratus* Silvestri collected in Indochina. In India this species was found on the citrus blackfly in the area between Delhi and Dehra Dun, with the greatest concentration at Saharanpur. Although there was some competition from *A. hesperidum*, *P. clypealis*, and *E. mercveti*, parasitization by *P. opulenta* ranged from 60 to 70 percent.

The life history of this species is similar to that of *P. clypealis*. Oviposition occurs in all larval stages and the pupal stage, but the second stage is preferred. As with *P. clypealis*, male eggs are deposited in their own sister pupae or pupae of other parasites within the host body. Under favorable conditions females live from 4 to 6 weeks in the field. The sex ratio is about 1 to 7.3, with females predominating. Emergence of *P. opulenta* from a host pupa is indicated by a hole slightly larger than that made by *P. clypealis* and by a yellow meconium.

Parasite Shipments From India

In the fall of 1949 preparations were made in Mexico to receive shipments of natural enemies of the citrus blackfly from India and Pakistan. The receiving station, which had been at Colima, was moved to the laboratory of the former U.S. Bureau of Entomology and Plant Quarantine at Mexico City. T. R. Gardner of the Bureau was assigned to the laboratory to receive, handle, and colonize the parasites that were collected and shipped by Herbert D. Smith from Asia. A quarantine rearing room was constructed in the laboratory and equipped with the necessary temperature-control chambers. Immediately upon receipt of a shipment, it was unpacked and the material placed in a chamber for parasite emergence. All shipping containers, leaves, and material from which emergence had not taken place were destroyed in the incinerator.

From November 1949 to April 1950, 16 air-express and 9 airmail shipments of parasitized material were made to Mexico City from India and Pakistan. These consisted of 8,000 canker-free citrus leaves bearing parasitized host pupae and more than 80,000 pupae scraped from citrus leaves. The air-express shipments proved to be

more satisfactory as they averaged 6 days en route, whereas the air-mail shipments averaged 12 days. Emergence of the various species of natural enemies of the citrus blackfly from these shipments was as follows:

Parasites

Hymenoptera:	Number emerged
Platygasteridae, *Amitus hesperidum*	2,823
Eulophidae:	
Encarsia merceti	54
Eretmocerus serius	264
Prospaltella clypealis	21,859
Prospaltella divergens	6
Prospaltella opulenta	654
Prospaltella smithi	139
Prospaltella sp. (near *citrofila* Silvestri)	2,053

Predators

Coleoptera, Coccinellidae, *Catana parcesetosa*	40
Diptera, Drosophilidae, *Acletoxenus indica* Malloch	99

The emerged parasites were collected in small glass vials and given honey-water solution for food. After mating they were released in colonies of approximately 100 individuals to a colony site in infested citrus groves. Releases were made under various environmental conditions in the principal infested citrus regions of Mexico. Repeated releases of the same parasite species were made in some groves to increase the possibility of its establishment.

Organization of the Blackfly Control Program

In 1948 the Regional Committee of the Northeast, an organization of citrus growers in the Northeastern States of Nuevo León, Tamaulipas, and San Luis Potosí, was established to control the blackfly in the older infested areas and to eradicate it in the newer areas of infestation within these States. Funds to defray expenses of the campaign were obtained by assessing taxes of 1 centavo, or approximately 0.116 cent, on each liter, or quart, of gasoline sold, and 10 centavos, or approximately 1.16 cents, on each of the estimated 10 million citrus trees in the three States. Later a similar regional organization was established and financed in the same manner in the important citrus-growing State of Veracruz.

By 1951 the blackfly had become such a serious threat to the citrus industry that the President of Mexico in November of that year decreed the establishment within the Mexican Department of Agriculture of the National Blackfly Committee to combat and to control the citrus blackfly in Mexico. This organization absorbed the Northeast and Veracruz committees. It was composed of a president, his staff, and directors of State committees in the States of Michoacán, Nuevo León, San Luis Potosí, Tamaulipas, and Veracruz. The National Blackfly Committee directed all phases of blackfly investigations in Mexico and cooperated closely with representatives of the Plant Pest Control Division of the U.S. Department of Agriculture in biological control work and in the maintenance of chemical control zones and quarantine stations near the U.S. border.

The State blackfly committees in Mexico were composed of directors, appointed by the National Blackfly Committee, and their staffs of technicians and brigade leaders. The technicians examined blackfly-

infested leaves from various citrus groves to determine the parasite species present and their abundance. This information furnished brigade leaders with data indicating where parasites were sufficiently abundant, so that they could be collected for recolonization within the State or in other States.

When the National Blackfly Committee was organized, it consisted of approximately 30 employees. As blackfly infestations spread and became more damaging, the force was increased by 1956 to about 1,600 employees, most of whom were engaged in various phases of biological control of the blackfly.

During the period of 1951–58, when the National Blackfly Committee was operative, a great deal was accomplished in the campaign to control the blackfly. In addition, an efficient and harmonious Mexican-North American blackfly program evolved, which has become increasingly effective in controlling this pest. Not least among the accomplishments of this period were the invaluable training and experience given to laboratory and field technicians that helped to insure the success of subsequent biological control activities.

An additional result of biological control successes during this campaign was reflected in the organization in 1954 of the Departamento de Control Biológico de Defensa Agrícola within the Mexican Department of Agriculture. This new organization handled all biological control problems other than that of the blackfly, which remained under the supervision of the National Blackfly Committee. In December of 1958 the National Blackfly Committee was dissolved, and biological control of the blackfly was directed by the Departamento de Control Biológico. This organization and the Plant Pest Control Division of the U.S. Department of Agriculture cooperate closely in all phases of control and quarantine of the citrus blackfly.

Colonization and Establishment of Indian Parasites

Early in the citrus blackfly program it became apparent that *P. smithi* and the three dominant parasites of this insect in India and Pakistan—*P. clypealis*, *A. hesperidum*, and *P. opulenta*—would prove to be the most effective species in the control of the pest in Mexico.

Prospaltella smithi Silvestri

In India *P. smithi* was observed to attack *A. spiniferus* more readily than the citrus blackfly. It was first released in Mexico in 1950 on a lime tree in Cuernavaca, where it became established. From this colony over 30,000 adults were collected and released in other parts of the country. In one of the liberation locations, a small grove near Ciudad Valles, San Luis Potosí, spectacular initial results were realized. A very heavy infestation was reduced to only a few lightly infested leaves per tree in a period of 8 months. Other successes were recorded in the same area, and by 1953 about 3 million *P. smithi* adults had been collected and colonized in all infested regions in Mexico.

However, *P. smithi* did not live up to its initial success of controlling the blackfly in Mexico. Under some climatic conditions and during favorable seasons it was effective, but in no region in Mexico has it given continuous commercial control as have *A. hesperidum*, *P. clypealis*, and *P. opulenta*.

Although *P. smithi* dominated *E. serius* wherever the two were present, it was, in turn, always dominated by the other three Indian parasites. The first larval stage of *P. smithi* attacks the nonaggressive second larval stage of *E. serius* and kills it. The larva of *A. hesperidum* lives in the host stomach where it is safe from attack. The *A. hesperidum* larva consumes most of the host body fluids by the time *P. smithi* reaches the second stage, and the latter apparently dies from lack of food. Wherever *A. hesperidum* occurs in controlling numbers, *P. smithi* is decimated but not eradicated. With *P. clypealis*, the explanation of dominance is not entirely clear. *P. clypealis* is a feeding, first-stage larva when *P. smithi* issues from the host malpighian tubes. The former has a much longer tail than the nonfunctional tail of *P. smithi*, which possibly gives it more agility. The explanation of dominance of *P. opulenta* probably is like that of *P. clypealis*, as their morphology and life history are very similar.

Prospaltella clypealis Silvestri

A total of 18,768 adults of *P. clypealis* were reared from the introduced Indian material during the spring of 1950 and were released in most of the infested citrus regions of Mexico. In July 1950 adult parasites were found in small numbers in only 5 of the 126 original colony sites. Parasitization in these five localities did not exceed 1 percent. Parasite populations remained at a low level until February of 1951, when they slowly began to increase in two of these localities. By April, parasitization had reached 40 percent in one grove, and by September, 90 percent was recorded. By the end of 1951 approximately 200,000 *P. clypealis* adults had been collected and recolonized. During the succeeding 2 years about 1 million adults were liberated in all infested regions in Mexico.

By the end of 1953 *P. clypealis* had become established in many widely separated areas. In Colima it effected complete control of the blackfly in two groves within 2 years, or seven generations, after its original release. At the port of Veracruz, heavily infested in the spring of 1952, *P. clypealis* became the dominant controlling parasite. In the Cuautla area in the State of Morelos it also became the dominant parasite. It was established successfully in northeast and northwest Mexico as well. In an area near Ciudad Valles, San Luis Potosí, it dominated *A. hesperidum* as the controlling parasite after the latter had greatly reduced a heavy infestation there. At the port of Tampico, Tamaulipas, the same thing occurred. This pattern of dominance by *P. clypealis* over *A. hesperidum* was observed in several regions of Mexico. In the northwest at Cocorit, Sonora, the northernmost locality in the uncontrolled infested zone, *P. clypealis* was well established and increasing in effectiveness by the end of 1953.

Amitus hesperidum Silvestri

In the spring of 1950, 2,700 *A. hesperidum* adults were reared from the Indian shipments and colonized in several citrus regions. In July 1950 the parasite was recovered in only two liberation locations. Population levels remained low until the spring of 1951, when 10-percent parasitization was obtained in one grove. By November, 60-percent parasitization was recorded, and by the end of the year

60,000 *A. hesperidum* adults had been collected in areas of high parasitization and released in other areas. During 1952 and 1953 about 242 million *A. hesperidum* parasites were collected for liberation in all infested regions in the biological control zone in Mexico.

A. hesperidum proved to be the most important parasite in controlling the blackfly during the early period of biological control. It became established easily and adapted itself readily to many of the varied climatic conditions in Mexico. If released in sufficient numbers under optimum conditions, it could control an infestation in one generation. In 1953 it was considered to be the only parasite that could be relied on to reduce a heavy infestation to commercial control status in a short time. However, as infestations became lighter, *A. hesperidum* was dominated by *P. clypealis* and *P. opulenta*.

During an exceptionally hot spring in 1953, when maximum temperatures ranged from 110° to 116° F. for several days in the Valles-Mante region of northeast Mexico, mortality of immature stages of *A. hesperidum* sometimes approached 90 percent. The normal mortality of this parasite in the host is about 20 percent in this region, or similar to that in India. This abnormal increase in mortality of immature stages resulted in a buildup of the blackfly. In groves where *A. hesperidum* had been released for only 6 to 9 months, infestations increased to damaging proportions and additional parasite releases were required. However, in many groves where the blackfly had been controlled for a year or more, damage was not great, and by the end of 1953 *A. hesperidum* again had the infestations under control.

Prospaltella opulenta Silvestri

In April 1950, 654 adults of *P. opulenta* emerged from the Indian material, and releases were made in a grove at Ciudad Valles, San Luis Potosí. This grove was in one of the driest localities in the Valles area. Parasitization had reached 40 percent when the grove was cut down in February 1951. A second grove where parasites had been released was destroyed before parasites could be collected. However, *P. opulenta* adults were observed to have migrated to another grove about one-half mile distant, and early in 1952 several hundred adults were collected at this location. The parasite population increased in this grove and in another nearby grove in which it had become established. Approximately 217,000 adults had been captured at these locations by the end of 1952. During 1953 about 2,600,000 *P. opulenta* parasites were collected, and by November of that year the parasite had effected control in the area.

At one locality in the State of Veracruz and another in the State of Morelos, *P. opulenta* gave good control 6 months after liberation. The former locality is very wet and the latter is extremely dry during most of the year. By the end of 1953 *P. opulenta* had been released in all infested regions in Mexico and had become established in most of them, including the State of Sonora.

Native Predator

In many areas, especially in certain heavily infested groves, the native coccinellid *Delphastus pusillus* (LeConte) (fig. 12) frequently

caused blackfly mortality as high as 80 percent and sometimes 90 percent. This predator has been found in all regions of Mexico. It appears to be most effective in heavy infestations when temperatures are moderate and humidity is high. Although it cannot alone be depended on to control the blackfly, it often has effected more rapid control with the Indian parasites when they have not been present in large numbers.

Other coccinellids, hemerobiids, mites, and entomophagous fungi have been unimportant in controlling the citrus blackfly in Mexico.

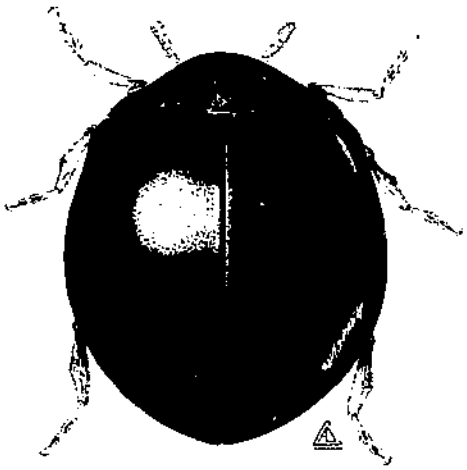

FIGURE 12.—*Delphastus pusillus* (LeConte) adult.

COMBINING CONTROL MEASURES

In some areas of the biological control zone (fig. 7) a combination of biological, chemical, and manual control measures was employed pending the liberation of sufficiently large numbers of parasites to obtain uniform and stable control. Sometimes individual heavily infested trees were spot sprayed, whereas at other times leaves from trees with heavy blackfly populations were removed and burned. The latter practice consists first of a survey to determine the percentage of parasitization in a given location. If the infestation of some trees is heavy and parasitization is less than 50 percent, all infested leaves readily seen are removed. If the infestation is moderate, infested leaves are removed when parasitization is less than 30 percent. This manual defoliation method is often less expensive than spraying and as satisfactory, especially in city gardens, patios, and other rather inaccessible locations.

SUCCESS OF THE PROGRAM, 1953–55

By the end of 1953 the citrus blackfly was well controlled by its natural enemies in many citrus groves in the following States: Morelos, Veracruz, Puebla, Oaxaca, Guerrero, Mexico, Colima, Jalisco, Guanajuato, Hidalgo, and San Luis Potosí. In Tamaulipas, Nayarit, Michoacán, Sinaloa, Sonora, and Baja California (La Paz area), most of the infested groves still had heavy infestations. In Sonora

and northern Sinaloa large-scale releases of the Indian parasites had been made too recently to expect control. However, initial results obtained there, especially with *P. opulenta*, were encouraging and eventual control was expected by 1955.

During 1954 and 1955, captures and colonizations of the Indian parasites continued, and the ability of one or more species to effect control of the blackfly under the varied climatic conditions of Mexico's citrus regions was further demonstrated. The relative effectiveness of *A. hesperidum*, *P. clypealis*, and *P. opulenta*, at least in broadly defined climatic zones, was becoming better understood, and these parasites were being used more effectively.

The citrus blackfly had been found in 24 States and Baja California. By March 1955 in almost all citrus areas in 21 of these States this pest was commercially controlled. Durango and Chihuahua had recent infestations, and because of the relative inaccessibility of these infested locations, parasite releases were difficult and few were made. However, *A. hesperidum* built up rapidly, and commercial control appeared probable within a short time. In Baja California heavy infestations existed in some areas, but both *P. clypealis* and *P. opulenta* had been established, and in some areas 80- to 90-percent parasitization occurred. In Sonora only partial control had been obtained, yet *P. opulenta* showed promise of becoming acclimated to the hot, dry conditions there. *P. opulenta* was established in many localities in the State, and in Cocorit, the northernmost town in the biological control zone, parasitization reached 95 percent. Groves that had been heavily infested in 1953 showed only a very light infestation by the end of 1955.

PRESENT STATUS OF THE BLACKFLY IN MEXICO

Effects of Climate

Fluctuations in parasitization by blackfly parasites with consequent buildups of the pest in Mexico are attributed to both natural and artificial phenomena. During extended periods of dry weather, mortality of immature stages of parasites is high. During periods of precipitation immediately following the dry season the blackfly builds up more rapidly than its parasites, and parasitization is low for a time. Toward the end of the rainy season parasitization increases rapidly, and from October to December it commonly reaches a maximum for the year. In the absence of other factors affecting such fluctuations, control normally is reestablished without the necessity of parasite releases. However, in order to hasten control, parasite releases are usually made. Where irrigation is practiced, fluctuations in parasitization are less common, but only a small percentage of citrus groves in Mexico receive regular irrigations.

Extended periods of hot weather likewise affect blackfly parasites adversely. *A. hesperidum* is particularly susceptible to this condition. *P. clypealis* is less so, and *P. opulenta* is relatively resistant to high temperatures. Following such periods, during which eggs and young larval stages of the blackfly and immature stages of parasites are

decimated, the blackfly builds up more rapidly than its parasites, and sometimes it is necessary to release additional parasites to reestablish satisfactory control.

Winds of high velocity have a pronounced effect on the interrelationship of host and parasite. After the hurricane of October 1959, the blackfly built up to damaging proportions in the State of Colima. Liberations of *P. clypealis* and *P. opulenta* were made there in December 1959 and January 1960. By January 1961 commercial control had been reestablished. It has been observed that light, persistent winds also affect parasite activity. In those locations where such winds occur, parasitization commonly is lower than in adjacent protected areas.

Effects of Insecticides

Maintaining commercial control of the blackfly is difficult in areas where insecticides are employed against insects of cotton and other crops. In such areas since parasites are more sensitive than the blackfly, they are decimated by insecticide drift, and blackfly populations increase during insecticide application. Under these conditions it is usually necessary to liberate parasites to reestablish control.

At Apatzingán, Michoacán, where cotton and melon crops adjacent to areas of lime production are treated regularly with insecticides, seasonal fluctuations in parasitization are common. In February 1961 all locations sampled showed parasitization of less than 30 percent. In April medium to heavy infestations of blackfly were reported in 76.6 percent of the lime groves of the area. More than 59,000 parasites were released there during this period of low parasitization. By August 1961 parasitization in most areas sampled reached 80 percent or more, and satisfactory control of the blackfly had been reestablished in these localities. It is noteworthy that during the buildup of the pest in the Apatzingán area, it was possible to capture 36,200 adult parasites in a locality of high parasitization there. This locality is remote from crop-producing areas where insecticides were being used.

Control Measures in Use

The present method of controlling fluctuations in parasitization due to climatic irregularities consists in releasing field-collected parasites in localities of low parasitization. Samples of infested citrus leaves are sent regularly from all regions of citrus production to the laboratory of biological control in Mexico City, where determinations of degree of infestation and percentage of parasitization are made.

The degree of infestation is established by making random counts of live forms on infested leaves from a given locality. Samples with 1 to 45 live forms per leaf indicate a light infestation, 45 to 75 a medium infestation, and more than 75 a heavy infestation.

The percentage of parasitization in a given location is determined by a comparative count of parasitized and unparasitized larvae and pupae on random leaf samples. If parasitization is less than 60 percent, liberations of parasites are made. If parasitization is between 60 and 80 percent, control sufficient to prevent damage is considered to exist, but the groves are kept under close observation. If parasitiza-

tion is greater than 80 percent in a given locality, it is considered to be under technical control with no existing problem. Captures of parasites for release elsewhere generally are made when parasitization reaches 90 percent or more. In evaluating percentages of parasitization, the degree of infestation is always considered, since it is obvious that a parasitization of 80 percent, for example, is less advantageous in a heavy than in a light infestation.

Similar guides for liberating parasites are employed to regulate fluctuations of parasitization caused by insecticide drift. However, if liberations under these conditions are to be effective, they must be timed with insecticide applications as well as with the stage of development of the host. When insecticide applications are made at close or irregular intervals, parasite releases are not warranted.

Parasite collecting methods were simplified early in the biological control program. *Prospaltella* species are collected as adults from leaves of the host plant. Their characteristic jumping or hopping movement makes it possible to "hop" them into long glass tubes. This is a more rapid and more efficient method than aspersion, and resulting injury to the parasites is negligible. An experienced worker can collect as many as 12,000 parasites in a day.

Adult parasites are shipped in glass vials, 3½ by ½ inches, with ventilated cork stoppers. Each vial contains 100 parasites. Around each group of 20 vials moist paper is wrapped to conserve humidity and to protect the vials from damage. Strong cardboard boxes are used for shipment. Individual shipments consist of from 1,000 to more than 100,000 parasites.

A. hesperidum parasites usually are collected as pupae inside the blackfly host, together with leaves of the host plant. Since *A. hesperidum* adults do not jump or hop as the *Prospaltella* species do, it is not convenient to collect them in this manner. Also, since the adults live only for 4 to 7 days, it is not practical to capture and ship them after they have emerged.

Leaves infested with blackflies and parasitized by *A. hesperidum* are put in wax-paper bags, 100 leaves per bag, together with strips of moist paper for humidity. These are shipped to liberation locations in cardboard containers. At liberation sites the parasitized material is placed on protected branches of blackfly-infested trees, where adults then emerge.

Since 1956 efforts to control the citrus blackfly biologically have been concerned largely with combating new small-scale infestations and regulating fluctuations in parasitization in previously infested regions. The most recent invasion of the pest in a region that had not been infested was reported from the city of Campeche on the Yucatán Peninsula in October 1960. Although heavy infestations continue to occur, they are relatively limited in extent and duration. In general, it can be said that as of September 1962 the citrus blackfly is satisfactorily controlled in the entire biological control zone of Mexico, as shown in figure 7.

SUMMARY

The citrus blackfly (*Aleurocanthus woglumi* Ashby) is native to south Asia. It was first discovered in the New World on Jamaica,

West Indies, in 1913. From there it spread to other West Indian islands, to Central and South America, and to Key West, Fla. It was eradicated at Key West in 1937. In 1955 it was found in Texas, where it was eradicated in 1956.

The blackfly was reported in Mexico in 1935. From the original infestation in Sinaloa, it spread along the western coastal plain. By 1943 all citrus-growing areas in Sinaloa and the coastal areas of the States of Nayarit, Jalisco, and Colima were infested. By 1950 the pest had spread north to Sonora, south to Guerrero, east to Tamaulipas and Veracruz, and west to Baja California. In 1952 the far-southern States of Chiapas and Tabasco were invaded, and in 1960 the most recent large-scale infestation occurred in Campeche on the Yucatán Peninsula.

In Mexico, citrus is predominately the preferred and most important host of the blackfly. However, 75 plant species on which development takes place have been recorded. In addition, 56 plant species are listed on which the blackfly oviposits but on which complete development does not take place.

Damage caused to citrus by the blackfly results from its feeding and from deposition of honeydew on which sooty mold fungus develops. Infestations of short duration reduce production as much as 50 percent. Infestations lasting longer than 1 year have caused almost complete crop failure in many citrus groves in Mexico.

The first attempts to control the citrus blackfly in Mexico were made with insecticides, but because of difficulties and prohibitive expenses this method of control gave way to biological control efforts. However, in extreme northeast and northwest Mexico chemical control measures continue to be used to maintain a blackfly-free barrier zone south of the U.S. border.

In cooperation with the U.S. Department of Agriculture, the Mexican Department of Agriculture introduced the parasite *Eretmocerus serius* Silvestri in 1938 and again in 1943. This parasite became established after the second introduction but failed to control the blackfly in Mexico, except in a few limited areas of persistent high humidity. In 1948, 1949, and 1950, parasites were introduced from Malaya, India, and Pakistan. Three of these—*Amitus hesperidum* Silvestri, *Prospaltella clypealis* Silvestri, and *P. opulenta* Silvestri—have become dominant in controlling the citrus blackfly in Mexico.

During the early years of biological control activities at least one of the three Indian parasites became established in all infested regions of the biological control zone in Mexico. The native predator *Delphastus pusillus* (LeConte) is present in all citrus regions of Mexico. Parasites are collected in areas of abundance in the field and recolonized in new infestations and in localities where low parasitization occurs.

A. hesperidum is an effective parasite when liberated in heavy infestations, but it is dominated by the two *Prospaltella* species as infestations become lighter. It is the least effective of the three parasites in hot, dry areas. *P. clypealis* attains optimum performance under humid conditions and is less effective in areas where long dry periods prevail. *P. opulenta* is better adapted to a wide climatic range than *A. hesperidum* or *P. clypealis* and is much more effective than these parasites in the hot, dry regions of northeast and northwest Mexico.

The predator *D. pusillus* is useful in reducing heavy infestations, but it cannot be depended on to effect satisfactory control in the absence of parasites.

In 1943 a cooperative working agreement was negotiated by the Governments of Mexico and the United States relative to biological, chemical, and quarantine measures to control the blackfly. The citrus blackfly program was initiated on a national scale in Mexico in 1951, when by presidential decree the National Blackfly Committee was established. In December of 1958 this committee was dissolved, and subsequently the work has been administered by the Departamento de Control Biológico.

An efficient and harmonious Mexican-North American blackfly program evolved, which has become increasingly effective in controlling this pest. In addition, invaluable training and experience in biological control procedures have been afforded laboratory and field technicians, who now conduct Mexico's extensive biological control programs against several important plant pests.

Since 1956 the blackfly biological control program has been concerned largely with regulating fluctuations in parasitization due to climatic irregularities and to drift of insecticides applied to crops near citrus groves. In general, it can be said that as of September 1962 the blackfly is satisfactorily controlled in the entire biological control zone of Mexico.

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