THE LEAFHOPPERS AND OTHER POSSIBLE INSECT VECTORS OF PLANT VIRUS DISEASES IN ARIZONA: A PRELIMINARY REPORT ON THEIR SEASONAL OCCURRENCE

by

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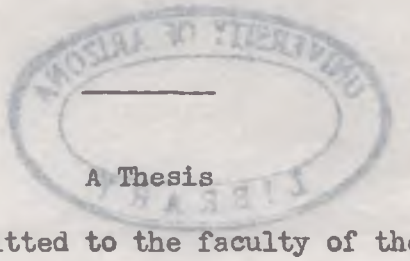

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INTRODUCTION

The first area of investigation when studying a plant virus disease is to obtain information regarding the possible insect vectors which are present (Leach 1940a). This paper is a preliminary report on the entomological phases of such an investigation and represents the first of a projected series to be prepared by the Department of Entomology of the University of Arizona.

Despite the fact that only a few species of the known insect vectors of plant virus diseases have actually been recorded as occurring in the state, Arizona growers of lettuce, melons, tomatoes and other crops have suffered serious losses from such diseases. The recorded presence of only a small number of known insect vectors does not justify the assumption that Arizona is relatively free of disease-transmitting insects. In numerous papers published by Dr. H. H. P. Severin, of the University of California, it has been demonstrated experimentally that many additional species of insects closely related to the first known vector of California aster-yellows have been found to be capable of transmitting that disease. Similar studies with species of insects closely related to known vectors of plant virus diseases will undoubtedly show that Arizona has far more vectors than is at present indicated by the information at hand.

In experimental work to determine the vectors of a given plant virus disease two groups of insects should be given particular attention: (1) those species which are closely related to known vectors of the disease and (2) those species which are the most active in the

area during the periods of greatest incidence of the disease. The importance of not stopping with the first vector or vectors discovered cannot be over emphasized. This viewpoint is supported by the work of Severin and Table 13 of the present paper.

SCOPE OF PRESENT PAPER

This thesis reports an analysis of the insects, known or believed to be actual or possible vectors of plant virus diseases, which were obtained from traps exposed adjacent to plantings of commercial crops at Peoria, Phoenix, Tucson and Yuma, Arizona.

The major portion of the present paper deals with the leafhoppers (Homoptera: Cicadellidae) with notes on their distribution, host plants and seasonal occurrence. In addition to the leafhoppers a brief resume is included of the Hemipterous families: Tingidae (lace bugs), Miridae (plant bugs) and Lygaeidae (chinch bugs); the Homopterous families: Fulgoridae (lanternflies), Membracidae (treehoppers), Chermidae (psyllids), and Aphidae (aphids); the Coleopterous family Chrysomelidae (flea beetles and Diabrotica beetles) and all members of the Order Thysanoptera (thrips).

It is clearly shown in Table 13 that the majority of the known vectors of plant virus diseases belong to the Orders of insects that have sucking mouth parts. With the exception of the flea beetles and the Diabrotica beetles (Coleoptera: Chrysomelidae) all insects discussed in the present findings have sucking mouth parts.

The material reported in this paper represents an essential preliminary step to later field studies to be made by the Department of Entomology of the University of Arizona dealing with the biology and control of the insect species which are of greatest economic importance. It will also provide essential information for the Department of Plant

Pathology of the University of Arizona in connection with their research projects dealing with insect transmission of plant virus diseases.

LITERATURE CONSULTED

All taxonomic arrangements of the Cicadellidae in this paper are based on Oman (1949a). This same paper has furnished a basis for all classification of the leafhoppers (Cicadellidae) to the generic level. Publications by Britton (1923a), DeLong (1948a) and Medler (1942a) were found to be extremely valuable because of their keys to the species.

Flock (1940a) was consulted as being the most complete work available containing information on the Cicadellidae and their host plants in Arizona.

An unpublished manuscript of the late Dr. L. P. Wehrle has provided the only known list of the aphids which occur in Arizona.

Bawden (1950a) and Leach (1940a) discuss at length plant virus diseases and their insect vectors. Bawden deals only with virus diseases of plants while Leach presents a review of plant diseases in general. All papers by Severin listed in the bibliography deal with insects as vectors of plant virus-diseases and present experimental evidence of insect transmission.

Metcalf (1942a) has been used as a basis for all bibliographic references up to 1942.

SOURCES OF MATERIALS

All insect material for this study was collected on sticky board traps (Pear Psylla Traps) as described by Kaloostain and Yeomans (1944a). In the present study a trap consisted of four boards instead of the one as used by Kaloostain and Yeomans.* The trap support consisted of a central pole with two cross bars at right angles to one another. Each of these cross bars supported two baords; therefore, there was exposed in each of the cardinal directions one surface of two boards or the equivalent of one trap as used by Kaloostain and Yeomans.

Material for the present study was obtained from traps maintained at four locations in Arizona; one trap was located in or near each of the following cities: Peoria, Phoenix, Tucson and Yuma. The last three areas named were sampled over a period of one year while the Peoria samples extended over a period of only six months. For data on the exact location and crops surrounding the traps see the discussion below on Trap Locations.

Due to the fact that the trap locations were so far apart it was impossible for one person to change them; to meet this situation special boxes were constructed to hold four boards. These boxes when closed were constructed so as to keep all foreign material from the outside from coming in contact with the boards within. Using this method a trap (four

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* The boards used in the present study were of the dimensions as set down by the workers mentioned above. In order to hold the boards more securely on the supports we had two holes drilled in the top and one in the bottom; thus, each board was anchored by three wires. The yellow paint used on the board surfaces was Sherwin Williams Industrial Finishes, Kem Lustra "42" Line, Medium Yellow number 42558.

boards) could be sent through the United States mails from one point to another at a small cost and with no loss of man hours.

Originally an attempt was made to expose all traps for a seven day period but due to circumstances beyond the control of those handling the traps it was often impossible to keep to this schedule. In most cases, when a trap could not be changed at the end of a seven day period it was exposed for an additional seven and occasionally fourteen days beyond the original seven days of exposure.

The sticky material used on the traps was a butylene polymer compound manufactured by the California Spray Chemical Corporation under the name of "Deadline." The "Deadline" was placed in a regular kitchen double boiler over an electric hot-plate until it had become soft enough to be applied to the boards by a paint brush. Traps which had been coated in this manner were sent from the University of Arizona to the points mentioned above and after being exposed were mailed back to the University for removal and analysis of the insects which had been trapped.

The following method was used to remove the insects from the "Deadline" on the sticky boards. The sticky material was partially dissolved by holding a board in a horizontal position and flooding it with xylene; the insects were then carefully lifted off of the boards by a small spatula and placed in a dish of xylene.

In the process of transferring the insects from the board to the dish some "Deadline" was left clinging to them and had to be removed before the specimens could be accurately determined. The excess "Deadline" was removed in the following manner: (1) The xylene was removed

by a medicine dropper* and replaced with chloroform. Depending upon the amount of "Deadline" present and the number of specimens in the dish, the insects were left in the chloroform from five to fifteen minutes. (2) The chloroform was removed and replaced by xylene. The insects were often left in this second xylene bath for several days; however, it was found that specimens which remained as long as two or three weeks in xylene had a tendency to deteriorate and were difficult to identify. (3) After removal of the xylene the specimens were covered with 95% ethyl alcohol for five to ten minutes. (4) From the 95% alcohol the specimens were transferred to 70% ethyl alcohol for storage and study purposes.

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* To avoid picking up small insects (thrips, etc.) the tip of the medicine dropper was heated and drawn out to a fine opening.

TRAP LOCATIONS

The sites of the four series of sticky board traps are given below, together with information concerning periods of exposure and the nature of adjacent crops.

Peoria (Eaton): six miles north and two miles west of Peoria, Arizona. Traps were exposed from February 10, 1950 to June 9, 1950. Crops: alfalfa, cantaloupe, cotton and spring lettuce.

Phoenix (Smith): lateral 18 and Christy Road, approximately six miles west of the center of the city of Phoenix, Arizona. Traps were exposed from March 17, 1950 to March 14, 1951. Crops: alfalfa, cantaloupe and spring lettuce.

Tucson (Keener): University of Arizona Campbell Avenue Farm, Tucson, Arizona. Traps were exposed from March 23, 1950 to March 23, 1951. Crops: alfalfa, cantaloupe, honey dew, lettuce and tomato.

Yuma: University of Arizona Yuma Valley Farm, approximately eight miles south of the city of Yuma, Arizona. Traps were exposed from January 30, 1950 to January 29, 1951. Crops: alfalfa, barley, beets, cantaloupe, carrot, flax, grain, lettuce and sweet corn.

INSECT DETERMINATION METHODS

Leafhoppers were classified to genus by the keys of Oman (1949a). It sometimes became necessary to consult keys in other works, especially those of Britton (1923a) and DeLong (1948a). For determinations to species numerous other papers were consulted and in all cases the original description of the species was compared with the specimens being studied.

After many specimens had been determined samples were sent for verification by specialists of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C. For purposes of accuracy two or three subsequent confirmatory identifications were also obtained for most species collected during the period of this study. This assistance was extremely valuable and built up a reference collection of accurately determined specimens which were readily available at all times for comparison with the newer leafhoppers removed from the traps.

Leafhopper determinations were frequently dependent upon a study of the internal male genital structures. For such studies two small incisions were made in the abdominal wall and the entire leafhopper placed in 10 per cent sodium hydroxide overnight. The sodium hydroxide was removed and replaced by two changes of 1 per cent hydrochloric acid an hour apart. When the specimens were not to be permanently mounted they were stored in 70 per cent ethyl alcohol for reference purposes. After the determinations were made cleared specimens which were to be kept for further study and reference were placed in small

vials containing glycerine as suggested by Oman (1949a). Because most of the color determination characteristics were destroyed in the process to remove the "Deadline" internal and external genital structures were usually used to make determinations.

Abbreviations

The following is a list of abbreviations of authors names as used in the charts, lists and tables:

Ash	Ashmead	Kbm	Kirschbaum
Buckt	Buckton	Kirk	Kirkaldy
Ckll	Cockerell	Lec	Leconte
Coq	Coquillett	Lind	Lindeman
Crawf	Crawford	Linn	Linnaeus
D & F	Davidson & Frazier	Mats	Matsumura
DeL & W	DeLong & Wolcott	Motsch	Motschulsky
Donc	Doncastor	Nott	Nottingham
Fabr	Fabricius	Oest	Oestlund
Fall	Fallen	O & L	Osborn & Lathrop
Fonsc	Fonscolombe	Prov	Provancher
Genn	Glendenning	Sulz	Sulzer
Gill	Gillette	Theob	Theobald
Godg	Goding	Thos	Thomas
Goot	Van de Goot	Uhl	Uhler
Kalt	Kaltenbach	Van D	Van Duzee

AN ANALYSIS OF INSECT GROUPS RECOVERED FROM TRAPS

The various insect groups represented in the trap recovery collections are discussed below in the approximate order of emphasis given them in this study.

Order: HOMOPTERA

Family: Cicadellidae (leafhoppers)

Subfamily: LEDRINAE

Tribe: Xerophloeini

Only one species of this group was collected in the present survey. No known plant disease vectors have been recorded from this subfamily. These two facts indicate that Xerophloea oraclis Lawson is probably not of economic importance in Arizona.

Subfamily: AGALLIINAE

Tribe: Agalliini

Four species from this subfamily were found in the present study. Aceratagallia gillettei (O & B) was the only species present in large enough numbers to even suggest it as being of economic importance, and then only at Tucson. The relatively large numbers of individuals of this species would suggest, however, that in any study of the Agalliinae as vectors of plant virus diseases this species should be given consideration. Nine species of Agalliinae are known to be vectors of plant virus diseases, of which four are in the genus Aceratagallia. It is not to be implied that the other genera should be ignored in disease trans-

mission tests although particular attention should probably be given A. gillettei.

It is of interest that both Ceratagallia nanella Oman and A. nitidula Oman are known to occur only in Arizona and have thus not been subjected to transmission tests in other areas.

Subfamily: MACROPSINAE

Tribe: Macropsini

Only one specimen, not determined to species, was recorded from this subfamily in this study. Macropsis trimaculata (Fitch), which has not been recorded from Arizona, has been reported as transmitting peach yellows (Table 11).

Subfamily: IDIOCERINAE

Tribe: Idiocerini

Species of this subfamily were collected in relatively large numbers on the Tucson and Peoria traps; the other two areas yielded but few of these species. This is a relatively small subfamily containing but one genus, Idiocerus, in the Nearctic region. The leafhoppers collected were not determined beyond the generic level because of the inadequacy of the available keys to the species. Dr. D. M. DeLong, principal authority in this group, stated in personal correspondence that he will soon publish a monograph on the genus. When this is done the specimens in the present study should be studied further to determine the species present and their possible economic significance. At present no members of this group are recorded as being vectors of plant virus diseases.

Subfamily: IASSINAE

Tribe: Iassini

Only one species, Stragania robusta (Uhler), was found in the present survey. This species is believed to be a complex of several species and is in need of taxonomic revision. This leafhopper was collected in numbers large enough in the Tucson area to make it worthy of investigation as a transmitter of disease. No plant disease vectors have yet been recorded from this subfamily.

Subfamily: XESTOCEPHALINAE

Tribe: Xestocephalini

No members of this subfamily are known to be plant disease vectors. Since only four specimens (two from Tucson and two from Yuma) were found in the present study this subfamily may be considered as probably being of little economic importance.

Subfamily: TETTIGELLINAE

Oman (1949a), Bawden (1950a) and Leach (1940a) indicate that this is one of the major groups of insect vectors of plant virus diseases. This is probably due to the fact that this is one of the largest subfamilies of the Cicadellidae. In the present records the Tettigellinae are represented by only two species.

Tribe: Tettigellini

The present study reports the occurrence of a known vector, Draeculacephala minerva Ball and an undetermined species of the genus Car-

neocephala, both of which were found only at Tucson and in relatively small numbers. Two members of the latter genus are known to be vectors of Pierce's disease of grapes.

Subfamily: CICADELLINAE

This is another large subfamily and contains the largest number of leafhoppers reported in the present investigation. It is here represented by three tribes and at least nine species.

Tribe: Alebrini

Represented by one specimen collected at Tucson which was not determined further.

Tribe: Dikraneurini

At least one member of this tribe, Kunzeana kunzei (Gillette), has occurred in large enough numbers to be given consideration in insect virus transmission tests. The species was collected mainly at Tucson.

Several species of Empoasca were quite abundant and well represented in all four locations. Chart III shows that the fall 1950 wave of leafhoppers at Tucson was due almost entirely to an increase in the numbers of Empoasca species present. This indicates that members of this genus should definitely be considered in insect virus transmission tests made at any of the four areas under observation. Time did not permit the determination of the Empoasca specimens to species.

Tribe: Cicadellini

Two species from this tribe, Erythroneura apacha Baker and E. vari-

abilis Beamer, were found in the present study. The former species, found only at Tucson, was alone sufficiently abundant to warrant possible consideration as a potential vector.

Subfamily: DELTOCEPHALINAE

This is the largest subfamily of the Cicadellidae in the Nearctic region. In the present investigation it was exceeded in number of species only by the Cicadellinae. This subfamily contains the largest number of known vectors of plant virus diseases but, as suggested by Oman (1949a), this may be due to the fact that it is the largest subfamily and the number of known vectors may be in proportion to the number of species.

Tribe: Scaphytopiini

One species, Scaphytopius nigriviridis (Ball), was recorded, although in numbers too small to make it a suspected vector. Two closely related species, Scaphytopius dubius (Van D) and S. irroratus (Van D), are known to be capable of transmitting California aster-yellows.

Tribe: Deltocephalini

This tribe contains more known plant virus disease vectors than any other tribe in the Cicadellidae. It is likewise the most abundantly represented tribe in the present investigation. Of the more than eight species found in this study only one, Circulifer tenellus (Baker) is known to be a vector of a plant virus disease. In all four areas of this investigation this species has occurred in numbers large enough to make it of possible economic importance.

At Tucson Opsius stactogalus Fieber was found in numbers large enough to warrant further investigation. It has been abundant on Bermuda grass at Tucson.

At Peoria and Tucson Ollarianus strictus (Ball) was by far the most abundant species and was also present in relatively large numbers at Phoenix and Yuma. Of all of the species recorded in this study this species is most clearly in need of further investigation. This species is easily confused with Circulifer tenellus and it is likely that numerous mis-determinations have occurred in the past. In spite of their close similarity the two species can be easily separated by the nature of the external genital plates of both sexes and by the internal male processes. Chart II strikingly indicates that the 1950 spring wave of leafhoppers at Tucson was due in large part to an increase of Ollarianus strictus. In the past Circulifer tenellus has probably been erroneously considered to be the dominant species involved in similar spring outbreaks of leafhoppers.

It has been shown that members of the genus Idiocerus have been sufficiently abundant at Peoria and Phoenix to be considered in any future investigations of insect transmission of plant virus diseases in Arizona.

At Tucson Aceratagallia gillettei (O & B), Kunzeana kunzei (Gillette), Opsius stactogalus Fieber and Stragania robusta (Uhler) have occurred in sufficient numbers to warrant further investigation.

Various species of Empoasca, not determined to species in the present study, were present in all four areas in relatively large num-

bers and were especially numerous at Phoenix and Tucson. In these two regions, at least, they should be studied further in disease transmission tests. These species will be more precisely determined at the first opportunity, under the sponsorship of the Department of Entomology of the University of Arizona.

By far the most abundant species found at Peoria and Tucson was Ollarianus strictus (Ball). This species occurred in such large numbers that future investigators of plant virus disease transmission should not ignore it.

Striking comparisons are evident in Charts I, II and III which show, respectively, the total number of leafhoppers, the number of Ollarianus strictus and the number of Empoasca spp. recorded from the Tucson traps. Chart I shows two definite waves of leafhoppers (one in the spring and one in the fall) during the year covered by this survey. Chart II shows that the spring wave is due almost entirely to the presence of Ollarianus strictus and Chart III shows that the fall wave is caused almost entirely by various species of Empoasca.

Some taxonomic work yet remains to be done on the leafhoppers found in this survey. The major groups requiring further study are the genera Idiocerus and Empoasca.

Family: Chermidae (psyllids)

No members of this family have been reported in the available literature as being vectors of plant virus diseases. These insects were collected in relatively large numbers from traps in all areas observed and are worthy of serious future consideration as potential

vectors because of their piercing-sucking mouthparts and plant feeding habits.

Family: Membracidae (treehoppers)

Family: Fulgoridae (lanternflies)

Members of these families were recorded occasionally from traps in all areas but were seldom numerous. No species in either family have been reported as plant virus disease vectors although their piercing-sucking mouthparts would class them as potential, if not serious, vectors.

Family: Aphidae (aphids)

This is one of the largest and most important groups of insect vectors of plant virus diseases. The late Dr. L. P. Wehrle recognized their importance in Arizona and studied them intensely during the period from 1930 until his death in 1950. During the last year of his life he was engaged in the study of that phase of the present investigation which involved the aphids. In this work he collaborated with Dr. F. C. Hottes, of Grand Junction, Colorado, an internationally known student of this group of insects. It was not originally planned to include any appreciable number of aphid records in the present thesis, since such information was to have been published separately by Dr. Wehrle. Dr. Hottes has kindly consented to make a number of aphid determinations in connection with this work and a series of records, representing an analysis of the aphid species found on one-fourth of each trap exposed at Tucson, is given in Table 15. Of the 27 Tucson traps, each of which was analyzed in part by Dr. Hottes, 12 contained Aphis gossypii Glover,

11 contained Aphis maidis Fitch, 10 contained Myzus persicae (Sulzer) and 7 contained Rhopalosiphum pseudobrassicae (Davis). None of these species has been experimentally observed to transmit a plant virus disease in Arizona. Although all four species should definitely be investigated in this manner. No other aphid species were sufficiently numerous on the traps analyzed to date to be yet considered as potentially serious transmitters of plant virus diseases.

Order: HEMIPTERA

Family: Tingidae (lace bugs)

Two members of this family are known to be vectors of plant virus diseases. Only in the Tucson area were they found to be numerous enough to warrant consideration in further studies of insect transmission of plant diseases.

Family: Miridae (plant bugs)

Family: Lygaeidae (chinch bugs)

No members of these families are known to be vectors of plant virus diseases. At Tucson they were found in relatively large numbers and are worthy of further investigation because of their piercing-sucking mouthparts and plant feeding habits.

Order: THYSANOPTERA

Two members of this order, Frankliniella insularis Franklin and Thrips tabaci Lindeman, are known to be vectors of plant virus diseases. These insects (Tables 1, 3, 5 and 6) occurred in extremely large numbers in all four areas of this survey. These numbers alone seem

sufficient reason to suggest them for further investigation as potential transmitters of plant diseases.

Order: COLEOPTERA

Family: Chrysomelidae

In the present investigation only members of the following three genera were studied: Diabrotica, Phyllotreta and Chaetocnema. Diabrotica soror Lec and D. trivettata Mann are known to be vectors of squash mosaic and cucurbit mosaic. Species of this genus were recorded in the present study only from Tucson.

Phyllotreta cruciferae (Goeze) and P. vittula Redt transmit the virus of turnip yellow mosaic. Neither of these species were found in this survey but a closely related form, Phyllotreta pusilla Horn is here recorded in relatively small numbers from all areas except Yuma.

The flea beetle Chaetocnema ectypa Horn was found to be abundant in all areas and is definitely worthy of further investigation in Arizona.

Numerous additional insect groups which could not be studied because of lack of time were collected on the traps during the period of this investigation. Many of these insects are of questionable importance in investigations of plant virus diseases. From an entomological standpoint, particularly in Arizona, insects collected in this manner could be studied with profit. Among such insects and allied Arthropods trapped but not studied were members of the following groups: Arachnida:

Araneida (spiders) and Acarina (mites); Insecta: Isoptera (termites), Corrodentia (psocids), Homoptera (cercopids, aleyrodids), Diptera (many types of flies and fly larvae), Lepidoptera (moths and butterflies), and Hymenoptera (many types including the chalcidflies).

SUMMARY STATEMENT

Insect transmitted plant virus diseases have caused serious losses to Arizona growers of melons, lettuce, tomatoes and other commercially important crops. This thesis reports a preliminary attempt to identify and record the seasonal occurrences of the leafhoppers and certain other insects involved. This represents an essential step preparatory to the investigation of the biology and control of the more important species of insects concerned and is based on the analysis of insects caught on four series of sticky board traps exposed near plantings of commercial crops. These traps were exposed near Tucson, Phoenix, Peoria, and Yuma during 1950 and 1951.

Leafhoppers occurred in greatest numbers during spring and fall "waves." At Tucson the spring "wave" was due almost entirely to the increased abundance of Ollarianus strictus (Ball) and the fall "wave" to various species of Empoasca.

An analysis of the leafhoppers recovered indicates that O. strictus (Ball), Empoasca spp. and Idiocerus spp. by their presence in large numbers warrant further investigation as possible vectors of plant virus diseases. Other Leafhoppers and insect groups are discussed in relation to their relative importance in possible future work at the University of Arizona.

Information of value to future investigators of insect transmission of plant virus diseases is shown in tables compiled from literature. The principal results are presented in tabular form and are further elucidated by appropriate charts.

CHARTS AND TABLES

The following Tables list the insects known to be vectors of plant virus diseases and information concerning those vectors which are known to occur in Arizona. These tables, are largely compilations of information scattered through the literature and summarizes information of value to future workers investigating insect transmission of plant virus diseases.

Other tables show the numbers of insects removed from each of the traps in four areas studied in this investigation and the numbers of leafhoppers of each species collected on each of the traps studied.

The charts show in graphic form the total numbers of leafhoppers removed from each of the traps included in this study. Two of the charts also show the true cause of the two waves of leafhoppers which occurred during the year of this investigation at Tucson.

Tucson records are summarized by a line graph chart, since every trap was analyzed and the information was, therefore, of a continuous nature. Time did not permit the complete analysis of all the traps from other areas. Leafhopper collections from Peoria, Phoenix and Yuma are, therefore, shown by bar graphs, based usually on the analysis of every second or third successive trap.

Table I

Insects removed from the Keener Sticky Board Traps
University of Arizona Campbell Avenue Farm, Tucson, Arizona

Trap numbers	Date of Exposure	Cicadellidae	Aphidae	Chermidae	Membracidae	Fulgoridae	Hemiptera	Thysanoptera	Chrysomelidae	Total
K 1	March 23-30, 1950	9	30	13	—	—	4	456	10	522
K 2	March 30—April 13	261	307	37	—	7	37	861	14	1524
K 3	April 13-20	93	107	6	1	8	3	201	3	422
K 4	April 20-27	139	65	17	1	5	22	237	1	487
K 5	April 27—May 11	203	30	18	—	6	27	245	3	532
K 6	May 11-18	263	43	14	6	1	63	1446	1	1837
K 7	May 18-25	349	17	12	11	3	46	393	9	840
K 8	May 25—June 8	250	21	19	9	1	13	114	4	431
K 9	June 8-15	474	6	7	1	1	8	81	—	578
K 10	June 15-27	412	13	5	1	4	11	46	14	506
K 11	June 27—July 10	135	12	6	4	3	8	31	33	232
K 12	July 10-24	60	122	1	6	—	9	59	35	292
K 13	July 24—August 4	99	1354	10	7	1	14	407	76	1968
K 14	August 4-23	82	330	162	13	3	49	335	120	1094
K 15	August 23-30	8	21	8	—	—	13	190	50	290
K 16	August 30—September 22	73	15	10	8	—	14	104	106	330
K 17	September 22-28	9	12	12	4	2	2	31	8	80
K 18	September 28—October 19	56	14	24	5	5	3	109	29	245
K 19	October 19-26	375	2	—	2	3	—	141	10	533
K 20	October 26—November 30	177	13	4	2	3	—	52	8	259
K 21	November 30-December 7	279	10	3	—	—	—	20	4	316
K 22	December 7-14	310	15	6	1	2	—	65	9	408
K 23	December 14-21	181	29	5	1	1	—	16	2	235
K 24	Dec. 21, 1950—Jan. 4, 1951	229	51	2	—	—	—	23	—	305
K 25	January 4-11	52	38	3	—	—	3	5	1	102
K 26	January 11-18	27	12	—	—	—	—	9	—	48
K 27	January 18—February 1	111	78	—	—	—	3	18	9	219
K 28	February 1-23	113	69	1	1	—	—	15	8	207
K 29	February 23—March 16	61	108	—	—	—	—	6	3	178
K 30	March 16-23	159	111	177	—	—	—	54	6	507
	Totals	5049**	3055	582*	84*	59	352*	5770	576*	15,527

*See table number 9 for an analysis of these figures.

**See table number 10 for an analysis of this figure.

Table II

Leafhoppers (Cicadellidae) removed from the Keener Sticky Board Traps
University of Arizona Campbell Avenue Farm, Tucson, Arizona

Trap Numbers	Aceratagallia gillettei O. & B.	Agallinae spp.	Circulifer tenellus (Baker) (a)	Draeculacephala minerva Ball (b)	Empoasca spp.	Erythroneura spp.	Kunzeana kunzei (Gillette)	Ollarianus strictus (Ball)	Opsius stactogalus Fieber	Stragania robusta (Uhler)	Other Leafhoppers (c)	Total
K 1	—	—	2	—	2	5	—	—	—	—	—	9
K 2	—	2	70	1	22	11	27	119	—	1	8	261
K 3	1	1	7	—	3	1	5	72	—	—	3	93
K 4	—	1	20	1	13	1	6	90	3	—	4	139
K 5	—	5	11	—	27	1	4	147	4	2	2	203
K 6	2	3	39	3	45	—	5	142	21	1	2	263
K 7	—	4	8	—	16	1	2	301	15	—	2	349
K 8	2	3	12	—	14	—	2	207	8	—	2	250
K 9	—	—	—	—	5	2	4	429	9	22	3	474
K 10	2	2	—	—	12	2	8	348	11	23	4	412
K 11	1	1	—	—	2	—	1	106	8	11	5	135
K 12	—	—	1	3	7	—	—	30	7	10	2	60
K 13	—	3	—	6	25	—	—	39	8	12	6	99
K 14	4	10	2	2	1	—	1	41	13	1	7	82
K 15	—	—	—	1	2	—	—	4	1	—	—	8
K 16	2	2	31	—	13	1	1	8	9	3	3	73
K 17	1	—	—	1	1	—	—	1	4	—	1	9
K 18	—	—	5	—	30	2	1	7	—	2	9	56
K 19	—	1	1	1	340	3	8	10	1	3	7	375
K 20	—	4	2	1	147	—	1	1	16	—	5	177
K 21	—	1	1	—	266	3	1	4	2	—	1	279
K 22	—	—	2	—	289	—	1	10	3	—	5	310
K 23	—	—	3	—	165	—	4	7	1	—	1	181
K 24	1	—	3	—	205	3	6	6	2	—	3	229
K 25	—	—	2	—	46	—	1	3	—	—	—	52
K 26	—	—	6	—	18	3	—	—	—	—	—	27
K 27	24	9	—	—	54	12	—	12	—	—	—	111
K 28	29	2	19	—	38	6	1	10	3	—	5	113
K 29	—	—	3	—	33	3	3	15	3	—	1	61
K 30	—	3	—	—	18	3	9	111	9	—	6	159
Totals	69	57	250	20	1859	63	102	2280	161	91	97	5049

(a) vector of sugar beet curlytop

(b) vector of Pierce's disease of grapes

(c) Carneocephala sp. 9, Deltocephalinae spp. 32, Dikrella cockerellii (Gill) 4, Exitianus exitiosus (Uhl) 5, Graminella sp. 2, Idiocerus spp. 12, Lycioides condalianus (Ball) 4, Macropsis sp. 1, Protalebra sp. 1, Scaphytopius nigriviridis (Ball) 10, Texananus vermiculatus DeL. 3, Xestocephalus sp. 2, Xerophloea oracilis Lawson 1, nymphs 11: total miscellaneous leafhoppers 97.

Table III

Insects removed from the Yuma Sticky Board Traps
University of Arizona Experimental Valley Farm, Yuma, Arizona

Trap numbers	Date of Exposure	Cicadellidae	Aphidae	Chermidae	Membracidae	Fulgoridae	Hemiptera	Thysanoptera	Chrysomelidae	Total
Y 1	January 30--February 6, 1950	11	2	7	---	---	---	6	1	27
Y 4	February 20-27	32	63	24	---	---	---	52	6	177
Y 7	March 13-20	55	498	5	---	1	1	158	6	724
Y 10	April 3-10	18	224	31	2	---	1	29	4	309
Y 13	April 24--May 1	120	13	87	---	6	---	221	---	447
Y 16	May 15-22	12	3	20	2	---	2	113	11	163
Y 19	June 5-12	1	10	9	---	---	2	16	---	38
Y 22	June 26--July 3	11	44	1	---	---	2	93	---	151
Y 25	July 17-24	2	7	---	---	1	---	15	68	93
Y 28	August 7-14	3	22	1	5	---	3	61	144	239
Y 31	August 28--September 4	2	20	3	3	3	4	46	46	127
Y 34	September 18-25	3	82	---	---	5	---	66	15	171
Y 37	October 9-16	19	43	---	---	---	3	138	6	209
Y 40	October 30--November 6	36	16	1	---	1	---	25	---	79
Y 43	December 4-18	40	41	1	---	1	---	39	1	123
Y 46	January 15-29, 1951	2	12	2	---	1	---	1	1	19
Total		367**	1100	192*	12*	19	18*	1079	309*	3096

*See table 9 for an analysis of these figures.

**See table 10 for an analysis of this figure.

Table IV

Leafhoppers (Cicadellidae) removed from the Yuma Sticky Board Traps
University of Arizona Experimental Valley Farm, Yuma, Arizona

Trap Numbers	*Acerataglallia nanella* Oman	*Circulifer tenellus* (Baker) (a)	*Deltocephalinae* spp.	*Empoasca* spp.	*Erythroneura apacha* Baker	*Idiocerus* spp.	*Ollarianus strictus* (Ball)	*Opsius stactogalus* Fieber	*Stragania robusta* (Uhler)	*Texananus rufusculus* (O.& L.)	*Xestocephalus* sp.	Total
Y 1	—	7	—	2	—	2	—	—	—	—	—	11
Y 4	—	5	—	2	1	17	6	—	—	1	—	32
Y 7	—	46	—	2	—	—	6	—	—	—	1	55
Y 10	1	16	—	1	—	—	—	—	—	—	—	18
Y 13	—	51	—	12	—	—	54	3	—	—	—	120
Y 16	—	1	—	—	—	—	11	—	—	—	—	12
Y 19	1	—	—	—	—	—	—	—	—	—	—	1
Y 22	2	—	—	5	—	—	3	1	—	—	—	11
Y 25	2	—	—	—	—	—	—	—	—	—	—	2
Y 28	3	—	—	—	—	—	—	—	—	—	—	3
Y 31	1	—	—	—	—	—	—	1	—	—	—	2
Y 34	—	1	—	2	—	—	—	—	—	—	—	3
Y 37	1	15	1	—	—	—	2	—	—	—	—	19
Y 40	—	31	2	1	—	—	—	—	1	—	1	36
Y 43	1	24	—	9	—	—	6	—	—	—	—	40
Y 46	—	1	—	—	—	—	1	—	—	—	—	2
Total	12	198	3	36	1	19	89	5	1	1	2	367

(a) vector of sugar beet curlytop.

Table V

Insects removed from the Smith Sticky Board Traps
Lateral 18 and Christy Road, Phoenix, Arizona

Trap Numbers	Dates of Exposure	Cicadellidae	Aphidae	Chermidae	Membracidae	Fulgoridae	Hemiptera	Thysanoptera	Chrysomelidae	Total
S 1	March 17-31, 1950	109	1220	14	—	—	5	79	167	1594
S 4	April 14-21	57	130	—	—	—	6	51	3	247
S 7	May 5-12	87	14	6	—	3	18	249	33	410
S 10	May 26--June 2	40	9	4	—	5	7	282	43	390
S 13	June 16--July 6	15	—	—	—	8	7	81	26	137
S 16	July 20--August 2	1	3	4	1	—	—	48	3	60
S 19	August 16-23	2	5	6	22	3	6	46	17	107
S 22	September 11-19	2	50	7	23	5	6	21	10	124
S 25	October 3-10	26	63	3	12	5	4	141	22	276
S 28	October 25-31	37	290	6	8	1	1	71	13	427
S 31	November 28--December 12	34	182	5	—	—	—	69	2	292
S 34	January 10-25, 1951	—	30	30	—	—	—	1	1	62
S 37	March 7-14	105	110	3	—	—	—	22	33	273
	Totals	515**	2106	88*	66*	30	60*	1161	373*	4399

Table VI
Insects removed from the Eaton Sticky Board Traps
Six miles North and two miles West of Peoria, Arizona

Trap Numbers	Dates of Exposure	Cicadellidae	Aphidae	Chermidae	Membracidae	Fulgoridae	Hemiptera	Thysanoptera	Chrysomelidae	Total
E 1	February 10-17, 1950	86	39	28	—	—	—	521	—	674
E 3	February 24--March 3	60	107	24	1	—	—	446	6	644
E 5	March 10-17	4	126	14	2	—	—	27	—	173
E 7	March 24-31	655	760	16	—	—	7	265	7	1720
E 9	April 7-13	9	297	3	—	—	—	—	—	309
E 11	April 21-28	1470	210	12	—	9	9	162	—	1872
E 13	May 5-12	1227	16	18	—	18	9	567	—	1855
E 15	May 19-26	822	4	6	9	3	—	141	—	985
E 17	June 2-9	41	2	4	—	—	12	4	—	63
	Totals	4374**	1561	125*	12*	30	37*	2133	13*	8285

*See table number 9 for an analysis of these figures.

**See table number 10 for an analysis of this figure.

Table VII

Leafhoppers (Cicadellidae) Removed from the Smith Sticky Board Traps Lateral 18 and Christy Road, Phoenix, Arizona

Trap Numbers	Aceratagallia nenella Oman	Ceratagallia dondia (Oman)	Circulifer tenellus (Baker) (a)	Deltocephalinae sp.	Empoasca spp.	Idiocerus spp.	Ollarianus strictus (Ball)	Stragania robusta (Uhler)	Total
S 1	---	5	97	---	3	2	2	---	109
S 4	3	---	51	---	---	3	---	---	57
S 7	3	---	36	---	24	---	24	---	87
S 10	4	---	7	---	8	---	20	1	40
S 13	2	---	8	---	2	---	3	---	15
S 16	---	---	---	---	1	---	---	---	1
S 19	2	---	---	---	---	---	---	---	2
S 22	---	---	---	---	2	---	---	---	2
S 25	3	---	2	---	19	---	2	---	26
S 28	4	---	2	---	29	---	2	---	37
S 31	---	---	11	1	20	---	2	---	34
S 34	---	---	---	---	---	---	---	---	---
S 37	---	---	---	---	9	96	---	---	105
Total	21	5	214	1	117	101	55	1	515

(a) vector of sugar beet curlytop.

Table VIII

Leafhoppers (Cicadellidae) Removed from the Eaton Sticky Board Traps six miles North and two miles West of Peoria, Arizona

Trap Numbers	Aceratagallia nanella Oman	Aceratagallia sp.	Ceratagallia dondia (Oman)	Circulifer tenellus (Baker) (a)	Deltocephalinae spp.	Dikrella cockerelli (Gill)	Empoasca spp.	Idiocerus spp.	Kunzeana kunzei (Gillette)	Ollarianus strictus (Ball)	Scaphytopius nigriviridis (Ball)	Stragania robusta (Uhler)	Total
E 1	—	—	—	3	—	—	14	62	—	6	1	—	86
E 3	—	—	—	1	—	1	6	44	—	7	1	—	60
E 5	—	—	—	—	—	—	2	2	—	—	—	—	4
E 7	1	—	4	340	5	—	20	1	1	283	—	—	655
E 9	—	—	—	3	—	—	—	—	—	6	—	—	9
E 11	—	—	—	162	6	—	—	—	—	1302	—	—	1470
E 13	—	—	—	9	—	—	6	—	—	1212	—	—	1227
E 15	—	3	—	—	—	—	6	—	—	813	—	—	822
E 17	—	—	—	—	—	—	3	—	—	37	—	1	41
Totals	1	3	4	518	11	1	57	109	1	3666	2	1	4374

(a) vector of sugar beet curlytop.

Table IX

Partial Analysis of Totals from Tables 1, 3, 5 and 6

Species involved in the totals as shown in Tables 1, 3, 5 and 6.	Eaton	Keener	Smith	Yuma
CHERMIDAE				
Leuronota maculata (Crawford)	—	103	5	—
Miscellaneous spp. listed below:	125	479	83	192
Aphalara sp.				
Aphalaroida inermis Crawford (?)				
Heteropsylla texana Crawford				
Kuwayama medicaginis (Crawford)				
Pachypsylla celtidis-vesicula Crawford				
Paratrioza cockerellii (Sulc.)				
Psylla confusa Tuthill				
Trioza sp.				
MEMBRACIDAE				
Stictocephala festina (Say)	10	27	66	8
Centrodontus atlas Godg.	—	33	—	—
Other species	2	24	—	4
HEMIPTERA				
Miridae and Lygaeidae species	29	208	53	18
Tingidae: Corythuca morilli Osb.& Drake, Gargaphia sp. and other undetermined species	8	144	7	—
CHRYSOMELIDAE				
Chaetocnema ectypa Horn	7	517	368	309
Phyllotreta pusilla Horn	6	24	5	—
Diabrotica spp.	—	35	—	—
Total	187	1594	587	531

Table X

Analysis of Leafhopper (Cicadellidae) Totals from Tables 1, 3, 5 and 6

Species involved in the totals as shown in Tables 1, 3, 5 and 6.	Eaton	Keener	Smith	Yuma
LEDRINAE				
Xerophloeini				
Xerophloea oracilis Lawson	—	1	—	—
AGALLIINAE				
Agalliini				
Agalliopsis sp.	—	5	—	—
Ceratagallia dondia (Oman)	4	7	5	—
Aceratagallia gillettei (O.&B.)	—	69	—	—
Aceratagallia nitidula Oman	—	2	—	—
Aceratagallia nanella Oman	1	29	21	12
Aceratagallia spp.	3	14	—	—
MACROPSINAE				
Macropsini				
Macropsis sp.	—	1	—	—
IDIOCERINAE				
Idiocerini				
Idiocerus spp.	109	12	101	19
IASSINAE				
Iassini				
Stragania robusta (Uhler)	1	91	1	1
XESTOCEPHALINAE				
Xestocephalini				
Xestocephalus sp.	—	2	—	2
TETTIGELLINAE				
Tettigellini				
Draeculacephala minerva Ball (a)	—	20	—	—
Carneocephala (?) sp.	—	9	—	—
CICADELLINAE				
Alebrini				
Protalebra sp.	—	1	—	—
Dikraneurini				
Kunzeana kunzei (Gillette)	1	102	—	—
Dikrella cockerellii (Gillette)	1	4	—	—

(continued on next page)

Table X

	Eaton	Keener	Smith	Yuma
Empoasca spp.: The species found most frequently are listed below:	57	1859	117	36
E. abrupta DeL.				
E. unca DeL. & D.				
E. solana DeL.				
E. calcea DeL.				
Cicadellini				
Erythroneura apacha Baker	—	55	—	1
Erythroneura variabilis Beamer	—	8	—	—
DELTOCEPHALINAE				
Scaphytopiini				
Scaphytopius nigriviridis (Ball)	2	10	—	—
Deltocephalini				
Ollarianus strictus (Ball)	3666	2280	55	89
Texananus vermiculatus DeL.	—	3	—	—
Texananus rufusculus (O. & L.)	—	—	—	1
Lycioides condalianus (Ball)	—	4	—	—
Opsius stactogalus Fieber	—	161	—	5
Circulifer tenellus (Baker) (b)	518	250	214	198
Exitianus exitiosus (Uhler)	—	5	—	—
Graminella sp.	—	2	—	—
Undetermined specimens	11	32	1	3
Leafhopper nymphs	—	11	—	—
Total	4374	5049	515	367

(a) vector of Pierce's disease of grapes

(b) vector of sugar beet curlytop

Table XI

Leafhopper vectors of plant virus diseases*

AGALLIINAE	
Agalliini	
Aceratagallia sanguinolenta (Prov.)	Potato yellow-dwarf
A. curvata Oman	Potato yellow-dwarf
A. longula (Van Duzee)	Potato yellow-dwarf
A. obscura Oman	Potato yellow-dwarf
Agallia albidula Uhler	Tomato "spotted wilt"
A. constricta Van Duzee	Potato yellow-dwarf; clover big-vein
A. quadripunctata (Prov.)	Potato yellow-dwarf; clover big-vein
Agalliana ensigera Oman	Argentine sugar beet curlytop
Agalliopsis novella (Say)	Clover club-leaf; clover big-vein
MACROPSINAE	
Macropsini	
Macropsis trimaculata (Fitch)	Peach yellows
IASSINAE	
Gyponini	
Gyponana hasta DeLong	Aster yellows
COELIDIINAE	
Coelidiini	
"Jassus" indicus (Walker)	Sandal spike
TETTIGELLINAE	
Proconiini	

* The arrangement of the leafhoppers in this table is based on the classification of Oman (1949a). The material contained herein is based on Oman (1949a), Bawden (1950a) Leach (1940a) and numerous papers by Severin as listed in the Bibliography.

Cuerna costalis (Fabricius)	Phony peach
C. occidentalis Oman & Ball	Pierce's disease of grape
Homalodisca triquetra (Fabr.)	Phony peach
Oncometopia undata (Fabr.)	Phony peach
Tettigellini	
Carneocephala fulgida Nott.	Pierce's disease of grape
C. triguttata Nott.	Pierce's disease of grape
Draeculacephala californica D & F	Pierce's disease of grape
D. minerva Ball	Pierce's disease of grape
D. portola Ball	Sugar cane chlorotic streak
Graphocephala versuta (Say)	Phony peach
Helochara delta Oman	Pierce's disease of grape
Hordnia circellata (Baker)	Pierce's disease of grape
Keonolla confluens (Uhler)	Pierce's disease of grape
K. dolobrata (Ball)	Pierce's disease of grape
Neokolla severini DeLong	Pierce's disease of grape
Errhomenellini	
Friscanus friscanus (Ball)	Pierce's disease of grape
Pagaronia confusa Oman	Pierce's disease of grape
P. furcata Oman	Pierce's disease of grape
P. tredecimpunctata Ball	Pierce's disease of grape
P. triunata Ball	Pierce's disease of grape
CICADELLINAE	
Dikraneurini	
Empoasca devastans Distant	Eggplant little-leaf
E. papayae Oman	Papaya bunchy-top
DELTOCEPHALINAE	
Scaphytopiini	
Scaphytopius dubius (Van D.)	California aster-yellows; Alfalfa witche's-broom
S. irroratus (Van Duzee)	California aster-yellows

Macrostelini	
Baldulus maidis (DeL & W)	Corn stunt
Cicadulina bipunctella (Mats)	Maize streak; maize wallaby ear disease
C. mbila (China)	Maize streak
C. storeyi China	Maize streak
Macrosteles divisus (Uhler)	Aster yellows
M. "quadripunctata" Kbm*	Aster yellows
Acinopterini	
Acinopterus angulatus Lawson	California aster-yellows
Deltocephalini	
Atanus exitiosus Beamer	Sugar beet yellow-wilt
Circulifer tenellus (Baker)	Sugar beet curlytop
Chlorotettix similis DeL	California aster-yellows
Colladonus commissus (Van D)**	California aster-yellows
C. flavocapitatus (Van D)**	California aster-yellows
C. geminatus (Van D)**	California aster-yellows
C. intricatus (Ball)*** **	California aster-yellows
C. kirkaldyi (Ball)**	California aster-yellows
C. montanus (Van D)**	California aster-yellows
C. rupinatus (Ball)*** **	California aster-yellows
"Deltocephalus" dorsalis Motsch.	Rice dwarf or stunt
Euscelidius schenkii Kbm	California aster-yellows
"Eutettix" phycitis	Eggplant little-leaf

* Oman (1949a) believes this to be a mistake for M. quadripunctulata Kbm.

** Formerly placed in the genus Thamnotettix

*** Formerly placed in the genus Thamnotettix; placed in the genus Friscanus by Severin (1948a).

Fieberiella florii (Stal)	California aster-yellows
Idioconus heidemanni (Ball)**	California aster-yellows
Nephotettix apicalis (Motsch.)	Rice dwarf or stunt
Orosius argentatus (Evans)	Tomato big-bud; tobacco yellow dwarf
Paraphlepsius apertinus (O & L)***	California aster-yellows
Psammotettix striatus (Linnaeus)*	Winter wheat mosaic
Scaphoideus luteolus Van D	Elm phloem necrosis
Scleroracus vaccinii (Van D)	Cranberry false-blossom
Texananus lathropi (Baker)	California aster-yellows
T. latiplex DeL	California aster-yellows
T. oregonus (Ball)	California aster-yellows
T. pergracus DeL	California aster-yellows
T. spatulatus (Van D)	California aster-yellows

* Most records of this species in North America refer to Psammotettix affinis (G & B); (Oman 1949a).

** Formerly placed in the genus Thammotettix.

*** Phlepsius apertinus (O & B) of Severin (1945a).

Table XII

Arizona Leafhopper vectors of plant virus diseases*

Aceratagallia sanguinolenta (Prov) Widely distributed in northern Arizona at high elevations: Granite Dells, Flagstaff, Oak Creek Canyon, St. Johns, Williams, Santa Catalina Mountains and Kaibab.

Hordnia circellata (Baker) Widely distributed throughout southern Arizona north to Granite Dells.

Draeculacephala minerva Ball Reported to be very common in Arizona; the present study failed to find this a common species.

Carneocephala triguttata Nott Reported from Sacatan and Yuma.

Scaphytopius irroratus (Van D) A California species found in the Lower Sonoran Zone of Arizona.

Circulifer tenellus (Baker) Common throughout most of the arid Western regions.

Texananus spatulatus (Van D) Found in all the border states.

Acinopterus angulatus Lawson In Arizona this species is restricted to the Lower Sonoran Zone.

Macrosteles divisus (Uhler) No actual records of this species in Arizona but believed by some to occur here.

* Based on Flock (1940a)

Table XIII

Insect vectors of plant virus diseases*

ORTHOPTERA (Grasshoppers)	
Chorthippus bicolor (Charp.)	Turnip yellow mosaic
DERMAPTERA (Earwigs)	
Forficula auricularia Linn.	Turnip yellow mosaic
THYSANOPTERA (Thrips)	
Frankliniella insularis Franklin	Tomato spotted wilt
Thrips tabaci Lind.	Pineapple yellow spot
HEMIPTERA	
Tingidae (Tingids)	
Piesma quadrata	Sugar beet leaf curl
Piesma cinera	"Savoy" of sugar beets
HOMOPTERA	
Cercopidae (Frog-hoppers)	
Aphrophora angulata Ball	Pierce's disease of grape
A. permutata Uhler	Pierce's disease of grape
Clastoptera brunnea Ball	
Philaenus leucophthalmus (Linn)	
Fulgoridae (Fulgorids)	
Delphax striatella Fall.	Cereal mosaic
Peregrinus maidis Ashm	Maize stripe
Perkinsiella saccharicida Kirk	

* Source of Data: Bawden (1950a), Leach (1940a) and Severin (1942b)

Cicadellidae (Leafhoppers)*	
Aleyrodidae (Whiteflies)	
Bemisia gossypiperda M & L	Cassava mosaic Cotton leaf curl Tobacco leaf curl
Bemisia spp. B. tabaci Genn.	Cassava brown streak Abutilon variegation
Aphidae (Aphids)**	
Acrythosiphon pisum (Harris)	Bean mosaic Alfalfa mosaic Narcissus mosaic Onion yellow dwarf Pea mosaic
Amphorophora rubi (Kalt)	Onion yellow dwarf Raspberry green mosaic Raspberry yellow mosaic
A. sensoriata Mason	Raspberry green mosaic Raspberry yellow mosaic
Anuraphis padi Linn	Plum pox (mosaic)
Aphis apigraveolens Essig A. apii Theobald A. fabae Scop.	Celery calico Celery calico Bean mosaic Narcissus mosaic Onion yellow dwarf Potato Y Soy bean mosaic Sugar beet mosaic Sugar beet yellows Tobacco etch Tulip break
A. ferruginea-striata Essig A. gossypii Glover	Celery calico Bean mosaic Cauliflower mosaic Cucumber mosaic Lily rosette Onion yellow dwarf Western celery mosaic

* See Tables XI and XII.

** See Table XIV for Arizona vectors of plant virus diseases.

A. idaei Goot	Raspberry curly dwarf
A. laburni Kalt	Groundnut rosette
A. maidis Fitch	Onion yellow dwarf
	Sugar cane mosaic
Aphis marutae Oest	Cineraria mosaic
A. middletonii Thomas	Celery mosaic
A. rhamni Fonsc	Potato A
	Potato Y
	Soy bean mosaic
	Tobacco etch
A. spiraecola Patch	Papaw mosaic
Aulacorthum circumflexum (Buckt)	Cauliflower mosaic
	Cucumber mosaic
	Henbane mosaic
	Potato A
	Potato Y
	Potato leaf roll
	Soy bean mosaic
	Tobacco etch
A. solani (Kalt)	Cucumber mosaic
	Narcissus mosaic
	Potato leaf roll
	Soy bean mosaic
Brevicoryne brassicae (Linn)	Bean mosaic
	Cabbage blackring
	Cauliflower mosaic
	Onion yellow dwarf
	Turnip mosaic
Hysteroneura setariae Thos.	Sugar cane mosaic
Macrosiphum euphorbiae (Thos)	Bean mosaic
	Cucumber mosaic
	Iris stripe
	Narcissus mosaic
	Onion yellow dwarf
	Potato A
	Potato Y
	Potato leaf roll
	Potato spindle tuber
	Tobacco etch
M. rosae (Linn)	Narcissus mosaic

Myzus ascalonicus Donc	Cucumber mosaic
	Dandelion yellow mosaic
	Henbane mosaic
	Sugar beet yellows
	Tobacco etch
M. cerasi (Fabr)	Narcissus mosaic
M. circumflexus (Buckt.)	Celery calico
M. convolvuli (Kalt)	Celery calico
Myzus ornatus Laing	Dandelion yellow mosaic
	Cucumber mosaic
	Potato Y
	Potato leaf roll
	Soy bean mosaic
M. persicae (Sulz)	Bean mosaic
	Cabbage blackring
	Cauliflower mosaic
	Commelina mosaic
	Cucumber mosaic
	Dahlia mosaic
	Henbane mosaic
	Iris stripe
	Lettuce mosaic
	Onion yellow dwarf
	Pea mosaic
	Potato A
	Potato F
	Potato Y
	Potato leaf roll
	Potato spindle tuber
	Potato unmottled curly dwarf
	Soy bean mosaic
	Sugar beet mosaic
	Sugar beet yellows
	Tobacco etch
	Tobacco mottle
	Tobacco vein-distorting
	Tulip break
	Turnip mosaic
	Western celery mosaic
Pentalonia nigronervosa Coq.	Banana bunchy top
Pentatrichopus fragariae (Theob)	Strawberry crinkle
	Strawberry witche's broom
	Strawberry yellow edge

Rhopalosiphum conii Davids	Celery yellow spot
R. melliferum (Hottes)	Celery calico
R. pseudobrassicae(Davis)	Bean mosaic
	Cauliflower mosaic
	Onion dwarf
Yezabura molifoliae Fitch	Narcissus mosaic
Y. tulipae (Fonsc)	Tulip break
Coccidae (Scales)	
Ferrisia virgata Ckll	Cacao swollen shoot (A and B)
Pseudococcus citri (Risso)	Cacao swollen shoot (A,C & D)
P. njalensis Laing	Cacao swollen shoot (A,B & D)
COLEOPTERA (Beetles)	
Chrysomelidae	
Diabrotica soror Lec	Squash mosaic
	Cucurbit ring mosaic
D. trivettata Mann	Squash mosaic
	Cucurbit ring mosaic
Disdonycha triagularis Say	Potato spindle tuber
Epitrix cucumeris Harris	Potato spindle tuber
Peptinotarsa decimlineata Say	Potato spindle tuber
Phaedon cochleariae (Fabr)	Turnip yellow mosaic
Phyllotreta cruciferae (Goeze)	Turnip yellow mosaic
P. vittula Reat	Turnip yellow mosaic
Systena toeniata Say	Potato spindle tuber

Table XIV

Arizona aphid vectors of plant virus diseases
with aphid host plants*

Aphid	Recorded from:
Aphis gossypii Glover	alfalfa, bachaaris, boerhaavia, callendula, cantaloupe, citrus, cotton, creosote bush, cresopis, cucumber, dock, dodder, flowering quince, garden beans, gourd, grape, mallow, okra, pea vine, puncture vine, pyracantha, squash, verbesina, violet and watermelon.
Aphis maidis Fitch	barley, broom corn and white Kaffir corn.
Brevicoryne brassicae (Linn)	cabbage, cauliflower, garden beans, rape and shepards purse.
Hysteroneura setariae Thos	apricot, Johnson grass, peach and plum.
Macrosiphum euphorbiae (Thos)	celery, garden beans, lettuce, mallow, rose and sow thistle.
Macrosiphum rosae (Linn)	rose
Myzus persicae (Sulz)	bachaaris, black walnut, box thorn, callendula, citrus, egg plant, garden beans, lettuce, mallow, mustard, pansy, peach, potato, raddish, red pepper, spaeralcea, tomato, verbena, and yellow composite.
Rhopalosiphum pseudobrassicae (Davis)	mustard, rape and turnip.

* Based on unpublished manuscript of Dr. Wehrle.

Table XV*

Aphids recorded from the Keener Sticky Board Traps
University of Arizona Campbell Avenue Farm, Tucson, Arizona

Trap Number	Aphid Species
K 1	Aphis gossypii Glover A. maidis Fitch Macrosiphum sp. Pemphigus sp.
K 2	Aphis gossypii Glover A. maidis Fitch A. medicaginis Koch Macrosiphum pisi (Kalt) Myzus persicae (Sulzer) Rhopalosiphum pseudobrassicae (Davis) Toxoptera gaminum (Rondani)
K 3	Aphis maidis Fitch
K 4	Aphis maidis Fitch A. tetrapteralis Ckll Macrosiphum pisi (Kalt) Rhopalosiphum pseudobrassicae (Davis)
K 5	Aphis gossypii Glover A. tetrapteralis Ckll Chaitophorus populella Gill & Palmer Rhopalosiphum pseudobrassicae (Davis)
K 6	Aphis maidis Fitch A. tetrapteralis Ckll Hyalopterus atriplicis (Linn) Macrosiphum dirhodum (Walker)
K 7	Macrosiphum pisi (Kalt) Rhopalosiphum pseudobrassicae (Davis)
K 8	Aphis gossypii Glover A. maidis Fitch A. tetrapteralis Ckll

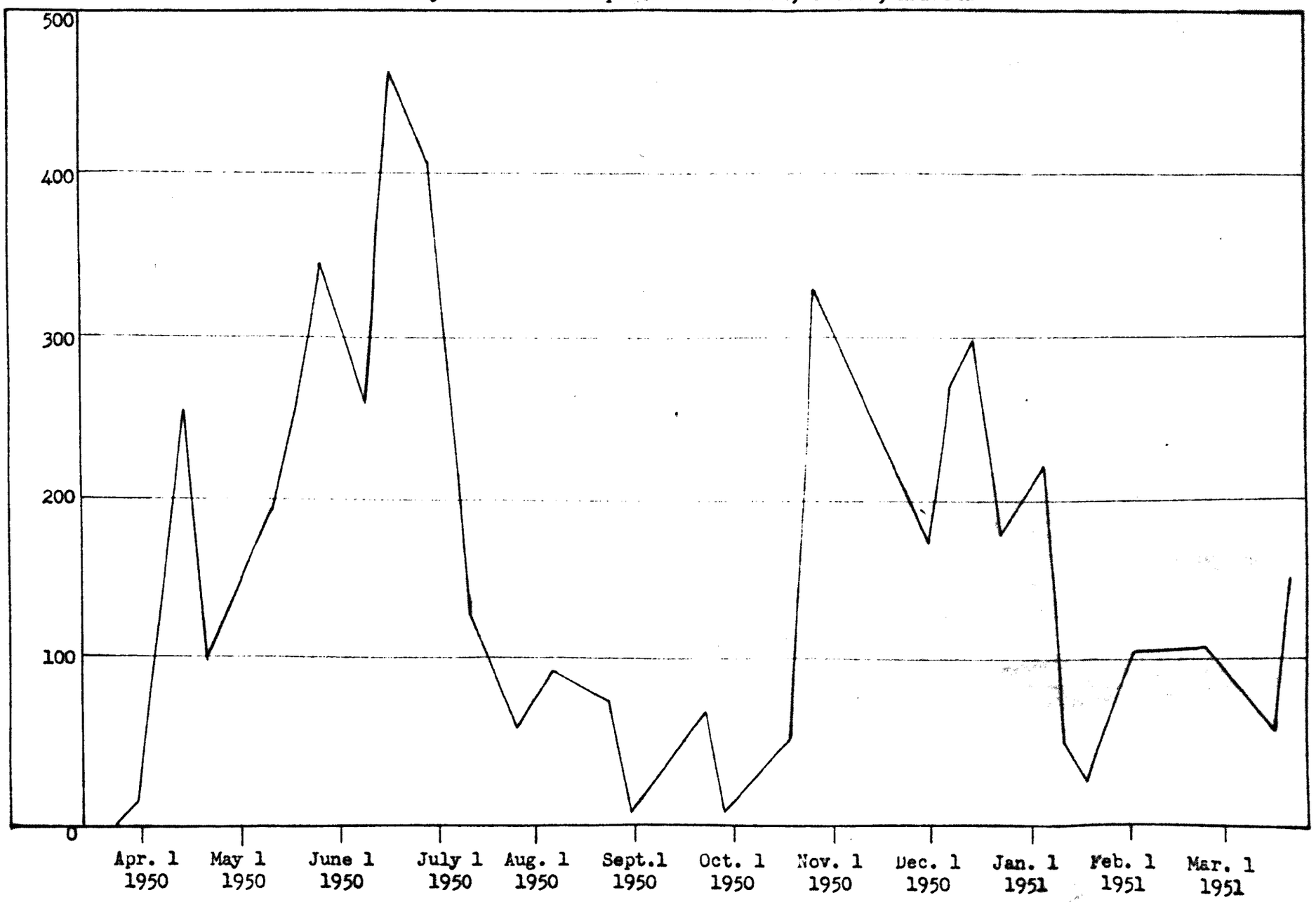
* All aphid determinations recorded in this table, except Trap K-2, were made by Dr. Hottes. The determinations for Trap K-2 were made by Dr. Wehrle. The aphids listed represent those collected from only one board of each trap.

Trap Number		Aphid Species
K	9	Rhopalosiphum pseudobrassicae (Davis)
K	10	Hyalopterus atriplicis (Linn)
K	11	Aphis gossypii Glover Monellia nigropunctata Gronovsky
K	12	Aphis gossypii Glover
K	13	Aphis gossypii Glover A. maidis Fitch
K	14	Aphis gossypii Glover A. maidis Fitch Cerosipha sp.
K	15	Aphis gossypii Glover
K	16	Aphis gossypii Glover A. maidis Fitch
K	17	Hyalopterus atriplicis (Linn) Myzus persicae (Sulzer) Phopalosiphum nympheae (Linn)
K	18	Aphis maidis Fitch Aphis sp.
K	19	None
K	20	Aphis gossypii Glover A. maidis Fitch Myzus persicae (Sulzer)
K	21	Myzus persicae (Sulzer) Rhopalosiphum pseudobrassicae (Davis)
K	22	Chaitophorus sp. Myzus persicae (Sulzer)
K	23	Myzus persicae (Sulzer)
K	24	Myzus persicae (Sulzer)
K	25	Myzus persicae (Sulzer) Rhopalosiphum pseudobrassicae (Davis)
K	26	Myzus persicae (Sulzer)

Trap Number	Aphid Species
K 27	*Aphis gossypii* Glover
	Myzus persicae (Sulzer)

Chart I

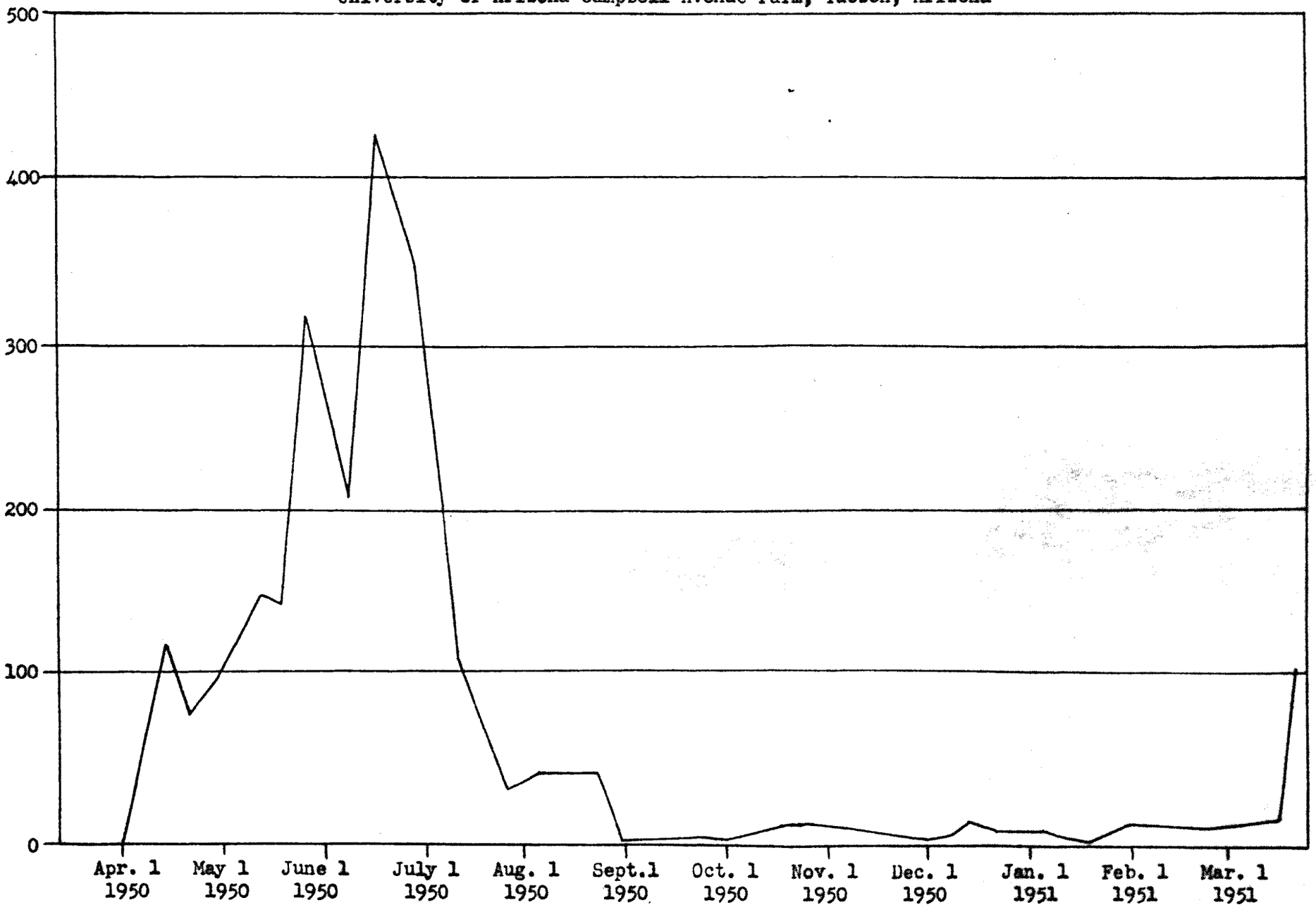
Leafhoppers removed from the Keener Sticky Board Traps
University of Arizona Campbell Avenue Farm, Tucson, Arizona



*Source of Data: Table II.

Chart II

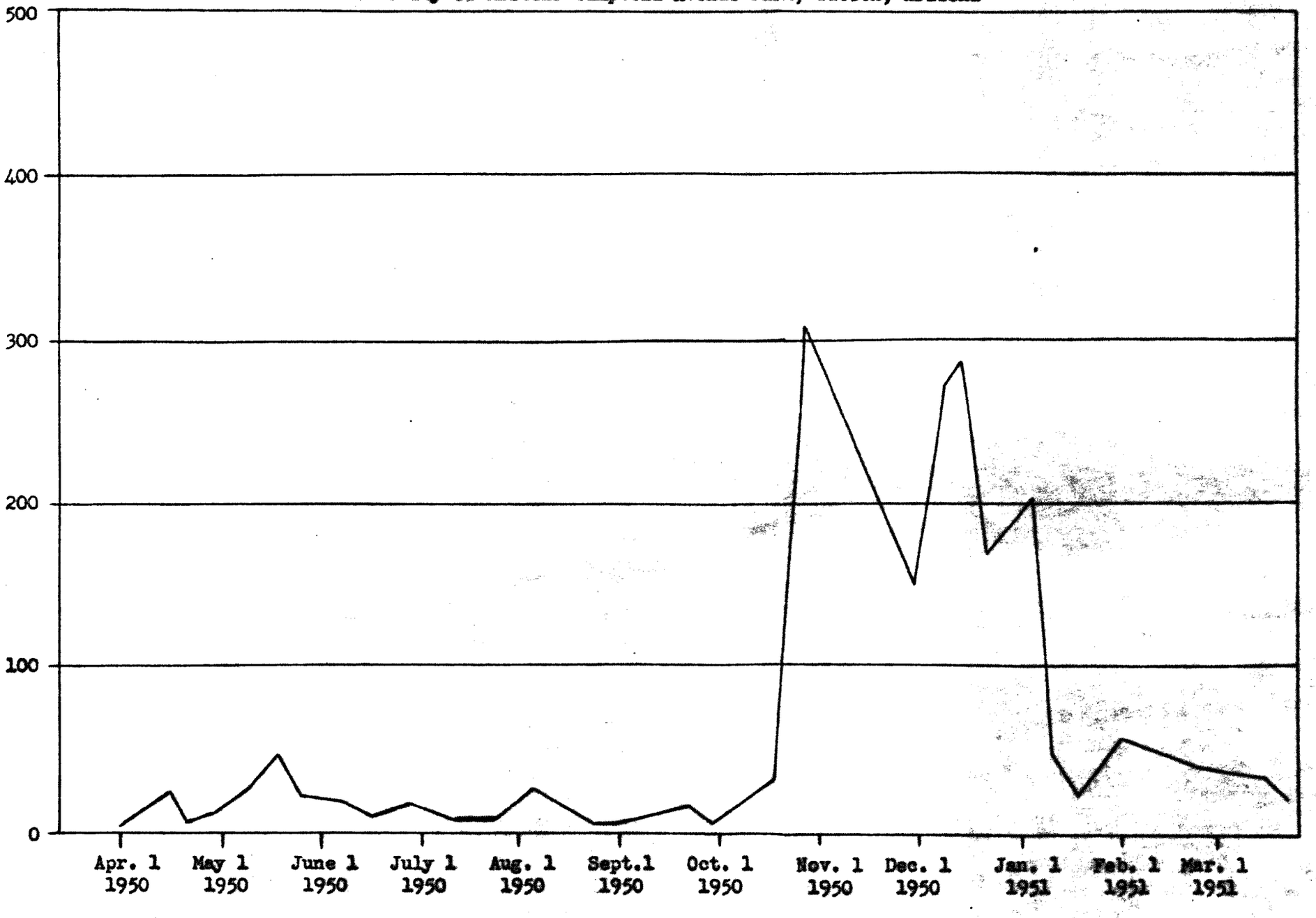
Ollarianus strictus (Ball) removed from the Keener Sticky Board Traps
University of Arizona Campbell Avenue Farm, Tucson, Arizona



*Source of Data: Table II.

Chart III

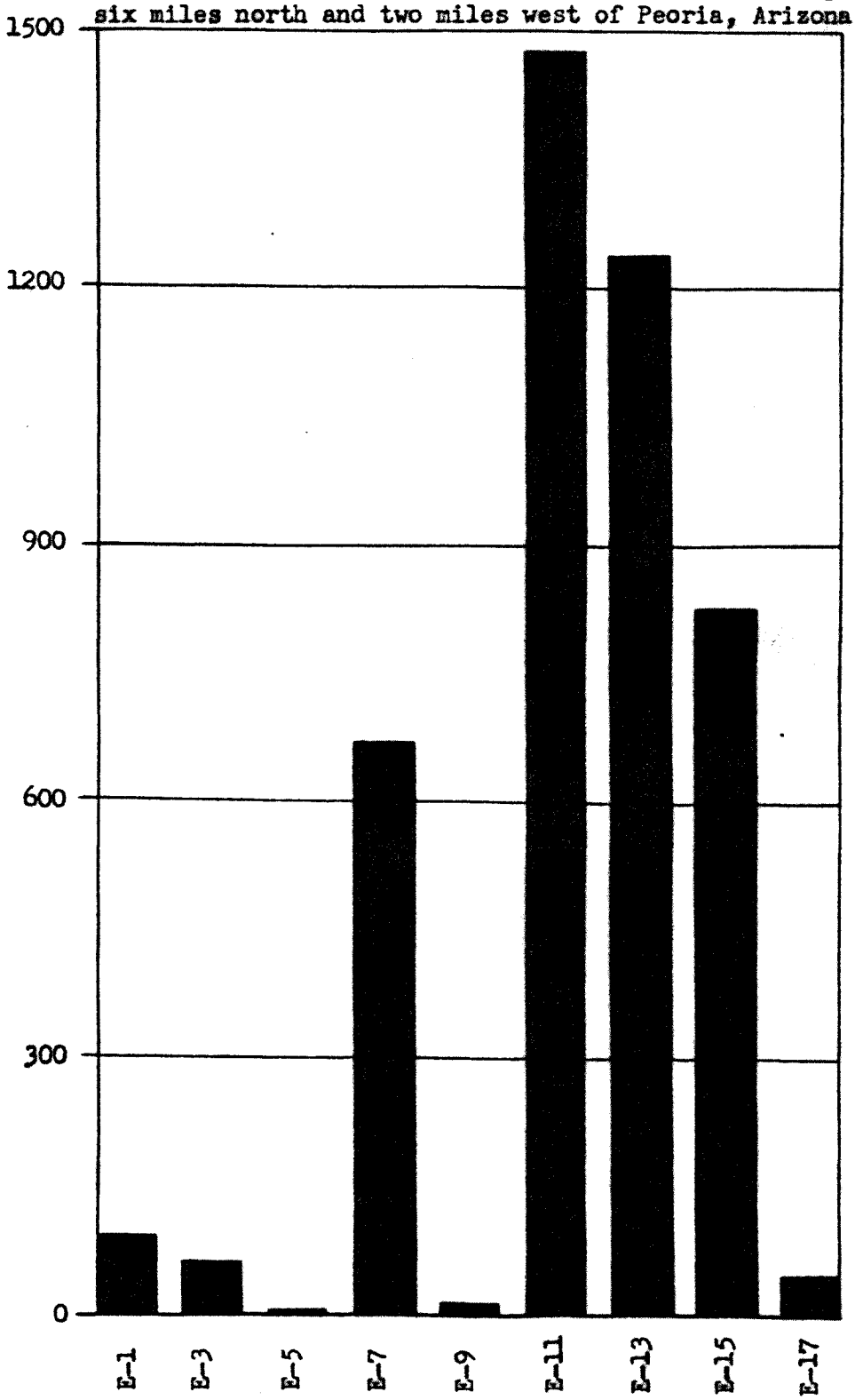
Empoasca spp. removed from the Keener Sticky Board Traps
University of Arizona Campbell Avenue Farm, Tucson, Arizona



*Source of Data: Table II.

Chart IV

*Leafhoppers Removed from the Eaton Sticky Board Traps six miles north and two miles west of Peoria, Arizona

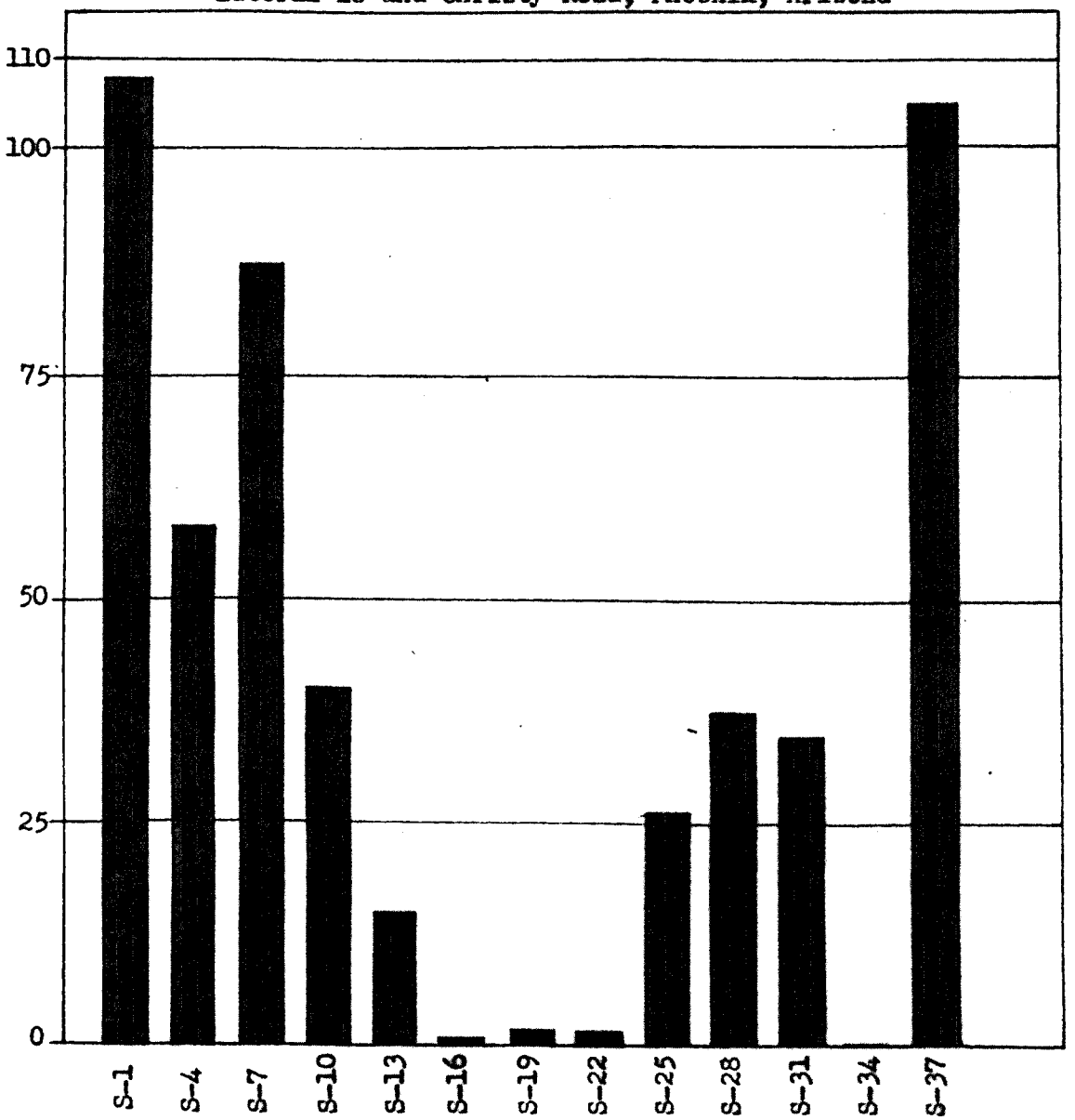


*All traps were exposed for seven day periods.

Source of Data: Table VIII.

Chart V

*Leafhoppers removed from the Smith Sticky Board Traps
Lateral 18 and Christy Road, Phoenix, Arizona

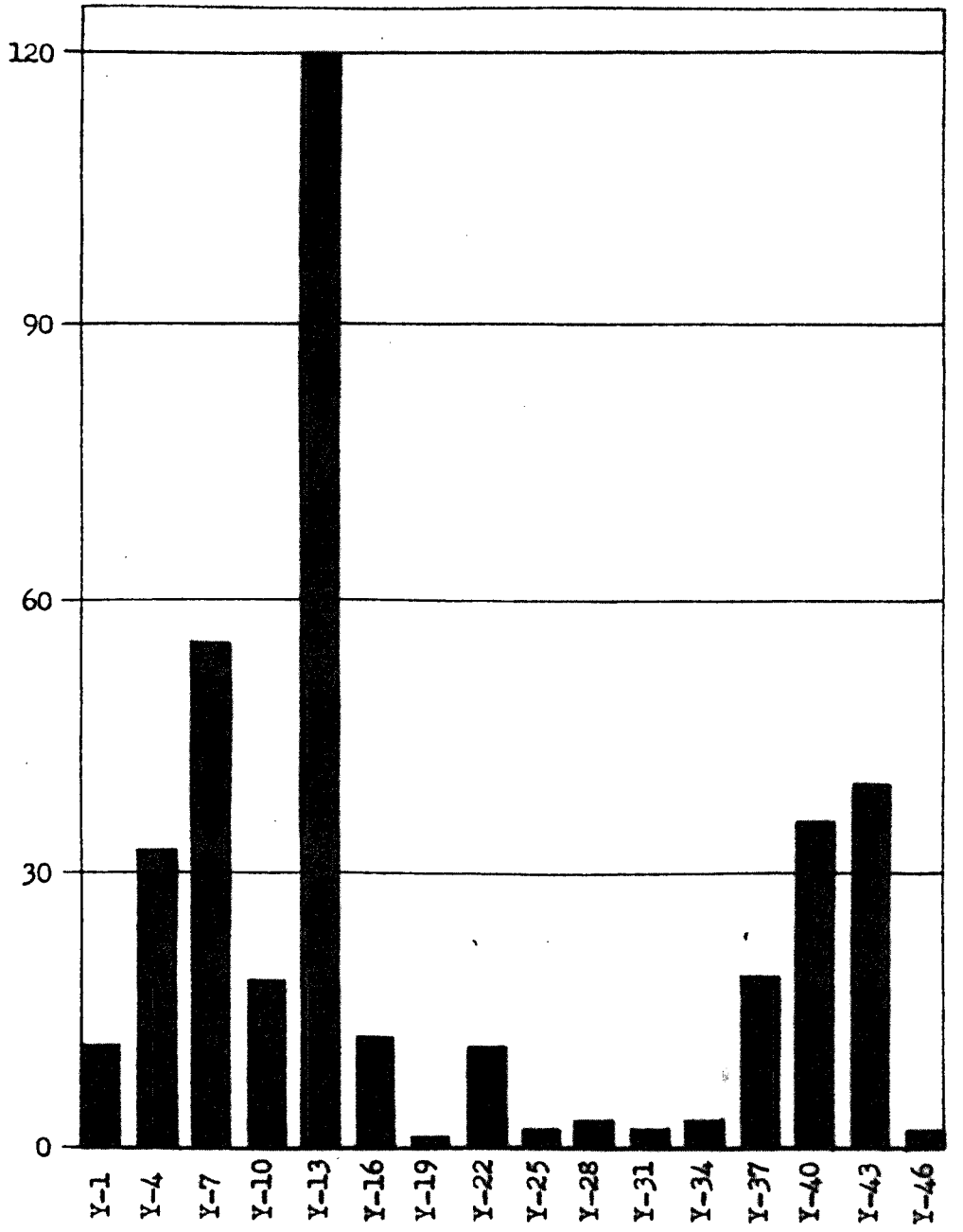


*The traps were not exposed for equal periods; see Table 5 for dates of exposure.

Source of Data: Table VII

Chart VI

*Leafhoppers removed from the Yuma Sticky Board Traps
University of Arizona Experimental Valley Farm, Yuma, Arizona



*All traps except Y-43 and Y-46 were exposed for seven day periods; see Table VI for dates of exposure.

Source of Data: Table IV.

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