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# TEXAS AGRICULTURAL EXPERIMENT STATION

B. YOUNGBLOOD, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

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## DIVISION OF ENTOMOLOGY

# Hibernation of the Cotton Flea Hopper

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
T. O. WALTON, President

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†As of January 1, 1928.
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***In cooperation with U. S. Department of Agriculture.
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# SYNOPSIS


The dormant or inactive period in an insect's life cycle is called hibernation. Cold weather in the fall kills all stages of the cotton flea hopper except the eggs, which remain dormant throughout the winter and hatch the following spring when the mean temperature reaches 58 or 60 degrees F.

This Bulletin reports the results secured in the hiberation studies on the cotton flea hopper during the seasons of 1925-26 and 1926-27. The average period of hiberation of this insect extends from October 1 to May 1. The time at which the overwintering eggs begin to hatch in the spring varies from year to year and depends largely on prevailing climatic conditions. In 1926 emergence from hibernation began on March 7, and continued over a period of 13 weeks; in 1927 it began on February 16, and extended over a period of nearly 20 weeks. When climatic conditions are optimum, emergence of the insects proceeds very rapidly. In the spring of 1926, 73 per cent of all the insects emerged from April 5 to April 26. In 1927, 79 per cent of the total emergence was completed from March 17 to April 7. There is a definite relation between the time of maximum emergence and the extent of injury to cotton. Normally the heaviest emergence of insects from hibernation occurs before young cotton is up in the field and little or no injury to the crop is the result. When climatic conditions delay emergence of the insects from hiberation in the spring, and cotton is planted at the average date, conditions are favorable for extensive injury to the crop by the cotton flea hopper.

Data are presented on emergence of the insects from 19 species of winter host plants which were collected locally and in several other localities in the State. During the season 1926-27 goatweed at College Station, and primrose at Wharton, contained the greatest number of cotton flea hopper eggs; averaging about 215 insects per plant. Fourteen new winter host plants of the insect have been discovered. These include many of our most common weeds and have a wide range of distribution over the State.

## CONTENTS

# HIBERNATION OF THE COTTON FLEA HOPPER

H. J. REINHARD

With the approach of cold weather in the fall of the year, insects generally become less active and are either killed by the occurrence of low temperatures or find shelter in which to pass the winter. This period of inactivity is called hibernation or the dormant period in an insect's life cycle. From the time that activity ceases in the autumn until its recurrence in the following spring insects do not multiply or require any food. They are dead to all outward appearances. Yet the importance of the hibernating stage in the life cycle of any major insect pest will be appreciated when it is realized that this is the only means by which the insect can pass through the cold season successfully and appear again with the advent of warm weather in the spring.

Hibernation may occur in various stages of the development of an insect. The boll weevil, for instance, passes through the winter as an adult or mature insect in practically any available shelter from the cold. On the other hand low temperatures kill all stages of the cotton flea hopper except the egg, which alone remains the source of infestation the following year.

Aside from its scientific interest, a knowledge concerning the hibernation of an insect pest often has a practical bearing on developing effective methods for its control. In fact, it has been demonstrated that some of the common destructive pests are most vulnerable during the inactive period of their life cycle.

In searching for effective methods to control the cotton flea hopper, the hibernation of this insect has been studied for the past two years at the Texas Agricultural Experiment Station. The data which have been accumulated in these studies are presented in this Bulletin as a contribution to our present knowledge of this insect with special reference to conditions affecting the extent of infestation and injury to cotton in Texas.

## METHODS OF CONDUCTING HIBERNATION STUDIES

Hibernation studies on the cotton flea hopper were begun during the fall and winter of 1925 and 1926 and have been continued up to the present time. The methods devised for conducting these studies are described briefly below.

It has already been pointed out that all the active stages of the cotton flea hopper are killed by cold weather in the fall and winter. Hence, all observations on the hibernation of this insect are necessarily confined to the egg stage. Since the eggs are laid within the host plants it is not possible to determine which are most heavily infested or how many eggs may be present in any single plant or lot of plants, except by the numbers of insects emerging from them. This makes it difficult to secure data on the extent of mortality during hibernation; however, a comparison of the results secured in these studies from year to year will be a valuable index in this connection.

To determine the extent of the period of hibernation and emergence therefrom in the spring, common weeds suspected of being winter host plants of the cotton flea hopper were gathered at varying dates during the fall and early winter. The plants were either cut close to the ground or pulled up and tied in loose bundles, which were kept under field conditions standing upright to prevent undue decay. Some time before the eggs were expected to hatch the weeds were placed in cages for observation on the emergence of the young insects.

The weeds were installed in the cages in an upright position as nearly intact as possible. In order to secure representative data on any species of host plant, a lot consisting of 100 average-size plants was selected as the minimum unit of installation. It was found necessary to break up the large varieties of plants to get the required number into a cage and in some cases they were packed tightly together. The possible effect of this procedure on the results secured will be referred to in a later paragraph.

The material used in these studies was collected at College Station and at several other localities in the State, viz., Wharton, Weslaco, Troup, San Antonio, and Corpus Christi. A complete record of the winter host plants collected and installed in the emergence cages is given in Table 3.

The cage designed for these studies is a wood frame constructed of 1 by 4 material and measures 2x2x3 feet. The sides and top are covered with one thickness of black percale to darken the interior and at the same time maintain ventilation, temperature, and humidity conditions as nearly natural as possible. A series of 28 vials (25x100 mm.) are inserted around the top and half-way down one edge on each side to admit light from all directions for the purpose of attracting the young insects as they hatch from the weeds within the cage. The vials are held securely in place by a cork washer which is fitted and glued in the frame exactly flush on the inner surface. As the insects enter the vials they can be readily removed and counted at any time without disturbing the contents of the cage. The emergence cages are illustrated in Figures 1 and 2.

The principal sources of error introduced which affect the results secured in the hibernation studies by the use of the cage and methods described above are: first, breaking the plants which may destroy some of the eggs present; and, second, packing the plants closely together in a cage, which increases the hazard of the young insects, especially those hatching in the center of the mass of plants, in reaching the vials. However, since all cages received the same treatment the error is assumed to be relative and in effect reduces the number of insects emerging from all the different host plants caged for observations. The data presented

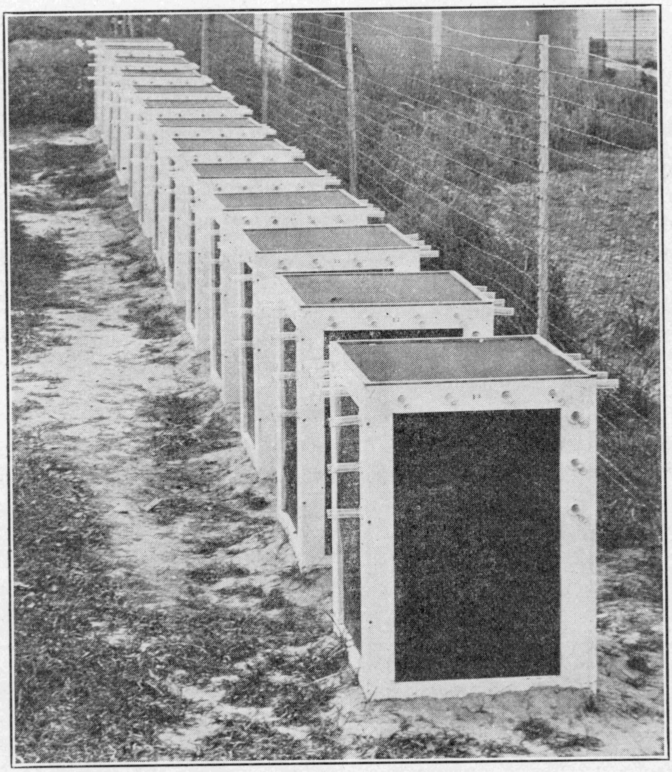

Fig. 1. The type of cage used for making observations on emergence of the cotton flea hopper in the spring of 1927

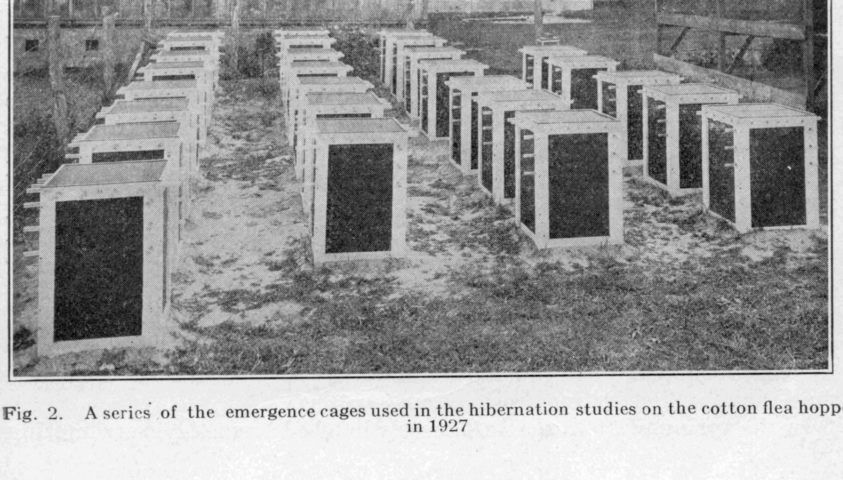

Fig. 2. A series of the emergence cages used in the hibernation studies on the cotton flea hopper in 1927

on the following pages is therefore considered a conservative index to the emergence from hibernation or the hatching of overwintering eggs under natural conditions.

## DURATION OF HIBERNATION PERIOD

Since practically all observations on this point were made at College Station, the data presented refer especially to that locality. Undoubtedly both seasonal variations and latitude affect the limits of the period.

To establish the extent or duration of the hibernation period of the cotton flea hopper, seven 100-plant lots of goatweeds were cut in the same locality at intervals of two weeks, beginning August 1, during the late summer and fall of 1926. These weeds were placed in separate cages for observations on the emergence of insects from each lot of weeds during the following spring. The data secured in this connection are given in Table 1. It will be noted that very few insects emerged from the weeds cut on August 1, August 15, and September 1, indicating that the eggs in these weeds hatched some time before conditions were favorable to effect dormancy. However, there was a decided increase in the number of insects emerging from the lot of weeds cut on September 15, showing that an appreciable per cent of the eggs

Table 1.—Emergence of the insects from 100 goatweeds cut at various dates in the late summer and fall of 1926

| Cage Number | Date Cut | First Emergence | Last Emergence | Total Number Emerged |
|---|---|---|---|---|
| | 1926 | 1927 | 1927 | |
| 1 | Aug. 1 | Feb. 16 | Mar. 30 | 9 |
| 2 | Aug. 15 | Mar. 19 | April 28 | 20 |
| 3 | Sept. 1 | Feb. 17 | May 1 | 82 |
| 4 | Sept. 15 | Feb. 17 | May 20 | 1380 |
| 5 | Sept. 30 | Feb. 16 | June 28 | 14714 |
| 6 | Oct. 15 | Feb. 16 | June 14 | 15324 |
| 7 | Nov. 3 | Feb. 16 | June 29 | 17275 |

were dormant on that date. There was very little variation in the number of insects emerging from the weeds cut on dates subsequent to September 15, and the data presented above show that practically all the eggs were dormant on September 30, during the season of 1926-27.

The results of a similar experiment conducted during the season of 1925-26, reported in Texas Experiment Station Bulletin 356, page 27, indicate that about 3 per cent of the cotton flea hopper eggs were dormant on September 15, and approximately 22.5 per cent were dormant on October 1.

According to these observations it may be stated that the hibernation period of the cotton flea hopper in this latitude begins about September 15. Although complete hibernation may not be effected until about the time that the first killing frosts occur.

In the spring of 1926 the first insects hatched from the overwintering eggs on March 7, while in 1927 first hatching occurred on February 16. By May 15 emergence from the winter host plants was practically completed although a few insects continued to hatch in the emergence cages over a period of 3 to 7 weeks thereafter.

At College Station, the average period of hibernation may be said to extend from approximately October 1 to May 1, or over a period of about 7 months, while the extremes of the period may possibly range from 4 to 8 months.

### Climatic Conditions During Hibernation Period

The principal climatic factors affecting the overwintering eggs of the cotton flea hopper during the dormant seasons of 1925-26 and 1926-27 are given in Table 2. Since enormous numbers of eggs were carried successfully through both of these dormant seasons it is evident that the eggs were not affected unfavorably by the prevailing climatic conditions. It will be observed that the monthly mean temperatures during the fall and winter of 1925-26 were consistently below the normal; however, the only apparent effect was delayed emergence in the spring. In 1926-27 the monthly mean temperatures more nearly approached the normal and the result was an earlier spring emergence. The minimum

Table 2.—Climatological data affecting the hibernation period at College Station during the seasons of 1925-26 and 1926-27

| Month | Year | Temperature, Degrees F. | | | Departure from Normal | Rainfall, Inches | Departure from Normal | Distribution of Rainfall Days |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Mean | | | | |
| September | 1925 | 99 | 65 | 82.0 | +2.8 | 2.41 | —0.39 | 6 |
| | 1926 | 100 | 57 | 82.8 | +3.6 | 1.10 | —1.70 | 9 |
| October | 1925 | 95 | 35 | 66.8 | —2.9 | 12.21 | +9.48 | 13 |
| | 1926 | 97 | 46 | 73.6 | +3.9 | 6.61 | +3.88 | 10 |
| November | 1925 | 80 | 32 | 57.4 | —1.6 | 5.67 | +2.27 | 9 |
| | 1926 | 80 | 30 | 56.6 | —2.4 | 2.50 | —0.90 | 5 |
| December | 1925 | 76 | 20 | 45.8 | —7.1 | 0.88 | —2.91 | 7 |
| | 1926 | 80 | 26 | 51.5 | —1.4 | 8.02 | —4.41 | 11 |
| January | 1926 | 70 | 25 | 46.2 | —5.2 | 4.53 | +1.27 | 10 |
| | 1927 | 78 | 24 | 52.2 | +0.8 | 1.28 | —1.98 | 5 |
| February | 1926 | 79 | 36 | 58.2 | +5.2 | 0.13 | —2.68 | 1 |
| | 1927 | 85 | 26 | 58.4 | +5.4 | 6.10 | +3.29 | 9 |
| March | 1926 | 79 | 32 | 56.0 | —4.4 | 8.03 | +5.34 | 17 |
| | 1927 | 87 | 31 | 60.6 | +0.2 | 2.20 | +0.49 | 8 |
| April | 1926 | 80 | 41 | 62.9 | —5.1 | 5.97 | +2.10 | 9 |
| | 1927 | 88 | 43 | 72.2 | +4.2 | 5.09 | +1.22 | 3 |

temperature at which the eggs are killed was not determined. During December, 1925, an average minimum temperature of 24 degrees F. prevailed over a period of four days, with 12 degrees below freezing obtaining on two successive days. These low temperatures apparently did not produce a high rate of mortality since the eggs hatched in large numbers during the following April. There is no evidence available which indicates that the excessive rainfall which occurred in October, 1925, March, October, and December, 1926, or February, 1927, affected the hibernation of the insect directly except possibly in being a factor influencing early spring emergence during 1927.

## Emergence from Hibernation

The time at which emergence begins varies from year to year and depends largely upon the prevailing temperatures. When conditions are favorable, as was the case early in the season of 1927, hatching of the overwintering eggs may begin by the middle of February. Emerg-

Table 3.—Data on collection of winter host plants of the cotton flea hopper

| Cage No. | Host Plant | | Date Collected | Locality Collected |
|---|---|---|---|---|
| | Scientific Name | Common Name | | |
| 1 | *Croton capitatus* | Goatweed | Aug. 1, 1926 | College Station |
| 2 | *Croton capitatus* | Goatweed | Aug. 15, 1926 | College Station |
| 3 | *Croton capitatus* | Goatweed | Sept. 1, 1926 | College Station |
| 4 | *Croton capitatus* | Goatweed | Sept. 15, 1926 | College Station |
| 5 | *Croton capitatus* | Goatweed | Sept. 30, 1926 | College Station |
| 6 | *Croton capitatus* | Goatweed | Oct. 15, 1926 | College Station |
| 7 | *Croton capitatus* | Goatweed | Nov. 3, 1926 | College Station |
| 8 | *Gossypium hirsutum* | Cotton | Nov. 23, 1926 | College Station |
| 9 | *Gaura brachycarpa* | Primrose | Oct. 19, 1926 | Wharton |
| 10 | *Solanum elaeagnifolium* | Horse Nettle | Oct. 19, 1926 | Wharton |
| 11 | *Ambrosia psilostachya* | Ragweed | Dec. 7, 1926 | College Station |
| 12 | *Croton capitatus* | Goatweed | Feb. 15, 1927 | College Station |
| 13 | *Amphiachyris dracunculoides* | Broomweed | Feb. 15, 1927 | College Station |
| 14 | *Xanthium speciosum* | Cocklebur | Feb. 17, 1927 | College Station |
| 15 | *Heterotheca subaxillaris* | | Feb. 17, 1927 | College Station |
| 16 | *Eupatorium compositifolium* | Dog Fennel | Feb. 17, 1927 | College Station |
| 17 | *Aster sp.* | Wild Aster | Feb. 19, 1927 | College Station |
| 18 | *Gossypium hirsutum* | Cotton | Feb. 19, 1927 | College Station |
| 19 | *Ambrosia aptera* | Ragweed | Feb. 21, 1927 | College Station |
| 20 | *Amaranthus Torreyii* | Careless weed | Feb. 21, 1927 | College Station |
| 21 | *Atriplex sp.* | Orach | Feb. 17, 1927 | Weslaco |
| 22 | *Helianthus Maximilianii* | Sunflower | Feb. 17, 1927 | Weslaco |
| 23 | *Ambrosia artemisiifolia ?* | Ragweed | Feb. 17, 1927 | Weslaco |
| 24 | *Gossypium hirsutum* | Cotton | Feb. 17, 1927 | Weslaco |
| 25 | *Helenium tenuifolium* | Bitterweed | Feb. 26, 1927 | College Station |
| 26 | *Leptilon Canadense* | Horseweed | Feb. 26, 1927 | College Station |
| 27 | *Ambrosia psilostachya* | Ragweed | Feb. 20, 1927 | Troup |
| 28 | *Croton capitatus* | Goatweed | Feb. 20, 1927 | Troup |
| 29 | *Monarda sp.* | Horsemint | Feb. 20, 1927 | Troup |
| 30 | *Gossypium hirsutum* | Cotton | Feb. 20, 1927 | Troup |
| 31 | *Gossypium hirsutum* | Cotton | Feb. 21, 1927 | San Antonio |
| 32 | *Ambrosia aptera* | Ragweed | Feb. 17, 1927 | San Antonio |
| 33 | *Helianthus annuus* | Sunflower | Feb. 17, 1927 | San Antonio |
| 34 | *Ambrosia artemisiifolia* | Ragweed | Feb. 16, 1927 | San Antonio |
| 35 | *Solanum elaeagnifolium* | Horse Nettle | Feb. 21, 1927 | San Antonio |
| 36 | *Croton capitatus* | Goatweed | Feb. 23, 1927 | San Antonio |
| 37 | *Gossypium hirsutum* | Cotton | Mar. 1, 1927 | Corpus Christi |
| 38 | *Croton capitatus* | Goatweed | Mar. 1, 1927 | Corpus Christi |
| 39 | *Solanum elaeagnifolium* | Horse Nettle | Mar. 1, 1927 | Corpus Christi |
| 40 | *Parthenium Hysterophorus* | | Mar. 5, 1927 | Corpus Christi |

ence, however, is a slow process until optimum conditions occur, at which time the insects hatch in enormous numbers over a period of two or three weeks. After the period of maximum emergence there is a sharp decrease in the number of insects hatching from the overwintering eggs. However, they may continue to hatch in small numbers over a period of two or three months after emergence has been practically completed.

During the season of 1926, emergence of the cotton flea hopper extended from March 7 to June 10, or over a period of about 13 weeks; while in 1927 the period of emergence comprised approximately 20 weeks extending from February 16 to July 3. Climatic factors appear to have a direct influence upon the rate of emergence and consequently also affect the limits of the period from year to year. This subject will be discussed in a later paragraph.

In Table 4 are presented the data secured on the emergence of the cotton flea hopper at weekly intervals from the various kinds of winter host plants which were caged for observation during the season of 1927. It will be noted that the date of first emergence in most cases occurred from February 25 to March 25, and apparently the time at which the eggs begin to hatch is little, if at all, affected by the character of the host plant in which they are laid. There also appears to be little or no difference in the rate of emergence from the different types of host plants. The last insects emerged from ragweed and bitterweed on July 3, from goatweed and primrose on June 29, while several other widely related host plants yielded insects up to the latter part of May.

A summary of the data secured in these studies on the emergence of the cotton flea hopper from the overwintering eggs in 19 different species of host plants collected at College Station and in other localities of the State is given in Table 5. These data illustrate the numerical progression of emergence by months from each lot of host plants. The duration of the composite emergence period averaged about 74 days, ranging from 16 to 134 days. The number of insects emerging during June was very small and in only three instances did any emerge after July 1. It will be noted that the maximum number of insects hatched during March, although large numbers continued to emerge throughout April from practically all species of host plants. The total number of insects emerging from each lot of host plants is a definite indication as to the plants preferred by the insects, and their importance in connection with hibernation of this insect.

**Rate and Time of Emergence:** The rate at which the insects emerged from all the host plants under observation in the spring of 1927 is illustrated graphically in Figure 3. Beginning on February 16, the insects emerged in small numbers during the following four weeks; in fact, less than 5 per cent of the total emergence was completed on March 16. From that date hatching of the overwintering eggs proceeded very rapidly and by April 6, three weeks later, about 79 per cent of the total

Table 4.—Total spring emergence from all plants, 1927

| Cage No. | Date First Emergence | Number of Insects Emerged | | | | | | | | | | | | | | | | | | | | Date Last Emergence | Total No. Emerged |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Feb. 16-23 | Feb. 24 Mar. 2 | Mar. 3-9 | Mar. 10-16 | Mar. 17-23 | Mar. 24-30 | Mar. 31 April 6 | April 7-13 | April 14-20 | April 21-27 | April 28 May 4 | May 5-11 | May 12-18 | May 19-25 | May 25 June 1 | June 2-8 | June 9-15 | June 16-22 | June 23-29 | June 30 July 3 | | |
| 8 | Mar. 1, 1927 | 0 | 1 | 0 | 1 | 28 | 16 | 10 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | April 30, 1927 | 58 |
| 9 | Feb. 16, 1927 | 411 | 287 | 325 | 122 | 8143 | 7939 | 2231 | 91 | 1 | 1168 | 780 | 34 | 0 | 74 | 0 | 0 | 1 | 0 | 10 | 0 | June 29, 1927 | 21617 |
| 10 | Feb. 16, 1927 | 5 | 4 | 4 | 3 | 60 | 65 | 25 | 0 | 0 | 9 | 19 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | May 20, 1927 | 199 |
| 11 | Feb. 23, 1927 | 1 | 0 | 1 | 2 | 10 | 109 | 98 | 4 | 0 | 7 | 276 | 29 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 51 | July 3, 1927 | 594 |
| 12 | Feb. 16, 1927 | 110 | 230 | 316 | 140 | 8413 | 7708 | 2823 | 363 | 20 | 1062 | 607 | 28 | 0 | 59 | 0 | 0 | 10 | 0 | 6 | 0 | June 29, 1927 | 21895 |
| 13 | Mar. 9, 1927 | 0 | 0 | 1 | 1 | 4 | 5 | 10 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | April 30, 1927 | 23 |
| 14 | Mar. 19, 1927 | 0 | 0 | 0 | 0 | 4 | 4 | 18 | 0 | 0 | 1 | 34 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | May 21, 1927 | 68 |
| 15 | Mar. 3, 1927 | 0 | 0 | 3 | 2 | 1 | 80 | 112 | 10 | 0 | 7 | 165 | 18 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | May 23, 1927 | 412 |
| 16 | Mar. 22, 1927 | 0 | 0 | 0 | 0 | 4 | 44 | 63 | 12 | 0 | 6 | 77 | 13 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | May 23, 1927 | 225 |
| 17 | Mar. 22, 1927 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | May 22, 1927 | 7 |
| 18 | Mar. 3, 1927 | 0 | 0 | 3 | 1 | 20 | 65 | 23 | 2 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 3, 1927 | 123 |
| 19 | Mar. 18, 1927 | 0 | 0 | 0 | 0 | 3 | 15 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | April 2, 1927 | 19 |
| 20 | Feb. 25, 1927 | 0 | 8 | 6 | 6 | 32 | 136 | 54 | 6 | 0 | 0 | 24 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 8, 1927 | 274 |
| 21 | Feb. 23, 1927 | 21 | 210 | 63 | 35 | 84 | 476 | 637 | 91 | 0 | 21 | 224 | 21 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | May 22, 1927 | 1911 |
| 22 | Feb. 24, 1927 | 0 | 1 | 1 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | April 4, 1927 | 6 |
| 23 | Feb. 23, 1927 | 5 | 10 | 4 | 2 | 5 | 21 | 14 | 1 | 0 | 2 | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | May 20, 1927 | 78 |
| 24 | Feb. 24, 1927 | 0 | 1 | 0 | 0 | 0 | 5 | 3 | 0 | 0 | 1 | 2 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | May 22, 1927 | 16 |
| 25 | Mar. 9, 1927 | 0 | 0 | 1 | 5 | 39 | 225 | 323 | 40 | 0 | 41 | 931 | 60 | 0 | 54 | 0 | 0 | 1 | 0 | 5 | 40 | July 3, 1927 | 1765 |
| 26 | Mar. 7, 1927 | 0 | 0 | 1 | 1 | 1 | 39 | 81 | 20 | 1 | 5 | 67 | 15 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | May 24, 1927 | 239 |
| 27 | Mar. 24, 1927 | 0 | 0 | 0 | 0 | 0 | 7 | 9 | 4 | 0 | 10 | 219 | 29 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 8 | July 3, 1927 | 300 |
| 28 | Mar. 10, 1927 | 0 | 0 | 0 | 2 | 76 | 253 | 258 | 109 | 7 | 445 | 388 | 26 | 0 | 22 | 0 | 0 | 4 | 1 | 1 | 0 | June 23, 1927 | 1592 |
| 29 | Mar. 26, 1927 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | 3 | 0 | 8 | 13 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 7, 1927 | 39 |
| 30 | Mar. 25, 1927 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 2 | 35 | 4 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | May 22, 1927 | 50 |
| 31 | Mar. 15, 1927 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | April 3, 1927 | 2 |
| 32 | Mar. 6, 1927 | 0 | 0 | 6 | 0 | 0 | 7 | 15 | 1 | 0 | 3 | 17 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 7, 1927 | 50 |
| 33 | ............ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ............ | ....... |
| 34 | Mar. 7, 1927 | 0 | 0 | 1 | 0 | 0 | 6 | 3 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 5, 1927 | 14 |
| 35 | Mar. 10, 1927 | 0 | 0 | 0 | 3 | 0 | 26 | 25 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 7, 1927 | 59 |
| 36 | Mar. 4, 1927 | 0 | 0 | 142 | 106 | 62 | 399 | 335 | 10 | 0 | 79 | 98 | 7 | 0 | 6 | 0 | 0 | 1 | 0 | 0 | 0 | June 13, 1927 | 1245 |
| 37 | Mar. 19, 1927 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | April 30, 1927 | 7 |
| 38 | Mar. 6, 1927 | 0 | 0 | 2 | 14 | 18 | 51 | 40 | 29 | 0 | 16 | 58 | 6 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | May 22, 1927 | 241 |
| 39 | Mar. 14, 1927 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 1, 1927 | 4 |
| 40 | Mar. 19, 1927 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | May 2, 1927 | 5 |

Table 5.—Summary of data on spring emergence, 1927

| Cage No. | Host Plant: Scientific Name | Host Plant: Common Name | Number of Insects Emerged During: February | March | April | May | June | July | Emergence Period Days | Total Number Emerged |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | *Gossypium hirsutum* | Cotton | 0 | 46 | 12 | 0 | 0 | 0 | 61 | 58 |
| 9 | *Gaura brachycarpa* | Primrose | 690 | 16684 | 3704 | 528 | 11 | 0 | 134 | 21617 |
| 10 | *Solanum elaeagnifolium* | Horse Nettle | 8 | 134 | 43 | 14 | 0 | 0 | 94 | 199 |
| 11 | *Ambrosia psilostachya* | Ragweed | 1 | 143 | 279 | 120 | 31 | 20 | 131 | 594 |
| 12 | *Croton capitatus* | Goatweed | 328 | 16836 | 4383 | 322 | 16 | 0 | 134 | 21895 |
| 13 | *Amphiachyris dracunculoides* | Broomweed | 0 | 11 | 12 | 0 | 0 | 0 | 53 | 23 |
| 14 | *Xanthium speciosum* | Cocklebur | 0 | 12 | 43 | 13 | 0 | 0 | 64 | 68 |
| 15 | *Heterotheca subaxillaris* | .............. | 0 | 108 | 236 | 68 | 0 | 0 | 82 | 412 |
| 16 | *Eupatorium compositifolium* | Dog Fennel | 0 | 51 | 125 | 49 | 0 | 0 | 63 | 225 |
| 17 | *Aster sp.* | Wild Aster | 0 | 4 | 3 | 0 | 0 | 0 | 62 | 7 |
| 18 | *Gossypium hirsutum* | Cotton | 0 | 92 | 27 | 4 | 0 | 0 | 62 | 123 |
| 19 | *Ambrosia aptera* | Ragweed | 0 | 18 | 1 | 0 | 0 | 0 | 16 | 19 |
| 20 | *Amaranthus Torreyii* | Careless weed | 8 | 190 | 60 | 16 | 0 | 0 | 73 | 274 |
| 21 | *Atriplex sp.* | Orach | 224 | 742 | 784 | 161 | 0 | 0 | 89 | 1911 |
| 22 | *Helianthus Maximilianii* | Sunflower | 1 | 4 | 1 | 0 | 0 | 0 | 40 | 6 |
| 23 | *Ambrosia artemisiifolia ?* | Ragweed | 15 | 34 | 18 | 11 | 0 | 0 | 87 | 78 |
| 24 | *Gossypium hirsutum* | Cotton | 1 | 5 | 5 | 5 | 0 | 0 | 88 | 16 |
| 25 | *Helenium tenuifolium* | Bitterweed | 0 | 320 | 1047 | 352 | 25 | 21 | 117 | 1765 |
| 26 | *Leptilon Canadense* | Horseweed | 0 | 48 | 131 | 60 | 0 | 0 | 79 | 239 |
| 27 | *Ambrosia psilostachya* | Ragweed | 0 | 7 | 163 | 122 | 1 | 7 | 102 | 300 |
| 28 | *Croton capitatus* | Goatweed | 0 | 346 | 982 | 258 | 6 | 0 | 106 | 1592 |
| 29 | *Monarda sp.* | Horsemint | 0 | 2 | 25 | 12 | 0 | 0 | 43 | 39 |
| 30 | *Gossypium hirsutum* | Cotton | 0 | 3 | 21 | 26 | 0 | 0 | 59 | 50 |
| 31 | *Gossypium hirsutum* | Cotton | 0 | 1 | 1 | 0 | 0 | 0 | 20 | 2 |
| 32 | *Ambrosia aptera* | Ragweed | 0 | 14 | 33 | 3 | 0 | 0 | 63 | 50 |
| 33 | *Helianthus annuus* | Sunflower | 0 | 0 | 0 | 0 | 0 | 0 | .......... | .......... |
| 34 | *Ambrosia artemisiifolia* | Ragweed | 0 | 7 | 5 | 2 | 0 | 0 | 60 | 14 |
| 35 | *Solanum elaeagnifolium* | Horse Nettle | 0 | 31 | 25 | 3 | 0 | 0 | 59 | 59 |
| 36 | *Croton capitatus* | Goatweed | 0 | 728 | 443 | 73 | 1 | 0 | 102 | 1245 |
| 37 | *Gossypium hirsutum* | Cotton | 0 | 6 | 1 | 0 | 0 | 0 | 43 | 7 |
| 38 | *Croton capitatus* | Goatweed | 0 | 87 | 102 | 52 | 0 | 0 | 78 | 241 |
| 39 | *Solanum elaeagnifolium* | Horse Nettle | 0 | 2 | 1 | 1 | 0 | 0 | 49 | 4 |
| 40 | *Parthenium Hysterophorus* | .............. | 0 | 3 | 1 | 1 | 0 | 0 | 45 | 5 |

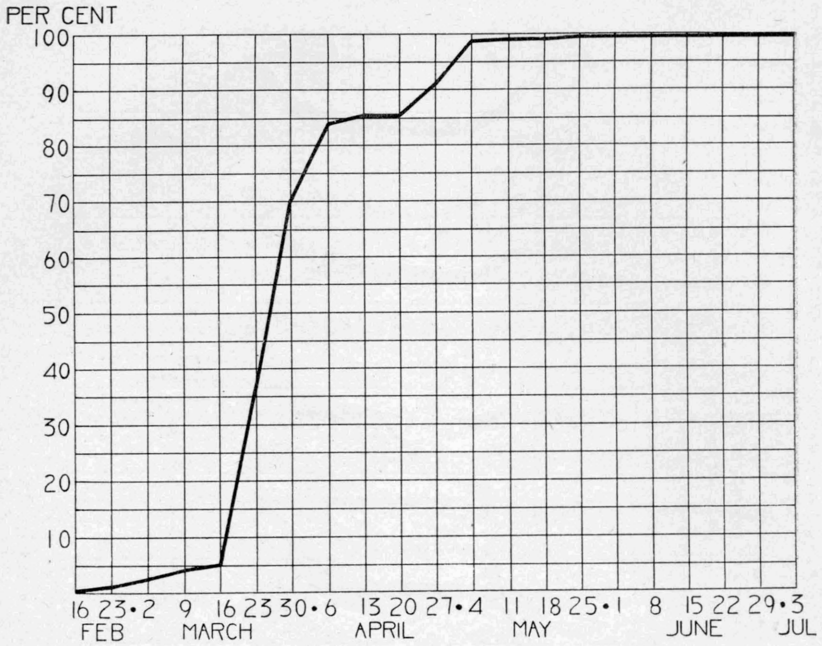


Fig. 3. Accumulative emergence of insects at weekly intervals from nineteen different species of winter host plants, during the spring 1927

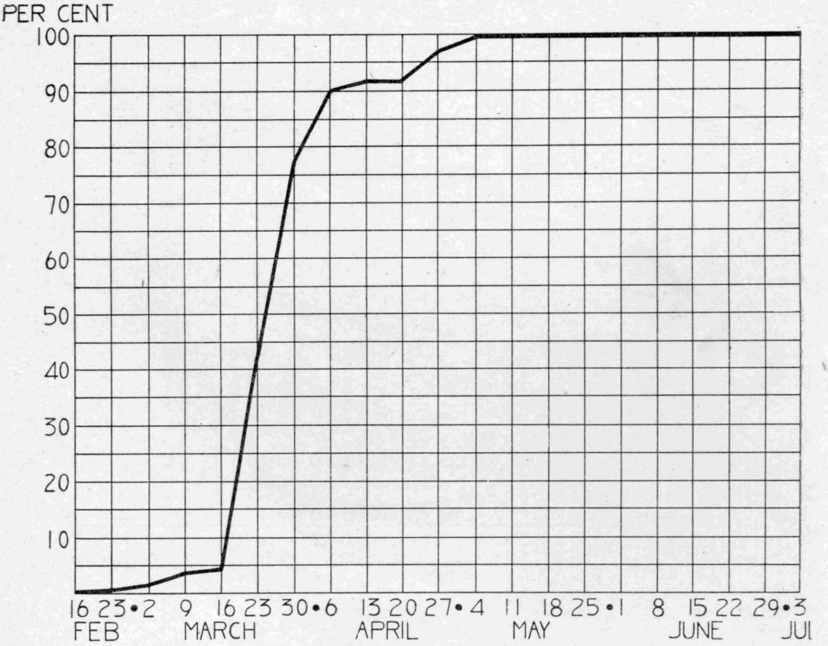


Fig. 4.—Accumulative emergence of insects at weekly intervals from goatweed during the spring 1927

emergence was completed. In other words, out of a total of 53,137 insects which emerged in the cages, 41,956 of them hatched from March 17 to April 7, a period of 21 days. The significance of this fact may be emphasized by pointing out that this number of insects emerged from only 3,200 host plants. Under field conditions where oftentimes many acres are literally covered with host plants of the cotton flea hopper the enormous number of insects which may hatch during a comparatively few weeks is beyond computation. It will be noted that few insects hatched during the two weeks immediately following the period of maximum emergence; however, the rate of emergence again increased rapidly from April 20 to May 4. On May 11 emergence was practically completed.

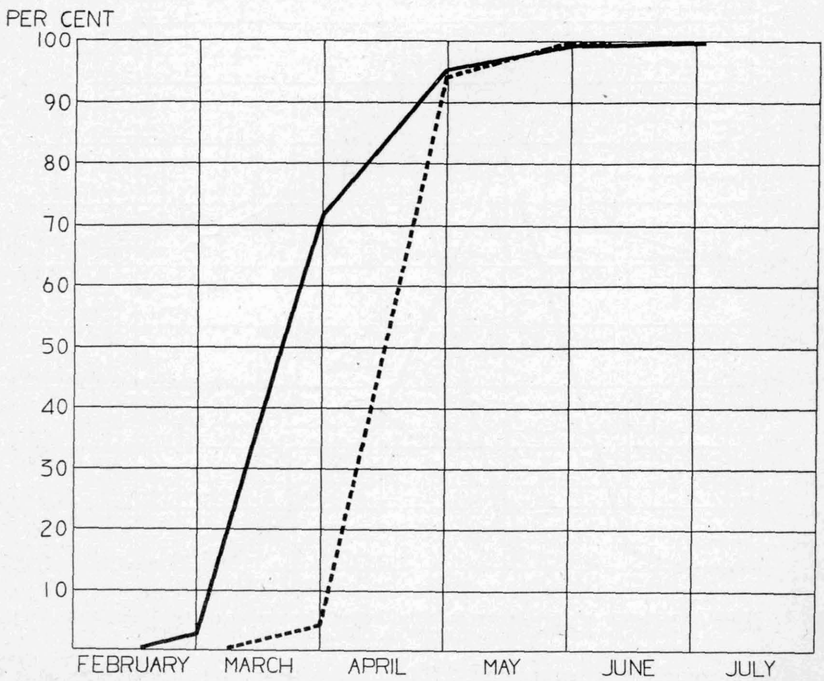


Fig. 5. Accumulative emergence of insects by months during the spring of 1926 and 1927. The broken line represents emergence in 1926; the solid line in 1927.

The discussion in the preceding paragraph refers to the composite rate of emergence from all host plants caged for observation. While this undoubtedly is the closest approximation of the rate of emergence under natural conditions, it is interesting to note that the rate at which the insects emerged from goatweed, as illustrated in Figure 4, is practically the same. In comparing the numerical rate of emergence from all the cages, as indicated in Table 4, it will be observed that a corresponding curve, with possibly a few exceptions, will represent the rate of emergence from any of the important host plants included in this list.

The rate and time of emergence during the spring of 1926 and 1927 are illustrated graphically in Figures 5 and 6. In the spring of 1927 emergence began on February 16 about three weeks earlier than in the previous season, and by April 1, more than 71 per cent of all the insects had emerged. On the same date in 1926 less than 4 per cent of the total emergence had been effected. However, hatching continued at a very rapid rate during April and on May 1 practically 95 per cent of the

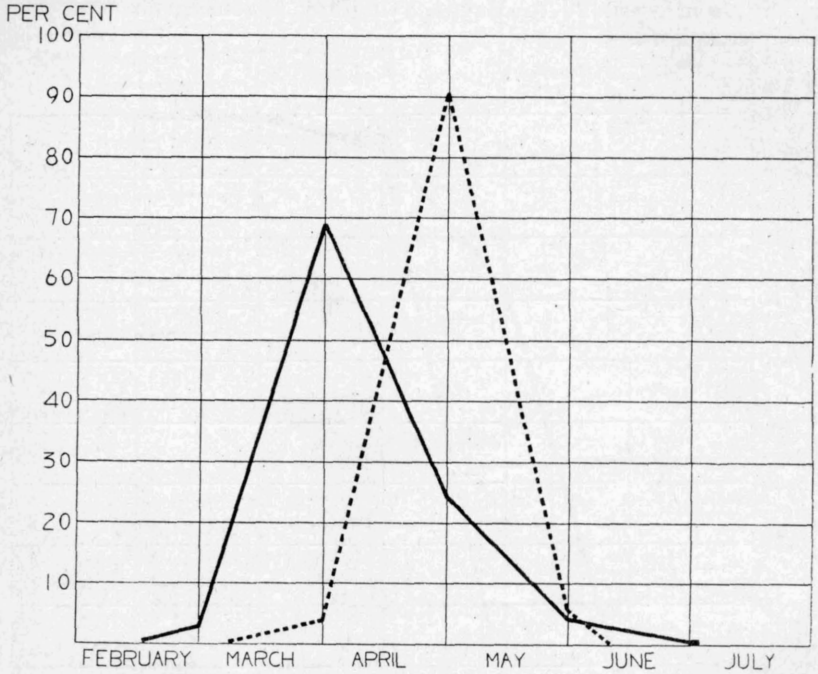


Fig. 6. **Total emergence of insects by months during the spring of 1926 and 1927. The broken line represents emergence in 1926; the solid line in 1927.**

total emergence was completed. The interesting and significant point in this connection is the early heavy emergence in 1927 contrasted by a later but even more rapid emergence in 1926. The effect produced by this difference in rate and time of emergence appears to be the logical explanation for the heavy infestation of the cotton flea hopper on cotton in 1926 and the contrasting lack or comparatively light infestations which occurred during 1927. This subject is discussed more fully on page 21.

**Peak of Emergence:** The per cent of total emergence at weekly intervals, from all the host plants which were caged for observation during

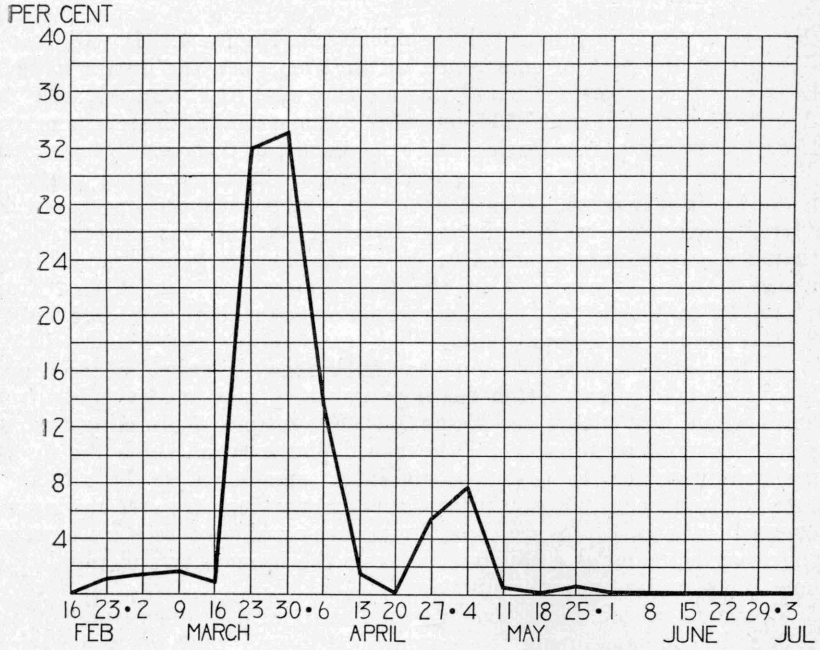


Fig. 7. Total emergence of insects at weekly intervals from nineteen different species of winter host plants during spring of 1927

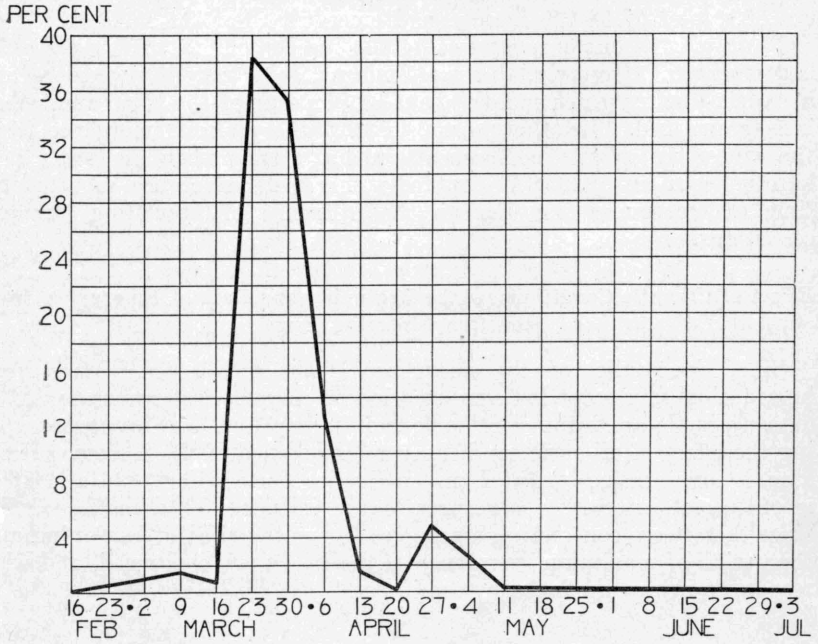


Fig. 8. Total emergence of insects at weekly intervals from goatweed during the spring of 1927

the season 1927, is illustrated graphically in Figure 7. It will be observed that the peak of emergence, or the time when the insects hatched in greatest numbers, occurred during the week beginning March 24. About 33 per cent, or 17,715 out of a total of 53,137 insects, emerged from 3,200 host plants during the brief period of 7 days.

The per cent of total emergence at weekly intervals from goatweed is shown in Figure 8. The peak or time of maximum emergence occurred during the week beginning March 17, which was a week earlier than the corresponding period in the composite emergence from all host plants. Over 38 per cent of the total emergence was effected from March 17 to March 24. In other words out of a total of 21,895 insects 8,413 emerged in 7 days.

On the basis of these data some conception may be gained of the countless myriads of young cotton flea hoppers which may appear suddenly in fields where host plants are abundant. For example, assuming that an acre of ground contains 20,000 goatweed plants from which the insects are hatching over the period of maximum emergence at the rate indicated above, then 1,700,000 insects may emerge per acre area during the course of one week. Since these figures are considered very conservative they may be taken as a concrete index to the immensity and rapidity of emergence under natural conditions.

The data which have been accumulated on the emergence of the cotton flea hopper during the season of 1926 and 1927 are summarized by months and illustrated graphically in Figures 5 and 6. During the month of March in 1927, it will be observed, about 69 per cent, or 36,719 out of a total of 53,137 insects, had emerged. For the same period in 1926 only 1,706 out of a total of 44,363 insects, or less than 4 per cent, had emerged. However, this was followed by a very heavy emergence in April, during which month about 91 per cent of the total number of insects emerged. In other words, in 1927 the peak of emergence from the winter host plants had been attained at a time when emergence had hardly begun in 1926. Undoubtedly this wide difference in rate and time of emergence was due to the influence of prevailing climatic conditions.

### Effect of Climatic Conditions on the Beginning and Rate of Emergence from the Overwintering Eggs

Since the studies on the emergence of the cotton flea hopper from hibernation have extended over a period of only the last two seasons, the data available are insufficient to formulate any final conclusions regarding the effect of climatic conditions on emergence of the insects. However, a comparative study of the emergence periods for 1926 and 1927 is of special interest with respect to the influence of climatic factors, since these were contrasting seasons so far as the time of beginning and the period of maximum emergence of the insect are concerned, and with respect to injury produced by the insect.

Table 6.—Climatological data affecting spring emergence at College Station during the seasons of 1926 and 1927

| Month | Year | Temperature Mean | Departure from Normal | Rainfall, Inches | Departure from Normal |
|---|---|---|---|---|---|
| February | 1926 | 58.2 | +5.2 | 0.13 | —2.68 |
| | 1927 | 58.4 | +5.4 | 6.10 | +3.29 |
| March | 1926 | 56.0 | —4.4 | 8.03 | +5.34 |
| | 1927 | 60.6 | +0.2 | 2.20 | —0.49 |
| April | 1926 | 62.9 | —5.1 | 5.97 | —2.10 |
| | 1927 | 72.2 | +4.2 | 5.09 | +1.22 |
| May | 1926 | 72.3 | —1.7 | 2.26 | —1.80 |
| | 1927 | 79.2 | +5.2 | 1.97 | —2.78 |
| June | 1926 | 81.0 | +0.1 | 0.68 | —2.60 |
| | 1927 | 80.9 | 0.0 | 5.43 | +2.15 |

The mean temperature, total precipitation, and the departure from the normal for each month during the emergence periods of the past two seasons are presented in Table 6. The apparent influence of these factors on hatching of the overwintering eggs will be considered briefly, by pointing out differences or approximations in temperatures and precipitation for various months in connection with the per cent of total emergence attained, as illustrated in Figure 6.

It will be observed that the mean temperatures for February, 1926, and February, 1927, were practically the same and slightly over 5 degrees F. above the normal. In 1926 the rainfall for the month was only 0.13 inches, while in 1927 the total was 6.10 inches distributed over 9 days. These amounts of rainfall represent marked departures in both directions from the normal.

During February, 1927, 2.4 per cent of the total emergence had been completed, indicating that an average mean temperature of 58.4 degrees F. becomes effective when rainfall is abundant. No insects emerged during February, 1926, although the average mean temperature was 58.2 degrees F., and the rainfall was very light. In other words, present knowledge indicates that the rainfall has an important influence on the hatching of the overwintering eggs after the effective mean temperature has obtained for several weeks.

During March, 1926, the mean temperature was 56.0 degrees F., or 4.4 degrees below the monthly normal. The rainfall on the other hand was 5.34 inches above normal, 8.03 inches being recorded over a period of 17 days. March, 1927, approached normal conditions very closely with respect to the mean temperature and the rainfall.

The climatic conditions which prevailed during March, 1926, were closely approximated in February, 1927. The per cent of total emergence effected during these months is practically the same, indicating that mean temperatures of 56 to 58 degrees F., with abundant rainfall, are effective factors in the emergence of insects from overwintering eggs. The small per cent of emergence which occurred during March, 1926, with an average mean temperature 4.4 degrees F. below the normal, is contrasted by the peak of emergence which occurred during March, 1927, with practically a normal temperature and rainfall. Apparently a mean temperature of 60 degrees F., with a normal well-distributed rainfall, is near the optimum conditions for the procedure of maximum emergence. Further evidence concerning this point is presented in the following paragraph.

Since the period of maximum emergence in 1926 and 1927 occurred during April and March, respectively, a comparison of the climatic conditions which prevailed during these months is pertinent to the optimum conditions which effect maximum hatching of the overwintering eggs. The mean temperature for April, 1926, was 62.9 degrees F., which was 5.1 degrees below the monthly average mean. The rainfall for the month was excessive, totaling 5.97 inches distributed over a period of 9 days. During March, 1927, the mean temperature was 60.6 degrees F., or practically normal. Similarly, the rainfall for the month closely approached the normal, a total of 2.20 inches occurring over a period of 8 days. Obviously, April, 1926, was an abnormal month and the climatic conditions which prevailed, it will be observed, approximated the normal for March. In other words, these observations indicate that the period of maximum emergence of the cotton flea hopper from the overwintering eggs is effected during March whenever the mean temperature and rainfall for the month approximate the normal.

The apparent effect of climatic conditions on the emergence of the cotton flea hopper in the spring of 1926 and 1927 may be summarized briefly as follows: In the spring of 1926 hatching of the insects from the overwintering eggs was retarded during March by abnormal climatic conditions, and the period of maximum emergence occurred in April, which was subsequent to the time when cotton was up generally in the field. On the other hand, climatic conditions in March, 1927, were nearly normal and maximum emergence of the cotton flea hopper was effected during that month, or at a time before practically any cotton had been planted.

## Dissemination at the Time of Emergence from Hibernation

The immensity of the generation of insects emerging from the overwintering eggs has been described in the preceding paragraphs. Often vast numbers of the insects emerge from weeds located on waste-lands or uncultivated fields which may be remotely situated from any fields of young cotton. It is therefore interesting to consider how the young insects are disseminated or spread over the surrounding territory from the centers of spring emergence.

Winds are probably the most important single factor effecting the wide dissemination or spread of the cotton flea hopper at the time of emergence from hibernation. The newly hatched insects are very delicate and fragile. In size they compare favorably with tiny particles of dust or sand which even moderate breezes could carry over considerable distances. It is also significant that the period of heaviest emergence normally occurs during a time when winds are usually blowing at a maximum average rate. Large fields of preferred host plants of the insect frequently are left unmolested until the period of maximum emergence occurs. At that time the young insects, present on the dried-up or dead host plants of the previous season, are doubtless scattered far and wide in prodigious numbers by the prevailing strong winds.

Thus far all the preliminary tests made to prove this point definitely have yielded only negative results. However, there is an abundance of indirect evidence which supports the theory of wind distribution in case of the cotton flea hopper, and further studies in this connection will undoubtedly show that the insects are commonly spread in this manner.

### Relation Between the Time of Emergence from Hibernation and the Extent of Injury to Cotton

It is significant that practically all the serious outbreaks of the cotton flea hopper in this State are in accord regarding the time when most of the injury to the cotton crop is accomplished. Invariably it has occurred early during the growing season. The evidence which has been accumulated on the activities of this insect indicates that the generation hatching from the overwintering eggs is responsible for making the greatest inroads on the crop.

It is a well established fact that cotton is an acquired food or host plant on which the insects, under normal conditions, do not multiply as rapidly as they do on the preferred host plants. Yet in the early part of the growing season large numbers of the insect may be encountered in cotton fields, which apparently could not have developed on the plants. Furthermore, as the season advances, the cotton flea hopper population decreases and usually by the end of June the number of insects remaining on cotton is practically insignificant. It therefore appears logical to assume that the early destructive infestations of the cotton flea hopper are composed principally of individuals which emerged from the overwintering eggs.

To illustrate the importance of the generation of insects emerging from the overwintering eggs, as a potential source for the origin of infestations during the early part of the growing season, a few data secured from individual emergence cages are presented below and used as the basis for some precise calculations on the extent of emergence. On March 22, Cage No. 9 containing 100 host plants, *Gaura brachycarpa,* yielded 4,438 insects in 8 hours; and 12,959 insects in 7 consecutive days, March 22-28. On March 22, Cage No. 12 containing 100 goatweed plants yielded 3,386 young insects in 8 hours; and 12,300 insects from March 22 to March 28. More data in this connection could be cited, but these are sufficient to illustrate the point. Assuming that an acre of ground contains 20,000 preferred host plants from which the insects are emerging at the maximum rate indicated above, it will be noted that 887,600 cotton flea hoppers may hatch per acre area in a single day; 2,591,800 in a week or at a daily rate of about 370,000 for 7 consecutive days. Obviously, in localities where the preferred host plants abound, the number of cotton flea hoppers which may emerge from the overwintering eggs is beyond comprehension. According to the figures given above, theoretically the number of insects which may hatch during one week on an acre of preferred host plants if transferred to an acre of cotton with a normal stand ranging from 15,000 to 20,000 plants would result in a ratio of approximately 150 insects to each cotton plant. Fortunately, however, such severe infestations do not occur, because a vast majority of the insects never reach young cotton plants in the spring. The principal limiting factor in this connection is the relation between the time at which maximum emergence occurs and the status or development of the current cotton crop.

Emergence depends largely, as has already been shown, upon the mean temperature and precipitation prevailing during February, March, and April. The observations made at College Station in this connection have added greatly to our knowledge of the relation between the time of maximum emergence and the extent of injury to cotton. In the spring of 1926 a late heavy emergence of the cotton flea hopper was followed by widespread infestations and considerable injury to the crop in nearly all cotton-producing regions of the State. In 1927, although the emergence of the insects was fully as great as during the previous spring, an early heavy emergence occurred before cotton was planted and practically no injury to the crop resulted anywhere in this State. The lack of injury to cotton was the direct result of a late emergence of the insects in 1926, contrasted with an early emergence of the insects in 1927, as illustrated in Figure 5. In other words, the time at which maximum emergence occurs in relation to the growth of cotton largely determines the extent of injury that is produced by the cotton flea hopper. This is a very significant point. To illustrate, if the time of maximum emergence of the insects is delayed, by abnormal conditions, to or after the time when young cotton is ordinarily up in the fields, then the plants are subject to infestation and subsequent injury results. These were precisely the conditions which existed generally throughout this State during the early part of the growing season in 1926. The result was widespread infestations of the insect accompanied by unprecedented injury to the crop. On the other hand when maximum emergence occurs at the normal time, as was the case in the spring of 1927, cotton, except that planted unusually early, is not available as a source of food. In fact, during 1927 much of the seed was not planted at the time when the insects were hatching in greatest numbers. In the absence of cotton the young insects must necessarily turn to other sources of food and very likely vast numbers of them perish before reaching suitable food plants.

According to these facts and observations made during the past two seasons, the general indications are: that whenever a normal mean temperature and precipitation prevail during March, the cotton flea hopper will do little, if any, injury to cotton; when the monthly mean temperatures for March and April are 4 or 5 degrees F. below the normal, with the rainfall for each month well above the average, and cotton is planted at the normal time, conditions are favorable for flea hopper infestations on cotton and considerable injury to the crop is likely to be the result.

## WINTER HOST PLANTS

In these studies much valuable information has been accumulated concerning the winter host plants of the cotton flea hopper. Heretofore only 5 or 6 different species of plants were known to be concerned in the hibernation of this insect, and the information available on the relative importance of these was very limited. In addition to securing more complete data on the number of eggs carried through the dormant season in these plants, 14 new winter host plants of the insect have been discovered. The data secured in the observations on emergence of the insects from these plants are presented in Table 5. It will be observed that this list of winter host plants contains many widely related forms. These plants, however, agree generally in having a semi-woody texture which hardens at maturity and results in rather tough woody plants which readily withstand the elements during the winter months. The present list of winter host plants is not considered inclusive or nearly complete. Undoubtedly there are many other species of plants, not yet discovered, which are important factors in the hibernation of this insect.

The importance of any winter host plant is determined, not only by the number of eggs which it carries through the winter, but also by its abundance and by the extent of its distribution. For example, the various species of *Croton,* or goatweed, are widely distributed over this State and in some sections at least rank among the commonest weeds. On the other hand, *Atriplex,* or orach, while also abundant in some localities, is not generally distributed over the State. Both *Croton* and *Atriplex* wherever they occur are preferred by the insect for food and reproduction. Assuming that they may contain approximately the same number of eggs, per unit of measure, during the dormant season, it will be appreciated readily that *Atriplex* is an important winter host plant only in the local areas where it is indigenous, while *Croton* assumes the status of being an important factor in hibernation over a vastly larger territory. To illustrate further, by accurate count the number of insects which emerged from 100 primrose plants, *Gaura brachycarpa,* collected at Wharton, Texas, and from 100 goatweed plants, *Croton capitatus,* collected at College Station, was 21,617 and 21,895, respectively. Evidently the number of eggs contained in these weeds during the winter of 1926-27 was approximately the same. However, primrose plants of this species are confined in distribution principally to southern Texas, and wherever the plant abounds in that section it undoubtedly is an important winter host of the cotton flea hopper, while goatweed, with approximately the same number of eggs per plant, by the virtue of its wide distribution and abundance, is a preeminent winter host of the insect. It will be observed that the number of insects emerging from the overwintering eggs in bitterweed, ragweed, dog fennel, horseweed, horse nettle, careless weed, *Heterotheca subaxillaris*, and others, are not as impressive as the number emerging from primrose or goatweed.

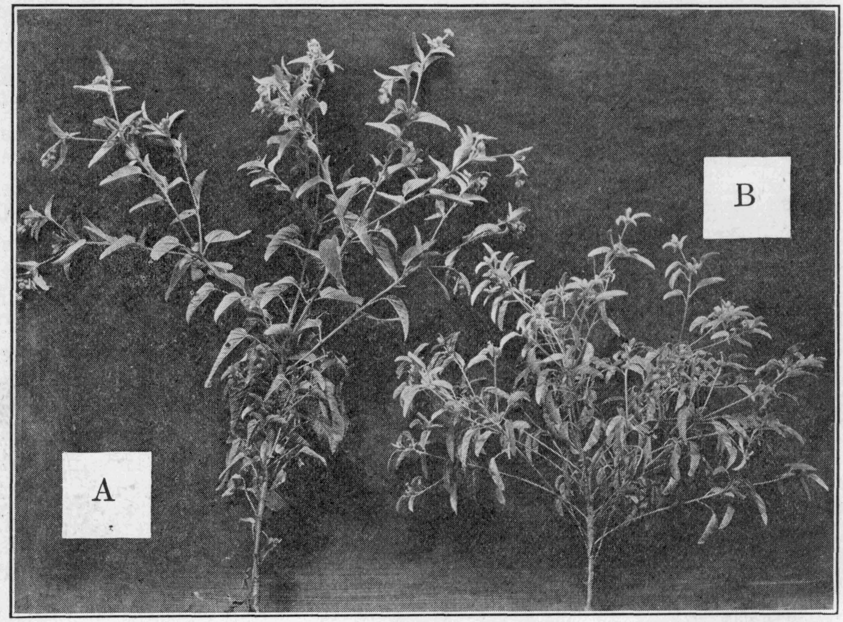


Fig. 9. Two common species of goatweed plants, (A) *Croton capitatus*, (B) *Croton Engelmannii*. These plants are preferred by the cotton flea hopper for food and as winter host plants.

Nevertheless, many of these are very common weeds with a wide range of distribution over the State and hence must be considered as potential factors in the hibernation of this insect.

It is interesting to note that out of a total of 19 different species of plants principally common weeds which were collected during the winter of 1926-27 and placed in emergence cages, only one, *Helianthus annuus*, failed to contain any overwintering eggs of the cotton flea hopper. This singular fact illustrates a remarkable flexibility in the habits of the insect when choosing its winter host plant. As these studies are continued, the list of plants concerned will very likely be extended to include other common weeds that may prove to be equally as important in the hibernation of the insect as any of those which have been discovered up to the present time.

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## SUMMARY

1. The hibernation period of the cotton flea hopper at College Station may begin as early as September 1 to 15, although the eggs are not dormant generally until October 1.

2. In the spring of 1926 the first insects hatched from the overwintering eggs on March 7, while in 1927 first hatching occurred on February 16. Emergence from the winter host plants was practically completed on May 15; however, a few stragglers continued to hatch up to June 10, 1926, and July 3, 1927.

3. The average period of hibernation at College Station extends from approximately October 1 to May 1, or over a period of about 7 months. The extremes of the period may range from 4 to 8 months.

4. Minimum temperatures of 20 degrees F. in December, 1925, did not kill the dormant eggs.

5. The time at which emergence from hibernation begins varies from year to year and depends largely upon the prevailing temperatures.

6. During the season of 1926 emergence of the cotton flea hopper extended from March 7 to June 10, or over a period of about 13 weeks. In 1927 the period of emergence comprised approximately 20 weeks extending from February 16 to July 3.

7. There is little or no difference in the rate of emergence from the different types of winter host plants.

8. The duration of the emergence from all winter host plants under observation in 1926-27 ranged from 16 to 134 days, and averaged about 74 days.

9. When climatic conditions are optimum, emergence proceeds very rapidly. In 1926, 73 per cent of the total emergence was effected from April 5 to April 26. In 1927, about 79 per cent of the total emergence was completed from March 17 to April 7.

10. The peak of emergence in 1926 occurred during the week beginning April 12 after cotton came up; in 1927 it occurred during the week beginning March 24 or before cotton was planted.

11. A mean temperature of 56 to 58 degrees F., with normal rainfall, becomes effective for emergence of the insects from the winter host plants. Maximum emergence occurred in mean temperatures of 60 to 62 degrees F.

12. Winds appear to be the most important single factor effecting dissemination at the time of emergence from hibernation.

13. There is a definite relation between the time of maximum emergence and the extent of injury to cotton. Normally the heaviest emergence of insects from hibernation occurs before cotton is ordinarily planted or at least before much young cotton is up in the fields. When climatic conditions delay emergence of the insects in the spring, and cotton is planted at the average date, conditions are favorable for extensive injury to the crop by the cotton flea hopper.

14. Fourteen new winter host plants of the cotton flea hopper have been discovered. Data on the emergence of insects from each are presented. These new host plants include many of our commonest weeds and have a wide range of distribution over the State.