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by

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# SUMMARY

In Nebraska seasonal fluctuations in the numbers of sweetclover aphids (*Therioaphis riehmi* (Börner)) follow the same pattern as that reported for Kansas and Minnesota. A peak is reached in the late spring and again in the fall, with the population at a low ebb during the summer.

Predators appear to be chiefly responsible for low summer populations. Their role in aphid control was demonstrated when an insecticide, used against the predators, caused the aphids to increase significantly. The principal predators present were five species of Coccinellidae and two of Chrysopidae.

Two species of Nabidae, abundant but not controlled by the insecticide, were difficult to evaluate. Other predaceous groups (including nine species) were not abundant enough, at least in their predaceous forms, to be considered important. Evidence presented in this report and supported by literature references indicates that the predator complex changes from year to year in a given locality.

Neither of the two species of insect parasites, reared from the sweetclover aphid during the course of these studies, was found to be abundant. The controlling influence of insect parasites was rated as negligible.

Hard rains were implicated as having an adverse effect on the sweetclover aphid. During the three growing seasons (1959, 1960, and 1961) rains of 1-inch accumulation in a 24-hour period occurred 17 times. Fourteen of these storms were associated either with drops in the aphid population or with a slowing or halt of population increase. Storms during periods of low predator activity produced only temporary effects on the aphid population. Thus the heavy rains in themselves could not explain the long period of low aphid activity during the summer.

One of the most interesting aspects of the field studies was observed at a time of year when aphid population is usually low. The predator balance had been upset by use of an insecticide in the test area, and the aphid population was on the rise. However, an entomophagous fungus appeared and was very effective in reducing the aphid populations. This fungus was detected only in the insecticide-treated plots where aphid numbers were high. Aphid populations were believed to be too low for dissemination of the fungus in the check areas. The disease appeared and behaved in the same manner during both years that predator control with insecticides was studied.

# Seasonal Population Fluctuations and Natural Control of the Sweetclover Aphid[1]

George R. Manglitz and Roscoe E. Hill[2]

## INTRODUCTION AND LITERATURE REVIEW

The history of the sweetclover aphid (*Therioaphis riehmi* (Börner)) is obscure. This aphid was not recognized as a species until 1949, when it was described by Carl Börner (1) in Germany. However, Kieckhefer (8) stated that this aphid was collected in Minnesota by A. A. Ganovsky in 1948. According to Peters and Painter (13), its presence in the United States was not fully recognized until extensive surveys were made during the early 1950's for a related and also introduced species, the spotted alfalfa aphid (*Therioaphis maculata* (Buckton)).

Subsequently the sweetclover aphid was recognized as a pest of sweetclover by Peters and Painter (13), Kieckhefer (8), Mac Nary (9), and Manglitz (11). Present distribution of the sweetclover aphid in the United States is shown in Figure 1 and nymphs of the species, with their distinctive spots, are shown in Figure 2.

The sweetclover aphid has a rather restricted host range, since its hosts are confined to genera of *Melilotus* and *Trigonella,* as reported by Peters and Painter (13, 14). *Melilotus officinalis* and *M. alba* are the only important economic hosts.

The result of aphid feeding was characterized by Kieckhefer (8) as beginning with a yellow discoloration and often resulting in eventual loss of the leaflet. Damage is especially marked on seedling plants. Such damage, in conjunction with that by the sweetclover weevil, can cause the loss of a sweetclover stand.

Manglitz and Gorz (10) showed that aphid populations which built up under greenhouse and field-cage conditions killed nearly all seedlings of the most susceptible varieties (Figure 3). Variability in host reaction within a given plant species was mentioned by Peters and Painter (13). Possibility of controlling the aphid with the development of resistant varieties of sweetclover was demonstrated by Manglitz and Gorz (10).

Kieckhefer (8) found that the sweetclover aphid passes the winter in the egg stage. The egg gives rise in early spring to a wingless stem

[1] Adapted from a portion of a thesis, by the senior author, presented to the Graduate faculty of the University of Nebraska in partial fulfillment of the requirements for the Degree of Doctor of Philosophy. Contribution No. 247 of the Department of Entomology, University of Nebraska, Lincoln, Nebraska.

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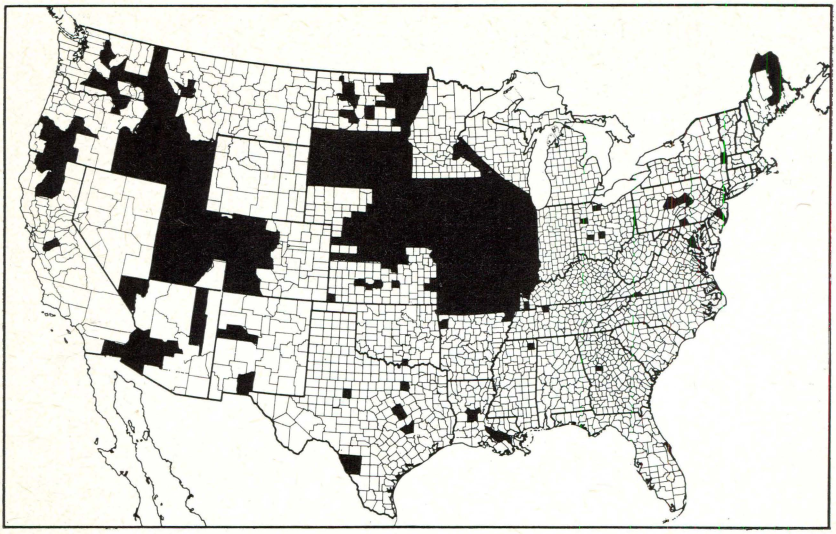

Figure 1. Reported distribution of the sweetclover aphid in the United States (taken from "Distribution Maps"—Cooperative Economic Insect Report, U.S.D.A., Plant Pest Control Division, 1959).

Figure 2. Nymphs of the sweetclover aphid feeding on the underside of a sweet-clover leaflet (highly magnified). The four rows of spots distinguish this species from the spotted alfalfa aphid and the yellow-clover aphid, both of which have six rows of spots.

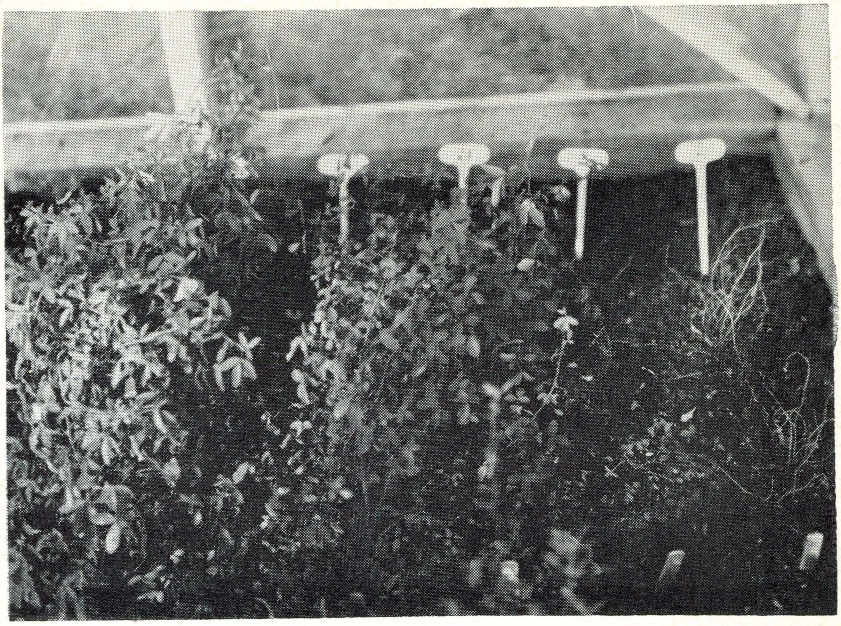

**Figure 3. Severe sweetclover aphid injury resulted in plant mortality in the two rows (2 and 3) of seedling common yellow sweetclover on the right. Other varieties shown are Spanish (on left—row number obscured), Madrid (14) and N-13 (21). These plants were grown outdoors in a screen cage.**

mother. In the generations immediately following, and throughout the summer, only parthenogenetic winged females are produced. In the fall wingless sexual females and males appear and, after mating, overwintering eggs are produced. Appearance of the sexual forms is largely controlled by a decrease in daily photoperiod.

The sweetclover aphid has two seasonal population peaks in Kansas (Peters and Painter (13)) and in Minnesota (Kieckhefer (8)). The first peak occurs in late spring or early summer and the second during late fall. Kieckhefer believed the principal controlling factor between the peaks in Minnesota to be heavy rains and the presence of predators of the family Syrphidae. Grable (4) suggested that host unsuitability may be responsible for low populations between the two seasonal peaks.

Because the potential of this aphid for damaging sweetclover is well documented, yet damage occurs only occasionally under field conditions, it would appear that natural factors which depress midsummer populations are important in preventing greater damage and worthy of detailed study. Thus, this study was begun early in 1959 to investigate the natural factors which generally keep populations of this aphid below levels causing economic damage.

# BIOLOGY OF THE SWEET CLOVER APHID

The biology study emphasized determining dates of seasonal occurrence of stages of the aphid near Lincoln, Nebraska, and whether seasonal population fluctuations in Nebraska follow the same pattern as reported elsewhere. In addition, laboratory studies were conducted to determine the effect of temperature on the rate of development and survival of this aphid.

## Seasonal Occurrence Dates

In 1959 the first hatching, as reckoned by the appearance of first instar nymphs, occurred on April 24 (Table 1). For the 3 years studied, the average date nymphs were first observed was April 21. The average date for the appearance of stem mothers during the next 2 years was May 5. Thus, the estimated average time for maturity of the first generation was 14 days.

The average date of appearance of the first alate female was May 23, indicating that the second generation developed in about 18 days. After the appearance of the alate forms, there were no morphological differences in the generations, and because much overlapping occurred, it was not possible to determine the number or length of generations. The only other distinct form observed was that of the sexuales, which appeared on the average, about November 2.

## 1959 Population Fluctuations

Periodic population counts in a sweetclover field near Lincoln during 1959 revealed two well-defined seasonal peaks (Figure 4). The first peak occurred on both first and second-year sweetclover. By the second peak the second-year plants had long since reached maturity and the aphids were present only on first-year plants.

Examination of temperature records (Figure 4) shows that population peaks came at rising or declining temperature means, but the midseason lull in aphid activity came during the period of highest temperatures. The sudden temperature drop in early November ap-

**Table 1. Dates of first observance of various stages of *Therioaphis riehmi* (Borner), Lincoln, Nebraska, 1959-1961.**

| Year | 1st-Instar Nymph | Adult Stem Mother | Alate Female | Sexual Female |
|---|---|---|---|---|
| 1959 | April 24 | . . . | May 28 | Nov. 9 |
| 1960 | April 22 | May 9 | May 23 | Oct. 25 |
| 1961 | April 18 | May 2 | May 19 | Nov. 2 |
| Average | April 21 | May 5 | May 23 | Nov. 2 |

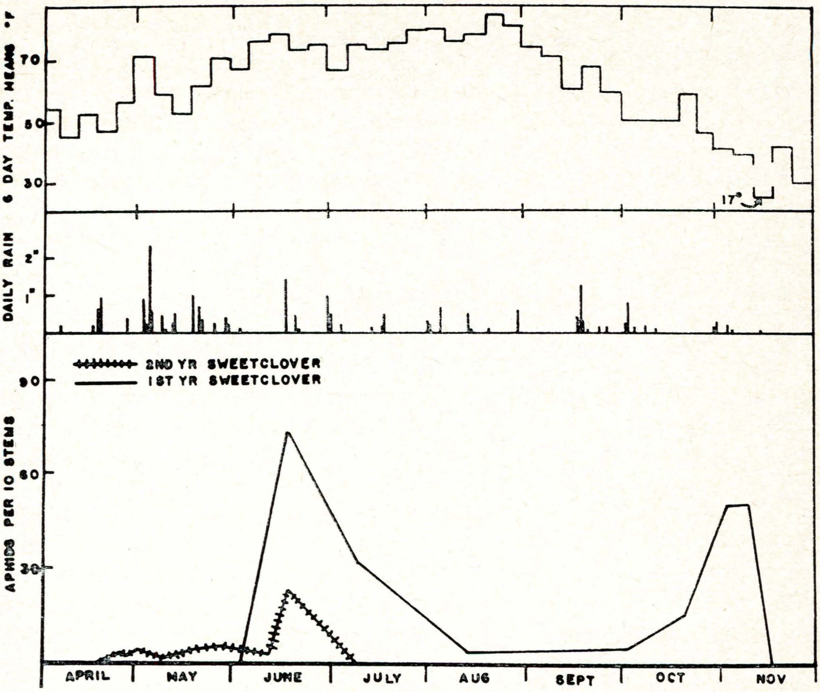


**Figure 4. Seasonal fluctuations in sweetclover aphid populations during 1959, shown with corresponding temperature and rainfall records. Lincoln, Nebraska.**

pears to have been responsible for the sudden cessation of seasonal activity.

No clear relationships between rainfall and sweetclover aphid populations could be detected during the 1959 season, although heaviest rainfall occurred at times of low or declining aphid populations.

## Effects of Temperature in the Laboratory

Studies on the effect of temperature and various plant selections on aphid survival and rate of development were conducted in constant-temperature cabinets where temperatures could be maintained within limits of ±2° F. Temperatures used were 55°, 65°, 75°, and 85° F. (12.8°, 18.3°, 23.9°, and 29.4° C). The cabinets were equipped with fluorescent lighting controlled by time switches. A daily photoperiod of 16 hours was used.

Saturated salt solutions (Mg $NO_2$. $6H_2O$), designed to hold relative humidities (within the temperature ranges used) somewhere near 59 per cent, were placed in the cabinets. Constant recording of humidity

**Table 2. The effect of plant resistance and temperature on aphid survival and length of the development period.**

| Plant species | Clones | Per cent aphid survival (birth to adult) | | | | Length of nymphal period in days | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 85°F | 75°F | 65°F | 55°F | 85°F | 75°F | 65°F | 55°F |
| *M. officinalis* | G337 (R)[a] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *M. alba* | G333 (R)[a] | 0 | 1.5 | 1.5 | 1.5 | 0 | 7.0[b] | 12.0[b] | 22.0[b] |
| *M. officinalis* | G220-2(S) | 21.5 | 45.0 | 20.0 | 24.0 | 5.6 | 6.3 | 8.5 | 20.1 |
| *M. alba* | *Span 3 (S)* | 26.5 | 45.0 | 38.5 | 35.0 | 6.2 | 7.8 | 11.3 | 21.9 |

**Analysis of Variance**

| Source of variation | Aphid Survival[c] | | | Nymphal Period | |
|---|---|---|---|---|---|
| | DF | Mean square | F ratio | Mean square | F ratio |
| Total | 47 | ... | ... | ... | ... |
| Blocks (B) | 2 | 6.3 | 1.80 | 12.4 | 0.85 |
| Temperature (T) | 3 | 10.1 | 2.88 | 211.1 | 14.55** |
| Error a | 6 | 3.5 | ... | 14.5 | ... |
| Clones (C) | 3 | 168.8 | 43.28** | 366.1 | 24.40** |
| Clones X temperature (C X T) | 9 | 4.2 | 1.07 | 35.1 | 2.34* |
| Error b | 24 | 3.9 | ... | 15.0 | ... |

[a] (R) designates clone was aphid resistant, (S) designates aphid susceptibility.
[b] Based on only one surviving individual at these temperatures (75, 65, 55°F).
[c] Analysis of variance based on number surviving out of 20, converted to percentage for presentation at top of table.
**Exceeds 0.01 level of significance.
*Exceeds 0.05 level of significance.

was not possible, but occasional checks indicated that humidities fluctuated between 60 and 75 per cent.

The experimental design belonged to the split-plot category, with the four-way split consisting of two aphid-resistant and two aphid-susceptible sweetclover clones. Three replications were accomplished by repeating identical tests.

Twenty newborn aphid nymphs, with a maximum age variation of 0 to 24 hours, were confined on each clone at each temperature for each test. Daily observations were made on rate of survival and time required to reach maturity. The test was concluded when all nymphs had either died or reached maturity.

Aphid survival was not influenced significantly by the temperatures used (Table 2). However, highly significant differences in aphid survival were produced by the resistant versus the susceptible clones. The length of the nymphal period was influenced significantly by temperature. At 55° F. more than 20 days were required for completion of the nymphal period, but at 85° F., it was completed in about 6 days. Thus, it would appear that high temperatures are favorable for aphid development and not responsible for the population reductions in the field during midsummer.

## NATURAL CONTROL OF THE SWEETCLOVER APHID

This part of the study was conducted entirely in the field, with the objective of discovering the factor or factors responsible for reducing sweetclover aphid populations during the midportion of the growing season. Possible influences centered around predators of the family Syrphidae, heavy rains, and temporary unsuitability of the host plants during the summer months. Other factors considered were the presence of other predators or parasites and the effect of temperature.

### Materials and Methods

Each spring between 1 and 2 acres of common yellow blossom sweetclover was seeded with a companion crop of oats. These fields were allowed to grow to maturity during the second year and new seeding was planted each spring adjacent to the one made the previous spring.

Aphid population samples were taken by the stem-count method, a procedure that Sifuentes and Young (18) considered most efficient when aphid populations were low. This method, satisfactory for sampling sweetclover aphid populations, was not satisfactory for pea aphids (*Acyrthosiphon pisum* (Harris)) the other aphid species present, because this species drops to the ground at the slightest disturbance. Ten stems were sampled in each of five locations. The stems were cut at the base and counts made in the field.

The plan was to study the effects of predators by attempting insecticidal control of predators in half the study field. The insecticide chosen to control predators was a 25% methoxychlor dust, shown by Howe and Pesho (7) to increase spotted alfalfa aphid populations in alfalfa observation nurseries. The material was applied with a rotary hand duster to the northern half of the field, because prevailing winds during the summer were from the south. Treatments were always made when the wind was not blowing from the north.

Predator populations were sampled with a 15-inch insect net. Aphids taken in the net were also counted because this was the only way relative abundance of the two aphid species (sweetclover aphid and pea aphid) could be determined.

A total of 100 evenly distributed sweeps was taken weekly in the treated and untreated area. The contents of the net were emptied into quart containers after each 25 strokes. At the laboratory the insects were killed with carbon tetrachloride, sorted, and counted. Sampling dates were selected to fall nearly halfway between treatment dates.

Parasitized aphids were easily spotted in the field by their characteristic mummified condition. These "mummies" along with the leaf to which they were attached, were placed in individual glass vials and held for parasite emergence.

Similarly, diseased specimens were easily detected because of discoloration. Diseased aphids were carefully removed from their leaves, placed in clean glass vials stoppered with cotton, and airmailed to the Insect Pathology Laboratory at Beltsville, Maryland, for pathogen identification.

Weather data used in these studies were taken at the U. S. Weather Bureau Station at the University of Nebraska Agronomy Farm. This station was located not more than 0.5 mile from the observation field.

## Results

### Parasites

Two species of parasites (*Trioxys utilis* Muesebeck and *Praon palitans* Muesebeck) were taken during the 3 years of observations (Figure 5). However, neither species was abundant enough to be considered an important controlling factor (Table 3). Also, it was evident that the methoxychlor had very little or no effect on the parasitic species.

Hyperparasitism was noted with the rearing of *Asaphes fletcheri* from an aphid which had been parasitized by *T. utilis*. Since *Praon* pupates beneath and *Trioxys* within the mummy, the parasite host in this record of hyperparasitism was easily identifiable. Hyperparasitism was observed only once and thus did not appear to have a controlling influence on the parasite.

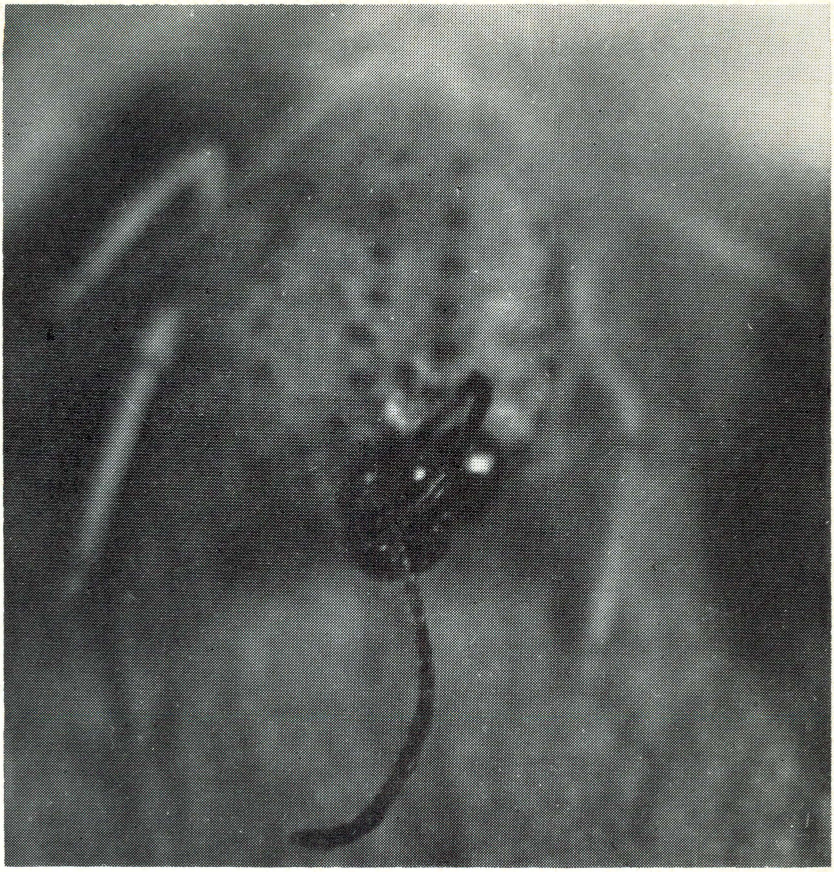

**Figure 5.** ***Trioxys utilis*** **Muesebeck emerging from a sweetclover aphid mummy (greatly enlarged).**

## Predators and Disease

Methoxychlor treatments for predator control were carried out every 7 to 10 days from mid-June to late September in 1960 and 1961. These treatments had a pronounced effect on the sweetclover aphid populations in the treated portion of the observation field (Table 4). The aphids were more numerous in the treated half of the fields during July and August of both years. Predator observations are summarized by months for the 2-year period in Table 5. Aphid counts, as measured by net sweeps, are also shown.

The pea aphid was the most abundant aphid during 1960, and was also affected by the insecticide treatment but was almost absent during the early part of the 1961 season. It was assumed that both species of aphids were equally acceptable as prey for the predators

**Table 3.** A 3-year record of sweetclover aphid parasites in the vicinity of Lincoln, Nebraska, from two areas, one receiving periodic methoxychlor treatments and the other untreated.

| Year | Date | Treatment[a] | Number of aphids examined | Number of mummies | Per cent parasitized | Rearing record |
|---|---|---|---|---|---|---|
| 1959 | September | None | ... | 6 | ... | 2 *T. utilis*[b] |
| 1960 | August 3 | C | 1 | 0 | 0 | 1 *Asaphes fletcheri*[b] |
| | | M | 134 | 3 | 2.1 | 2 *T. utilis* |
| | August 9 | C | 10 | 0 | 0 | |
| | | M | 126 | 1 | 0.8 | 1 *T. utilis* |
| | August 16 | C | 0 | 0 | 0 | |
| | | M | 5 | 1 | 16.6 | 1 *T. utilis* |
| 1961 | May 22 | C | 538 | 4 | 0.7 | 8 *T. utilis* |
| | | M | 1039 | 5 | 0.1 | 1 *P. palitans* |
| | May 29 | C | 216 | 2 | 0.9 | |
| | | M | 469 | 4 | 0.8 | 4 *T. utilis* |
| | June 5 | C | 152 | 1 | 0.6 | |
| | | M | 208 | 1 | 0.5 | 1 *P. palitans* |
| | August 7 | C | 56 | 0 | 0 | |
| | | M | 926 | 1 | 0.1 | |
| | October 2 | C | 109 | 1 | 0.9 | 1 *P. palitans* |
| | | M | 15 | 0 | 0 | |
| | October 13 | C | 618 | 3 | 0.5 | |
| | | M | 36 | 0 | 0 | |
| | October 24 | C | 156 | 1 | 0.6 | 1 *P. palitans* |
| | | M | 30 | 0 | 0 | |
| | November 2 | C | 174 | 1 | 0.6 | 1 *T. utilis*[c] |
| | | M | 49 | 0 | 0 | |
| | November 15 | C | 24 | 2 | 7.7 | 1 *T. utilis*[c]<br>1 *P. palitans*[c] |

[a] C = check, M = methoxychlor dust.
[b] Braconidae determined by C. F. W. Muesebeck, secondary parasite determined by B. D. Burks.
[c] No emergence–identification based on cocoon type.

Table 4. **Sweetclover aphid counts from first-year sweetclover fields, half of which received weekly methoxychlor treatments from mid-June to late September each year.**

| Date | Aphids per 10 stems from | | B-A | t Values |
|---|---|---|---|---|
| | Untreated Area (A) | Treated Area (B) | | |
| *1960* | | | | |
| June 27 | 1.6 | 4.0 | +2.4 | 0.983 |
| July 5 | 7.4 | 19.6 | +12.2 | 2.613* |
| 11 | 5.8 | 25.8 | +20.0 | 3.664** |
| 19 | 0.6 | 2.2 | +1.6 | 1.081 |
| 27 | 3.0 | 36.4 | +33.4 | 4.783** |
| Aug. 3 | 0.2 | 26.8 | +26.6 | 3.375** |
| 9 | 2.0 | 25.2 | +23.2 | 4.130** |
| 16 | 1.0 | 1.0 | 0 | 0.707 |
| 22 | 1.0 | 7.6 | +6.6 | 1.820 |
| 29 | 3.8 | 1.2 | –2.6 | –2.394* |
| Sept. 6 | 1.4 | 2.0 | +0.6 | 0.382 |
| 12 | 1.2 | 14.0 | +12.8 | 2.165 |
| 20 | 4.2 | 14.0 | +9.8 | 1.139 |
| 27 | 9.8 | 88.4 | +78.6 | 2.960* |
| Oct. 3 | 44.3 | 67.0 | +22.7 | 0.484 |
| 11 | 24.8 | 26.0 | +1.2 | 0.095 |
| 18 | 110.6 | 58.0 | –52.6 | –0.894 |
| 25 | 42.8 | 10.8 | –32.0 | –6.517 |
| *1961* | | | | |
| June 26 | 1.0 | 6.0 | +5.0 | 3.62** |
| July 3 | 2.2 | 3.0 | +0.8 | 0.26 |
| 10 | 0.4 | 5.0 | +4.6 | 2.82* |
| 17 | 4.2 | 8.6 | +4.4 | 1.19 |
| 24 | 22.8 | 66.4 | +43.6 | 6.18** |
| 31 | 28.8 | 86.4 | +57.6 | 3.55** |
| Aug. 7 | 11.2 | 185.2 | +174.0 | 4.40** |
| 14 | 0.6 | 35.4 | +34.8 | 3.33* |
| 21 | 1.4 | 41.6 | +40.2 | 3.51** |
| 28 | 3.8 | 42.8 | +39.0 | 6.39** |
| Sept. 5 | 10.6 | 55.6 | +45.0 | 3.33* |
| 15 | 8.6 | 18.6 | +10.0 | 1.98 |
| 19 | 7.4 | 6.6 | – 0.8 | –0.30 |
| 26 | 29.2 | 3.2 | –26.0 | –4.48** |
| Oct. 2 | 21.8 | 1.0 | –20.8 | –7.61** |
| 13 | 123.6 | 6.6 | –117.0 | –4.63** |
| 24 | 31.2 | 6.0 | –25.2 | –3.21* |

*Exceeds the 0.05 level of significance.
**Exceeds the 0.01 level of significance.

observed. A third aphid species, *Aphis craccivora,* was taken only on isolated occasions in very low numbers.

Insects of the family Coccinellidae were the predators most affected by the insecticide. Control even of this group of predators was far from complete. The species of Coccinellidae present along with their mean abundance each year are shown in Table 6. The species most abundant (*Hippodamia convergens*) in both years appeared to be the one least affected by the insecticide.

The species influenced to the greatest extent by the treatment in 1960 (*Coleomegella maculata*) was present in more or less negligible

**Table 5. Summary, by months, of aphid and predator counts in first-year sweetclover which had and had not been treated with methoxychlor dust (25%) for predator control.**

| Insect | Treatment | Number of insects per 100 sweeps | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1960 | | | | | | | 1961 | | | | | | |
| | | June | July | Aug. | Sept. | Oct. | Nov.[a] | Mean | June | July | Aug. | Sept. | Oct. | Nov.[a] | Mean |
| *Aphids* | | | | | | | | | | | | | | | |
| *A. pisum* | Check | 546 | 5 | 1 | 18 | 62 | 68 | 98 | 0 | 0 | 0 | 1 | 120 | 309 | 34 |
| | Dust | ... | 214 | 573 | 2995 | 84 | 2 | 891 | 1 | 0 | 0 | 9 | 577 | 1563 | 166 |
| *T. riehmi* | Check | 5 | 4 | 5 | 1 | 1 | 8 | 3 | 0 | 174 | 133 | 69 | 660 | 547 | 187 |
| | Dust | ... | 121 | 24 | 2 | 38 | 2 | 43 | 1 | 202 | 398 | 162 | 100 | 53 | 172 |
| *Predators* | | | | | | | | | | | | | | | |
| Coccinellidae[b] | Check | 42 | 19 | 9 | 2 | 1 | 12 | 13 | 11 | 8 | 10 | 2 | 23 | 15 | 11 |
| | Dust | ... | 1 | 5 | 2 | 0 | 2 | 2 | 5 | 4 | 12 | 4 | 4 | 3 | 5 |
| Nabidae[b] | Check | 9 | 22 | 16 | 5 | 10 | 0 | 12 | 8 | 15 | 17 | 7 | 24 | 12 | 14 |
| | Dust | ... | 18 | 49 | 12 | 10 | 2 | 23 | 8 | 19 | 22 | 7 | 34 | 15 | 18 |
| Chrysopidae[b] | Check | 3 | 4 | 1 | 1 | 0 | 0 | 1 | 19 | 5 | 2 | 1 | 7 | 0 | 7 |
| | Dust | ... | 2 | 0 | 1 | 0 | 0 | <1 | 10 | 5 | 6 | 4 | 2 | 1 | 5 |
| Syrphidae[c] | Check | 2 | 2 | 3 | 1 | 1 | 0 | 2 | 1 | 0 | 5 | 1 | 4 | 1 | 2 |
| | Dust | ... | 13 | 8 | 1 | 4 | 2 | 6 | 1 | 0 | 9 | 2 | <1 | 0 | 3 |
| Cantharidae[b] | Check | 0 | 0 | <1 | 0 | 0 | 0 | <1 | 0 | 0 | <1 | 0 | 0 | 0 | <1 |
| | Dust | ... | 0 | 0 | 0 | 0 | 0 | <1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Anthocoridae[b] | Check | 0 | 0 | 9 | <1 | 0 | 0 | 2 | 5 | <1 | 33 | 5 | 2 | 6 | 9 |
| | Dust | ... | 0 | 5 | <1 | 0 | 0 | 1 | <1 | <1 | 14 | 20 | 2 | 0 | 6 |
| Reduviidae[b] | Check | 0 | 0 | 0 | 1 | 1 | 0 | ... | 0 | 1 | 6 | 2 | 1 | 2 | 2 |
| | Dust | ... | 0 | 0 | 1 | 4 | 0 | 1 | 0 | <1 | 4 | <1 | 0 | 2 | 1 |

[a] Result of only one sample which was taken during first week of Nov. each year.
[b] Adults and nymphs or larvae.
[c] Adults only.

**Table 6. Species composition of adult Coccinellidae taken in untreated and methoxychlor dusted first-year observation fields over a 2-year period.**

| Species | Treatment | Number per 100 sweeps | |
|---|---|---|---|
| | | 1960 | 1961 |
| *Hippodamia convergens* Guérin-Méneville | Check | 7.0 | 13.8 |
| | Dust | 7.3 | 8.6 |
| *H. parenthesis* (Say) | Check | 0 | 9.0 |
| | Dust | 0 | 3.0 |
| *H. tredecium-punctata tibialis* (Say) | Check | 1.0 | 1.3 |
| | Dust | 0.3 | 2.5 |
| *Coleomegella maculata* (De Geer) | Check | 11.7 | 2.0 |
| | Dust | 0.3 | 0.8 |
| *Cycloneda munda* (Say) | Check | 0 | 0.2 |
| | Dust | 0 | 0.2 |

numbers during 1961, but the species reduced most by the methoxychlor dust in 1961 (*H. parenthesis*) was totally absent from the observation fields the year before. The other two species observed were not abundant either year.

The two species of Nabidae present, *Nabis alternatus* Parshley and *N. roseipennis* Reuter, tended to be either equally distributed or more abundant in the treated area.

Chrysopidae were more abundant during 1961 than during 1960, but were not greatly reduced by the insecticide during either year. Chrysopidae species detected were *Chrysopa oculata* Say and *Chrysopa carnea* Steph.

Populations of the Syrphidae present consisted entirely of the non-predaceous adults. Larvae were rarely found in the observation fields and never taken during the course of the regular observations. At least four species of Syrphidae with predaceous habits were observed: *Mesograpta marginata* (Say), *Allograpta obliqua* (Say), *Sphaerophoria cylindrica* (Say), and *Syritta pipiens* (Linnaeus).

The Anthocoridae represented by *Orius insidiosus* (Say) were so sporadic in their appearance that their importance as predators was difficult to evaluate. The remaining two predaceous groups observed were not at all abundant and each was represented by one species of Reduviidae—(*Sinea diadema* (Fabricius)) and one of Cantharidae—(*Chauliognathus marginatus* (Fabricius)).

Partial predator control seemed adequate to explain the increased aphid populations in the treated area. However, there were periods during both years when aphid numbers in the treated area were so reduced that they were significantly less than in the check area (Table 4). This reduction was the result of a pathogenic fungus, *Entomophthora sphaerosperma* Fresenius, which was almost exclusively present in the treated area (Table 7).

A comparison of disease incidence (Table 7) with aphid counts (Table 4) indicates that the reduction of aphid numbers in the treated

**Table 7. Sweetclover aphids killed by a fungus, *Entomophthora sphaerosperma* in an area treated with methoxychlor for predator control and in an adjacent untreated area over a 2-year period. The only observation dates included are those on which at least one diseased aphid was detected.**

| Date | | | Methoxychlor | | Check | |
|---|---|---|---|---|---|---|
| | | | Number diseased | Per cent diseased | Number diseased | Per cent diseased |
| *1960* | | | | | | |
| | August | 3 | 11 | 7.6 | 0 | 0 |
| | | 9 | 39 | 23.6 | 0 | 0 |
| | | 16 | 42 | 89.3 | 0 | 0 |
| | | 22 | 18 | 32.2 | 0 | 0 |
| | | 29 | 16 | 72.7 | 0 | 0 |
| | October | 25 | 1 | 1.8 | 8 | 3.6 |
| *1961* | | | | | | |
| | June | 5 | 2 | 0.9 | 0 | 0 |
| | July | 24 | 1 | 0.3 | 0 | 0 |
| | | 31 | 1 | 0.2 | 2 | 1.4 |
| | August | 7 | 17 | 1.8 | 0 | 0 |
| | | 14 | 4 | 2.2 | 0 | 0 |
| | | 21 | 2 | 0.9 | 0 | 0 |
| | | 28 | 81 | 27.5 | 0 | 0 |
| | September | 5 | 90 | 24.5 | 0 | 0 |
| | | 15 | 56 | 37.6 | 0 | 0 |
| | | 19 | 53 | 61.6 | 1 | 2.6 |
| | | 26 | 14 | 46.6 | 0 | 0 |
| | October | 2 | 10 | 66.6 | 15 | 12.0 |
| | | 13 | 5 | 12.2 | 11 | 1.7 |

area coincided with a high incidence of disease in that area, except for the latter part of October 1960. During October and November of 1960, disease incidence in pea aphids, quite high in the treated area, was responsible for the reduction of pea aphid populations, as shown in Table 5.

Diseased sweetclover aphids might also have been present at that time and confused with diseased pea aphids, resulting in the omission of the disease record for the sweetclover aphid. The fungus appeared at different times in the 2 years, but each time it was confined almost exclusively to the treated area where aphid populations were higher.

## Effect of Rainfall and Temperature

In Figures 6 and 7 the sweetclover aphid populations for the two seasons are plotted graphically, along with the corresponding rainfall and temperature records.

In 1960 (Figure 6) there were six rains which exceeded the 1-inch mark. Almost every time they were followed by aphid population reductions. In the treated area (with fewer predators) the reductions, such as the one occurring in mid-July, were temporary in nature.

During 1961 (Figure 7) an even greater number of rains over the 1-inch mark occurred. The first of these fell on May 4 with no noticeable effect. The second fell on May 17, with a reduction noted in the

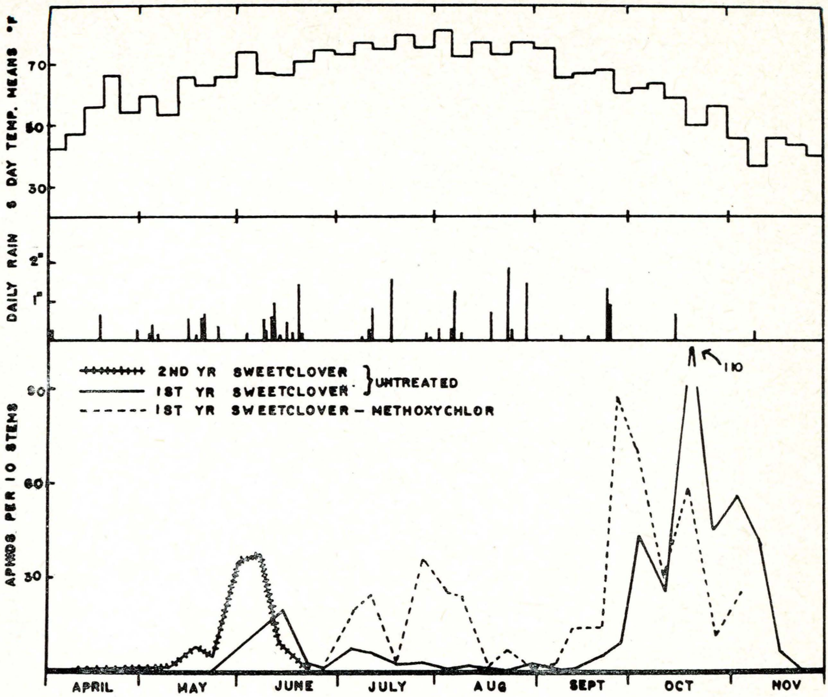


**Figure 6. Seasonal activity of the sweetclover aphid with corresponding temperature and rainfall records. Lincoln, Nebraska. 1960.**

population on first-year but not on second-year plants. This lack of change on second-year plants may have resulted from the greater protection these larger plants afforded the aphids. The third on the 12th of June occurred at the time of general aphid decline. The fourth and fifth heavy rains occurred close together on the 19th and 23rd of August during a period of general population decline, but a quick recovery was made particularly in the treated area. The sixth and seventh heavy rains occurred as one storm on the 12th and 13th of September, and coincided with a temporary halt in population buildup rather than an actual decline. The eighth heavy rain occurred on October 10 immediately before the fall peak population began declining. In the ninth and final storm of the season on November 16, precipitation occurred in the form of rain and snow.

Thus, heavy rains were associated with adverse effects on populations of the sweetclover aphid but did not appear responsible for the low numbers of aphids during the summer months.

Each year aphid activity began when mean temperatures were fluctuating around 50° F. At times and under normal conditions peak populations occurred before and after the period of highest seasonal

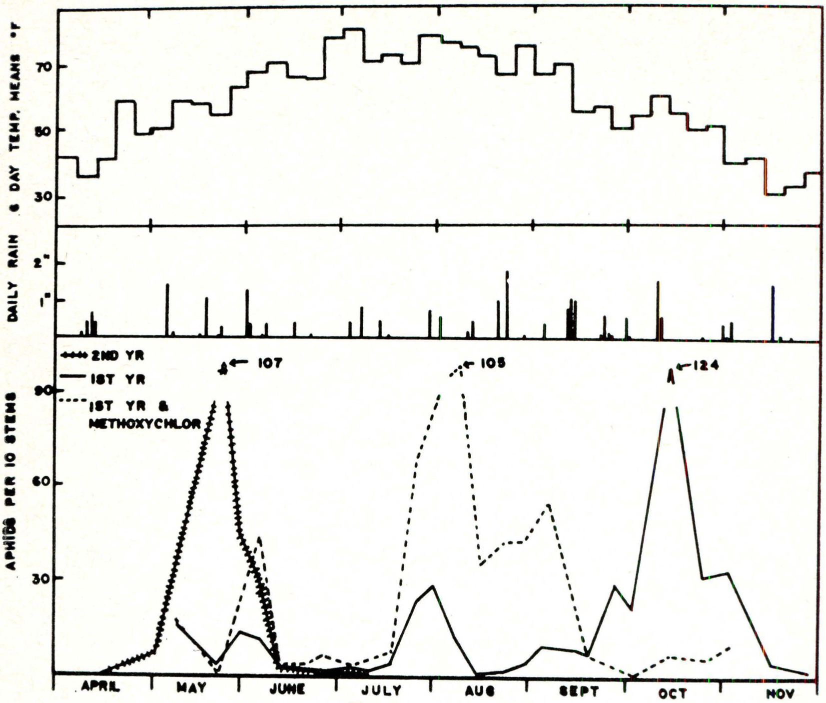


**Figure 7. Seasonal activity of the sweetclover aphid with corresponding temperature and rainfall records. Lincoln, Nebraska. 1961.**

temperatures. However, during 1960 and 1961 in the areas treated for predator control, heavy aphid populations were present when the highest mean temperatures were recorded.

## DISCUSSION

Sweetclover aphid population fluctuations during a season in Nebraska appear to follow the same pattern reported for Kansas and Minnesota. As in those states, predators appeared to be chiefly responsible for low aphid populations between the spring and fall peaks. Kieckhefer (8) also reported this observation but also implicated heavy rains.

In the experiments reported here, heavy rains adversely affected aphid populations; but when these rains occurred at times of low predator activity, their effect was temporary. Thus, it does not appear that rain alone would reduce aphid populations for long periods.

Furthermore, the suggestion of Grable (4) that a temporary unsuitability in the host plant was responsible for low summer populations does not appear to explain the results of the present study in which aphid populations were increased in midsummer by controlling predators with an insecticide and without altering the condition of the host plant.

The concept of using an insecticide to measure the efficacy of entomophagous insects was first proposed by DeBach (2), who evaluated scale insect predators by the use of DDT. Many authors (Hill and Tate (5), Hill (6), and Goodarzy and Davis (3)) reported that use of certain insecticides was followed by increases in aphid populations. The use of an insecticide to control predators proved to be a useful tool in studying the causes of sweetclover aphid population fluctuations.

In his studies Kieckhefer found syrphid flies to be the most important predators of the sweetclover aphid in Minnesota during 1956 and 1957. Grable (4), working in the same area during 1960-61, rarely found Syrphidae in the sweetclover fields.

In the present study syrphids seemed to be unimportant since their larvae were rarely found, and Coccinellidae appeared to be most important. However, the species present and their relative abundance were not the same for both years. Thus it is apparent that the overall composition of predator populations changes considerably from year to year for any given locality.

Parasites of the sweetclover aphid did not play a very important role in the natural control of the aphid. It is of interest to note that the two species of parasites reared from the sweetclover aphid were species introduced into this country from Europe for spotted alfalfa aphid control. It is of further interest to note that, at least one of them, *Trioxys utilis,* appeared to be present in Nebraska even before the recent European introductions (Muesebeck (12)).

Though these parasite species appeared to be ineffective in controlling the sweetclover aphid during the present 3-year study, both were reported as effective parasites of the spotted alfalfa aphid in California (Schlinger and Hall (15, 16, 17)). These authors listed *Therioaphis maculata* as the preferred host and other hosts as *T. trifolii* and *T. riehmi.* Grable (4) reported *T. utilis* to be an important parasite of the sweetclover aphid in Minnesota. The parasitism of *T. utilis* by *Asaphes fletcheri* has not been reported before.

One of the most interesting aspects of the present study was the appearance of the entomophagus fungus, *Entomophthora sphaerosperma* in the area where predators were controlled with methoxychlor but not in the check area. Aphid populations were much higher in the treated areas and most likely were responsible for the spread of fungus.

According to Ullyet and Schonken (20), humidity is the important factor in the epidemiology of *E. sphaerosperma.* But humidity cannot account for the differences between the methoxychlor-treated and the untreated plots in incidence of this disease. That host density is important in disease spread and that a minimum host population density is necessary for disease maintenance are not new concepts; literature on the subject is reviewed by Steinhaus (19).

Thus, a variety of natural factors exert some degree of control upon the sweetclover aphid. Predators appear most important, but the principal species apparently change from year to year and from locality to locality. Heavy rains may contribute to aphid control, especially when predators are present. Furthermore, when insecticide treatments upset the predator-aphid ratio, as reported here, a pathogenic fungus becomes an impotant natural factor in reducing aphid populations. This complex of factors, rather than any single factor, appears responsible for the rather consistent natural control of the sweetclover aphid during the summer months.

## LITERATURE CITED


1. BORNER, CARL
   1949. Kleine Bertrage zur Monographie de europaischen blaltlause. Bertrage zur taxonomishen Zoologie 1:44–62. (In German)
2. DE BACH, P.
   1946. An insecticidal check method for measuring the efficacy of entomophagous insects. Jour. Econ. Ent. 39(5):695–697.
3. GOODARZY, K., AND DAVIS, D. W.
   1958. Natural enemies of the spotted alfalfa aphid in Utah. Jour. Econ. Ent. 51(5):612–616.
4. GRABLE, A. E.
   1962. Seasonal abundance of principal phytophagous insects of first-year yellow sweetclover, (*Melilotus officinalis* (L.) Lam) in Minnesota. Master's thesis, University of Minnesota (Unpublished) 104 pp.
5. HILL, R. E., AND TATE, H. D.
   1943. Increases in aphid populations on potato plants sprayed with zinc arsenite in western Nebraska. Jour. Econ. Ent. 36(1):63–66.
6. HILL, R. E.
   1945. Effects of DDT and other insecticides on several species of potato insects. Nebr. Expt. Sta. Res. Bul. 138, 14 pp.
7. HOWE, W. L., AND PESHO, G. R.
   1960. Spotted alfalfa aphid resistance in mature growth of alfalfa varieties. Jour. Econ. Ent. 53(2):234–238.
8. KIECKHEFER, R. W.
   1958. The biology of *Therioaphis riehmi* (Borner). Master's thesis, University of Minnesota (Unpublished) 54 pp.
9. MACNARY, C. G.
   1959. Summary of important insect infestations, occurrences and damage in agricultural areas of Canada in 1958. Annual Rept. Ent. Soc. Ontario 89:73–87.
10. MANGLITZ, G. R., AND GORZ, H. J.
    1961. Resistance of sweetclover to the sweetclover aphid. Jour. Econ. Ent. 54(6): 1156–1160.
11. MANGLITZ, G. R.
    1961. Insects and sweetclover seedlings. Nebraska Experiment Station Quarterly 7(4):23.

12. Muesebeck, C. F. W.
1956. Two new parasites of the yellow clover aphid and the spotted alfalfa aphid (Hymenoptera: Braconidae). Bul. Brooklyn Ent. Soc. 51(1):25–28.
13. Peters, C. D., and Painter, R. H.
1957. A general classification of available small seeded legumes as hosts for three aphids of the "Yellow clover aphid complex." Jour. Econ. Ent. 50(3):231–235.
14. Peters, D. C., and Painter, R. H.
1958. Studies on the biologies of three related legume aphids in relation to their host plants. Kansas Expt. Sta. Tech. Bul. 93, 44 pp.
15. Schlinger, E. I., and Hall, J. C.
1960. The biology, behavior, and morphology of *Praon palitans* Muesebeck, an internal parasite of the spotted alfalfa aphid, *Therioaphis maculata* (Buckton) (Hymenoptera; Braconidae, Aphidiinae) Ann. Ent. Soc. Amer. 53(2): 144–160.
16. Schlinger, E. I., and Hall, J. C.
1960. Biological notes on Pacific coast aphid parasites, and lists of California parasites (Aphidiinae) and their aphid hosts (Hymenoptera: Braconidae). Ann. Ent. Soc. Amer. 53(3):404–415.
17. Schlinger, E. I., and Hall, J. C.
1961. The biology, behavior, and morphology of *Trioxys* (*Trioxys*) utilis, an internal parasite of the spotted alfalfa aphid, *Therioaphis maculata* (Hymenoptera: Braconidae, Aphidiinae). Ann. Ent. Soc. Amer. 54(1):34–45.
18. Sifuentes, J. A., and Young, W. R.
1960. El pulgon manchado de la alfalfa y su combate en el valle del Yagui. Agricultura Technica en Mexico. Invierno 1959–60. No. 9:18–22. (In Spanish)
19. Steinhaus, E. A.
1954. The effects of disease on insect populations. Hilgardia 23 (9):197–261.
20. Ullyett, G. C., and Schonken, D. B.
1940. A fungus disease of *Plutella maculipennis* Curt. in South Africa, with notes on the use of entomogenous fungi in insect control. Union South Africa, Dept. Agri. and Forest. Science Bul. 218, 24 pp.