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STUDIES ON THE LIFE HISTORY AND HABITS OF THE BEET LEAFHOPPER[1]

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INTRODUCTION

Much has been published concerning the distribution and history of the beet leafhopper and its relation to the curly-top disease of sugar beets, but no complete account of its life history and habits has appeared. The present paper gives a brief summary of observations bearing on these points made during the past few years at Jerome, Idaho, and in the sugar-beet growing regions of California.

DESCRIPTION

EGG

The egg when first laid is transparent, elongate, and slightly curved. The posterior end tapers gradually almost to a point. Length 0.0612 to 0.0696 mm.; average width 0.0182 mm.

As the embryo develops, faint spots which later become conspicuous eye spots appear on either side of the anterior end. During development the color of the egg changes from white to lemon yellow with a slight tinge of green.

NYMPH

The recently hatched nymph is nearly transparent, with a light yellow tinge in the thorax and abdomen. The antennæ are hairlike and more than half as long as the body. The head is wider than the thorax or abdomen and is the most distinctive characteristic of this instar.

After the first molt the nymph is more slender and the head and antennæ are not nearly so conspicuous. Average length 1.40 mm.; width 0.45 mm. Color usually milky white with a green tinge. Faint brown blotches may be distinguished on the thorax.

In the third instar there is more variation in the coloring. General color varying from yellow with light brown markings to almost black. The pattern made by the brown blotches does not seem to be constant, but the denser coloration on the thorax has been designated as a "saddle" (*3, p. 21*).[2] Length 1.99 mm.

[1] *Eutettix tenella* Baker, suborder Homoptera, family Jassidae.

[2] Reference is made by number (italic) to "Literature cited," p. 252.

The color variations in the fourth instar are similar to those of the third. A red coloration is often observed. The spines on the legs are more conspicuous than formerly, and the wing pads extend to the dorsal margin of the third abdominal segment. Length 2.30 mm.

After the fourth molt the nymph has a slender appearance and is nearly the size of the adult. The wing pads extend approximately to the dorsal margin of the fourth abdominal segment. Length 3.2 mm.

ADULT

In California, during the summer, adults of this species may be collected showing a gradation in color from light green with no markings to dark gray with numerous markings on the elytra (Pl. 42, A–C). In the fall the percentage of dark forms is much larger, and during the winter it is unusual to find a light form. Some of the winter forms appear almost black.

The following color details are given to show, to some extent, the extreme contrast in coloration:

LIGHT FORM (Pl. 42, A).—Front yellow, with faint, light brown, transverse stripes. Eyes gray, with occasional brown spots. Vertex green and lemon yellow, the yellow predominating. Pronotum green. Scutum deep yellow. Elytra hyaline with light brown venation. No pigment in the elytra. Tergum appearing as dark bands through the folded elytra.

DARK FORM (Pl. 42, B).—Front yellow, with irregular, testaceous, transverse bands. Eyes a mixture of red and brown, red usually predominating. Vertex fulvous, apical portion with a white band cut in center by a narrow dark band. Pronotum olive, except for ivory anterior band with several black spots. Scutellum with two square, black spots at basal angles. Elytra subhyaline, marked with black about as follows: Two large, almost circular spots on corium; apical portion and irregular black blotches on claval region. Nervures dark brown, with dark pigment on each side forming irregular bands.

RESEMBLANCE TO OTHER SPECIES

There should be little difficulty in distinguishing the beet leafhopper from other leafhoppers commonly found on sugar beets in California. Occasionally the darkest forms resemble some species of Agallia in coloration, but even a superficial examination will be sufficient to separate these two genera. These species of Agallia do not have the slender appearance of the beet leafhopper and are much slower in their movements. After a little experience in collecting it is possible to distinguish between the two genera by their movements. *Eutettix tenella* rarely, if ever, feigns death when disturbed; but some of the species of Agallia are almost certain to fall over on their backs and lie for some time as if dead. This habit is often an aid in collecting when the leafhoppers are not abundant and a careful search is necessary. One species, *Cicadula 6-notata* Fallen, may often be confused with the beet leafhopper, especially when individuals of the latter are mainly of the green coloration. The six spots on the vertex of *C. 6-notata* are usually plainly evident, however, and will serve to distinguish this species from *E. tenella*.

LIFE HISTORY AND HABITS

REPRODUCTION

During the summer season mating occurs within a few days after the last molt is accomplished, but during the fall this period is greatly prolonged. In Idaho adults were observed copulating in cages during the late fall as well as during the summer season. At Spreckels, Calif., mating continued throughout the winter. Unfertilized females have been known to lay sterile eggs under certain conditions, but parthenogenesis has never been observed.

The preoviposition period is comparatively long. In all experiments 15 to 17 days elapsed between the date the female reached maturity and the date the first eggs were laid. A much longer period is common, especially during the winter and early spring.

OVIPOSITION

Under normal conditions the eggs of the beet leafhopper are usually placed in the petiole or midrib of the sugar-beet leaf, beneath the fibrous strands and at a slight angle. They are invariably deposited one at a time, but often they are arranged in rows of from two to five, placed end to end so that they give the appearance of overlapping. It is almost impossible to find the recently deposited eggs in the petioles; but after the embryo has developed a little and the eye spots have appeared they are comparatively conspicuous. When deposited in the leaf tissue the eggs are more easily detected by the raised areas on the leaf surface. By transmitted light eggs in this position appear as small, transparent slits.

While apparently preferring the sugar beet as a plant in which to deposit its eggs, this leafhopper will oviposit in a large number of other plants. Fleshy or succulent species offer the most suitable conditions for oviposition. Russian thistle (*Salsola kali* var. *tenuifolia*), filaree (*Erodium cicutarium* and *E. moschatum*), *Chenopodium* spp. (especially *murale*), and *Atriplex* spp. are plants from which eggs have been most commonly noted hatching under natural conditions. Most perennial plants are too tough and woody to be suitable for this purpose, and it is doubtful if they are of any great importance as hosts during the egg-laying period.

Ball (*2*, *p. 40*) records the number of eggs deposited by a single female of this species as about 80. At Spreckels, Calif., the maximum number of eggs deposited by one female was 237, while at Riverside, Calif., the maximum was 247. Many difficulties were encountered in the conduct of these experiments, and it is probable that, given more favorable conditions, the females might have deposited a larger number of eggs.

Meteorological conditions influence greatly the incubation period. A maximum period of 52 days has been observed during the early spring and a minimum of 10 under most favorable conditions. During the

height of the egg-laying season the incubation period ranged from 10 to 15 days.

Seasonal variations in the development of the nymph are wide, due mainly to differences in temperature and food supply. The entire nymphal period ranged from 25 to 52 days, while from 4 to 10 days were required for the completion of each instar.

NUMBER OF GENERATIONS

Ball (*1, p. 93; 3*) states that the beet leafhopper is a single-brooded species and implies that such is the case for conditions even as far south as Glendale, Ariz. Experiments conducted at Spreckels, Calif., demonstrated that there were unquestionably at least two generations annually in that locality. Under conditions more favorable than was usual for this part of the Salinas Valley, a third and even a fourth brood were obtained. There was only one brood on sugar beets in southern Idaho, but it seems probable that further investigation would reveal an additional brood, possibly on the wild vegetation.

LONGEVITY OF ADULTS

Under natural conditions it is doubtful if the normal length of life of the adult is more than 4 or 5 months. Fall-brood adults are not found in the fields during the summer, and the spring brood is rarely noted in the fall. Females have been kept alive in cages for 19 months, but it is doubtful if they would ever survive so long under field conditions.

SEASONAL HISTORY

IN SOUTHERN IDAHO

Although persistent effort was made to locate adults of the beet leafhopper during the winter and early spring in southern Idaho, they were not observed until their appearance on the sugar beets. The earliest record for this was June 6, 1914, when several individuals were collected on volunteer sugar-beet plants at Jerome. Apparently the leafhoppers are in the cultivated fields as soon as the beets are up.

Oviposition begins in the field as soon as the adults appear. Records have been made as early as June 22, when the beets were still young and had not yet been thinned. June 28 was the earliest hatching record obtained in cage experiments. Starting thus, early in June, oviposition continues throughout the season until late in October.

During 1913 adults were not observed copulating until late in the fall. On October 12, a large number of adults confined in a lantern globe were noted copulating for several days. During the one winter spent by the writer in this district only a few adults placed in cages in the fall survived the winter, and all of these were females. These observations indicate that the females are fertilized in the fall before hibernation and that a large percentage of males perished during the winter.

Weather conditions were severe enough during the winter in this district to necessitate hibernation. All attempts to determine the method of hibernation, however, as well as the places in which it takes place were failures. Adults in cages survived the winter underneath dead beet leaves and in the crown of the plant.

IN CALIFORNIA

Under California conditions adults and nymphs are most abundant in the field during August. At harvest time they are scattered, and no doubt a large number perish. After the beets have all been removed from the fields the leafhoppers seem to be greatly diminished in numbers, although they may be collected from certain weeds growing in the fields and along the irrigating canals. No indications of a general migration have been noted at such times, so it is assumed that the surviving individuals scatter over wild vegetation, selecting that which is most suitable for food and protection. Later they may congregate in certain spots which furnish especially favorable conditions during winter.

There is no true hibernation in the districts of California that have been under observation. Adults have been collected every week in the winter under conditions indicating that they were feeding when captured. Under cage conditions food must be available at all times. As a rule, all individuals kept without food died within 48 hours.

The characteristic dark-colored individuals of the fall brood that leave the beet fields could hardly be confused with the light-colored adults that appear the next spring. A small percentage of the fall-brood adults may remain in or near the beet fields during the winter and be responsible for the early injury in the spring, but it is usually not until the light forms appear in considerable numbers that attention is directed to the damage. The striking difference in coloration between the fall and spring forms suggests at once the possibility of a new brood on wild vegetation before migration into the beet fields. Observations and cage experiments have proved that such a brood occurs.

The time when the leafhoppers first appear in fields in spring in California varies with the seasonal conditions in different localities, being from April 1 to June 1. The condition of wild vegetation in the natural breeding areas is an important factor in determining when migration to the beet field will take place. As long as this vegetation is abundant and succulent it is doubtful if there is any general movement into the cultivated areas.

Oviposition begins as soon as the adults appear in the field and continues throughout the season. There is an overlapping of broods which makes it impossible to determine the exact number under field conditions. Cage experiments, however, have demonstrated that there may be from one to three each year on the beets. Thus the maximum number of broods in one year would be four.

NATURAL ENEMIES

EGG PARASITES

The following three species of egg parasites have been reared from the beet leafhopper and studied to some extent. They are given in the order of their importance.

POLYNEMA EUTETTIXI GIRAULT (*4, p. 18*) (PL. 43, A).—This small brown or black species was first reared from eggs of *Eutettix tenella* at Spreckels, Calif., early in 1915 and has proved to be the most effective parasite of this group in the Salinas Valley. Eggs parasitized by this species are conspicuous in the petioles of the beets because of the black color of the parasite pupæ. Development is rapid, the life cycle from adult to adult covering about 35 days on an average, and there are at least nine generations annually.

ABBELLA SUBFLAVA GIRAULT.—Concerning this parasite W. J. Hartung (*5*) writes as follows:

> Hyper-parasites were bred from parasitized eggs of Eutettix. These were determined by Girault as *Abbella subflava* Girault.

This species[1] was never found among the parasites reared from material collected at Spreckels, Calif., but at Riverside it was reared in about equal numbers with *Polynema eutettixi*.[1] It is a primary parasite, ovipositing readily in eggs of the beet leafhopper. It has also been reared from eggs of *Empoasca* sp.

ANAGRUS GIRAULTI CRAWFORD.—This common orange or red jassid egg parasite has been reared in each locality where parasite studies have been conducted. It oviposits readily in eggs of the beet leafhopper and is usually reared along with *Polynema eutettixi*, but not in such large numbers. The presence of this species in the petioles of the beet can be detected by the red or orange color found in both larva and pupa.

PARASITES OF THE NYMPHS AND ADULTS

As previously reported by Hartung and Severin (*6*), two species of the dipterous family Pipunculidae are known to be parasitic on the nymphs and adults of the beet leafhopper. These have been described (*7*) as *Pipunculus industrius* Knab and *Pipunculus vagabundus* Knab. The former is the more common species in the Salinas Valley.

PIPUNCULUS INDUSTRIUS KNAB (PL. 43, B).—Eggs of this species are deposited in both nymphs and adults of the beet leafhopper, but mature larvæ have never been known to emerge from a nymph. There are no indications that the adult female prefers either the mature or immature stages of the host in which to deposit her eggs, very small parasitic larvæ having been dissected in about equal numbers from both stages. It is known, by dissection, that eggs may be deposited in small nymphs

[1] Specimens identified by Mr. A. B. Gahan.

no further developed than the third instar. In all instances, however, where an action thought to be oviposition was observed, the adult host was the victim.

The adult is very graceful in flight, darting here and there so suddenly that it is impossible to follow the movements with the eye. The beet leafhopper, also, is very quick in its movements, but none is quick enough to avoid this active little parasite.

PIPUNCULUS VAGABUNDUS KNAB.—This species is not common in the Salinas Valley and is of little importance. Its habits are similar to those of *Pipunculus industrius*, and, with the exception of the conspicuous stigma which is absent in the wings of *P. vagabundus*, the two species are similar in appearance.

DRYINIDAE.—Occasionally beet leafhoppers, both adults and nymphs, are found with a dark brown sac or pouch protruding from the abdomen (Pl. 42, D). This pouch contains the larva of a dryinid parasite. Hartung and Severin (*6*) report a parasite of this family, *Gonatopus contortulus* Patton, from the Salinas Valley. Although the writer has reared many specimens of this family, none has been determined. Judging from the number of parasitized leafhoppers collected, these dryinids are not of much economic importance. It has been observed, however, that the adults devour a larger number of the leafhoppers, especially nymphs, than they parasitize. In this way they may be of more importance than would at first appear.

SUMMARY

Eggs of *Eutettix tenella* are deposited in a wide range of cultivated and wild plants, but the sugar beet seems to be preferred for this purpose during the summer season. A maximum record of 247 eggs was obtained for a single female. The incubation period covered from 10 to 15 days during the height of the egg-laying season and the nymphal period from 25 to 52 days.

One generation only was observed in southern Idaho, while from two to four were observed under California conditions.

In southern Idaho the beet leafhopper appears in the beet fields in June and starts reproducing at once, oviposition continuing throughout the season. After harvest the leafhoppers enter a true hibernation period.

In California the adults appear in the beet fields soon after April 1 and remain until harvest time, when they disperse to wild vegetation suitable for food and protection. No true hibernation was noted in California.

Three species of egg parasites were reared and studied. Two of these are very effective. Two species of Pipunculus, internal parasites of the nymphs and adults, were reared; and one of these was quite effective. Dryinid parasites, also, were reared but are not considered very efficient.

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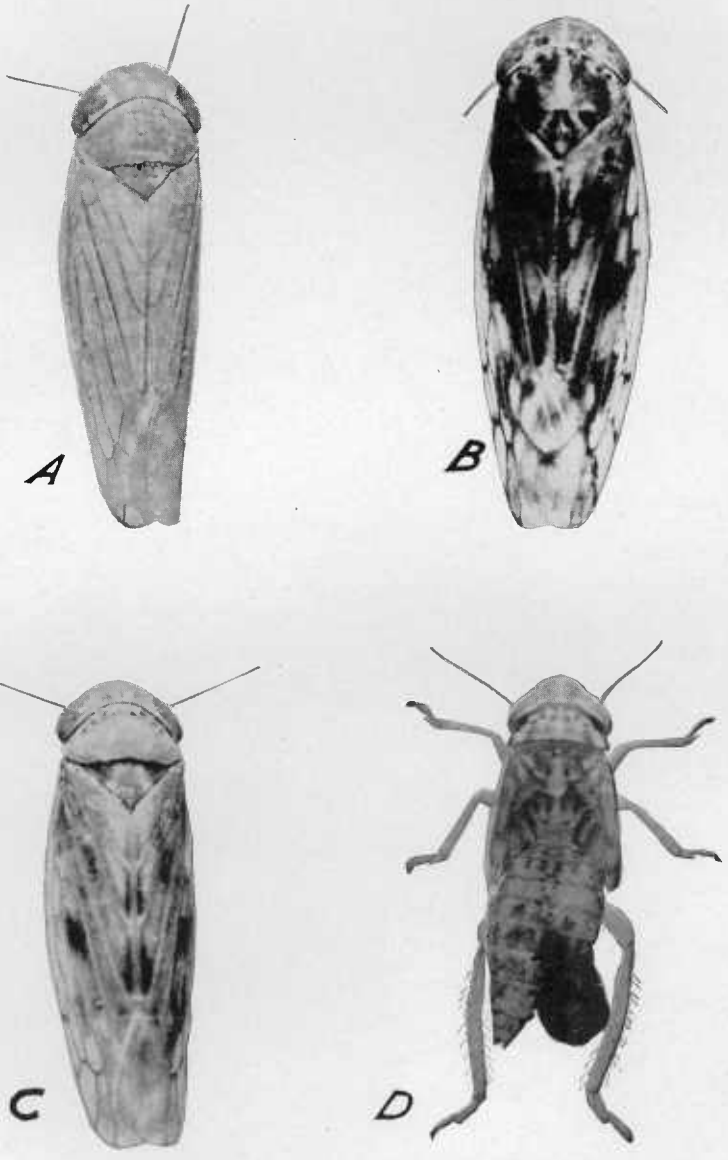
PLATE 42

Eutettix tenella:

A.—Adult, light form.
B.—Adult, dark form.
C.—Adult, color gradation between A and B.
D.—Nymph with protruding sac of dryinid parasite.
All much enlarged.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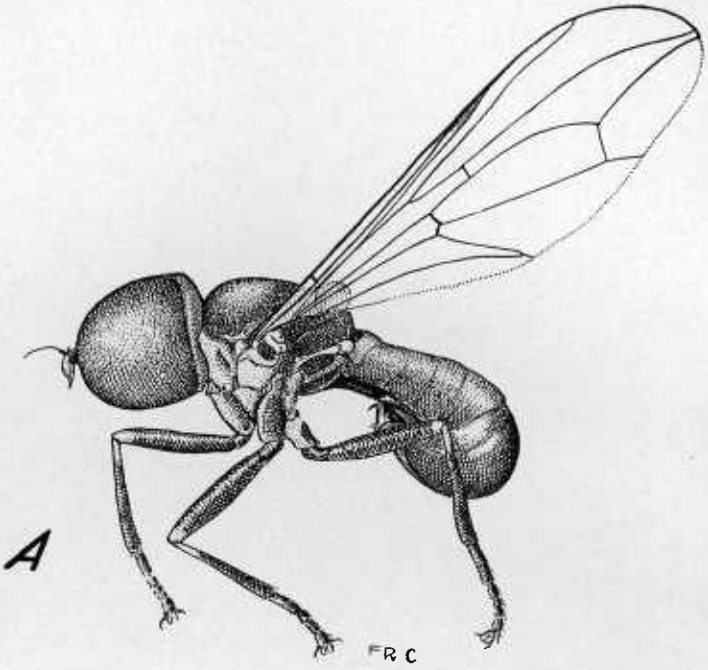
D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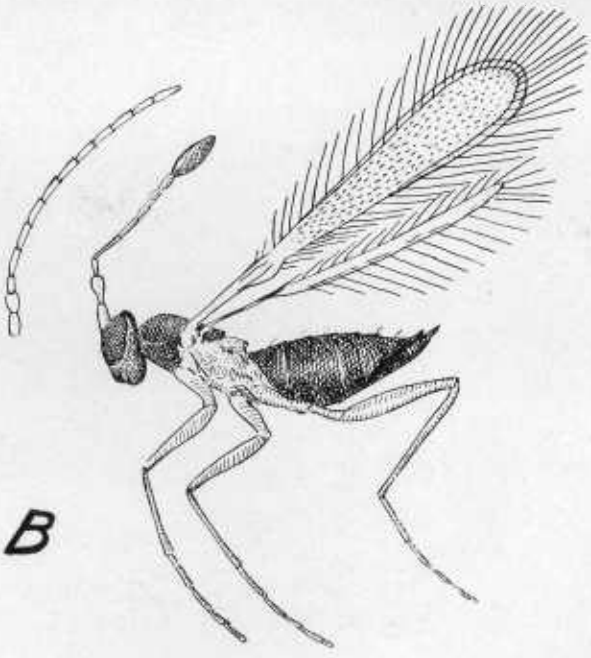
B

PLATE 43

Parasites of *Eutettix tenella:*

A.—*Pipunculus industrius:* Adult, much enlarged.
B.—*Polynema eutettixi:* Adult, much enlarged.