

soon learn what plants could be utilized for this purpose, employing either cultivated species or wild plants obtained from seed scattered in waste places.

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## FEDERAL PROTECTION TO AMERICAN AGRICULTURE AND HORTICULTURE FROM INVASION BY FOREIGN INSECT PESTS

By JACOB KOTINSKY, *Honolulu, Hawaii.*

(Withdrawn for publication elsewhere.)

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It was impossible to publish the following paper in regular sequence, owing to a failure to submit the manuscript in due time. The discussion relating thereto follows. Ed.

## LIFE HISTORY OF THE STRIPED CUCUMBER BEETLE WITH A BRIEF ACCOUNT OF SOME EX- PERIMENTS FOR ITS CONTROL

By T. J. HEADLEE, *Manhattan, Kan.*

In this paper it is purposed to give briefly the results of a study of the striped cucumber beetle, undertaken at the New Hampshire station for the purpose of clearing up certain doubtful points in its life history, its action under local conditions, and the practicability of the common remedial measures. Credit is due Prof. Sanderson for constant aid and encouragement.

### Life History

*Egg.* In 1907 the first eggs discovered were laid by a caged beetle on July 2d, but it was not until July 16th that they were found in the field. Eggs were last taken in the cages the 7th of August, and oviposition in the field appeared to have ceased some time before. The egg-laying period, therefore, occupies about one month in New Hampshire.

The eggs are deposited singly or, with equal frequency, in groups, in the soil, usually just beneath the surface, but sometimes on the surface or, again, a considerable distance down. The variation seems to be largely dependent upon the compactness and moisture of the ground. When it was dry and cracked, the beetle was likely to deposit her eggs on the moist soil in some crevice, but if damp and com-

pact, she would deposit them in shallow crevices, or even right on the surface. The female certainly shows a preference for a crack or crevice as a place to deposit her eggs. She oviposits in the soil anywhere within a radius of five or six inches of the stem of the young plant. Although the eggs are frequently laid between the plant stem and the surrounding earth, we have found no evidence to show that this is a favorite place. In instances where oviposition was observed, and this happened to be on damp soil, she simply brought the tip of her abdomen down nearly or quite to the surface of the ground, and pushed the eggs out, or, finding a furrow, she crawled into it and deposited eggs on the sides and bottom.

Experiment has shown that while the eggs are generally deposited on moist soil, they can withstand some desiccation if again returned to moist conditions, but that they never hatch if kept continuously in a dry situation.

A dissection of 18 gravid females collected at different times from late June to September showed an average of only 33 well-developed eggs per individual, with the upper extreme as 59. Yet in the breeding-cages, five females produced an average of 88 eggs each, with 54 and 117 as extremes. The cage records indicate that, once the beetle begins to oviposit, she continues at frequent intervals until her supply of eggs is exhausted.

Careful records of 32 eggs show that an average of 8.75 days is required under an average mean temperature<sup>1</sup> of 74° F. with an accumulation of 653.8° F. (read) or 651.03° F. (measured) to bring them from deposition to hatching.

Inasmuch as recent studies point to the fact that each insect has a different critical temperature, no effort has been made to compute the effective temperature, but the amount given represents all the degrees above 0° F.

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<sup>1</sup>The average mean temperature has been computed by (1) averaging the mean temperature of the days through which each egg passed before hatching, and then (2) averaging the average mean temperature of all the eggs. The mean temperatures of the days through which each egg passed were summed for each egg, and the average sum of the temperatures for all the eggs was taken as the sum temperature of the egg stage. Finding that the daily mean derived by measuring the irregular polygon made by the thermograph pen on the revolving record-sheet showed less variation, and hence was likely to be freer from the variation to which any such instrument is likely to be subject, I have given it as the *measured* sum, and also to conform to common practice, the sum derived in the usual way has been given as the *read* sum. In case the average means were practically the same, only one has been given, but when both are given, they are distinguished by the same method as that used in distinguishing the sum temperatures.

*Larva.* Even when first hatched, the larva can crawl rapidly about and, fastening its single proleg, can raise one-half of its body free of support and wave it about. Under moist conditions the just-hatched larva can remain active for as much as two days without food, but if subjected to drying, it will quickly perish. Careful experiments have shown that the just-hatched larva can crawl at least four inches through moist soil under ordinary weather conditions. There is, however, no evidence to show that it crawls in any especially determined direction, except, possibly, downward. It will as readily crawl away from food as toward it, but enters the soil at the first crevice it finds. As the larva grows, the yellow color so characteristic in early stages becomes less and less apparent until, in its later stages, it is white without a trace of yellow. During its entire life, the larva lives in the soil on or in the roots of its food plant, or in the stem. It is perfectly capable of passing from root to root, or even from plant to plant. So long as the larva has moist soil it can live and work for its food, but with the advent of drought it dies. Certainly these experiments and observations abundantly confirm Sirrine's statement that the larva requires moist earth to live in. When it becomes full-grown, it crawls out of and away from the plant from one-fourth of an inch to several inches, and by turning movements of its body, forms an oval earthen cell. The cell is frail, but very smooth and cozy, with no evidence of silk of any sort being used in its construction. This cell may be broken and, unless the larva has begun to shorten and stiffen for pupation, it will crawl away and construct a new one.

By the records of 24 individuals the length of time required to pass from hatching to larval cell was shown to vary from 26 to 38 days, with an average of 28.1. This stage was passed under an average daily mean temperature of 73° F. with sum temperatures of 2068.9° F. (read) or 2063.8° F. (measured).

*Pupa.* The location of the pupal cell appears to vary with moisture. It is always, so far as our observation goes, constructed in moist soil, although later it may become very wet or very dry. The actual location of the cells varied from one-half to two and one-half inches below the surface.

Records for 10 pupæ show an average of 13.9 days as the length of pupal stage. Records of 14 individuals show that an average of 24 days is required for the insects to pass from larval cell to adult, under an average mean temperature of 66° F. (read) or 65° F. (measured), with a sum temperature of 1590.78° F. (read) and 1576.78° F. (measured).

*Seasonal History.* The beetles were first observed in 1907, June

1st, on a small elm bush growing in a slough in the midst of heavy conifer timber. They were found in the same situation again two days later. On June 18th they were found on the blossoms and leaves of syringa near the experiment station in such numbers that we counted at least a half-dozen every time we visited the bush. Throughout June 19th and 20th they continued to feed in the same place and in about the same numbers. On June 21st the beetles were discovered in great numbers on volunteer squash near a small woodland, and by June 24th they had appeared in injurious numbers in a squash patch that lay a little farther from the same woodland. At this time they were found copulating freely. On June 25th they appeared in injurious numbers on the trap squash of our cucumber experimental plats. These plats were twice as far from the woodland as the squash fields first infested. By June 26th the beetles had begun to eat the cucumbers, but evidently preferred the squash plants, picking them out even from the midst of cucumber plants. On June 29th they appeared for the first time in the experimental plats of squash. This was fully one-eighth of a mile from any woodland and the late infestation points significantly to the probable winter quarters of the beetles. They continued in the plats from this time forward until August, in the latter part of which the remainder of the old brood practically disappeared. The new brood, particularly the males, began to appear in late August and the majority were out by the middle of September. Practically all had gone into winter quarters by early October. Dissection of material collected at intervals from June until the middle of October showed clearly that the species is single-brooded in New Hampshire.

It has been found that the disturbance necessary to the determination of length of pupal period hastened the development of the insects. It was, of course, necessary to break the earthen cells and, once pupation had occurred, no more cells were constructed. The pupæ exposed were carefully embedded in moist earth and allowed to produce adults. Twenty-two individuals that came through to adults and were thus disturbed at pupation, occupied an average of 47.81 days under an average mean temperature of 70° F. and with an accumulation of 3363.04° F. (read) or 3351.5° F. (measured), while 14 specimens that passed without disturbance from hatching to adult required an average of 55.14 days under an average mean temperature of 69° F., with an accumulation of 3814.96° F. (read) or 3802.35° F. (measured). The specimens that were disturbed by breaking the pupal cell required an average of 56.5 days to pass from deposition of egg to adult beetle, under an average temperature of 70° F. with

an accumulation of 4016.8° F. (read) or 4002.5° F. (measured), while those that were thus undisturbed required an average of 63.8 days under an average mean temperature<sup>2</sup> of 70° F., with an accumulation of 4468.78° F. (read) or 4453.3° F. (measured).

### Injury

The insect injures the plants both as an adult and as a larva, but in New Hampshire the adult is much the more serious, for it attacks the plants while they are young and when they are less able to withstand injury. Frequently it will attack the stalk just below the surface of the ground and eat almost, if not quite, through it. Many an injured plant will not be eaten enough to kill it, but the wound will harden and the plant grow, even until it has begun to run, when the first hard wind snaps it off at the point of injury. If the insects are abundant and prompt measures are not taken, the whole crop will be utterly destroyed in a few days. Even when plants have reached a height of three or four inches and have grown strong and stocky, the beetles will sometimes concentrate, especially on replants, and destroy them.

In New Hampshire the larvæ are rarely sufficiently abundant to do serious damage, although plants may be found every year which have been attacked and killed by them. Larvæ have been found among squash roots in the field, but there was little evidence that they had been feeding on the finer roots and only a few instances where they were found feeding on the larger ones. In potted squash where the larvæ were relatively more abundant, they were found feeding within the roots and the stems, even going as high as three or four inches above the ground. Certainly where the larvæ were sufficiently abundant, they would do serious damage.

From the time the plants begin to flower, the beetles desert the foliage and feed on the pollen until driven into winter quarters in the fall.

### Natural Enemies

Certainly at least one, if not two, dipterous parasites prey on adult beetles, and doubtless many such predaceous enemies as ground

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<sup>2</sup>The average mean temperature for the whole period was determined in this case by dividing the accumulated temperature by the total number of days required for the transformation, and the accumulated temperatures were determined by adding the average accumulated temperature for egg-state to average accumulated temperature for period extending from hatching to adult. Circumstances rendered the data such that the average mean and accumulated temperatures from egg-deposition to adult could not be computed directly.

beetles and ants feed on the larvæ. Dissections, beginning with beetles collected in June and extending to the time the beetles left the plants, show first a great increase and then a decrease of parasitism, as the following per cents will indicate. Beetles collected during the first two-thirds of June showed 3% containing parasites; those on June 28th, 7%; those on July 30th, 7½%; those on August 5th, 18%; those on August 8th, 42½%; those on August 13th, 50%; those on August 14th, 50%; those on August 22d, 24%; those on August 31st, 12%; those on September 7th, 0%; those on September 12th, 0%; those on September 18th, 0%.

Some idea of the mortality that may well occur in nature may be gathered from the fact that in soil regularly watered and kept constantly producing young plants, out of 329 larvæ introduced into the soil at hatching, only 34 reached maturity.

### Methods of Combating

In the study of artificial methods we experimented with several substances as preventatives, as the solution of this problem appears to lie in prevention rather than in cure. One-half of an acre of cucumber plants and two and one-half acres of squash were used in the experiment. These were divided into plats and treated with Bordeaux (3 pounds Copper Sulphate, 4 pounds lime, to 50 gallons of water), Bordeaux plus Paris green, air-slaked lime plus sulphur, sulphur, "Bug Death," Hammond's "Slug-Shot," tobacco dust, road dust, arsenate of lead (3 pounds to 50 gallons), and arsenate of lead (6 pounds to 50 gallons). The Bordeaux plats were further protected by plantings of squash as trap crops, according to Sirrine's suggestion.

The beetles were serious enough to destroy only about one-fourth of the plants in the check plats, but the effect of their work was well shown in the setback these plats experienced. Bordeaux mixture alone or with Paris green, sulphur, and "Slug-Shot" appeared to stunt the plants. Road dust afforded but little protection, "Bug Death" and tobacco dust when used carefully enough seemed to be fairly efficient, but the air-slaked lime and sulphur mixture seemed just as successful and was certainly much cheaper. Arsenate of lead, however, gave the most efficient protection and injured the plants least of any mixture used. Three pounds seemed almost as successful as six pounds. Our experiments would lead us to advise the following treatment where fungus enemies are a serious problem: Plant trap squash for either cucumber or squash between the hills of every other row, or if the piece be small, about the edge a week or ten days before

the regular crop is set out; plant other trap seed when the regular crop is put in; plant still other trap seed a week or ten days later; keep the regular crop sprayed with arsenate of lead (3 pounds to 50 gallons) until the plants begin to run, then keep sprayed with Bordeaux mixture (3 pounds Copper Sulphate, 4 pounds of lime, 50 gallons of water).

From the very nature of these materials, it is evident that in a bad beetle year, they would be insufficient to protect the plants. In such cases, the only efficient method of protection is by means of covers. Many forms have been invented, all either costly to purchase or to apply, and some both. But the market gardener, who can secure high prices for his prime cucumbers, can afford to use them, so I will take a few minutes of your time in suggesting what has seemed to us a practical sort of cover. Secure yard-wide screen wire of slightly smaller mesh than the ordinary window screening, and cut off one yard. The piece will then be one yard each way. Describe a circle on this piece, having a diameter of 36 inches, and cut off the corners. Then divide this circular piece of wire into two equal parts. Join the cut edges by drawing them together and folding them over, hammering them down firmly. Thus a cone-shaped wire cover costing a few cents and capable of withstanding several years' usage is ready for use. Two covers can be made from each square yard of wire.

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Mr. J. B. Smith suggested that the wire used for screens to protect the plants must have a very small mesh.

Mr. R. L. Webster asked concerning the parasites bred from *Diabrotica*, and in reply Mr. Headlee stated that they were Tachinids.

Mr. Burgess inquired concerning the length of time that the adults deposited eggs. He had been able to secure eggs for two successive seasons from a female of *Calosoma frigidum* that had been kept in captivity. To this Mr. Headlee replied that as far as he had observed, the females of *Diabrotica vittata* deposited all their eggs in one season.

A. F. BURGESS, *Secretary*

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## UNIFORM COMMON NAMES FOR INSECTS

By A. F. BURGESS, *Washington, D. C.*

At the sixteenth annual meeting of the Association of Economic Entomologists held at St. Louis, Mo., in December, 1903, a Committee on Nomenclature was elected to secure the adoption of uniform names for our more common insects. In the past much confusion has re-