6
§ Insects

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part I.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.

BY

A. W. MORRILL,
Special Field Agent.

ISSUED APRIL 2, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

CONTENTS.

ILLUSTRATIONS

PLATE.

TEXT FIGURES.

U. S. D. A., B. E. Bull. 64, Part I. Issued April 2, 1907.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.

(*Pentatoma ligata* Say.)[a]

By A. W. Morrill,
Special Field Agent.

INTRODUCTION.

In a recent bulletin of the Bureau of Entomology[b] the writer gave an account of the Mexican conchuela (*Pentatoma ligata* Say, fig. 1), based upon an investigation conducted in northern Mexico in September, 1904. It was predicted that should the pest ever become very abundant in this country, where more diversified farming is usually practiced, it would be likely to affect a wide range of farm crops instead of confining its attacks to cotton alone. Almost unknown in 1903, the conchuela, as it is called by the natives of Mexico, first became of considerable importance as a cotton pest in the leading cotton district of Mexico—the "Laguna"—and in 1904 established its reputation as an enemy of alfalfa in western Texas by ruining in specific instances seed valued at over $1,000, representing the loss to the crops of two growers from whom definite reports were obtained. This loss in western Texas was, however, first made known to entomologists in July of the following year (1905), through correspondence of a resident of Barstow, Tex., with Mr. W. D. Hunter, in charge of the investigations on cotton insects conducted by this Bureau. As the writer was at that time in Mexico, continuing his investigations of this pest, Mr. J. C. Crawford was sent to Barstow to investigate the economic status of the insect there. His preliminary observations were made on July 20 to 22, inclusive, and were followed by visits to Barstow by the writer on August 11 and 12 and September 12, and by Mr. Crawford on October 13 and November 14. The reports of Mr. Crawford, which were duly submitted to Mr. Hunter, have been freely used by the writer in preparing this paper.

---

[a] Order Hemiptera, family Pentatomidæ.

[b] Bul. 54, Bur. Ent., U. S. Dept. Agric., pp. 18–34, 1905.

AN ASSOCIATED SPECIES.

An allied pentatomid, the grain bug[a] (*Pentatoma sayi* Stål), was found at Barstow associated with the conchuela. In 1905 this species was not plentiful enough to cause much damage to crops by itself, but as the character of its injury and that of the conchuela is the same it is necessary to consider the two species together when they are found on the same food plant. In this case they were found together only on alfalfa and Milo maize, although the grain bug is known to have a wide range of food plants and probably is fully as general in its feeding habits as is the conchuela. The history of the former species as a pest antedates, even in western Texas, that of the latter, for as long ago as December, 1895, specimens of *Pentatoma sayi* were received by this Bureau from Toyahvale, Reeves County, Tex., with a report that they had destroyed 40 acres of peas and 2 acres of lima beans on the correspondent's farm. It is interesting to note that this report came from a point not 50 miles from Barstow. Since that time this species has earned a bad reputation by its destructiveness to wheat and oats in Colorado and elsewhere.

GENERAL AGRICULTURAL CONDITIONS AT BARSTOW, TEX.

Ward County, of which Barstow is the county seat, is situated in western Texas, a short distance south of the southeastern corner of New Mexico. With the exception of a narrow valley along the river the country consists of high rolling prairie covered in large part with a short growth of mesquite and sage. Being in the arid region the rainfall is too light to be depended on for agricultural purposes and all crops are grown under irrigation, a practice which began with the settlement of the county in 1891. Water for irrigation is obtained from the Pecos River, and at present about 10,000 acres are under cultivation in the county. Of this area, in 1905, about 5,000 acres were devoted to cotton and the greater part of the remainder to grapes, peaches, and alfalfa. The elevation of Barstow is about 2,500 feet above the sea level.

DAMAGE TO CROPS PREVIOUS TO 1905.

According to residents of Barstow who are best informed concerning the conchuela, the insect never, previous to 1904, attacked crops of any kind in sufficient numbers to attract attention. As far as can be learned there had been, previous to that time, no attempt to produce a seed crop of alfalfa. The occurrence of this pest on cotton in moderate numbers is not likely to be associated with the

---

[a] In using this common name for this species the writer follows Prof. C. P. Gillette. Bul. 94, Colo. Exp. Sta., p. 3, Dec., 1904.

injury which usually first becomes apparent upon the opening of the bolls. The most notable losses in 1904, which with little doubt were due to the conchuela, were on the farms of Mr. C. E. Pierce and Miller Brothers. The former had 120 acres of alfalfa which was cut for the seed crop about the middle of July, from 150 to 200 pounds of seed per acre being expected. It was noticed that this insect was very abundant in the field, but the extent of the damage was fully realized only when an average of 83⅓ pounds of seed per acre was obtained. At the prevailing value of 12 cents per pound the estimated loss was from $8 to $14 per acre, or from $960 to $1,680 for the entire field. The 10 acres of alfalfa belonging to Miller Brothers should have produced at least 150 pounds of seed per acre, according to general estimates, but so much of the seed was ruined, supposedly by the conchuela, that the yield was reduced to 60 pounds per acre. The average loss per acre was estimated as at least $10. Other losses of this kind occurred in Ward County during 1904, but the information obtainable concerning them is less definite. According to one report, alfalfa growers at two other points in the Pecos River Valley—Grand Falls and Toyah Creek—experienced a failure with a seed crop of alfalfa in that year which they attributed to "weevil," a term commonly applied to the cause of such losses even before an insect has been located upon which to place the responsibility. In this case the writer believes that at least the greater part of the losses in question can be safely considered as due to the work of *Pentatoma ligata*, together with the grain bug, *P. sayi*.

CROPS DAMAGED IN 1905.

ALFALFA.

Direct observations, both in western Texas and northern Mexico, showed that fields devoted to alfalfa are capable of harboring the conchuela in enormous numbers. In the Laguna district in Mexico alfalfa has been grown for several years, but only for hay and forage, and in comparatively small quantities on the cotton plantations. As far as could be learned, previous to 1905 the pest here considered never attracted attention on account of its occurrence in the alfalfa fields, but in that year it became so abundant that at Tlahualilo, State of Durango, upon the cutting of a crop, adjacent cotton fields and a small vineyard were overrun by myriads of the insects, while several miles distant at another plantation it was first brought to the notice of the managers by appearing in large numbers in the troughs in which green alfalfa was fed to stock. In these cases, no seed crop being grown, the attack was limited to the leaves and stems. The effect of the extensive feeding on these parts can not be definitely stated, as in all cases where plants without seed were heavily infested the cutting was made before the writer had an opportunity to make an examination. According to report, however, no marked effect upon the plant was produced in the instances here recorded, and, accordingly, until more is known, we may assume that where it is not intended to produce seed the principal danger incident to the occurrence of the conchuela in alfalfa fields lies in the fact that a choice breeding place is furnished the insects, which may multiply to enormous numbers and spread to other crops. This phase of the subject will be discussed elsewhere in this paper and also in a report on Heteroptera attacking the cotton plant.

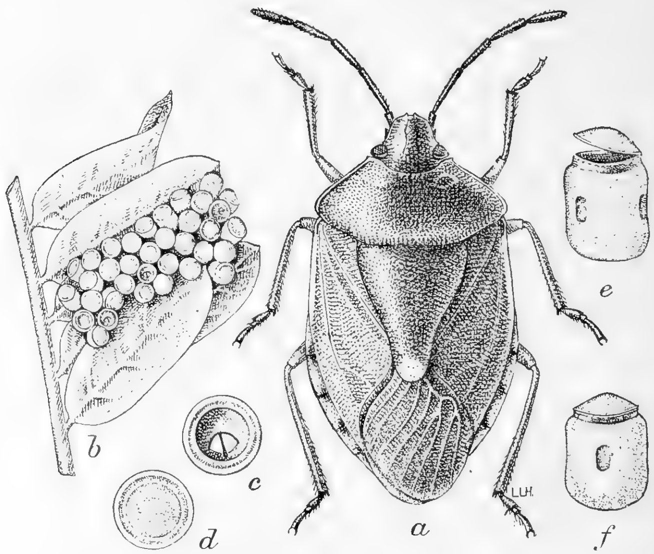


FIG. 1.—The conchuela (*Pentatoma ligata*): *a*, adult bug; *b*, egg mass on leaves; *c*, egg after hatching, lid removed showing egg burster; *d*, egg before hatching, from above; *e*, egg from side, showing lid above exit hole; *f*, egg before hatching, from side; *a*, enlarged 4 diam.; *b*, enlarged 2⅔ diam.; *c-f*, enlarged 9 diam. (Author's illustration.)

In infested fields when the seed is present the bugs may be seen clinging to the seed clusters extracting the rich juices by means of their thread-like setæ. The seed pod, when once fed upon, shrivels and turns dark and is readily distinguished from uninjured seed pods. No attempt has been made to determine how rapidly a bug progresses with its destructive feeding, but as these insects are usually observed to be engaged in this way as long as desirable food remains, and as the individual seed is small, undoubtedly each one of the insects is capable of destroying a very large number of the seed pods during its existence.

Cutting of the alfalfa checks the multiplication of the pest, but also has the effect of driving the bugs elsewhere in search of food, often with more or less serious results to neighboring crops. It should also be noted that the longer time required to produce a seed crop is favorable to the production of large numbers of the insects. Windrows of alfalfa hay, originally intended for thrashing for the seed, in the field of Mr. Carson, at Barstow, were found to harbor many adult conchuelas which were for the most part busily engaged in destroying the last few seed clusters. It would thus appear that the danger is not over with the cutting of the alfalfa, and that thrashing should be attended to as soon as possible if the insects are present and injury is to be avoided.

The only extensive damage to alfalfa by this insect at Barstow during 1905 was on the farm of Mr. J. P. Carson. Other growers, owing to their experience of the previous year, decided to grow no seed crop; thus indirectly many suffered a loss which should be charged up to the insect, as an average crop of seed has a value equal to several times that of a single cutting for hay. Mr. Carson had 55 acres ready for cutting for the seed the last week in July, but the damage by the bugs amounted to complete destruction, for although the land was originally heavily seeded, there was not sufficient uninjured seed to defray the expense of thrashing. The loss was considerably more than $1,500, in addition to the partial loss of a hay crop in the extra time allowed for the maturity of the seed.

Miller Brothers in 1905 fortunately avoided the destructive work of the insects and made a fair seed crop. At Barstow the interval between cuttings for hay is on the average about four and one-half weeks, while for the maturity of the seed an additional period of about three and one-half weeks is necessary. Other farm work prevented Miller Brothers from cutting their alfalfa when it was in prime condition for cutting for hay. As the seed began to mature, the scarcity of the pest which had proven so destructive the previous season caused the owners to anticipate a successful seed crop. On September 13 the writer, who made a careful examination of the condition of the alfalfa field referred to, found the bugs scarce, as reported, and the damage to the seed, which was already mature, very slight. The yield of seed reported by Miller Brothers for the 10 acres was 1,499 pounds.

MILO MAIZE.

On August 11 a field of Milo maize was examined at Barstow, and it was found that in certain spots a considerable proportion of the seed was ruined, while more or less ruined seed could be found throughout the field. According to the owner, Mr. Carson, the conchuelas had been very abundant a week previous, as many as 25 of the insects frequently being noted on a single seed head. They were found to be generally distributed throughout the field on August 11.

but in small numbers, the largest number found on a single seed head being five—two adults, two fourth-instar nymphs, and one fifth-instar nymph. On the Milo maize, as on the alfalfa, *Pentatoma ligata* was accompanied by *P. sayi*, but in more nearly equal numbers; this is not necessarily of any special significance, though possibly it may indicate a preference of the latter species for the seed of the grains.

COTTON.

The first examination for the conchuela in the cotton fields at Barstow was on August 11, when of the five fields visited specimens of the insect were found in all except one. In every case the number of damaged bolls, although in small proportion, gave evidence of the occurrence of the insect in somewhat larger numbers some weeks previous. In one field an examination of 100 plants showed an infestation of 5 per cent of the plants, with 12 adults per 100 plants. The damage to the bolls in this field amounted approximately to 15 per cent. Another field of about 10 acres was found to be damaged to a less extent except for about one-half an acre near one side where, of 60 bolls selected at random, 30 per cent were destroyed by bugs. The writer estimates, as a result of personal examinations in many fields at and near Barstow, that the average damage to cotton by the conchuela in 1905 was about 10 per cent.

PEACHES.

Although peaches have been grown at Barstow for several years we have no report of damage to the fruit by the conchuela or other bugs until 1905, when the matter was reported by Mr. C. E. Pierce and investigated, as stated in the introduction, by Mr. Crawford and the writer. The attack was confined to the fruit of the earliest varieties in their first fruiting season. The trees were located on the side of the orchard adjacent to the 120-acre alfalfa field, the damage to the seed crop of which in the previous year has already been mentioned. Shortly after the 10th of July, coincident with the cutting of the alfalfa, the bugs were noticed on the fruit of these trees, which was just beginning to ripen. The trees soon became very heavily infested, and on July 20 it was not uncommon to observe from 10 to 15 on a single peach and in one instance 20 were counted. The tendency of the conchuelas to congregate on certain individual peaches was very marked, as has likewise been observed in their occurrence upon cotton bolls.[a] On the most heavily infested trees, owing to this habit, many peaches at any given time seemed neglected, but all on the attacked trees were ultimately destroyed. The injured fruit became shrunken in spots and sponge-like to the touch, finally

[a] Bul. 54, Bur. Ent., U. S. Dept. Agric., p. 26, 1905.

falling to the ground. It was apprehended that the pests would transfer their attention to the late peaches when these began to ripen, and a few were observed to do so, but apparently when the supply of early peaches was exhausted or rendered unfit for further feeding, the late peaches were not mature enough to be attractive, and consequently suffered practically no injury from this source.

GRAPES.

In 1905 at Barstow the fruit in the vineyards was in general only slightly affected by *Pentatoma ligata*. The principal damage was in the small gardens in town, where in certain instances the destruction was practically complete. Probably owing to the large area occupied by the vineyards and to the fact that the fruit of the different varieties ripens at about the same time, no especial concentration of the insects in the large vineyards was noticed, and there was no indication that any such concentration occurred. The ripe fruit is preferred, although when the food supply is short it may be attacked when immature. The injured berry shrivels and under the influence of the hot sun soon becomes raisin-like.

At Tlahualilo, Durango, Mexico, on July 17, 1905, a vineyard of about 10 acres with vines heavily loaded with fruit became thoroughly infested by direct migration from an adjacent alfalfa field of adults and of nymphs in the last two instars. Each cluster of grapes was attacked by several bugs, the maximum noted on a single cluster being 25. Without consultation with the writer the grapes were picked immediately upon discovery of the infestation, the presumption being that the removal of their food would serve as a check to the insects, to the benefit of the cotton fields. This step was, however, inadvisable, since the fruit, which was of comparatively small value, would have served as a trap at which the bugs could have been easily destroyed when so thickly congregated. As it was, the bugs gathered in groups of hundreds on the trellis posts and on the vines, principally at the forks, where they were destroyed, partly by spraying and partly by use of a gasoline-blast torch. The last-mentioned method, while effective in its destruction of the pest, injured the vines to a certain extent in nearly all cases.

GARDEN VEGETABLES.

Between the middle of July and the middle of August garden crops at Barstow were affected to a considerable extent by this destructive pest. Owing to the comparatively small amount of land devoted to such crops, the actual money equivalent of the loss was not great. The crops which suffered most were peas, beans, and tomatoes. In each case the attack was restricted almost entirely to the seed or fruit, thus accomplishing a maximum of damage. Under another heading the writer has referred to the destruction of peas and beans in Western Texas, not far from Barstow, by the grain bug. Among other cases on record which give further evidence of the losses pentatomid bugs may cause by their attacks on vegetables is one quoted by H. G. Hubbard[a] from the report of a Florida correspondent on his experience with a species commonly called the green tree bug (*Nezara hilaris* Say). According to the report, this species attacked cowpea vines before any seed was developed and completely ruined 35 acres of this crop, so that no good seed was obtained. A garden crop of tomatoes was also reported to have been entirely destroyed, the ground under the vines being almost covered by the fallen fruit. The injured fruit was described as reddish-yellow in color at the point punctured, and when cut was found to be "full of lumps and totally devoid of flavor." These records of the damage by other pentatomid bugs to general garden crops show the extent to which the conchuela is capable of affecting these crops when they are grown on a more extensive scale than was the case at Barstow at the time the observations recorded in this paper were made.

OTHER FOOD PLANTS.

The principal natural food plants of the conchuela are the mesquite and related leguminous plants, the beans being the object of attack. It would require more than one season's observations to determine how important is the connection between the abundance of mesquite beans and the abundance of the insects on cultivated plants. It is presumable that during the period when the insects are multiplying most rapidly the abundance of rich food such as the mesquite bean provides is an important factor in determining the amount of subsequent injury to crops. At Barstow, in addition to the mesquite and the crops which have been separately discussed, the conchuela has been found feeding on the fruit of peppers, on squash vines, and on the leaves of yucca. It has also been reported on good authority to have been observed in considerable numbers on corn, and the writer has in Mexico found egg batches of this species attached to the green leaves of corn. In general, the species may be said to be almost omnivorous, showing a preference, however, for fruits and seeds.

SEASONAL HISTORY.

The multiplication of the conchuela in western Texas seems to follow the same course as has been observed in northern Mexico; in other words, the maximum number is reached between the middle and

[a] Report on Insects Affecting the Orange. Div. Ent., U. S. Dept. Agric., p. 160, 1885.

last of July, after which the number diminishes rapidly. The bugs are strong fliers, which accounts for their sudden appearance on a given crop, and in some cases for their sudden disappearence from it.

On July 20–22 no eggs or young could be found on the infested peach trees, nor could any of these stages be found on August 11 and 12 after the adults had entirely disappeared from the trees. If any eggs were deposited by the bugs when the latter were attacking the peaches the resulting nymphs were probably carried to the ground with the falling of the fruit, for the interval between the examinations was not sufficiently long for them to have reached the winged or adult stage. The only breeding places of consequence found at Barstow were in the alfalfa fields. Here eggs and nymphs were found in large numbers on August 11 and 12. A month later the insects had been reduced by at least one-half, and their scarcity was noticeable everywhere except in small areas in some fields of alfalfa and along the borders near fences and ditches where the cuttings had not been made at regular intervals. Of 32 adult pentatomids collected in the alfalfa fields September 12, 26 were *P. ligata* and 6 *P. sayi*. At the next examination, on October 13, it was evident that the insects were still decreasing in numbers, but the nymphs in the last two stages were proportionally more abundant than before. In the lot of 16 adults and 49 nymphs collected at that time, *P. sayi* was not represented. The last examination, made on November 14, showed that the conchuelas had almost entirely disappeared; a half hour's search where, at the time of previous examinations, they had been found most abundant, resulted in the capture of only 6 adults, no nymphs being seen.

NATURAL ENEMIES.

EGG PARASITES.

Minute egg parasites belonging to the family Proctotrypidæ are generally known among entomologists to play an important rôle in checking the multiplication of many insects, so that anything which affects the numbers of these parasites frequently results in a corresponding benefit or injury to the crops attacked by the host insects. If these parasites of the eggs of pentatomids were eliminated, many of the pentatomids would undoubtedly be ranked among our most important insect pests. The importance of these parasites in checking the multiplication of the conchuela at Barstow in 1905 can be best emphasized by summarizing the results obtained by rearing parasites from eggs collected at that place.

Summary of results obtained by rearing parasites from eggs of Pentatoma ligata collected at Barstow, Tex., in 1905.

When collected.	Number of egg batches.	Total number of eggs.	Number of eggs hatched.	Per cent hatched.	Number of parasites emerged.	Per cent producing parasites.	Number of eggs destroyed by other agencies.	Per cent failing to produce nymphs.
August 11-12	6	181	35	19	41	22	0	81
September 12	13	246	20	8	148	54	[a] 35	92
Total	19	427	55	13	189	44	35	87

[a] Representing two batches of 13 and 22 eggs, respectively. Presumably destroyed by ants, the broken eggshells remaining.

Shrinking of the eggs, indicating infertility, occurred in no case among the eggs included above. From the fact that adult parasites frequently fail to emerge from the egg of the host even after

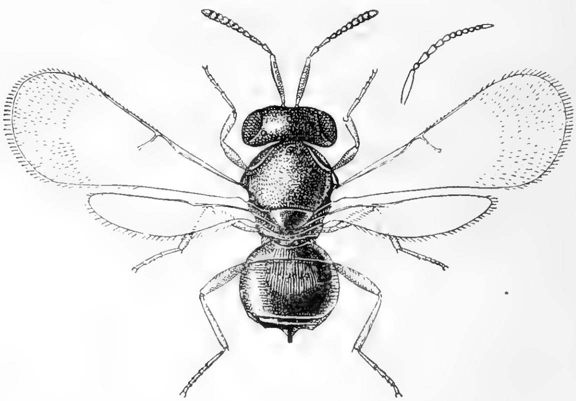


FIG. 2.—*Telenomus ashmeadi*, an important egg parasite of *Pentatoma ligata:* Adult female and antenna of male. Highly magnified (original).

breaking through the shell—and as far as observed it seldom occurs in nature that eggs of the conchuela fail to hatch when not destroyed by outside agencies—it may be concluded that practically all the eggs appearing intact which failed to hatch were destroyed by the parasites. In support of this supposition 10 eggs which neither hatched nor from which live parasites emerged, selected at random from the 19 batches above mentioned, were opened and each was found to contain a dead adult parasite. The specimens bred from the eggs of *P. ligata* and also of *P. sayi* from Barstow were all of the same species and identified by Dr. William H. Ashmead, of the U. S. National Museum, as a new species of the genus Telenomus (fig. 2). The writer will describe the species under the name *Telenomus ashmeadi*. An egg batch of the conchuela containing hatched and unhatched eggs is shown in Plate I, figure 1, and a parasitized egg batch in Plate I, figure 2.

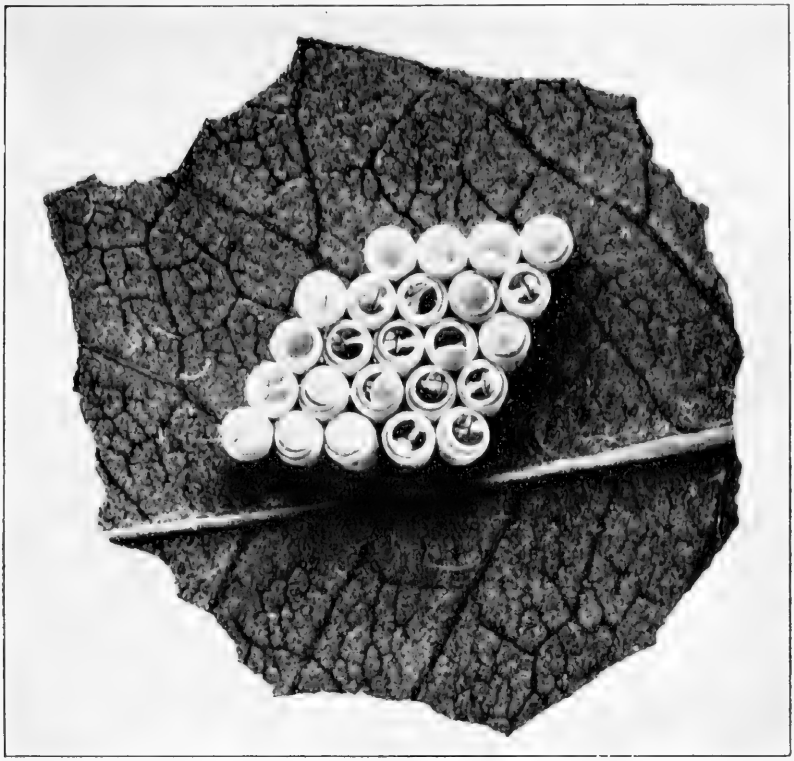


FIG. 1.—EGG BATCH OF CONCHUELA (PENTATOMA LIGATA), SHOWING HATCHED AND UNHATCHED EGGS. ENLARGED 6⅔ DIAMETERS (ORIGINAL).

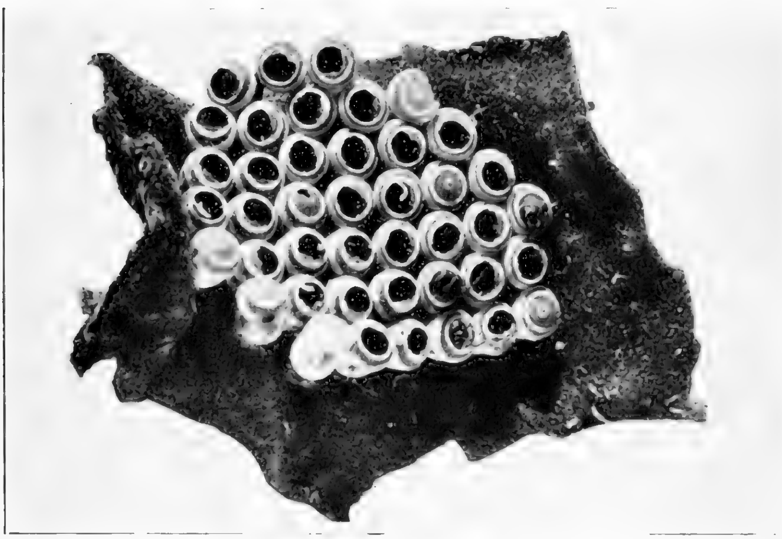


FIG. 2.—EGG BATCH OF CONCHUELA (PENTATOMA LIGATA) FROM WHICH 32 PROCTOTRYPID PARASITES (TELENOMUS ASHMEADI) HAVE EMERGED. ENLARGED 6⅔ DIAMETERS (ORIGINAL).

The illustration shows three parasites, including male and female, ready to emerge; also an egg destroyed, probably by an ant.

TACHINID PARASITES.

A species of the very useful family Tachinidæ, *Gymnosoma fuliginosa* Desv., has been reared from adults of the conchuela. The victims of this parasitic fly are distinguished by the yellowish-white egg or eggshell which remains attached to the thorax of the host unless it happened to have been attached to a nymph in the fifth instar, which afterwards molted. On August 11 and 12 only three parasitized specimens were discovered, two in the fifth nymphal instar and one an adult. An adult of this species of Tachinidæ was bred from one of these bugs. On September 12 parasitism by these tachinids was found to be more common than at the time of the previous visit. Of 24 adults examined at that time, 4 were found to be parasitized. On October 13, of 18 adults and 31 nymphs in the fifth nymphal instar, 2 only had been parasitized, both nymphs. While these parasites are decidedly beneficial and may be more useful under some conditions, they were not sufficiently abundant at Barstow in 1905 to explain the rapid decimation of the numbers of the conchuela which has been described under the subject of seasonal history.

PREDACEOUS ENEMIES.

Although no observations on the subject of predaceous enemies were made at Barstow, it seems important to refer briefly to the records of observations by others along this line, in order that it be not inferred that because pentatomids in general are characterized by their ability to produce an offensive odor they are immune to the attacks of insectivorous birds and of toads. On the contrary the crow[a] is believed to be especially fond of bugs of this group, and many other birds,[b] as well as the common toads,[c] seem to find them unobjectionable as food. If we accept the evidence of definite reports and observations during three successive seasons as indicative of the usual seasonal history of the conchuela, the period of maximum abundance is followed closely by a marked reduction in the numbers of the pest. In this it is not unlikely that birds will prove to be an important if not the leading factor.

METHODS OF CONTROL.

Under some conditions farm practices, such as the destruction of weeds in the fall and otherwise hindering the sucessful hibernation of the conchuelas, would be of unquestioned value in control, but under

[a] Bul. 6, Div. Orn. and Mam., U. S. Dept. Agric., p. 63.

[b] Buls. 13, Biol. Surv., Dept. Agric., U. S., pp. 25, 62, 70; 15, p. 23; 21, p. 43; 23, p. 26. Yearbook U. S. Dept. Agric. for 1895, pp. 417, 423, 429; Yearbook U. S. Dept. Agric. for 1900, p. 414, Plates L, LI.

[c] Bul. 46, Hatch (Mass.) Exp. Sta., p. 26. Bul. 91, Ky. Exp. Sta., pp. 62, 64.

the conditions in western Texas, such as those obtaining at Barstow, probably little good could be accomplished by such measures. With the mesquite-covered surrounding districts as a stronghold these insects probably will become established in the alfalfa fields each year and become more or less numerous as the season progresses, their numbers being governed by conditions which for the most part exert their influence secondarily through the natural enemies of the species. The question of control at Barstow, and where similar conditions prevail, resolves itself into: First, avoidance of damage to the seed crop of alfalfa; second, methods tending to prevent the insect's spread from alfalfa to other crops, or otherwise preventing infestations; third, direct remedies applicable for use when crops other than alfalfa become infested.

AVOIDANCE OF INJURY TO THE SEED CROP OF ALFALFA.

At Barstow the experience of alfalfa growers for two successive seasons, supported by direct observation by Mr. Crawford and the writer at regular intervals during 1905, has shown that the conchuelas are so numerous during July and August that an attempt to produce a seed crop during this period would be inadvisable. In northern Mexico observations extending over three seasons have shown the insects both to reach a maximum in numbers and to show a marked decrease therefrom during the last two weeks of July. This corresponded with the history of the pest at Barstow, and it is believed that the danger limits above given are sufficiently wide to cover all but exceptional cases under the present conditions. If a crop intended for seed promised to mature before July 1, probably but little damage would be accomplished by the conchuela, but this is entirely a surmise which it is hoped will be thoroughly tested when an opportunity presents itself. The same probabilities hold for a crop of seed which would mature after the 1st of September. This, moreover, has been substantiated by the experience of Miller Brothers at Barstow, which has been described under the subject of damage to alfalfa in 1905. Avoidance of the injury as here outlined is undoubtedly simpler than actually defending the seed in the field from attack.

A SUGGESTION AS TO MECHANICAL CONTRIVANCES FOR COLLECTING THE INSECTS.

Between the conchuela (*P. ligata*) and its near relative, the grain bug (*P. sayi*), whose reputation as a pest has already been mentioned, it may be anticipated here that in the course of time remedies will be demanded for use against such insect enemies of alfalfa in other sections of the country. In a field with ripening seed an experiment with an insect-collecting net in one hand and a stick in the other, simulating the action of an imaginary specially constructed hopperdozer with a revolving fan, convinced the writer of the practicability of collecting these insects mechanically. The great majority of the insects, when undisturbed, may be found near the tops of the plants, on the seed clusters when these are present. They drop to the ground when slightly disturbed, much more readily, in fact, than when they have a footing on a more substantial object like a cotton boll. It is safe to predict that a contrivance for collecting will be devised when the necessity arises. It should be light, operated from behind, and consist essentially of an elongate metallic pan suspended below a revolving fan geared to the supporting wheels.

PREVENTIVE AND PROTECTIVE MEASURES.

If, as advised in one of the preceding paragraphs, no attempt is made to produce a seed crop during the period of the year when the conchuelas are dangerously abundant, an important factor in their multiplication and spread will be eliminated. But the shorter period required for the hay crop is sufficient to permit the insects to reach the enormous numbers indicated in the writer's reference to the occurrence on alfalfa in northern Mexico in 1905. Usually the greater number of the insects will not reach maturity during the interim between cuttings, and the work of preventing the spread will be in part the checking of the migration of the crawling nymphs. This can be readily accomplished when necessary by leaving an uncut border around the field, where the insects when trapped can be destroyed by spraying with kerosene emulsion. As the insects show a marked tendency to concentrate in certain limited areas rather than to spread evenly over the fields, this can be taken advantage of by making a general examination of the field, before cutting, to locate the colonies. A few small boys in a few hours might pick up several quarts [a] of the adults when these are abundant and well concentrated. If this is not feasible, small heavily infested areas may be treated with kerosene emulsion, although adult pentatomids are apt to be quite resistant to this insecticide. At Tlahualilo, Durango, Mexico, on July 11, 1905, after the alfalfa hay had been made and stacked, countless hosts of the insects still remained in the alfalfa field in spite of the extensive migration to neighboring crops. Those that remained were largely concentrated near one corner of the field and, as suitable spraying apparatus was not available, destruction of the pest was accomplished by respreading about 3 or 4 tons of alfalfa hay over the ground and then burning it. This operation for the protection of the surrounding cotton fields against further invasion from this source was effective, but would be unnecessarily costly under ordinary

[a] One quart contains approximately 1,500 adult specimens of *P. ligata*.

circumstances. In the case of the chinch bug a practice of destruction by burning similar to the one here mentioned has been recommended for use under certain conditions.[a] Cooperation among the owners of adjoining farms is necessary in order to obtain the best results in the attempt to check the spread of the conchuéla, as well as in the case of the chinch bug and many other insects.

A protective measure which may in some cases be recommended, especially for use in small gardens, consists in screening such crops as tomatoes with a cheap quality of mosquito netting.

REMEDIES WHEN CROPS OTHER THAN ALFALFA ARE ATTACKED.

The subject of remedies for use in protecting cotton against damage by the conchuela and related pests will be reserved for a future publication. When this insect attacks the seed of Milo maize and related grains little can be done except when the bugs are concentrated in large numbers in limited areas; then hand collecting or jarring from the plants may be advisable, particularly as a protective measure when such an infestation is an element of danger to neighboring crops. For remedial measures against the insect when it attacks garden vegetables and grapes we can suggest spraying with kerosene emulsion and collecting by hand, or, if it is necessary to carry on operations on a large scale, the bugs may be jarred into convenient receptacles containing kerosene and water, so arranged that they can be dragged between the rows if desired.

When attacking peaches a certain proportion of the bugs can be jarred from the fruit and killed on the ground, but this is at the best far from satisfactory, as the fruit itself is likely to be shaken off or otherwise injured and many of the bugs will escape by flying. Peach trees when pruned in accordance with the practice of the leading growers are low enough to permit hand picking of all the fruit and are correspondingly easy of fumigation. A light tent made of ordinary cotton sheeting can be placed over an infested tree by the use of poles and held in place at the bottom by dirt or stones. The burning of tobacco stems, pyrethrum, or buhach powder inside the tent will soon stupefy the insects and cause them to fall to the ground, where they can be easily and quickly killed. The fumes can be prevented from escaping too readily through the cloth by lightly painting it with linseed oil thinned with turpentine. This method of fumigation is inexpensive and has the further advantage of requiring but a few minutes' work for each tree.

[a] Bul. 17, old series, Div. Ent., U. S. Dept. Agric., p. 37, 1888.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part II.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.

BY

W. DWIGHT PIERCE,

Special Field Agent.

Issued April 2, 1907.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1907.

CONTENTS.

ILLUSTRATION.

U. S. D. A., B. E. Bul. 64, Part II. ISSUED APRIL 2, 1907.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.

By W. DWIGHT PIERCE,
Special Field Agent.

Having been detailed to investigate certain injuries attributed to sowbugs, the writer presents the following notes concerning the life history and habits of three species of these isopods, namely, *Armadillidium vulgare* Latr., *Porcellio lævis* Latr., and *Metoponorthus pruinosus* Brandt. The first species, at least, is capable of doing considerable injury to garden crops, flower gardens, vines, and field crops in the vicinity of buildings, although it is also found to be a valuable scavenger. The scavenger habit, however, makes it an undesirable intruder in the house owing to the possibility that it may convey disease.

ARMADILLIDIUM VULGARE Latr.

The sowbug *Armadillidium vulgare* Latr. is commonly known as the "pill-bug," on account of its habit of rolling into a ball whenever disturbed. Ordinarily it is found only in the vicinity of habitations, in dark, damp places, such as woodsheds and cellars, under boards and rubbish, and around wells, cisterns, and water barrels. The open foundations under houses in the South give very favorable locations for breeding.

For several years the Department of Agriculture has received reports of injury from sowbugs to one or another crop in various parts of Texas. The sowbugs seem to have been on the increase from year to year. In 1905 the spring rains, although at times occasioning a natural check to these pests, brought about a series of conditions favorable to a rapid increase in their numbers. Moisture is a requisite to their life, and it also seems that vegetation is a standard article of food. The bad conditions of the ground throughout Texas during that year made all crops very late, so that by the time the succulent cotton and garden crops were coming up the new broods of young sowbugs were everywhere engaged in finding delicate, tender food.

At Dallas the cotton patch of the boll-weevil laboratory furnished ample evidence of the capacity of these crustaceans in devouring vegetation (see Pl. II). By April 14 the cotton was sending up the second, and in some cases the third, pair of leaves. At this time Mr. Springer Goes noticed that the growing tips in rows adjacent to buildings were badly eaten, although the injury extended over the entire patch to a greater or less degree. All plants which were tipped died very shortly, with the result that seven rows had to be entirely replanted. A great many of the seedlings of the second planting also were killed. Many gardens had suffered through attacks on the young sprouts of beans, peas, and tomatoes, and on rose bushes and other cultivated flowers. In December Mr. R. C. Howell found the sowbugs doing serious damage to roots of palmetto, one large plant being entirely killed. From Austin there came a note published in Farm and Ranch, dated April 29, 1905, which enumerated the following plants as subject to the attacks of this species: Butter beans, radishes, lettuce, mustard, potted plants, and also flower seed. The earlier planting of beans was untouched, while the late planting, owing to the favorable conditions for multiplication afforded the sowbugs, was seriously injured.

From economic literature the writer finds the following records of injury attributed to this species:

Miss Richardson [a] cites injuries to cucumbers and hothouse vegetables at New Orleans, La., to various plants at Fort Worth, Tex., and to date palms from Algeria, located at Washington, and states that these sowbugs are a most serious pest on mushrooms at Berkley, Va.

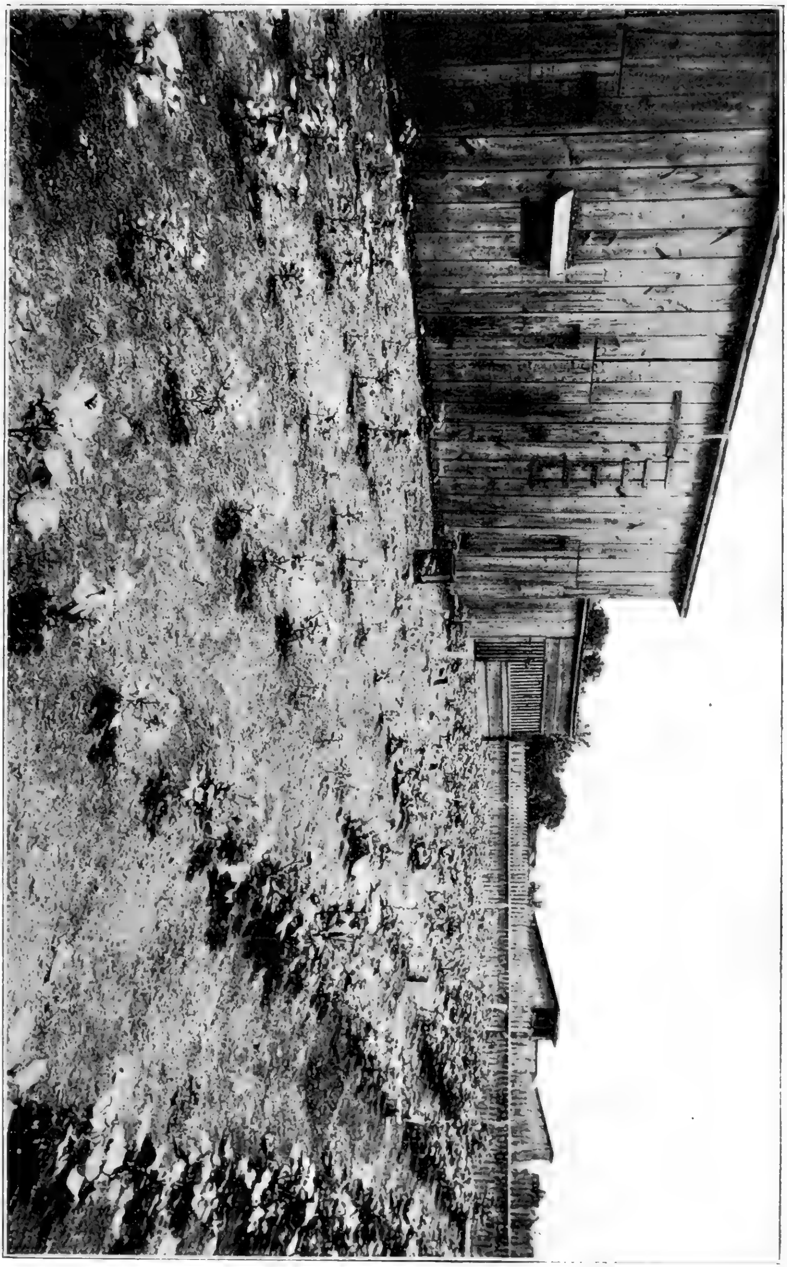
Mr. H. Garman [b] cites this species as very injurious to young cucumbers and lettuce in greenhouses, and recommends carbon bisulphid as a remedy.

With this information in hand, a series of seventy-five experiments was conducted in the laboratory in order to compare various conditions and foods in their effects upon this species. Over 900 individuals were involved in the experiments, of which the results may be here summarized.

The most favorable condition under which to keep the sowbugs was found to consist of a mixture of gumbo and sand kept moist, and a supply of fresh cotton leaves, leaving some old ones to decay and mold. Moisture is absolutely essential. With such conditions, sowbugs were carried through the entire period of the investigation, e. g., 10 females and 1 male were kept alive eighty days, and 4 of these

[a] Monograph on the Isopods of North America. By Harriet Richardson. Bul. 54, U. S. Nat. Mus., 1905.

[b] Bul. 91, Ky. Agric. Exp. Sta., 1901.



WORK OF ARMADILLIDIUM VULGARE ON COTTON.

[This shows the center of the injured area, which was replanted, and also the source of the infestation—the sheds. (Original.)]

females were still alive one hundred and sixty days after the beginning of the experiment. The cotton leaves, when tender, were eagerly eaten.

Fungous growth was favorable only under certain conditions. In the experiments cited above the leaves in contact with the earth decayed and accumulated a rich growth of mold. Upon these decayed leaves the sowbugs seemed to thrive, although there was always evidence of feeding on green leaves when such were present. Fungous growths on dry leaves, on decaying fruit, and on moist dead wood were only capable of sustaining them as long as the moisture was conserved. Fungus found on earth moistened with molasses sustained 9 sowbugs thirty-six days, and 2 survived as long as seventy-five days. Green cotton leaves alone will sustain the life of these crustaceans longer than any other simple condition tried—thirty-two days being the longest any remained alive under these conditions. The other vegetation provided was not favorable, and the sowbugs seemed rather to keep alive on the moisture from the blotter or on the fungus-covered decayed leaves; thus, rose buds and leaves, and the leaves of violet, mint, and chrysanthemum were untouched by the sowbugs. These leaves did not retain their moisture long after picking. When moist earth alone was provided, some found sufficient food to sustain life eighteen days. Additional proof that nourishment is sought in the soil was obtained by mixing London purple or Paris green with the earth. Death always resulted very quickly. When other conditions were unfavorable it was often found that some were sustained by feeding upon the bodies of their dead associates, which were completely devoured. The molted skins were generally devoured.

Experiments with the cattle tick (*Boophilus annulatus* Say) and its eggs evidenced the fact that the sowbugs fed on the dead ticks and ate the eggs when no other food was present. Thirty-eight sowbugs were furnished with a large number of eggs of the tick, and it was found that in several instances as many as 13 tick eggs each were eaten per day for a series of days. This, however, was a maximum, the average during the conduct of the experiment being about 3 eggs per day each. Experiments to find whether the sowbugs fed upon the pupæ of a cutworm (*Prodenia ornithogalli* Guen.) proved futile.

A series of outdoor tests was also conducted with baits to find what substances might be used to attract these crustaceans, and finally a series of poison tests to ascertain the most advisable remedy.

Bread proved attractive, but as every piece tried was carried away by some mammal or bird its use seemed inadvisable. Flour, bacon, potatoes, radishes, and sugar proved to be good baits. To ascertain the relative value of different insecticides several poison tests were conducted with pyrethrum, Paris green, London purple, and arsenic. Few dead sowbugs were found, however, and it was noticed that a less number approached the poisoned baits than those not poisoned. A series of tests with repellents showed that barriers of powder—whether pyrethrum, arsenic, London purple, or Paris green—proved obnoxious, the sowbugs quickly turning away to avoid the danger, and showing, by the frantic waving of the antennæ, that they had a perception of something wrong. London purple seemed the least repellent and yet practically as effective as any of the others. Sowbugs placed in a jar with a biscuit rolled in arsenic became frantic and died in a few minutes, as did others placed in jars with earth mixed with either London purple or Paris green.

After sprinkling Paris green under boards which had been favorite haunts of the sowbugs, no more live specimens could be found, although each day several dead ones were discovered. In April, when the sowbugs were doing considerable damage to the cotton, a mixture of Paris green and lime was dusted on and around the sprouts with the result that under the poisoned plants great numbers of dead sowbugs were found. No dead could be found around the unpoisoned plants. The dusting was harsh treatment for the plants, being in many cases fatal. It is, however, as proved by other tests, unnecessary to dust the plants. The poison will be picked up by the sowbugs in foraging over the ground.

Under a roll of wire matting in his back yard the writer found the sowbugs so abundant that they crawled over each other in their haste to get away. Having very little poison on hand, he sprinkled what he had of Paris green, London purple, and arsenic over the ground in an area of about 1 square yard and rolled back the matting. Next morning he found 21 sowbugs alive and over 800 dead. Those alive died in a few days, apparently from the effects of the poisoning. The poison washed from these dead sowbugs and used to saturate the soil in jars in several experiments proved fatal to all sowbugs placed in the jars.

Kerosene emulsion as a contact spray was fatal. In spraying a water barrel with kerosene the writer generally sprayed the ground around it also, with the result that the sowbugs were always killed.

These experiments and tests were supplemented by numerous observations of actual conditions from which also data may be derived regarding means of control.

Concerning the plant-feeding habits, definite proofs were obtained as follows:

May 25, at 7.30 a. m., sowbugs were noted at various distances above the ground feeding on the foliage of weeds and honeysuckle. On June 30, at 7 a. m., three sowbugs were discovered feeding on weeds, and one at 8 feet above the ground feeding on a honeysuckle leaf. Nine others were found on the honeysuckle vine at various heights up to 3 feet; also two on grass blades and seven on the ground under the honeysuckle. On July 3, at 7.30 p. m., the sowbugs were just commencing to climb the various plants, and none were feeding as yet. On the honeysuckle 19 were seen at various heights up to 3 feet, and all but two on the stems and moving upward.

The following definite proofs of the scavenger habits of this sowbug were obtained: May 17 a dead rat near the house was found covered with a great number of sowbugs and almost entirely eaten, even the skin being eaten in places. At another time several sowbugs were discovered diligently cleaning a peach pit.

Concerning the haunts of these animals the following observations were made: In April and May there was considerable moisture, and under every shaded, moist board, cinder, and clod, and under straw, refuse, garbage, and carrion, one could easily find many adult sowbugs and multitudes of young. In the cotton patch, at the base of each plant, the ground became cracked, and here sheltered great numbers of sowbugs, which very likely did injury to the roots. May 17, under the trees and in shady places, the sowbugs were so plentiful that at every step numbers were crushed. July 3, at 8 p. m., sowbugs to the number of 14 were found on an oak tree, the highest being 5 or 6 feet above the ground. July 26, in the late afternoon and early evening, some five dozen sowbugs were found in cracks and holes on three trees, many of them as high as could be seen.

Regarding the effect of natural and field conditions upon these crustaceans certain notes were made. Susceptibility to varying weather conditions was very noticeable. May 25, at 7.30 a. m., a large number of sowbugs had gathered at baits. At 8 o'clock a sudden storm commenced to rise. The sowbugs seemed immediately conscious of danger and hastened in all directions for the highest shelter possible, gaining protection on the fence and beneath the clapboards of the house. All were out of sight when the first drops of water fell. In April and May there was considerable rain, and during the periods of sunshine, at whatever time of day, the sowbugs were to be seen everywhere, crawling over the sidewalks and pavements. April 23 and 24 the ground was drenched with water, and on the 25th dead sowbugs were to be found everywhere on the ground and on the sidewalks. On June 3 a similar observation was made in a spot where the water had stood for several days. By June 15 the intense heat had driven the sowbugs from the open so that few could be found in unprotected places.

The writer's notes upon the biology of the isopods are based on observations of about a thousand individuals in the large series of experiments that has been already referred to.

Copulation was frequently noted out of doors during April and May. The males may be distinguished from the females by their colors as well as by the specific sexual characters. They are a dark slaty blue, while the females are lighter and have yellow markings.

The period of incubation in this species is long, between fifty-six and ninety-three days, according to the varying results obtained. As no individuals were secured in copula, the exact time of its duration was not recorded. The development of the eggs may be watched from the exterior. The females should be treated very carefully, but with a lens one may see on the ventral side, in the marsupium, the distinct form of the eggs, and may notice the increase in size and finally note the young embryos and the little white young. One experiment with 10 females was most fruitful in giving data on this point. On May 8, June 16, and July 8 young had been produced, and on examination on July 26 all were found to be unfertilized except one, which had eggs apparent. On August 7 the fertile female produced a brood of young. This was ninety-three days after being placed in captivity. A male was admitted on July 26, and on September 30 a brood of young was produced. This would indicate a period of incubation of, at the most, sixty-eight days. In another experiment a female which had just produced a brood of young was placed with 3 males on August 7. On October 2 a brood of young was produced, making the period of incubation fifty-seven days. The number of young in a brood varied from 29 to 79.

The little isopods are pure white when they leave the marsupium. They have six pairs of legs. Within twenty-four hours of birth they molt, and still have only six pairs of legs. Between the fourteenth and eighteenth days another molt takes place and the resulting third instar has seven pairs of legs. The young continue to grow and molt, having been observed in the act of molting on the twenty-eighth, thirty-sixth, fifty-eighth, and sixty-eighth days. After the first molt there is no regularity as to times of molting in the brood, all depending on the food supply. After the first molt a slight darkening of the intestines is noted, and by the twenty-first day the sowbugs are of a gray color throughout and under 3 mm. in length. In fifty-eight days they have not increased beyond 4 mm. in length. The greatest size of any found was 15 mm. This specimen was probably several years old. Females not over 7 mm. long are capable of reproduction.

Before molting, the body of all sowbugs becomes a very dirty gray color. The act of molting is peculiar. At first a white border indicating the loosening of the old skin appears at the front edge of the fifth free thoracic segment, then another on the sixth, and still another on the seventh. Finally the entire posterior half of the skin is free and the isopod steps out of it. This process consumes about twenty-four hours, and when completed the posterior part of the body is of fresh slate color, while the old anterior part appears very dull. Following the first stage of the molt the anterior segments commence to loosen and are slid forward. The dorsum of the third and fourth thoracic segments is loosened before the legs of these segments are released. From then on the last two pairs of legs in the very young and the last three in later stages are used to hold the animal in position. The anterior legs are not available for use for some time after they are free. The antennæ are withdrawn last.

Regeneration of parts takes place in the antennæ and legs. Several times individuals with aborted members were noticed. These latter would gradually attain full length, then budding of the succeeding segment would be noted and finally this member would be normal. The regenerated part is white for some time.

REMEDIES.

In the treatment of sowbugs poisoned baits are standard remedies. The great fondness of sowbugs for potatoes long ago led to these being used, poisoned either with Paris green or London purple. The potatoes are sliced and a thin covering of powder applied. Sprinkling the soil around an injured plant with Paris green, or dusting the same under boards and other haunts of the sowbugs is also very effective. If the sowbugs are injurious in a garden patch—after treating the ordinary haunts—it is best to keep the ground well broken and raked to prevent clodding and cracking, which gives them protection. Old boards, cans, and rubbish should not be allowed to accumulate. Such precautions will tend greatly to prevent any great damage or annoyance.

Carbon bisulphid has been recommended for the treatment of sowbugs in greenhouses and dwellings, but no special experiments along this line have been tried by the writer.

PORCELLIO LÆVIS Latr.

Porcellio lævis Latr. is a lighter colored sowbug than the preceding, and does not roll up in a ball when disturbed, but instead runs rapidly away to cover. The only definite point in favor of considering it as naturally a plant feeder was the discovery of one dead specimen under cotton dusted with Paris green. It was found, however, that the best way to keep this species alive in the laboratory was to furnish it with fresh cotton leaves and loose mixed soil. Sowbugs of this species were not found far from the barns, and were not numerous in the laboratory cotton patch. They were generally under moist, dark objects and seemed to prefer damp wood piles. Several were found with Armadillidium in crevices and in trees at various heights. One Porcellio was found in the skeleton of a carabid beetle, which was entirely eaten out. In numerous cases this species was found devouring those of its own kind. The molted skin is usually eaten. A chest of old clothes, which had been wet in a flood, was found to be literally alive with this sowbug. Experiments with eggs of the cattle tick (*Boophilus annulatus* Say) gave the following results: Four sowbugs provided with over 300 eggs devoured 153 at the rate of between 5 and 6 a day each.

The broods of this species are small, numbering from 8 to 30. Metamorphosis is more rapid than in Armadillidium. The seventh pair of legs is attained before the twelfth day. Molting is as in Armadillidium.

The same remedies as recommended for Armadillidium were found to be effective.

METOPONORTHUS PRUINOSUS Brandt.

Metoponorthus pruinosus Brandt is a much rarer sowbug than either of the two preceding species. It is also more delicate and more agile. The color is a beautiful blue-gray in the male and somewhat tinged with red in the female. Its haunts are damp, earthy places in sheds, etc.

These sowbugs feed very eagerly on cotton leaves and were kept under the same condition as the two preceding species. Forty tick eggs were eaten by two individuals at the rate of about 7 per day each. They may be poisoned by dusting the soil in their haunts with arsenicals.

Reproduction and development is very rapid, much more so than in either Armadillidium or Porcellio. One pair produced four broods of young in sixty-two days, there being seventeen, sixteen, and twenty-one days between broods. The broods are small. The young grow so rapidly that in two months they are one-half as large as their parents. They molt frequently. It is very difficult to observe this species closely because of its rapidity of movement.

CONCLUSIONS.

In conclusion it may be said that (1) in a damp year the sowbugs may do considerable damage to the young growing vegetable crops; (2) they serve at all times as scavengers; (3) their exclusion from houses is advisable because of the scavenger habit, there being a possibility of the transmission of diseases; (4) in the case of the cattle-tick problem they may be beneficial by eating such eggs as are deposited in barns, sheds, pens, in the woods near the watering places, and in moist meadows. Finally, cleanliness is probably the best preventive against sowbug inroads, arsenical compounds the best outdoor remedies, and carbon bisulphid the best indoor remedy.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part III.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON "PUNKIES."

BY

F. C. PRATT,

Special Field Agent.

ISSUED APRIL 2, 1907.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1907.

CONTENTS.

ILLUSTRATIONS

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON "PUNKIES."

(*Ceratopogon* spp.)

By F. C. Pratt,
Special Field Agent.

INTRODUCTION.

While in the Blue Ridge Mountains near Bluemont, Va., a few years ago the writer heard reports concerning "biting gnats," which were said to bite furiously before rains. At that time his stay was of short duration, and a dry summer prevented him from securing specimens. In 1904, however, during another visit to the same locality one rainy week, July 21–28, he was harassed by myriads of these minute flies, which were extremely numerous and active after as well as before rains. They proved to be *Ceratopogon guttipennis* Coq., one of the smaller Chironomidæ. Mr. D. W. Coquillett has recently made a careful systematic study of the specimens belonging to the genus Ceratopogon contained in the United States National Museum collection, including those reared at the insectary of this Department and by the writer, and the determinations of the species here mentioned are his. The records of these rearings are brought together in the present paper with the addition of such data as have been communicated by collectors and correspondents.

Prior to 1902 little had been published on any of these pernicious insects beyond scattered notices such as were furnished in a previous bulletin[a] of this Bureau, on the bite of *C. stellifer* Coq. in Texas. As the bibliographic references have never been collected, the writer has brought together all data and accompanying illustrations, with such references to the biting and other habits of this group as he has been able to find.

CERATOPOGON GUTTIPENNIS Coq.

The flies of the species *Ceratopogon guttipennis* will bite any exposed part of the body, preferring, however, the hairy parts. At one time 25 individuals were counted in the hair on the head of the writer's 8-year-old boy guide at Bluemont, Va. They are persistent in their endeavors to obtain blood, piercing the skin and filling up with blood so as almost to lose semblance to flies. In many cases an itching

[a] Bul. 44, Div. Ent., U. S. Dept. Agric., p. 92, 1904.

pimple results from the punctures, the eruptions, in appearance,

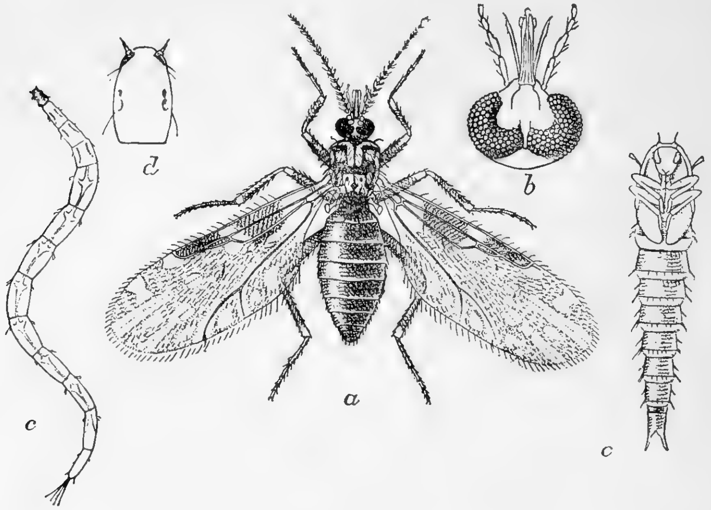


FIG. 3.—*Ceratopogon guttipennis: a,* adult; *b,* head of same; *c,* larva; *d,* head of same; *e,* pupa. All greatly enlarged (original).

being very much like the vesicles caused by contact with poison ivy. The adult is a minute fly 1 mm. in length, appearing blackish to the naked eye, but under a lens seen to be of a deep gray hue, with mottled wings (fig. 3). Its mouth parts are illustrated in figure 4. The species was described by Mr. D. W. Coquillett,[a] to whose paper the reader is referred for descriptions of many species of this genus. The Virginia punkie is the name which the writer would suggest for this particular species, as it may possibly be distinct from the one occurring in Maine which the Indians called "no-see-um," and which is popularly known as "punkie," the latter name being corrupted according to locality. The flies of this species are very troublesome to man and domestic animals. If milking is put off later than usual in the morning, they drive the cows almost frantic by their persistence, and while that process is going on the operator, having both hands engaged, is at their mercy.

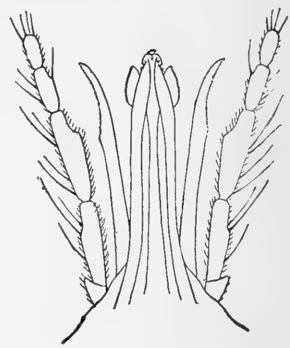


FIG. 4.—*Ceratopogon guttipennis:* Mouth parts of adult. Highly magnified (original).

THE LARVA.

Larvæ were found in the very dirty water in holes in the middle of poplar stumps, in company with larvæ of mosquitoes (*Anopheles bar-*

[a] Proc. U. S. Nat. Mus., Vol. XXIII, No. 1225, p. 603, 1901.

beri Coq., *Culex signifer* Coq., and *C. triseriatus* Coq.), larvæ of the dascyllid beetle *Prionocyphon discoideus* Say, and a rat-tailed maggot related to Eristalis. Eggs could not be found on account of the dirty condition of the water. The larval food seems to be the débris at the bottom of the holes, as well as dead mosquito and other larvæ, and cast larval and pupal skins. In one instance the larvæ had accomplished the complete disintegration of a rat-tailed maggot, and the writer has seen them render the skin of the beetle larva just referred to transparent. On several occasions larvæ were seen inside the skin. They were taken also at Woodstock under similar conditions, that is, in holes containing water in living trees.

The larva (fig. 3, *c*), when full grown, is 4.7 mm. in length and very slender. It has 12 segments exclusive of the head, the two segments following the head together being about the length of each of the other segments. It is white in color, threadlike, and has a brownish head. Locomotion is undulatory. The larvæ frequently come to the surface and then descend, squirming along the bottom of a jar and apparently never remaining quiet, as does the larva of Culex at times. Some of the larvæ were carried through the winter in a room which was moderately cool, but seldom near freezing. From these over-wintered larvæ adults issued April 27 to May 8, 1905. Later investigation may prove that the larvæ freeze up just as do the larvæ of some mosquitoes, then thaw out in the spring and complete their life cycle.

FIG. 5.—Pupa of *Ceratopogon varicolor*. Much enlarged (after Dyar).

THE PUPA.

The pupa (fig. 3, *e*) is 3.01 mm. in length and 0.84 mm. in breadth. It is of a brown color, a little more than half as long as the mature larva, but much stouter, and has eight abdominal segments, each succeeding segment being narrowed to the last, which is bifurcated, the claspers being 0.35 mm. in length. It is provided with two short breathing tubes. In this stage the insect does not move frequently, remaining in a perpendicular position in the water just below the surface. For comparison the figure of an allied species, *C. varicolor* Coq. (fig. 5), from Bellport, N. Y., is reproduced from Plate I, Volume V, of the Proceedings of the Entomological Society of Washington.

The known distribution, gathered from specimens in the U. S. National Museum collection, is as follows: Plummers Island, Md., June 6 (H. S. Barber); Medina, Ohio, August 5 (J. S. Hine); Bluemont, Va., July 29 and 30, and Woodstock, Va., August 8 and 9 (F. C. Pratt); Santa Rita Mountains, Arizona, July 8 (E. A. Schwarz).

A specimen of *Ceratopogon guttipennis* has recently (April 13, 1906) been reared from a larva collected from water in a hollow living tree at Dallas, Tex., April 9, 1906, under conditions similar to those at Bluemont and Woodstock, Va. This water had been frozen during the winter.

OTHER SPECIES OF CERATOPOGON.

There are nearly one hundred known species of Ceratopogon represented in the U. S. National Museum collection, and several species besides the one under discussion are known to bite, among them

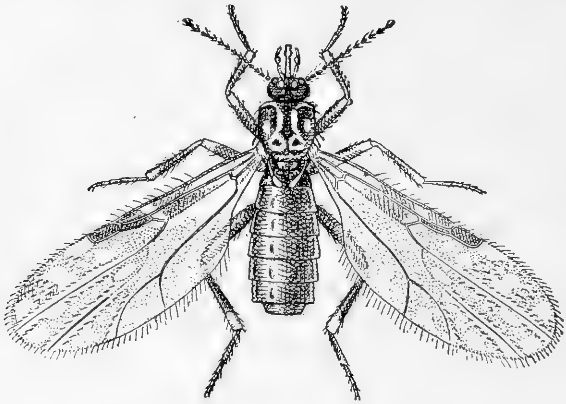


FIG. 6.—*Ceratopogon stellifer:* Adult. Highly magnified (original).

C. sanguisuga Coq., *C. stellifer* Coq., *C. variipennis* Coq., *C. unicolor* Coq., and *C. cinctus* Coq. Many others will undoubtedly be found to have similar habits.

C. sanguisuga Coq. has been collected at the following localities: Marlboro, Md., May 13 (H. S. Barber); Woodside, Md., October 12 (J. E. Benedict, jr.); Kaslo, British Columbia, June 29 (H. G. Dyar).

C. stellifer Coq. (fig. 6) is a little smaller than *C. guttipennis* and is a most notorious biter. Its distribution, as shown by specimens in the U. S. National Museum, is as follows: District of Columbia, May 12, June 6, September 9 (H. S. Barber, collector); Fairfax County, Va., August 18 (J. E. Benedict, jr.); Corinth, Miss., August 19, and Athens, Tenn., August 22 (H. S. Barber); Las Vegas Hot Springs, N. Mex., August 7, 11, and 19, and Hot Springs, Ariz., June 27 (H. S. Barber).

C. variipennis Coq. A female of this species was collected while sucking blood by W. P. Cockerell at Las Vegas, N. Mex., May, 1902, and has been collected at Westville, N. J., in June, by J. B. Smith and on July 2 by C. W. Johnson; also at Richmond, Va., by Mrs. A. T. Slosson, and at Mexico City, Mexico, by O. W. Barrett.

C. unicolor Coq. has been taken at Eureka and Fieldbrook, Humboldt County, Cal., by H. S. Barber in May and June.

C. cinctus Coq. was found at Lake Worth and Biscayne Bay, Fla., by Mrs. A. T. Slosson, who braved its biting in order to collect specimens of it.

C. websteri Coq. was collected April 17, 1887, by Prof. F. M. Webster at Ashwood, La., on bushes in company with a species of Simulium.

C. mutabilis Coq., reared from human excrement by the writer in the District of Columbia June 17, occurs also at Jacksonville, Fla. (Mrs. A. T. Slosson, collector).

C. griseus Coq. was captured on human excrement by the writer at Travilah, Md., in June. It has been collected also in Florida and Arizona, and Prof. T. D. A. Cockerell found it on a horse at Pecos, N. Mex. This species, as well as *C. mutabilis*, were recorded by Dr. L. O. Howard in an article on the insect fauna of human excrement as "Ceratopogon species." [a]

C. specularis Coq. was reared by Mr. C. L. Marlatt from horse and cow manure during his investigation on the horn fly (*Hæmatobia serrata* R.-D.) in Virginia in 1889. It has been collected also at Springfield, Mass. (Dimmock); Philadelphia, Pa., June 28, and Natrona, Pa., July 30 (C. W. Johnson); District of Columbia, August 11 (F. C. Pratt); Woodside, Md., October 12 (J. E. Benedict, jr.); Warrenton, Va., August 23, and Rosslyn, Va., December 30 (C. L. Marlatt), and in Colorado.

W. H. Long[b] found larvæ of this species on the under side of dry cow dung from August to December, but more abundantly during November and December, in company with *C. brumalis* at Austin, Tex.

C. brumalis Long. Mr. W. H. Long writes of this species as follows: [c]

During November, December, and January the larvæ of this species were found in immense numbers on the under side of nearly dry cow dung. They seem to feed on the dung, never penetrating very far into the substance. No eggs were found. The duration of the larval stage seems to be several weeks, that of the pupal stage seven to ten days. * * * Several hundred larvæ of all ages were found on the under surface of a piece of moist rotting elm wood; similar larvæ and puparia were also found in the nests of the common foraging ant (*Eciton cæcum*) on several different occasions.

Mr. Long states that he reared imagines from larvæ taken in these various situations and they proved to be the same species. It is known from Austin, Tex.

C. stenammatis Long. Long writes of this species as follows:[d]

The specimens were received from Dr. W. M. Wheeler, who found them in the nest of an ant (*Stenamma fulvum* subsp. *aquia*) at Colebrook, Conn., August, 1900. They were moving about in the refuse heaped up by the ants in certain portions of their nests. The species seems to be a genuine myrmecophile like the European species (*C. Braueri* Wasmann).

---

[a] Proc. Wash. Acad. Sci., Vol. II, p. 559, 1900.

[b] Biol. Bul., Vol. III, pp. 7–10, figs. 3–6 (in part), 1902.

[c] L. c., Vol. III, pp. 3–7, figs. 1, 2, 6 (in part).

[d] L. c., p. 10, figs. 4, 6 (in part).

C. texanus Long.

The larvæ of this species are gregarious in small numbers beneath the bark of old dead trees in moist places, or on the under side of very damp rotting wood during December and January. Rare.[a]

Austin, Tex.

C. wheeleri Long. Adults of this species have not been reared on account of a proctotrypid parasite (*Adeliopria longii* Ashm.).

The Ceratopogon puparia were found December 15, 1900, beneath a stone, in what seemed to be an abandoned ant's nest. The parasites issued, one from the thoracic dorsum of each of the Ceratopogon puparia December 31 and lived eight or ten days.[b]

Austin, Tex.

The late Dr. O. Lugger[c] calls attention to the "cussedness" of an unidentified species and gives a figure which may possibly be *C. stellifer*. Ceratopogon has also been recorded as breeding under leaves and in flowing sap from trees; thus the group is seen to have diversified habits.

In Europe, Professor Mik[d] described as *Ceratopogon hippocastani* a hairy-winged species having a footless larva, found in the very moist or wet ulcerous parts of stems of horse-chestnut (*Æsculus hippocastanum*).

OTHER BLOOD-SUCKING CHIRONOMIDÆ.

A related form which may be mistaken for Ceratopogon is *Œcacta furens* Poey, taken in June at Cardenas, Cuba, by Mr. E. A. Schwarz, and at Montserrat, West Indies, April 8, by Mr. H. G. Hubbard. It was also taken at Perihueta and Laguna Carmen, Mexico, by Dr. Alfredo Dugès.

Another related form, *Tersesthes torrens* Towns., described by Prof. C. H. T. Townsend[e] with notes on habits, has been collected at the following localities: Filmore Canyon, and Las Vegas Hot Springs, N. Mex. (Townsend); Fort Grant, Ariz., July 19 (H. G. Hubbard); Ash Fork, Ariz., June 18 (H. S. Barber); Lake Worth, Fla. (Mrs. A. T. Slosson); Salt Lake, Utah (H. S. Barber), and Baracoa, Cuba, August (A. Busck).

Mr. Barber has collected from thirty to forty species of Ceratopogon and states that Tersesthes is much worse as a pest than any Ceratopogon he has ever encountered.

---

[a] Long. L. c., pp. 10-12, figs. 5, 6 (in part).

[b] Long. L. c., pp. 12–14, fig. 5 (in part).

[c] Second Rept. Ent. of Minn. Exp. Sta., pp. 171–172, fig. 142, 1896.

[d] Wiener Ent. Ziet., Vol. VII, pp. 183–192, Pl. II, 1888.

[e] Psyche, Vol. VI, pp. 369–371, pl. 8, 1893.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part IV.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.

BY

F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

Issued January 14, 1908.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1908.

CONTENTS.

ILLUSTRATION.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

In economic works of European authors a very considerable number of species of Apion are mentioned in connection with injuries to cultivated plants, and particularly to the Papilionaceæ, for which a large proportion of species show a preference. Certain European forms are sufficiently abundant to receive common English names, among which are the clover weevil, the Dutch-clover yellow-legged weevil, the cinquefoil weevil, the tare or vetch weevil, and others, the popular name being indicative of each insect's food habits.

None of our native species, so far as known to the writer, has hitherto been recorded as injuring useful plants; hence a note received from Mr. James K. Metcalfe, Silver City, N. Mex., of injuries to forage plants by *Apion griseum* Sm. is of interest.

APION GRISEUM Sm.

September 25, 1899, our correspondent sent seedpods of the Metcalfe bean (*Phaseolus retusus*), together with specimens of the beetle. This weevil was stated to be very destructive to this plant, which has been mentioned by Dr. Jared G. Smith as one of the most promising of our native forage plants.[a] The weevil was said to be also destructive to the "Raphael" bean (*Phaseolus wrightii*), and we have received the same species from Phaseolus beans from Tolima, Mexico.

This species has also been observed by the writer to develop in the seedpods of a wild bean, *Phaseolus polystachyus* (*perennis*). Eighteen individuals were found on opening a pod of this plant at Rosslyn, Va., April 22. One seed had harbored eleven Apions, all of which perished owing to their inability to escape from the pod.

[a] Yearbook, U. S. Department of Agriculture, for 1897, p. 506.

which had evidently died prematurely as a result of overinfestation by the weevils. Pods were examined during the first week of October, and at this time half of those gathered were infested. The sound pods may be easily separated from the infested ones, since the latter are flattened, discolored, and sometimes even distorted, while sound and fully matured pods are full and round like a diminutive pea-pod. Most individuals were in the pupal condition at the last-mentioned period. The adults, like others of the genus, feed upon the leaves, piercing them with innumerable holes, from 20 to as many as 60 such punctures being sometimes visible on a single small leaf.

The insect hibernates in the beetle condition, escapes from the pod about May or June, or earlier if the pod happens to crack, and the punctures made upon the early appearance of the insect are plainly visible in October.

Careful comparison of the writer's reared material of *Apion griseum* with typical specimens in the U. S. National Museum (some of which appear to be types) of *A. fraternum*, identified as such by Dr. J. B. Smith, who described that species, shows that this is the same insect which was found by Dr. C. V. Riley on *Strophostyles* (*Phaseolus*) *pauciflora* as cited by Smith. The identity of these two forms has also been recognized by Fall in his revision of the genus.[a]

The chalcidid fly *Catolaccus incertus* Ashm. was reared from infested pods, and is undoubtedly parasitic on this Apion.

APION COLON Sharp.

February 6, 1903, Dr. Edward Palmer furnished specimens of this species collected at Alvarez, San Luis Potosi, Mexico, on a species of wild bean with scarlet flowers and tuberous roots, which is used as a cure for hydrophobia (Palmer's No. 63).

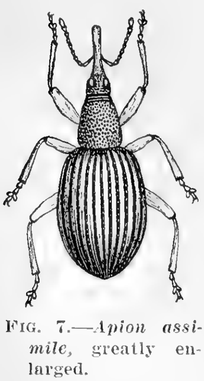


FIG. 7.—*Apion assimile*, greatly enlarged.

This species is not known to occur in our limits, but is mentioned because of possible economic importance.

The accompanying illustration (fig. 7) represents a European species, and will assist the average student of entomology in recognizing weevils of the genus. Upward of 100 species of the genus Apion have been recognized in America north of Mexico, and most of these are minute or almost microscopic. It follows, therefore, as there is considerable generic resemblance throughout, that these many different forms are difficult of differentiation, both sexes being frequently required to make specific determination. The body is

[a] Trans. Amer. Ent. Soc., Vol. XXV, p. 147, 1898.

elongate pyriform, or pear-shaped; the rostrum or beak is more or less prolonged in front of the eyes, and the head back of the eyes is usually constricted, forming a neck. The antennæ are delicate and elbowed.

NOTES ON RELATED FORMS.

The following observations on other species of Apion are chiefly from the writer's personal experience, and all rearings should be so credited, with the exception of those where the collector or observer is mentioned:

Apion æneipenne Sm.—During the first two weeks of June numerous examples of this species were obtained at Rosslyn, Va., by beating a common tick-trefoil (Meibomia [Desmodium]). When the beetles were confined with leaves they riddled them with minute holes after the manner of the commoner *A. nigrum* on locust.

Apion turbulentum Sm.—This species was observed during the latter half of September in and near Cabin John, Md., and in considerable numbers on *Meibomia marylandica.* The beetles were numerous, occurring on the seeds, in which they undoubtedly live, although they were not reared.

Apion cribricolle Lec.—We have, among the Department notes, one on the rearing of this beetle from a species of lotus (*Lotus* [*Hosackia*] *glabra*) from Henwood, Santa Cruz County, Cal.

Apion proclive Lec.—July 18, 1898, Mr. E. M. Ehrhorn reported that this species was infesting the pods of *Lupinus arborea* at Pacific Grove, Cal., where nearly every pod showed signs of attack. A similar attack to lupine was reported by Mr. Ehrhorn in 1907 at San Francisco, Cal. The beetles issued September 5–19. The species proves to be parasitized by a chalcidid.

Apion patruele Sm.—This species was found abundantly on a climbing wild legume at Cold Spring Harbor, Long Island, N. Y., in July. The plant at this time was in bloom, and there is little doubt that the larva inhabits the pods.

Apion segnipes Say.—The writer has reared from this species, found in its well-known food plant, the goat's rue (*Cracca* [*Tephrosia*] *virginiana*), the chalcidid parasite *Eurytoma tylodermatis* Ashm., in August, in Maryland, near the District of Columbia. The writer has also reared this species from its larva found in the cells of *Tyloderma foveolatum* in October. There is fair indication, therefore, of two generations.

Apion decoloratum Sm.—This species breeds in the seed pods of the genus Meibomia. Beetles have been reared from *M. paniculata* and *M. grandiflora*, and exit holes have been observed in pods of all of the species of this genus of plants that have come under observation in Maryland and Virginia about Washington. The beetles began issuing from the pods September 21, and most of those in the field had escaped by the end of the month. Stragglers, however, continued to issue from the material gathered until the end of October. Mr. Fall states that "Mr. Wickham has found the species in some abundance on Desmodium in Iowa City." *Catolaccus incertus* Ashm. was reared with this species.

Apion herculanum Sm. was reared July 24–28 from the dried fruit of sheepberry (*Viburnum lentago*), and beetles were taken in the same locality, Marshall Hall, Md., in May on *V. acerifolium* in bloom. At Ithaca, N. Y., it was taken in fair abundance on the flowers of this same plant, collected May 28, June 5–20, and July 2–6 several years previously. Mr. Schwarz informs the writer that he has reared the species also from dogwood (*Cornus* sp.).

○

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part V.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

INSECTS INJURIOUS TO THE LOCO WEEDS.

BY

F. H. CHITTENDEN, Sc. D.,

Entomologist in Charge of Breeding Experiments.

Issued May 29, 1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

CONTENTS.

ILLUSTRATIONS.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

INSECTS INJURIOUS TO THE LOCO WEEDS.

By F. H. Chittenden, Sc. D.,
Entomologist in Charge of Breeding Experiments.

For many years the Bureau of Entomology has conducted correspondence in regard to insects found on the loco weeds of the semiarid regions of the West. In earlier years these insects were found chiefly on purple or woolly loco, *Astragalus mollissimus*, and more recently on the white loco, *Aragallus lamberti*. It was at one time supposed by stockmen that the insects might be the cause of the poisoning to sheep, cattle, and other stock, but such is not the case.

The general subject of loco poisoning to stock has been treated in various publications, but the insect inhabitants of the weeds have never received mention in this connection, with the exception of the false-indigo gall-moth,[a] which is apparently the principal insect destroyer of the loco. Numbers of correspondents and observing botanists have noticed that the caterpillar of this insect, which feeds at the roots and crowns of locos, is quite instrumental in reducing their abundance. Recently Dr. C. Dwight Marsh, Bureau of Plant Industry, has collected many insects on locos and expresses the opinion that several other species are concerned in this work. Chief among these are the fickle midge,[b] the loco root-maggot,[c] the four-lined loco weevil,[d] and the spotted root fly.[e] Of these the root-maggot, midge, and root fly are probably in the main attracted to the plants after the gall-moth has first caused injury, but the weevil also attacks living roots, usually, however, according to observations, after the plant has produced its quota of seed.

The following account of loco insects has been prepared from the records of the Bureau of Entomology, much of the material having also been supplied by Doctor Marsh, and in the list which follows it

[a] *Walshia amorphella* Clem.

[b] *Sciara inconstans* Fitch.

[c] *Pegomya lupini* Coq.

[d] *Cleonus quadrilineatus* Chevr.

[e] *Euxesta notata* Wied.

will be understood that the locality Hugo, Colo., is the one in which he collected specimens for identification. This account does not pretend to be an exhaustive one, but is more in the nature of a list, with notes on such species as appear to be concerned in killing out the weed. Considering the toxic qualities of the locos, the insects which affect them, with some exceptions, may be classified as highly beneficial, since the species which have just been mentioned have in some cases completely rid large areas of loco weeds.

THE FALSE-INDIGO GALL-MOTH.

(*Walshia amorphella* Clem.)

Prior to 1886 the larva of this species was known only as a gall maker on the stems of false indigo (*Amorpha fruticosa*) and was described from moths reared from that plant in 1864. An account of the species and its habits was afterwards given by Riley in 1870.[a] He stated that as the twigs invariably withered and died above the gall, and as the shrub was of no special value, the species might be placed among our harmless insects. In early records of the Bureau of Entomology there are numerous references to this species and its occurrence on false indigo. In 1886 a second food plant, *Astragalus mollissimus*, was recorded.[b]

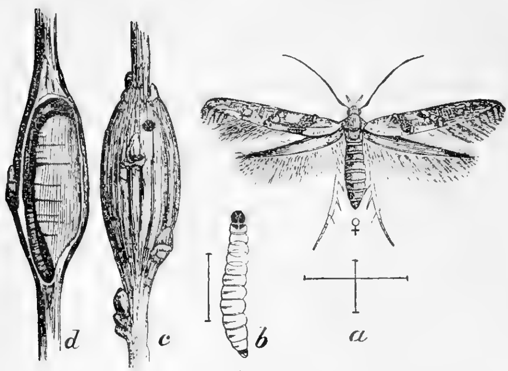


FIG. 8.—False-indigo gall-moth (*Walshia amorphella*): *a*, Female moth; *b*, larva; *c*, gall in false indigo, showing exit hole near top; *d*, gall opened, showing larva *in situ*. *a*, *b*, 3 times natural size; *d*, *c*, natural size. (After Riley.)

This moth (fig. 8, *a*) belongs to the family Tineidæ and has a wing expanse of about half an inch. It is grayish yellow, spotted with dark brown, and both wings are provided, as in others of this group, with very long posterior fringes, longer than the wings themselves. The larva or caterpillar (fig. 8, *b*) is yellowish white, with the head and thoracic plate dark brown. It measures from a third to two-fifths of an inch in length.

Our records of the distribution of this species show that it has been observed most commonly from Iowa and Missouri westward to California, although it occurs also in the Atlantic region. It is quite

[a] 2nd Rept. State Ent. Mo., pp. 132–133.

[b] Proc. Ent. Soc. Wash., Vol. I, p. 30.

singular that the larva should have the dual habit of forming galls on a shrub, as in the case of its occurrence eastward, and at the same time boring into the roots of weeds, as is its western habit. From the experience of many persons who have been in correspondence with this office in regard to the habits of this insect, there can be no hesitation in reiterating that it is the most potent element in the destruction of the loco weed of the West. In this connection it may be well to mention briefly what some of our correspondents have reported. Mr. Thomas J. Quillian, Birmingham, Colo., wrote, April 9, 1889, that from observations conducted by himself and a fellow stockgrower he was led to believe that possibly the "worms" eaten by the stock produced the craziness (and sometimes death) instead of the plant, as was generally supposed, this conclusion being more plausible because upon opening the dead animals many "worms" were always found. Mr. D. H. Marum, Woodward, Okla., has written that in that vicinity the plants begin to die about the last week in May. At that time the small "worms" are found in the roots, which they hollow out completely, leaving practically nothing but a shell. He suggested the possibility of propagating these and other loco insects with a view to destroying the weed. Mr. Thomas Carson, Bovina, Tex., writing of the great loss in cattle in that section, stated that this insect, which he had observed devouring the heart of the loco, was very efficient in reducing the abundance of this noxious weed and had proved very beneficial to the cattle interests. In closing, it should be added that in the extreme west, as, for example, at Alameda, Cal., this species has been observed breeding on *Lupinus arborea.*

THE LOCO ROOT-MAGGOT.

(*Pegomya lupini* Coq.)

The loco root-maggot has been prominent among insects found feeding on the roots of *Astragalus mollissimus* for a number of years. Doctor Marsh says that in the neighborhood of Hugo, Colo., it is apparently the most important agent in the suppression of the purple loco. It is probable that it will rank second to the false-indigo gall-moth as a destroyer of this plant. On this head Mr. George Hochderffer, Flagstaff, Ariz., who, on April 7, 1907, sent specimens found at the roots of the plant, stated that hundreds of acres of loco had been destroyed by this insect, and he believed not only that it might prove to be a valuable friend to stockmen, but that it had already proven so.

It is the larva of a species of anthomyiid fly closely related to the seed-corn maggot,[a] the adult being readily distinguished from that

[a] *Pegomya fusciceps* Zett.

of the latter by the long bristles on the underside of the posterior femora or hind thighs. It was described in 1901 from flies obtained from the stems of *Lupinus alba* from Los Angeles, Cal.[a] This species resembles the common house fly, though more slender and of a more distinctly gray color. The larvæ are white maggots and resemble the seed-corn maggot. They infest chiefly the crown of the plant, seldom, if ever, entering the roots, but penetrating into the larger stems; sometimes, it is reported, going as far as the base of the flowers.

We have records of the rearing of this species from *A. mollissimus* from material collected at Sherlock, Kans., and from *Lupinus arborea* at Alameda, Cal., in April. In June, 1887, it was received from New Mexico with statement by Dr. V. Havard that it was breeding in the roots of *A. mollissimus.* At this time we were conducting considerable correspondence with Doctor Havard in regard to the insect enemies of this plant in Kansas, New Mexico, and Texas. Doctor Havard stated, among other things, that at that time it was somewhat generally believed that "locoism" on the part of stock animals was due, not to any deleterious property of the plants, but to the larvæ of insects found abundantly in the stems and roots. In all specimens received by him from New Mexico the stems, without exception, were bored by the larvæ of this species. Flies from this last lot began issuing June 10. In May, 1905, and January, 1908, this species was again received from locos from Hugo, Colo. In that locality it was associated with *Euxesta notata* and *Sciara inconstans.*

THE FICKLE MIDGE.

(*Sciara inconstans* Fitch).

This minute gnat-like fly was reared from purple loco received from Hugo, Colo., in 1906, the adults issuing May 24. During 1907–8 additional specimens were received from the same source. Doctor Marsh has expressed the belief that this species, with the larger maggot, *Pegomya lupini* Coq., is one of the chief causes of the destruction and apparent temporary extermination of this loco weed in that section of Colorado. The members of the family to which it belongs, the Mycetophilidæ, are for the most part scavengers, feeding on decomposing vegetable matter, including fungous growths, whence their name of "fungus gnats." Taken as a whole, however, the family displays great diversity in habits and the present species is the most widely distributed and most nearly omnivorous of its kind. It feeds on vegetation of almost all forms, occurring destructively in greenhouses, as also in the open, in cultivated and uncultivated regions. It appears to be most abundant in the Northern States.

---

[a] Ent. News, September, 1901, pp. 206–207.

The insect is shown in its different stages, highly magnified, in figure 9. The size is indicated by the hairlines at the right of the figure. It will be noticed that the female fly (*c*) is larger than the

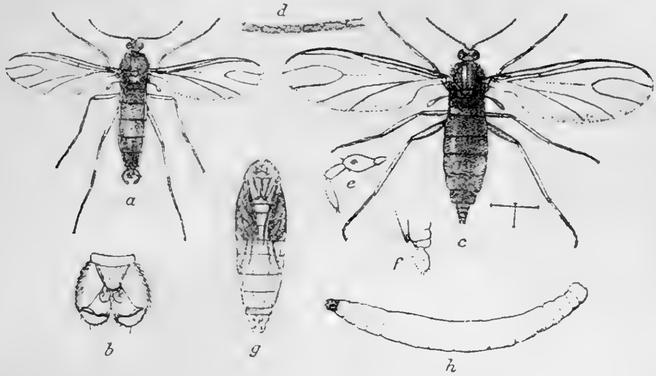


FIG. 9.—Fickle midge (*Sciara inconstans*) : *a*, Male fly ; *b*, external genital organs of male ; *c*, female ; *d*, enlarged antennal joints of same ; *e*, maxillary palpus of same ; *f*, tip of abdomen of female from side ; *g*, pupa, ventral view ; *h*, larva, dorsal view. *a, c, g, h*, Much enlarged ; *b, d, e, f*, more enlarged. (Author's illustration.)

male. The latter (*a*) is recognized by its claspers, shown much enlarged at *b*. The larva is a delicate, thread-like maggot of milk-white color with a jet-black head. On account of its minute size—about $\frac{1}{5}$ of an inch in length—its presence is very frequently unnoticed in greenhouses, although the flies are more conspicuous, from their habit of flying about on the "glass." In some cases this species is confused with nematodes or eel-worms.[a]

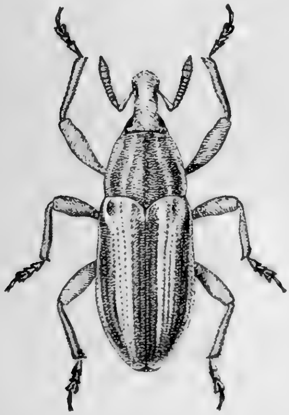


FIG. 10.—Four-lined loco weevil (*Cleonus quadrilineatus*): Adult. Much enlarged (original).

THE FOUR-LINED LOCO WEEVIL.

(*Cleonus quadrilineatus* Chevr.)

This curculionid weevil was found breeding in considerable numbers on *Aragallus lamberti* at Hugo, Colo., during 1907, by Dr. C. D. Marsh, who reports very appreciable injury. As a rule, however, this species does not occur in numbers until after the plants have made good growth and have seeded.

This beetle, (fig. 10) measures about half an inch in length; has a stout rostrum or beak, a little shorter than the thorax; is black, and densely coated with gray pubescence alternating with two pairs of longitudinal black lines, one subsutural and the other submarginal.

---

[a]A more complete account of this insect appeared in Bul. 27, n. s., Div. Ent., U. S. Dept. Agric., pp. 108–113, 1901.

Practically nothing is known of the life history of any species of the genus, of which there are quite a number. The beetles are partial to Astragalus and Aragallus and feed also on lupines and related plants. The larvæ are undoubtedly root or stalk feeders. The present species in the larval stage affects the roots and transforms in the ground in comparatively large earthen cocoons, such as are shown in the illustration (fig. 11).

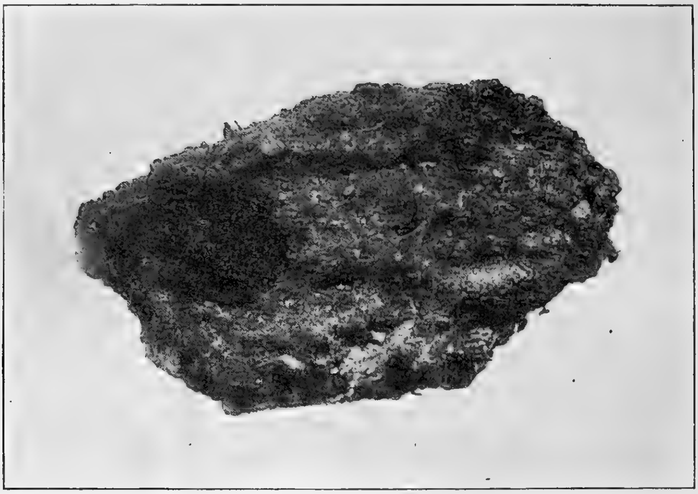


FIG. 11.—Four-lined loco weevil (*Cleonus quadrilineatus*): Cocoon. (Original.)

THE YELLOW LOCO FLY.

(*Tritoxa incurva* Loew.)

This species was collected at Hugo, Colo., on *Aragallus lamberti*. It is a two-winged fly of the family Ortalidæ and is recorded as having the same habits as the black onion fly (*Tritoxa flexa* Wied.), whose larva or maggot lives in the bulbs of onions; indeed, it was at one time considered a color variety of the latter. The wing markings are almost identical, but the face, thorax, and most of the abdomen are brownish yellow, whereas in the onion fly these parts are black. Its body is about one-third of an inch long, each wing having a little shorter measurement. Neither species under consideration is, as a rule, especially abundant, but both are capable of being very destructive to plant life when they multiply in numbers, as may happen any year in some localities.

THE SPOTTED ROOT FLY.

(*Euxesta notata* Wied.)

This pretty little fly of omnivorous habits was reared from *Astragalus mollissimus* from Hugo, Colo., in June and July, 1905, being associated with the fickle midge and the loco root-maggot. In its larval stage it displays a remarkable diversity of habits, although it is evidently by choice a root feeder and is also, with the seed-corn maggot and many related insects, a scavenger by nature, following in some cases original attack by some other form of insect. It has been recorded by Dr. L. O. Howard as having been bred from larvæ in human excrement in houses and out of doors. Mr. E. G. Titus has reared it from sugar beet collected at Olney, Colo., and from cocklebur collected at St. Matthews, S. C., where it was feeding in the cells of a weevil, *Baris transversa.* In September, 1905, it was reared by the writer from onions infested by *Tritoxa flexa* from Williamson School, Pa., and there is positive evidence that it had fed on the onion bulbs, as neither stems nor leaves were present. Dr. J. B. Smith also has reared it from onions. In 1906 it was reared from corn on the farm of Dr. B. T. Galloway near the District of Columbia, where it was reported injurious, the injury being at first attrib-

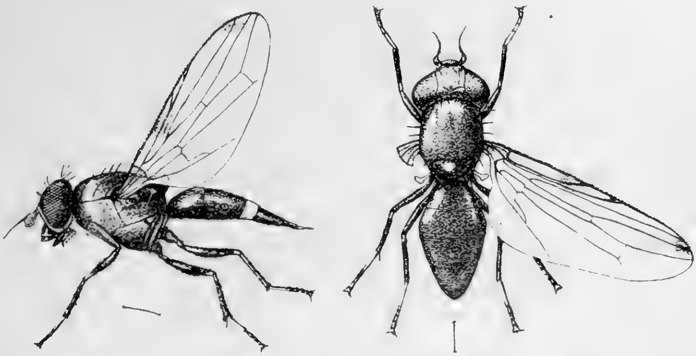


FIG. 12.—Spotted root fly (*Euxesta notata*): Adult male at right; female at left. Much enlarged (original).

uted to the seed-corn maggot, as attack was to seed corn and resembled the work of the latter species. From cabbage it has been reared on two occasions, viz. from the roots collected at Washington, D. C., and from maggot-infested roots received from Bethel, Alaska. It has also been bred from the pulp of Osage orange, from apples infested by the codling moth, from sumach fruit, from the bolls of cotton, and from Solanum. It is not rare in diseased cotton bolls.

This fly belongs to the same family as the preceding, the Ortalidæ, and is shown in figure 12, where it will be seen that it has a large head and flat body. Each wing is marked with two black spots. The female is distinguished from the male by its more slender form, smaller head, and pointed abdomen, which bears near the anal extremity a distinct white transverse band. The body is metallic blue.

Our rearings show that larvæ have come under observation from May 27 to as late as October 2 and that flies have issued from various sources June 10–July 30, September 8–21, and throughout October.

THE BUR-CLOVER APHIS.

(*Aphis medicaginis* Koch.)

This species is well known to attack both Astragalus and Aragallus, as well as various other related plants, including clover, cowpea, alfalfa, coffee bean (Cassia), bur-clover, *Caragana arborescens*, *Robinia viscosa*, *Melilotus italica*, and *Glycyrrhiza lepidota*. It has also been observed on oxalis, and on cotton associated with the common and more destructive cotton or melon aphis.

Certain of our correspondents have remarked on the occurrence of ladybirds and ants on infested loco plants, conclusive evidence in the case of the ladybirds, *Hippodamia convergens* Guér., that aphides were present.

The present species has a considerable literature, having been described in 1857 and afterwards treated more or less fully by Monell, Thomas, Oestlund, Cowen, Osborn, Hunter,[a] and Sanderson.

A somewhat complete account of this aphis was given by Sanderson in 1906,[b] including a consideration of its food plants and descriptions of different stages as well as references to literature. Still other bibliographical references have been given by Hunter.[a] This species is evidently of foreign origin and was first noticed in this country at St. Louis, Mo., by Monell in 1879.

THE MEAL SNOUT-MOTH.

(*Pyralis farinalis* L.)

During July, 1907, a colony of the larva of this beautiful pyralid moth was observed by the writer breeding in the roots of *Astragalus mollissimus* received from Hugo, Colo. Since the species is of cosmopolitan distribution and commonly found in most barns, storehouses, and even in dwellings, it can not be positively stated that it attacks loco roots in the open, but it quite likely infests the dead roots. Frequently this species breeds in clover hay, after the manner of the clover-hay worm,[c] to which it is related. As a rule the larva requires for its development a certain amount of moisture, feeding on dry material which has become heated, as in the case of stored grain or stacked hay. This species is shown natural size, the moth at *a* and the larva at *b* of figure 13. More complete accounts of the meal snout-moth are given elsewhere.[d]

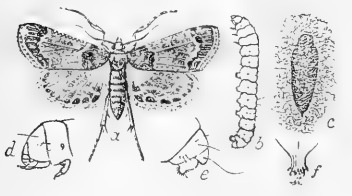


FIG. 13.—Meal snout-moth (*Pyralis farinalis*): *a*, Moth; *b*, larva; *c*, chrysalis, natural size; *d*, head of larva; *e*, anal segment of larva; *f*, tip of pupa. Enlarged (author's illustration).

---

[a] Bul. 60, Iowa Agr. Exp. Sta., The Aphididæ of North America, 1901, p. 101.

[b] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 26–29.

[c] *Hypsopygia* (*Asopïa*) *costalis* Fab.

[d] See Yearbook U. S. Department of Agriculture for 1894, p. 286, and Farmers' Bulletin 45, pp. 10, 11.

PLANT-BUGS, LEAFHOPPERS, ETC.

Numerous plant-bugs, leafhoppers, and related insects were observed and collected at Hugo, Colo. As a considerable portion of these were in the nymph or immature stages, comparatively few were identified specifically. The list follows:

Alydus eurinus Say and *A. pluto* Uhl., coreid plant-bugs bearing some relation to the squash bug, were among the number. The former has been recorded attacking Lima beans and cowpeas; hence, it is quite probable that both feed on loco and lupines, which are of the same botanical family.

Dasycoris humilis Uhl., another coreid of unknown habits.

Geocoris griseus Dall., a plant-bug of the family Lygæidæ.

Hadronema militaris Uhl., a small capsid or leaf-bug. It infests Amaranthus and beets. Probably accidental.

Stiphrosoma atrata Uhl., also a capsid, of unknown habits.

Philænus bilineatus Say, a cercopid leafhopper which probably feeds on grasses.

Deltocephalus flexulosus Ball, a jassid leafhopper.

Bruchomorpha dorsata Fitch, a fulgorid.

Nabis ferus L., a predatory form. It doubtless destroys many of the other bugs, especially in their immature stages.

MISCELLANEOUS INSECTS.

Agromyza æneiventris Fallen, a small fly, was reared from pupæ at the roots of Aragallus from Flagstaff, Ariz., received in April, 1907, from Mr. Geo. Hochderffer. We have office records of the rearing of this species from the roots of clover and from larvæ found in burrows in the stems of Ambrosia. The fly was reared by the writer from mines in garden peas collected at Washington, D. C., August 10, 1904. The insects issued July 30. Pea leaves are, in fact, quite often infested by this miner.

Unknown leaf-beetle.—December 14, 1901, Mr. D. P. Marum, Woodward, Okla., wrote of an insect which fed upon the leaves of *Astragalus mollissimus.* During April of that year he noticed that a few stems in each hill of loco were stripped of leaves, and found on the plants a small beetle which he believed to be a ladybird, although it did not have the bright spots known to be present on Coccinellidæ inhabiting that region.

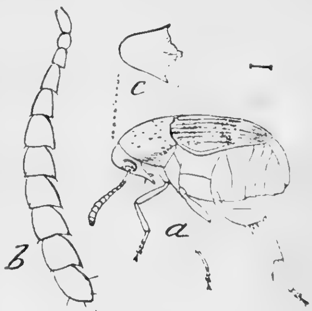


FIG. 14.—*Bruchus obsoletus*: *a*, Beetle; *b*, antenna; *c*, prothorax. *a*, *c*, Much enlarged; *b*, more enlarged. (From Riley.)

Bruchus obsoletus Say (fig. 14) was stated by its describer to have been found on a species of Astragalus, but recent researches show that the plant in question was a related one, the goats' rue, *Cracca* (*Tephrosia*) *virginica.*[a]

Bruchus aureolus Horn.—Recorded as occurring on the flowers of Astragalus in Owens Valley, Cal. (Insect Life, Vol. V., pp. 166, 167).

Unknown hymenopterous gall.—Among other material collected at Hugo, Colo., were stems of *Aragallus lamberti* containing elongated fusiform galls one-half to one inch in length and about one-third that in width. Each of these contained a single large hymenopterous larva; these, however, were not reared.

[a] An illustration of this insect and its food plant were furnished in the Annual Report of the Department of Agriculture for 1892, p. 172, Pl. VII.

Rusticus (*Lycæna*) *acmon* Doubl. & Hew. This very pretty blue butterfly was reared from *Astragalus mollissimus* from Hugo, Colo., the adult issuing July 20, 1906. Nothing has been published in regard to the natural habits of this species, and it is not known if it plays any important part in the reduction of the loco weeds.

Grasshoppers and related insects were collected in some numbers at Hugo, Colo., on *Aragallus lamberti.* They were mostly in the nymph condition and therefore could not be readily identified. There were two species of grasshoppers (*Melanoplus* spp.), each occurring in about equal numbers, and a smaller grasshopper (*Opeia obscura* Scudd.), a walking stick (*Parabacillus coloradus* Scudd.) and a tree-cricket (*Œcanthus* sp.). Probably none of these accomplishes much in the line of defoliation of the loco with the exception of the two Melanopli, which are allied to the pernicious Rocky mountain locust.

Aphiochæta pygmæa Zett.—This small fly, which belongs to the Phoridæ, was reared from *Astragalus mollissimus*, from Hugo, Colo., July, 1906, from roots in which other species were breeding. This is a European species known from Texas westward to California.

In the compilation of the above list the writer is indebted to Mr. D. W. Coquillett for assistance in identifying some of the Diptera mentioned, to Mr. Otto Heidemann for the identifications of the plant-bugs, leafhoppers, etc., and to Mr. A. N. Caudell for naming the grasshoppers and related insects.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part VI.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE GREENHOUSE THRIPS.

BY

H. M. RUSSELL,

Agent and Expert.

Issued August 4, 1909.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1909.

CONTENTS.

ILLUSTRATIONS.

U. S. D. A., B. E. Bul. 64, Part VI. Issued August 4, 1909.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE GREENHOUSE THRIPS.

By H. M. Russell,
Agent and Expert.

INTRODUCTION.

This insect has been known since 1833 to have been the cause of much injury to greenhouse plants; but its life history has never been fully worked out.[a] The writer, while engaged in field work in the State of Florida during 1907, had his attention called to a "diseased" condition of crotons in one of the greenhouses at Orlando. This condition was found to be caused by the extreme abundance of a species of thrips feeding on the foliage. Specimens of the adult were sent to Dr. W. E. Hinds, who determined them to be *Heliothrips hæmorrhoidalis* Bouché. While working under the direction of Dr. F. H. Chittenden during the winter of 1907–8, the writer made a study of this insect's life history and the means by which it might be controlled.

HISTORY.

The species was first described by Bouché,[1] in 1833, as *Thrips hæmorrhoidalis* from specimens taken in a greenhouse in Europe. At that time he wrote that he believed the native land of the species to be America. That this supposition was correct appears evident at the present time.

Packard,[10] writing in 1870, described this species for the first time from this country. He wrote: "This is one of the greatest pests in our hothouses. It is the *Heliothrips hæmorrhoidalis* of Burmeister." Packard called it the greenhouse thrips and gave a meager description of the larva and adult, and an illustration of the latter, but neither descriptions nor drawing are exact enough to identify specimens. He furnished a list of food plants, a description of injury, and recommended washing plants with soapsuds as a remedy.

---

[a] The external and internal anatomy of this insect has been fully worked out by several European entomologists, while others have made incomplete studies of the life history on the Continent.

Under the name *Thrips adonidum*, A. J. Cook,[11] writing of this species, in 1874, said: "Around Detroit, here at Adrian, and in our southern counties they are likewise a serious pest."

In 1882 Mr. Th. Pergande[13] recorded this insect as taken out of doors at Washington, D. C., on apple late in November. J. A. Lintner,[15] in 1885, on this authority, lists it as an insect affecting the apple.

Nothing more was written about this species in this country until 1896, when G. C. Davis[21] wrote of "a black species, *Heliothrips hæmorrhoidalis*, which we have found most common on croton plants. As far as noticed its work is confined to the underside of the leaves, where the spots are eaten, so that the work clearly resembles that of the red spider."

Dr. F. H. Chittenden,[24] in 1902, predicted that this species, which he called the "greenhouse thrips," would probably increase in numbers and destructiveness with time.

Hinds[25] wrote of this insect the same year: "It has been very injurious in some places." He also added that it was called the "black fly" in Germany and that its life history was unknown.

RECENT RECORDS.

This species, determined by Mr. Pergande, was sent in to the Bureau of Entomology, January 8, 1908, by Mr. P. J. Wester, of Miami, Fla., who collected it on mango (*Mangifera indica*). He wrote: "It has never appeared to do serious damage until this year." Mr. I. J. Condit, a collaborator of this bureau, at San Luis Obispo, Cal., reported it injurious in a greenhouse at that place in September, 1908, and again reported it on November 2, 1908, as injurious to ornamentals in one of the parks at Santa Barbara, Cal.

NATURE AND EXTENT OF INJURY.

The damage caused by the greenhouse thrips is confined to the foliage of ornamental plants entirely, in so far as the author is aware, for he knows of no recorded injury to the blossoms of plants nor has he noticed any. Injury effected by the thrips is due to the method of feeding on the plants. Adults and larvæ both obtain their food by puncturing the epidermis of the leaf with their sharp mouth-parts,[a] and after lacerating the tissue they suck out tissue and plant juices at the point of attack. The insects then attack the leaf in a new place, so that in time it becomes full of tiny, pale-colored spots where the tissue and chlorophyll have been extracted.

In the case of croton plants, upon which this insect was studied, injury was noticed first on the older leaves and gradually, as these became badly infested, the injury spread until the young leaves were

[a] For structure of mouth-parts see "The Pear Thrips," by Dudley Moulton, Bul. 68, Part I, Bur. Ent., U. S. Dept. Agr., pp. 2–3, 1907.

attacked, soon after unfolding. The infested leaves first showed injury on the underside, where the surface appeared full of minute white spots. As attack continued, these spots became more numerous and united, forming blotches where the leaf was devoid of tissue. The injury then became apparent from the upper side, as the surface developed a twisted and distorted aspect between the lateral veins, and was finally evidenced by wilted and dead areas around the edges of the leaf. In severe attacks the insects spread to the upper surface of the leaves, and in a short time this as well as the underside is nearly devoid of color. Both surfaces become thickly covered with minute drops of reddish fluid voided by the thrips, which gradually change to black. As the attack continues, the leaves become limp and yellow and eventually drop off, so that plants that were not treated to prevent injury in many cases lost their entire foliage. The injury is similar on other ornamentals.

This insect injures plants in two ways: First, it causes a serious drain on the vitality of the plant from the feeding of thousands of thrips, so that the growth is seriously checked and in neglected cases would cause the death of the plant. Secondly, it destroys the beauty of the plants for ornament by despoiling them of their foliage.

ORIGIN AND DISTRIBUTION.

Although this insect was first described from Europe and is there widely distributed, it is without doubt indigenous to tropical America. Pergande[19] writes that this insect was "probably introduced with ornamental plants from the warmer regions of America;" and that it "is found upon wild and cultivated plants in Brazil." Franklin[27] records it in Barbados as follows: "This species is found in the open in St. Vincent and Barbados. It is evidently a tropical species." This insect has been collected at Miami, Fla., on plants growing in the open in midwinter. Moulton[26] says, "out of doors it feeds and becomes very destructive to Laurestinas." Mr. Condit, writing of this species from Santa Barbara, Cal., November 2, 1908, said that it was doing considerable damage to ornamentals in one of the parks.

These records of occurrences at several localities in the Tropical and Lower Austral life zones of this country point strongly to tropical America as its original home. This is further strengthened because of its well-known habit of living in greenhouses, in many localities, upon exotic plants from the Tropics. From this habit it has become widely distributed in Europe and North America. In Europe, Walker and Cameron record it from several places in England, Bouché and others from Germany, Heeger and Löw from Vienna, and Reuter from Finland. It has also been recorded from France and Italy.

In this country it has been recorded from Massachusetts, from several places in Michigan, and from Washington, D. C., Florida, and

California. It has been collected in Iowa and Pennsylvania and recently in the Barbados and the island of St. Vincent.

Because of the fact that it has been collected in such widely distant places in all sections of the country, we can safely say that *Heliothrips hæmorrhoidalis* is generally distributed in greenhouses throughout the United States.

DESCRIPTION.

Heliothrips hæmorrhoidalis belongs to the family Thripidæ, the genus being characterized by having antennæ with 8 segments and the body with a markedly reticulated surface. This is especially

FIG. 15.—Greenhouse thrips (*Heliothrips hæmorrhoidalis*): Adult female, enlarged about 50 diameters, and greatly enlarged drawing of antenna underneath. (Original.)

pronounced on the head and thorax. The legs are unarmed and the wings are characterized by having the fore-wings broad at the base, with 2 longitudinal veins.

The adult (fig. 15).—When the adult first emerges the abdomen is pale yellow, with the head and thorax darker, and the antennæ, legs, and wings appearing white. In the course of several hours, however, the insect becomes fully colored. The head and thorax are then dark brown, the abdomen yellowish brown, fading at the apex to brownish-yellow. In the female the antennæ are twice as long as the head. The total length is about 1.25 mm. and the greatest width, across the mesothorax, is about 0.30 mm.[a]

The male has not been described, and this species is without question parthenogenetic for many generations.

The egg.—The egg (fig. 16, *a*) is bean-shaped, 0.296 mm. in length and 0.088 mm. in width, very delicate, with a thin shell, and colorless. Eggs are laid in the leaf tissue of the host plant, generally on the underside.

The larva, first stage (fig. 16, *b*).—[Description made while larva was very young and before it had commenced to feed on the plant.] Length, 0.31 mm.; width of mesothorax, 0.10 mm. General shape fusiform; antennæ, head, and legs very large in proportion to the rest of the body. Color translucent white. Head large, quadrate; eyes reddish, ocelli absent. Antennæ 0.16 mm. in length; 7-segmented;[b] basal segment cylindrical, short, with spine on inner side; second segment twice as long as basal one and not as wide, with 4 or 5 spines; third pedunculate, ringed, as long as segments 1 and 2 combined, 2 long spines near tip of segment; fourth pedunculate, nearly twice as long as third, tip more slender than third, ringed, a number of prominent spines near tip; fifth, sixth, and seventh slender, equal in length, and together equaling the length of the fourth, each with one or two small spines near the tip. Legs translucent white, long. Abdomen tapering posteriorly; with 10 segments, the first 8 nearly equal in length, ninth and tenth somewhat longer than others. Each abdominal segment with longitudinal rows of setæ, the ninth with 2 and tenth with 4 spines that are three or four times the length of the setæ.

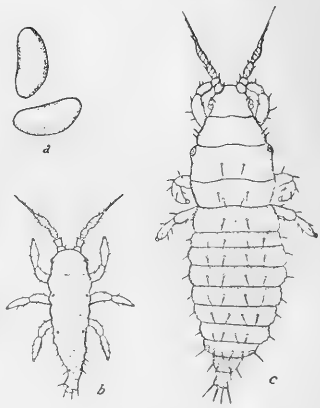


FIG. 16.—Greenhouse thrips: *a*, Egg; *b*, larva, first stage; *c*, larva, full grown. All enlarged about 40 diameters. (Original.)

The larva, second stage.—Length, 0.90 to 0.97 mm.; width of mesothorax, 0.22 to 0.23 mm.; shape about same as in first stage; body long, cylindrical, sides nearly parallel until fifth abdominal segment, where they begin to taper to blunt point. Color of thorax and abdomen slightly yellowish, last two segments of abdomen translucent white; alimentary tract plainly indicated by the brownish color given to it by inclosed food; this extends from the metathorax to the sixth abdominal segment. Surface of the body covered with minute granulations. Head quadrate, but with notch behind the eyes on each side; eyes reddish, ocelli absent. Antennæ 7-segmented, third and fourth distinctly spindle-shaped and annulated, fifth and sixth slightly annulated, and together with seventh segment quite slender. Legs translucent white. Abdomen 0.50 mm. in length, fusiform, ovipositor not formed; segments with rows of fine setæ, similar to those in adult, increasing in length toward posterior end, ninth and tenth segments equal in length (0.059 mm.).

The young nymph or prepupa (fig. 17, at left).—Length, 1.184 mm.; width of mesothorax, 0.3404 mm. Shape similar to adult. Head, length, 0.148 mm.; width at eyes, 0.1628 mm. Head translucent white, vertex slightly yellowish, ocelli absent, head

---

[a] For a full characterization of the genus and of the species see Hinds's Monograph of the Thysanoptera, pp. 168–170.

[b] After careful search the writer has been able to make out what he considers 7 segments in the antennæ.

deeply notched behind eyes; eyes red, made up of a few large facets, surface faintly reticulated; head rounded in front; a pair of setæ over rear angle of eyes, another pair in front of the eyes, and a third over the antennæ. Antennæ translucent, extending forward about twice the length of the head and composed of 7 segments; first segment cylindrical, broader than long; second cylindrical, nearly twice as long as segment 1 and not so broad; third longer than second, base constricted but not pedunculate, and with constriction at third and two-thirds length from base, so that it appears to be made up of 3 segments; fourth spindle-shaped, about as long as third; 5, 6, and 7 short and slender and not very clearly defined. Segments bear few spines on sides.

Prothorax nearly one-half again as wide as long, sides rounded, posterior edge broadest, semitranslucent white to faint yellow, a few prominent setæ around edges. Mesothorax with prominent rounded angles, translucent white to faint yellow, surface faintly reticulated, wing-cases translucent white, distinct from each other, those of fore-wings extending to second abdominal segment and those of hind-wings extending to middle of second abdominal segment. Legs translucent white to faint yellow, strong. Abdomen shaped as in adult, white to faint yellow, last few segments translucent, eight rows of setæ in pairs, increasing in length from anterior to posterior end. Length of abdomen, 0.5956 mm.

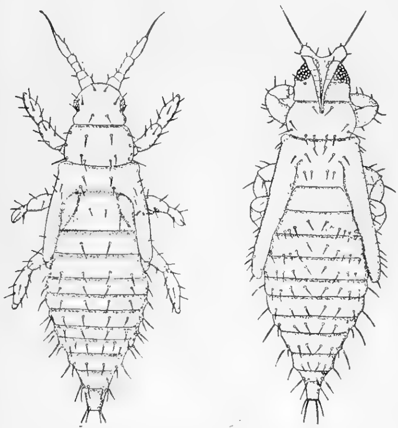


FIG. 17.—Greenhouse thrips: Prepupa on the left and pupa on the right. Enlarged about 40 diameters. (Original.)

The full-grown nymph or pupa (fig. 17, at right).—Length, 1.25 mm.; width at mesothoracic angles, 0.2812 mm. Shape similar to that of adult. Color translucent white to slightly yellowish. Head, length, 0.1628 mm.; width, 0.1924 mm.; translucent white, distinctly reticulated, eyes dark red, larger than in prepupal stage, facets large. Three ocelli present in close triangle between eyes, color chitinous yellow. Antennæ laid backward on head and reaching to near middle of prothorax, segments indistinct, translucent white. Segments 1 and 2 projecting in front of the head and 2 with a long spine extending forward, 0.1332 mm. in length. Thorax plainly reticulated, translucent white to faint yellow. Prothorax more than twice as broad as long. Wing cases 0.4736 mm. long, extending to near middle of fifth abdominal segment, translucent white to faint yellow. Length from head to end of wing-pads, 0.6512 mm. Legs translucent white to pearly white. Abdomen broader and shorter than in adult, contracted, but of same general shape, surface plainly reticulated, setæ well developed, the longest ones at posterior end. Length of abdomen, 0.6956 mm.; width, 0.3552 mm.; length of posterior setæ, 0.0888 mm.

HABITS OF THE ADULT.

After emerging from the pupæ, the mature thrips feed on the underside of the leaves for several weeks. They are not, as a rule, as abundant on the upper surface. One plant, on which there were about 150 adults, had only 3 or 4 of this number feeding on the upper surface of the foliage.

Adults walk over the leaf quite rapidly, and if disturbed they raise the tip of the abdomen and move rapidly away, walking in any direction. In a few cases they have been observed to jump when disturbed, but generally they simply move rapidly. The writer has never observed adults in flight, but that they do fly is certain, as he has found that plants free from thrips and at a distance from infested plants after a time will become infested by adults. As the study of the life history of this species was carried on in an unheated greenhouse with low temperature, it is quite possible that the adults were rendered sluggish. It seems strange that the writer has not observed their flight, for in studying this thrips he has examined a large number on plants and has purposely disturbed them to induce flight. Adults often remain motionless for long periods, and in such cases rest close to the veins of the leaf.

The eggs are laid singly in the tissues of the leaf, the female first making an incision with her ovipositor and then pushing the egg into the incision. She probably lays only 1 or 2 eggs in a day, as the eggs are large and the ovaries will hold only a few matured eggs at one time. One female examined had 6 eggs partly formed in her ovaries and 3 of these were quite small. As the leaves become exhausted from the feeding of larvæ and adults, the latter leave them and oviposit in fresh young leaves, so that in time the exhausted leaves are deserted and fall off and gradually the remainder of the plant becomes infested.

HABITS OF THE LARVÆ.

On March 5 larvæ were observed hatching from the eggs about 10 a. m. In all cases where larvæ emerged the leaf was marked by a dark spot and the surface was slightly swollen.

When first observed the head of the larva was projecting slightly out of a slit in the leaf epidermis, probably the same one that was made in depositing the egg, and the light red eyes were very conspicuous. Little by little the body is worked more and more out of the opening, and as it projects in the air, working vigorously back and forth, with its limbs folded against the body and invisible, it has the appearance of a minute worm in motion. When all but the tip of the abdomen is free the tiny larva remains quiet for a very short time, then one by one, beginning with the antennæ, but the legs in no regular order, the appendages unfold. The larva moves them around freely for a time and then, bending over, grasps the leaf surface and commences to pull, in an effort to free the end of the abdomen. After considerable work the larva frees itself and after a short rest moves around in search of a place to feed. Some only travel a few inches, others travel over a considerable portion of the leaf surface before settling down to feed. The time required for the larva to emerge varies from 6 to 12 minutes.

As a rule the larvæ are found on the underside of the leaves, but when crowded, as in severe infestations, they attack the upper surface.

While they will feed anywhere on the leaf, in many cases they will cluster together in colonies between two veins of the leaf. In one case observed by the author a number of larvæ hatched from eggs on one edge of the leaf and the next day were all feeding together on the opposite edge. In another case a colony of 85 larvæ was observed collected in a circle between two veins near the edge of the leaf. Many of the larvæ in this colony were moving around, but would not separate from the colony.

The larvæ when first hatched are minute and colorless, but as soon as they begin feeding the alimentary tract becomes plainly marked from the dark reddish fluid contained in it. This fluid is excreted and collects in globules on the tip of the abdomen, being held in place by the terminal setæ. The tip of the abdomen is elevated, and it is an interesting sight to see numbers of these larvæ moving over the leaf with globules of red liquid suspended in the air on the tips of the abdomen. When disturbed they become excited and move around rapidly, jerking the abdomen from side to side. The globule of liquid gradually increases in size until it is too large to carry, and is then left on the surface of the leaf, where it dries as a small reddish spot.

As long as the food supply in the leaf is fresh and abundant these arvæ will remain on it, and thus the number becomes very large. One leaf was found with about 250 larvæ, besides a number of pupæ and adults. If disturbed, or if the leaf is beginning to wilt and lose its vitality, the larvæ become restless, separate, and move around over the leaf in search of fresh food, but eventually many will collect again in colonies. They feed unprotected on the leaf, as far as their own efforts are concerned, but in many cases they secrete themselves under a slight web made by red spiders and are protected by it. Upon leaves exposed in part to sunlight the larvæ seek that part of the leaf which is the least exposed. They molt unprotected in the midst of the feeding colony. These larvæ are delicate little creatures, and if for any reason they are knocked from the plant most of them soon die, not being able to travel far in returning to the food plant.

HABITS OF THE PREPUPA AND PUPA.

The larvæ change to prepupæ in the midst of the feeding colony without seeking protected quarters, but nearly always on the underside of the leaf. The prepupæ move around a little on the underside of the leaf and generally are clustered in groups of from 4 to 10 prepupæ and pupæ. In many cases they are under the web of red spiders, but if no red spiders have been on the plant they are then unprotected.

The pupæ are associated with the prepupæ, but do not move about unless disturbed. Not only are the prepupæ more active than the pupæ, but they carry the antennæ in front of the head and frequently move them, while the pupæ have the antennæ laid back on the head and motionless. Neither prepupæ nor pupæ take any nourishment.

FOOD PLANTS.[a]

Heliothrips hæmorrhoidalis feeds on a large number of ornamental plants. In this country it has been recorded as feeding on the following: Liliaceous plants, azalia, *Pellea hastata*, aspidium, crotons, dahlias, phlox, verbena, pink, ferns, vines, cherry laurel, lauristina, palms, ficus, and fuchsia.

This year this thrips damaged the mango (*Mangifera indica*) at Miami, Fla., and was recorded [27] from St. Vincent and the Barbados Islands on cacao, kola, and the date palm. In Europe the following list includes most of the ornamentals preyed upon by this thrips: Ærides, azalia, begonia, camarotes, catleyia, crinums, dendrobuim, eucharis, ficus, grape, lælia, lefortia, marcintacia, pancratium, phalenopsis, and viburnum.

LIFE HISTORY.

In order to study the life history of this insect, solitary females were put on isolated plants that were previously uninfested and carefully watched. An attempt to study isolated females, in small vials with bits of leaves, failed of results and after 2 weeks was discontinued.

Life cycle.—The life cycle, as detailed, is probably very near the maximum length, as the studies were conducted with the temperature of the house quite low, frequently falling to 50° F. at night. With these conditions the length of the egg stage is about 8 days, but possibly in a well-heated greenhouse this would be cut almost in half. The larvæ molt twice, the last time transforming to prepupæ, and during the cool weather require from 16 to 20 days to obtain full growth. The prepupal period is of short duration, occupying only from 10 to 15 hours, while the pupal period is from 4 to 5 days. This gives a total of 33 days as a maximum, and with favorable conditions this is probably reduced to 20 days or less.

Longevity.—The greenhouse thrips, for such a minute insect, has quite an extended duration of life and evidently feeds on the leaves for a number of days before starting egg-deposition. In one case ob-

---

[a] Since the above was submitted for publication some new food plants for this species have been reported. Dr. E. A. Back found it feeding on maples at Orlando, Fla., and on alligator pear (*Persea gratissima*). The fact that this insect feeds on the mango and alligator pear serves to indicate that at some time in the future it may be of great importance in Florida, as both are valuable fruits in that State.

served, no larvæ hatched until 19 days after the female was placed on a plant. This insect was about 1 day from the pupa when placed on the plant. Another female was observed for 4 weeks, when she disappeared, quite probably dying of old age. Probably this thrips lays from 10 to 20 eggs during her lifetime. The writer observed 10 larvæ on 1 plant with a single adult, and possibly some were killed by mites, etc.

Generations.—In greenhouses this insect is active during the entire year, so that the number of generations is quite large. Taking the maximum life cycle, this thrips might produce as many as 12 generations a year, provided that the species breeds continuously and conditions are favorable to rapid growth.

NATURAL CONTROL.

Rain.—In its native home this thrips is probably kept under control by frequent rains. At Miami, Fla., where hundreds of crotons are planted on hotel and private grounds, the author could find no traces of injury and collected only 1 adult. Crotons that were badly infested by this insect, kept in a greenhouse at Orlando, Fla., during the winter of 1907, were placed outside in June and by the end of the summer it was almost impossible to find specimens of the thrips on them. In times of drought this insect may increase in such numbers as to cause serious injury where it occurs in the open.

Natural enemies.—Frequently a mite is found on plants infested with the greenhouse thrips. On a few occasions the author has found thrips with one of these mites fastened to its dorsum. Specimens of this predaceous enemy were determined by Mr. Nathan Banks as *Lælaps macropilis* Bks.

ARTIFICIAL CONTROL.

EXPERIMENTS WITH REMEDIES.

FUMIGATION EXPERIMENTS.

A series of fumigation experiments was conducted against this insect in its occurrence on croton at Orlando, Fla. All were made in a small, fairly tight room, containing 660 cubic feet.

Experiment No. 1.—April 27, 1908, at 4 p. m., a plant was fumigated all night with one sheet of nico fume. It was a cloudy, cool day, just after a rain, and a good breeze was blowing. On opening the room at 8.15 a. m. there was quite a pronounced odor of nicotine.

April 28, the paper below the plant was covered with this insect in all stages, and many were also found on the plant.

Result of the fumigation, counting the thrips on the plant:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	109	30	436	575
Alive	10	26	10	46
Per cent killed	91.6	53	97.6	92+

May 2, the plant was in fine condition and uninjured. About 10 live adults remained. No live larvæ were seen, but the leaves were covered with hundreds of dead ones.

Experiment No. 2.—May 16, at 5.45 p. m., a plant was fumigated overnight with one-half sheet of nico-fume paper. At 5.45 p. m. it was dark from rain clouds.

May 17, the plant was uninjured. Red spiders and mealy bugs were alive. Few thrips were on the plant.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	2	5	10	17
Alive	0	13	0	13
Per cent killed	100	27+	100	$56\frac{2}{3}$

Experiment No. 3.—April 28, at 5.15 p. m., fumigated a plant overnight with one sheet of aphicide. The sky was cloudy and there was a strong breeze. The plant had a few thrips on it.

April 29, when examined at 8.45 a. m., the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	30	1	6	37
Alive	3	0	2	5
Per cent killed	90	100	75	88+

May 2, the plant was in fine condition.

Experiment No. 4.—May 24, at 7 p. m., fumigated a plant with one sheet of aphicide. There was a strong breeze.

May 25, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	10	67	80
Alive	0	2	0	2
Per cent killed	100	$83\frac{1}{3}$	100	97+

Experiment No. 5.—May 22, at 6 p. m., fumigated a plant overnight with one-half sheet of aphicide. There was a strong breeze.

May 23, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	6	15	31	52
Alive	2	21	11	34
Per cent killed	75	$41\frac{2}{3}$	73.8	60.4+

Experiment No. 6.—April 30, at 8.30 a. m., a plant was fumigated with one sheet of aphis punk (=2 sheets of nico fume or aphicide) all day; cloudy. Toward the end of the fumigation the punk began to burn in strips, so it was not all consumed. It gave a very dense smoke. The room was opened late in the afternoon.

May 1, the plants were uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	0	3	10
Alive	14	11	18	43
Per cent killed	$33\frac{1}{3}$	0	14.2	18.8

May 2, live thrips were abundant on the plants.

Experiment No. 7.—April 30, fumigated with one-half sheet of aphis punk (equal to 1 sheet of other kinds), but as it did not burn up, the house was opened at 5.30 p. m. and a fresh piece put in. The fumigation lasted all night. This piece also burned in strips and a third was not consumed.

May 1, the plants were uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	0	2	3	5
Alive	11	13	15	39
Per cent killed	0	$13\frac{1}{2}$	$16\frac{2}{3}$	11+

It seems that the thrips that drop to the ground have a better chance to recover than those on the plant.

Experiment No. 8.—May 1, at 5.15 p. m., fumigated all night with one-half sheet of aphis punk (fresh box from the factory). This was entirely consumed and the room well filled with smoke.

May 2, the plants were uninjured; red spiders were alive.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	68	1	42	111
Alive	4	24	1	29
Per cent killed	94.4	5	97+	86.4

Experiment No. 9.—May 26, at 7 p. m., fumigated with one-half sheet of aphis punk (fresh box). Fumigation lasted all night. The sky was cloudy.

May 27, the plant was uninjured. The condition of the thrips was as follows:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	2	2	11
Alive	0	7	0	7
Per cent killed	100	22+	100	61⅑

Experiment No. 10.—May 20, at 5.50 p. m., fumigated with nico-fume liquid (1 tablespoonful = ½ ounce + 1 ounce water, vaporized over an alcohol lamp). The sky was partly cloudy. Sprinkled the plant with water.

The vapor rose slowly until 6 p. m., when small flies on the window began to drop. House flies were still flying around the room at 6.15 p. m., when the liquid was all evaporated.

May 21, the plant was uninjured. Red spiders were apparently all alive. A very careful examination of the plant failed to show a live thrips.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	74	12	8	94
Alive	0	0	0	0
Per cent killed	100	100	100	100

Experiment No. 11.—May 27, at 3.50 p. m., fumigated with nico-fume liquid (½ tablespoonful to 2 tablespoonfuls of water, vaporized). Sky clouded, breeze strong.

May 28, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	2	1	6
Alive	0	2	0	2
Per cent killed	100	50	100	75

Experiment No. 12.—May 21, at 6 p. m., fumigated with rose-leaf insecticide (29 c. c. + 25 c. c. water, vaporized over an alcohol lamp). The sky was cloudy, with rain falling.

May 22, the plants were apparently uninjured. Red spiders were alive.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	2	4	13
Alive	0	0	0	0
Per cent killed	100	100	100	100

Experiment No. 13.—May 18, fumigated with potassium cyanid (0.00⅔ gram per cubic foot. In 660 cubic feet used 4.4 grams potassium cyanid, 7.92 c. c. sulphuric acid, and 15 c. c. water). Time, 5.30 p. m. Sky clouded; temperature 82° F; breeze strong; length of fumigation, overnight.

May 19, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	8	0	1	9
Alive	2	17	54	73
Per cent killed	80	0	1.8	10.9

This strength was entirely too weak.

Experiment No. 14.—May 19 fumigated with potassium cyanid (0.02 gram per cubic foot. In room used 13.2 grams potassium cyanid, 26.8 c. c. sulphuric acid, and 53.6 c. c. water). Time, 6 p. m. Length of fumigation, all night. Temperature, 78° F.; breeze strong.

May 20, the plants were uninjured. Flies and bees in the room were all dead. Red spiders were alive. The thrips were all dead.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	10	28	41
Alive	0	0	0	0
Per cent killed	100	100	100	100

May 25, the plant was uninjured.

SPRAYING EXPERIMENTS.

Experiment No. 15.—February 25, sprayed very thoroughly with rose-leaf insecticide (1 part to 48 parts water) a large croton infested with this thrips in all stages. Gave the upper and under sides a very thorough spraying so as to cover entirely the surface and be sure to hit nearly all of the thrips. The spraying was done in the afternoon when the house became shaded from the sun. A fine spray from a small hand pump, common in greenhouses, was used.

February 26, examined the plant at 9.30 a. m. and find results as follows:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	34	5	5	44
Alive	1	2	2	5
Per cent killed	97.1	71.4	71.4	90

May 12, 1908, this plant had then a number of young thrips upon it again and a lot of adults that had flown onto it.

Experiment No. 16.—February 20, 1908, sprayed with cold water. Took hose and washed off all of the plants in the greenhouse with cold water. The next morning found the adults still common and also many larvæ on the crotons, but many leaves badly infested before washing were then entirely free from them. Probably the spraying with cold water washed away and killed 40 to 50 per cent of young thrips.

SUMMARY OF EXPERIMENTS.

The fumigation and spraying experiments in the control of the greenhouse thrips may be summarized as follows:

No. of experiment.	Date.	Method.	Material.	Amount per 660 cubic feet.	Per cent killed.	Injury to plant.	Status of red spider after treatment.
1	Apr. 27	Fumigation	Nico-fume paper.	1 sheet	92	None	Alive.
2	May 16	do	do	½ sheet	56.6	do	Do.
3	Apr. 28	do	Aphicide	1 sheet	88	do	Do.
4	May 24	do	do	do	97	do	Do.
5	May 22	do	do	½ sheet	60.4	do	Do.
6	Apr. 30	do	Aphis punk	1 sheet	18.8	do	Do.
7	do	do	do	½ sheet	11+	do	Do.
8	May 1	do	do	do	86.4	do	Do.
9	May 26	do	do	do	61+	do	Do.
10	May 20	do	Nico-fume liquid.	½ ounce	100	do	Do.
11	May 27	do	do	¼ ounce	75	do	Do.
12	May 21	do	Rose-leaf insecticide.	29 c. c	100	do	Do.
13	May 18	do	Potassium cyanid.	0.00⅓ gram per cubic foot.	10.9	do	Do.
14	May 19	do	do	0.02 gram per cubic foot.	100	do	Do.
15	Feb. 25	Spray	Rose-leaf insecticide.	1 part to 48 parts water.	90	do	Do.
16	Feb. 20	do	Water in hose	Drenching	40–50	do	Do.

REMEDIES RECOMMENDED.

For the treatment of this pest there are a number of good remedies. The question as to the best method to employ depends upon the size of the house infested and upon the experience of the person engaged in treating the insect.

Fumigation with nicotine papers.—Any of the standard fumigating papers will give good results against this pest if they are strictly fresh and kept tightly sealed. Fumigation should be done at night in a moist atmosphere and the papers should be used at the rate of about 2 sheets for every 1,000 cubic feet of space. Early in the morning the house should be opened and thoroughly aired.

Fumigation with nicotine liquid extracts.—Liquid extracts of nicotine offer one of the best methods of greenhouse fumigation and against this pest are very successful. Those made up of 40 per cent nicotine should be used at the rate of 1 ounce to every 1,000 cubic feet of space and the weaker solutions at greater strengths. The preparation should be evaporated over small lamps or stoves, and to prevent scorching should be diluted with water, approximately two-thirds. Fumigation should be carried on at night in a moist atmosphere, and the house should remain closed all night.

Fumigation with hydrocyanic-acid gas.[a]—*When fumigating with hydrocyanic-acid gas great care should be taken, as this gas is fatal to all animal life.* The work must be conducted at night and *the plants should have dry foliage.* In treating this insect, use from 0.01 to 0.05 grams of potassium cyanid per cubic foot for from 2 hours to all night, the strength and length of exposure varying according to the tightness of the house and the kind of plants being treated, as there is considerable difference between various plants as to their resisting power to this gas.

Spraying with nicotine liquids.—Nicotine extracts diluted with water, if carefully applied to plants, will kill large numbers of the greenhouse thrips, but the great objection is that many are not hit by the spray, and therefore the plants become infested again in a short time.

Spraying with kerosene emulsion.[b]—It is quite possible that kerosene emulsion spray will be effective against the greenhouse thrips when used at the strength of 1 part of stock to 10 parts of water and it costs considerably less and is more readily obtained than the nicotine preparations. It should be very carefully prepared and used experimentally at first until the effect on the foliage of the different plants is noted. Care should also be taken to prevent a quantity of emulsion from collecting around the roots.

Water spray.—Frequent treatment with a stiff spray of water from a garden hose will tend to keep this insect down, but unless there are only a few plants it would be better to use one of the other remedies.

Any treatment for this insect should be repeated in from 7 to 10 days to destroy the young larvæ that have hatched from the eggs. This should be sufficient, but it may be best to give a third treatment in another week or two.

BIBLIOGRAPHY.

1. BOUCHÉ, P. F.[c]—Schädliche Garten Insecten, p. 42, 1833.
   Original description of the species.

2. HALIDAY, A. H.—Entomological Magazine, Vol. III, p. 443, 1836.
   Description of the female as *Heliothrips adonidum.*

3. BURMEISTER, H.—Handbuch der Entomologie, Vol. II, p. 412, 1838.
   Description of adult female and habits of insect.

---

[a] For complete directions for the use of hydrocyanic-acid gas, see Cirs. 37 and 57, Bur. Ent., U. S. Dept. Agr.

[b] For the method of making emulsions, see Farmers' Bulletin 127, pp. 22–23, or Cir. 80, Bur. Ent., U. S. Dept. Agr.

[c] Not seen by author.

4. Burmeister, H.—Genera Insectorum, Fasc. 5, 1838.
Short description and excellent colored plate of the adult female.

5. Haliday, A. H.—Walker, Homopt. Ins. Brit. Mus., p. 1102, Pl. VI, fig. 13, 1852.
Short description and figures of parts of head.

6. Heeger, E.—Fünfte Fortsetzung Sitzungsb. Kais. Akad. Wiss., Wien, IX, p. 473, Pl. XVII, 1852; separate, Wien, Gerold, VIII, pp. 3–4, 1852.
Description of egg and young stages and adult with account of habits.

7. Bremi-Wolf, J. J.—Stett. Ent. Zeit., pp. 313–315, 1855.
Reprinted from Abh. Zurick Gartenbau-Geselle, 111, pp. 260–261. Short description and account of habits.

8. Löw, F.—Verhandl. k. k. zool.-bot. Ges., Wien, XVII, p. 747, 1867.
Brief account of injury.

9. Boisduval, J. A.—Essai sur Entomologie Horticole, pp. 233–235, fig. 32, 1867.
Description of adult, account of habits with long list of host plants, and figure of leaf injured by this insect.

10. Packard, A. S.—17th Ann. Rep., Mass. Bd. Agr., p. 263, pl. 1, fig. 2, 1870.
Short account of habits of this insect and a poor illustration of adult.

11. Cook, A. J.—3rd Ann. Rep. Pom. Soc. Mich., 1873–74, p. 501, 1874.
Brief notice in which this insect, mentioned as *Thrips adonidum*, is called a serious pest in Michigan.

12. Packard, A. S.—Half Hours with Insects, pp. 118–119, fig. 86, 1881.
This account is nearly identical with No. 10.

13. Pergande, Th.—Psyche, Vol. III, p. 381, 1882.
Brief note on occurrence out of doors, at Washington, D. C., Nov. 14.

14. Lefevre, E.—Entomologist, Vol. XV, p. 240, 1882.
Mentioned as injurious to greenhouse plants.

15. Lintner, J. A.—2nd Rep. Ins. N. Y., pp. 29, 31, 38, 56, 1885.
There is some doubt as to whether this insect or a leaf-hopper is referred to in the first, second, and third references.

16. —— ——.—Ann. Soc. Ent. Belg., Vol. XXIX, p. lxx, 1885.
Note on use of tobacco as a fumigant.

17. Jordan, K.—Zeitschrift für Wiss. Zool., XLVII, pp. 541–620, Pls. XXXVI–XXXVIII, 1888.
Anatomy and biology of Thysanoptera, with frequent mention of this insect.

18. Uzel, J.—Monographie der Ordnung Thysanoptera, pp. 168–170, Pl. VI, figs. 90–92, 1895.
Description of adult and figures of head, antenna, and wing.

19. Pergande, Th.—Insect Life, Vol. VII, p. 390, 1895.
Observations on this and other thrips.

20. Frank, A.—Die tierparasitären Krankheiten der Pflanzen, p. 134, 1896.
Short account of habits and advice as to remedies.

21. Davis, G. C.—Special Bull. No. 2, Mich. Agr. Exp. Sta., p. 13, 1896.
Brief note on occurrence in Michigan.

22. Buffa, P.—Estratto dalla Rivista di Patologia Vegetale, VII, Nos. 1–4, pp. 94–108; continued, VII, Nos. 5–8, pp. 129–135, 136–142, 1898.
Study of the external and internal anatomy of the species. Illustrated by 5 plates.

23. Tümpel, R.—Die Geradflügler Mitteleuropas, p. 290, 1901.
Description of female and poor figure in colors.

24. Chittenden, F. H.—Weekly Florists' Review, April 17, p. 739, 1902.
Short popular article on thrips in greenhouses.

25. HINDS, W. E.—Proc. U. S. Nat. Mus., vol. 26, p. 168, 1903. Issued as separate No. 1318, 1902.

Description of adult and account of habits as far as known.

26. MOULTON, DUDLEY.—Tech. Ser. 12, Part III, Bur. Ent., U. S. Dept. Agr., pp. 43, 51–52, 1907.

Brief notes on characters and habits. Destructive to laurestinas out of doors.

27. FRANKLIN, H. J.—Proc. U. S. Nat. Mus., Vol. XXXIII, p. 719, 1908.

Notes on occurrence out of doors in the Barbados.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part VII.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.

BY

E. S. TUCKER,
Special Field Agent.

ISSUED AUGUST 5, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

CONTENTS.

ILLUSTRATIONS.

PLATE.

TEXT FIGURE.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.

(*Aræcerus fasciculatus* De Geer.)

By E. S. Tucker,
Special Field Agent.

INTRODUCTION.

While making field observations upon the cotton boll weevil during the past season (1908), a large plantation situated 6 miles south of Alexandria, La., was visited on September 18 and again on December 4. On my first visit at this place the overseer directed my attention to the work of strange weevils occurring in dried cornstalks in fields adjacent to cotton. Upon examination the larval and pupal stages and sometimes a few adults of the insects were found in the pith, at or close to the joints (Pl. III). These specimens were identified as the coffee-bean weevil (*Aræcerus fasciculatus* De Geer) (fig. 18), and the selection of cornstalks for breeding purposes places the species on record as a new enemy to be encountered in cornfields.

NATURE OF INJURY TO CORN.

According to the statements of the overseer, the working of these weevils in cornstalks during the past year was more noticeable than in the preceding season, when he first detected the insects at work. He claimed that the attacks began in green stalks before the corn matured and thus caused stunted ears. Being a close observer, he first noticed their attacks during the last week of August, while the stalks were still fresh and sappy, although the leaves had begun to dry. These facts prove beyond question that the larvæ were hatched within living tissues of the plants. Furthermore, he expressed a firm belief that the holes made by these insects for emergence from the stalks afterwards offer a retreat for cotton boll weevils, which may enter and hibernate in the pith. His opinion in this respect was supported by the claim that he had found boll weevils in such places at the time the land was being prepared for spring planting.

In the course of such work many old cornstalks were dragged out of the dirt that had been thrown over them by means of a "middle-buster" plow used for breaking the ground during November and December; and in two or three instances, which he remembered as having occurred in February, he found stalks with boll weevils secreted in the cavities evidently formed by the stalk pests.

At the time of my first examination the emergence holes and other signs of work by *Aræcerus fasciculatus* were not visible unless the leaves were stripped from the stalks as they stood in the fields. Centers of infestation were then located in different parts of the fields by breaking open a number of stalks to ascertain the extent of depredations. As most of the ears had been gathered, inspection of the greater part of the fields was freely made and infested sections of the stalks were collected. The damaged stalks broke easily at the joints where larvæ had worked, and usually but one injured place was found on a stalk. All attacks by the weevils at this time were

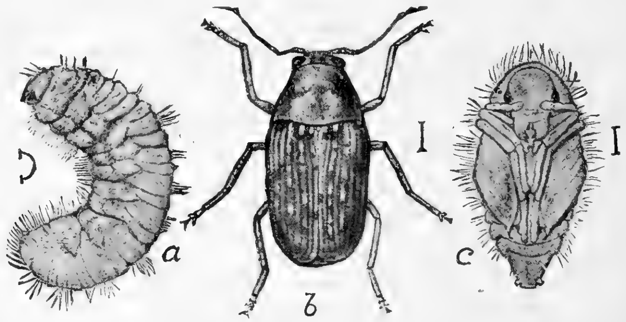
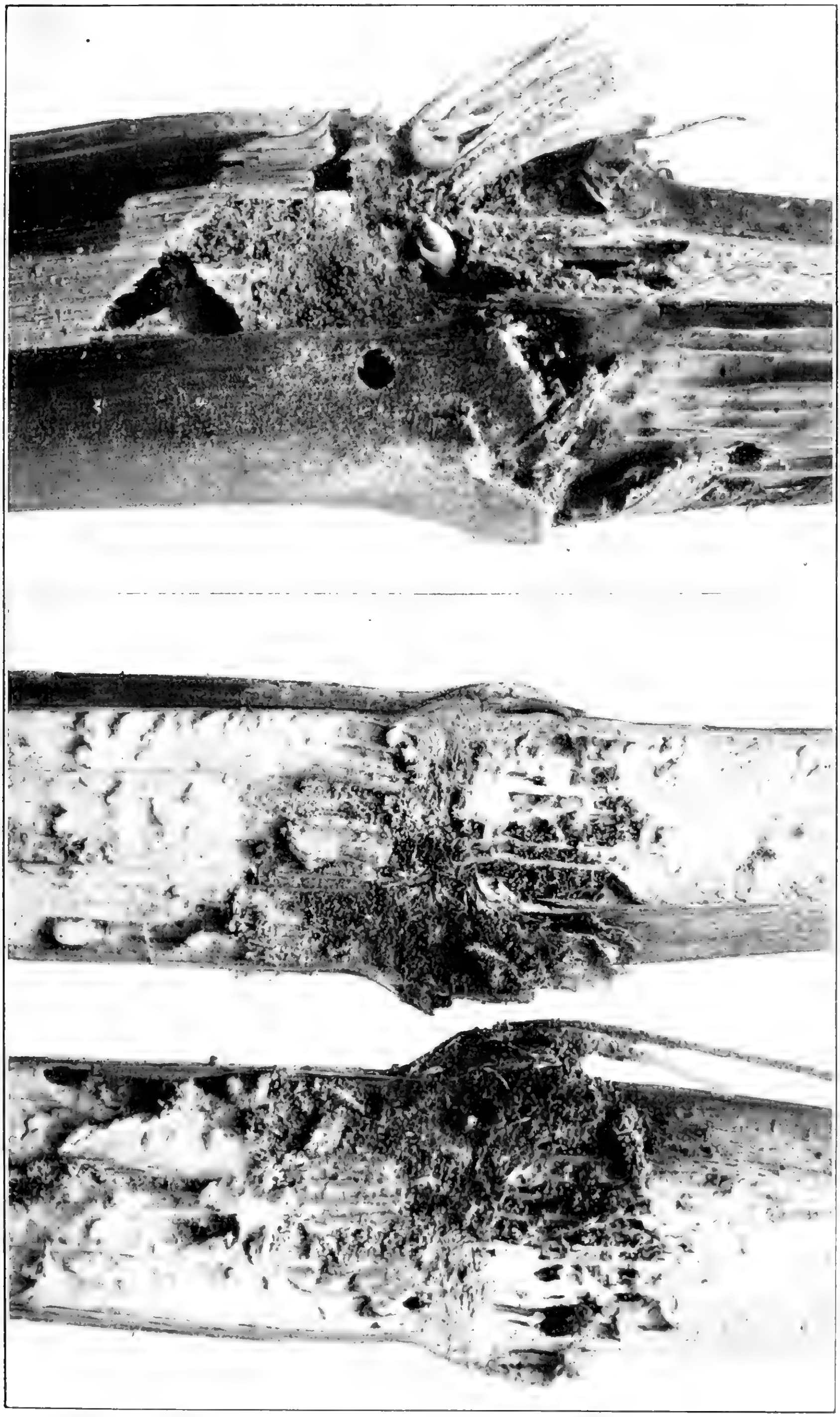


FIG. 18.—Coffee-bean weevil (*Aræcerus fasciculatus*): *a*, Larva; *b*, adult or beetle; *c*, pupa. Greatly enlarged. (From Chittenden.)

confined to the upper joints. These damaged joints varied in thickness from a little more than an inch to slightly less than one-half inch. The extra thick and hard structure of the lower joints was then thought to present unsuitable conditions for the breeding of the weevils, at least where the pith incompletely filled the stem. Further developments which were noted on my second examination showed, however, that the insects had bred extensively and worked downward into the lowest joints, their tunnels running through the pith from one joint to another. Since all stages were found again, the prospect for continual breeding of the weevils, which perhaps depends upon mild weather, seemed to be assured as long as the stalks were not destroyed. As previously observed, the effects of their work were most noticeable at the joints. The common occurrence of damaged stalks, which were readily detected on account of the emergence holes being exposed to view by reason of the partial loss of the leaves, indicated that the infestation was widespread.



WORK OF THE COFFEE-BEAN WEEVIL (ARÆCERUS FASCICULATUS) IN CORNSTALKS.
(ORIGINAL.)

NOTES ON LIFE HISTORY IN CORN.

Judging from the appearance of damaged stalks when split open, the larvæ evidently begin work at a joint and form wide cavities, mainly in a crosswise direction, as they progress into the pith. All examples of their injuries showed that irregular portions of the pithy substance, excepting most of the fibers, had been reduced to a discolored, powdery condition, which was usually more pronounced above the joint than below it. The greater part of the time necessary for the growth of the grubs is probably spent in the excavation of these spaces to satisfy their demands upon the pith as a food supply. In preparation for the pupal stage the grown or nearly grown larvæ manifest a tendency to burrow into fresh pith some distance from the area of early operations. A considerable proportion of them does this; though few grubs proceed farther than 2 inches upward or downward. These burrows run in somewhat deflective courses, but when finished always terminate just under the hard surface of the stem and afford a convenient position at the far end for each insect upon attaining maturity to gnaw its way out, as was proved in many cases by an emergence hole being already cut to afford means of escape to the tenant. Nearly every closed burrow contained either a grown larva, a pupa, or an adult. These stages commonly occurred also in or close to the large primary cavities, indicating that not all the larvæ undertake special measures for pupation away from their original place of development, though all apparently provide for facility of emergence as adults, and the greater number perhaps complete their transformations in the same relative position. In fact, the greater number of openings appearing through the surface immediately surrounding the worst damaged places close to the joints shows that emergence is most frequently effected there.

OCCURRENCE IN CHINABERRIES; PARASITES.

The further records on the habits of *Aræcerus fasciculatus* are obtained from the notes on file at the laboratory of the Bureau of Entomology at Dallas, Tex., all of which pertain to the breeding of the species in berries of the chinaberry tree (*Melia azedarach*). Several larvæ and pupæ and one adult were found in the pulp of old chinaberries collected at Victoria, Tex., April 24, 1907, by Mr. R. A. Cushman. From other collections of similarly infested berries, made at the same place on May 12, by Mr. A. C. Morgan, adult weevils first emerged seven days later, and on the 27th and 28th of the same month the first rearings of parasites were recorded. These parasites represented a species which was later described by Mr. J. C. Crawford as *Cerambycobius cushmani*, and further developments not only proved it to be the most important enemy of *Aræcerus fascicu-*

latus, but highly inimical to the cotton boll weevil. Numbers of these parasites, together with *Eurytoma tylodermatis* Ashm., which also attacks the boll weevil, matured during the following June and July from another lot of old berries infested by the immature stages of *Aræcerus fasciculatus,* the material having been collected by Mr. Cushman on June 11. Other species of parasites were reared from these lots, but so far remain undetermined. The latest date recorded for the emergence of weevils in confinement was July 11, but under natural conditions these insects probably breed continuously throughout the season in berries which are apt to be hanging on trees or falling from them at all times of the year.

During the past year opportunities permitted me to make personal observations upon the work of these weevils in chinaberries. While at San Augustine, Tex., on March 22, my attention was drawn to an infestation occurring in both fallen and hanging berries. Fallen berries in a soft, shriveled, or rotting condition frequently contained well advanced larval stages. Seldom were more than one or two grubs found in a berry. The larvæ in hanging berries were generally younger. Some of the hanging berries contained very small grubs, evidently newly hatched, that had scarcely begun working in the firm pulp. The falling of infested berries seemed to be induced by the softened condition resulting from the more advanced work of the larvæ, and the pupal stage must necessarily be passed in fallen berries. Collections of these berries were placed in breeding boxes, and adult weevils emerged from April 16 until June 16, but no parasites appeared, probably because of the earliness of the collection. On March 25, at Longview, Tex., the species was again taken by me, but only fallen berries were examined. A live adult was removed from one berry.

At Monroe, La., on the 21st of the same month, Mr. R. A. Cushman made an interesting find in regard to a new enemy of the coffee-bean weevil. In a number of infested berries one weevil larva was found to be attacked by a new species of mite belonging to the genus Pediculoides. This mite is also known as an enemy of boll weevil larvæ.

HABITS IN GENERAL.

Previously published records of *Aræcerus fasciculatus* show it to be a common insect in warm climates, and that it has no particular food preferences. It is as likely to be found breeding in beans or any stored dry vegetable products, including dried fruits, as in dry pithy stalks, and is commonly found breeding as a scavenger in dry decayed cotton bolls. In common with most other weevils, the adults feign death for a short time when disturbed, and then suddenly become active and seek to escape.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part VIII.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE WOOLLY WHITE-FLY:

A NEW ENEMY OF THE FLORIDA ORANGE.

BY

E. A. BACK, Ph. D.,

Agent and Expert.

Issued May 7, 1910.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1910.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*
R. S. Clifton, *Executive Assistant.*
Chas. J. Gilliss, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

CONTENTS.

ILLUSTRATIONS.

PLATE.

TEXT FIGURES.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE WOOLLY WHITE-FLY: A NEW ENEMY OF THE FLORIDA ORANGE.

(*Aleyrodes howardi* Quaintance.)

By E. A. Back, Ph. D.
Agent and Expert.

INTRODUCTION.

The attention of entomologists is called, for the first time, to the discovery in this country of a new species of *Aleyrodes* which attacks citrus trees. In view of the widespread havoc played among the orange groves of Florida by the citrus white-fly (*Aleyrodes citri* Riley and Howard) and the spotted-wing white-fly (*Aleyrodes nubifera* Berger), the appearance among the orange trees at Tampa of another aleyrodid which has already demonstrated itself to be of economic importance is of interest, if not, indeed, a subject for considerable concern.

During a recent examination of orange trees along several of the streets in the business section of Tampa in connection with government white-fly investigations that are being carried on in Florida by the Bureau of Entomology, the attention of the writer was attracted to dense white and grayish woolly secretions on the under surface of many leaves. At first this was supposed to be a heavy infestation of the rather scarce *Paraleyrodes perseæ* Quaintance, but on closer examination proved to be *Aleyrodes howardi* Quaintance, up to the present time known only to infest orange trees on several of the West Indian islands, especially Cuba.

INJURY AND EXTENT OF INFESTATION.

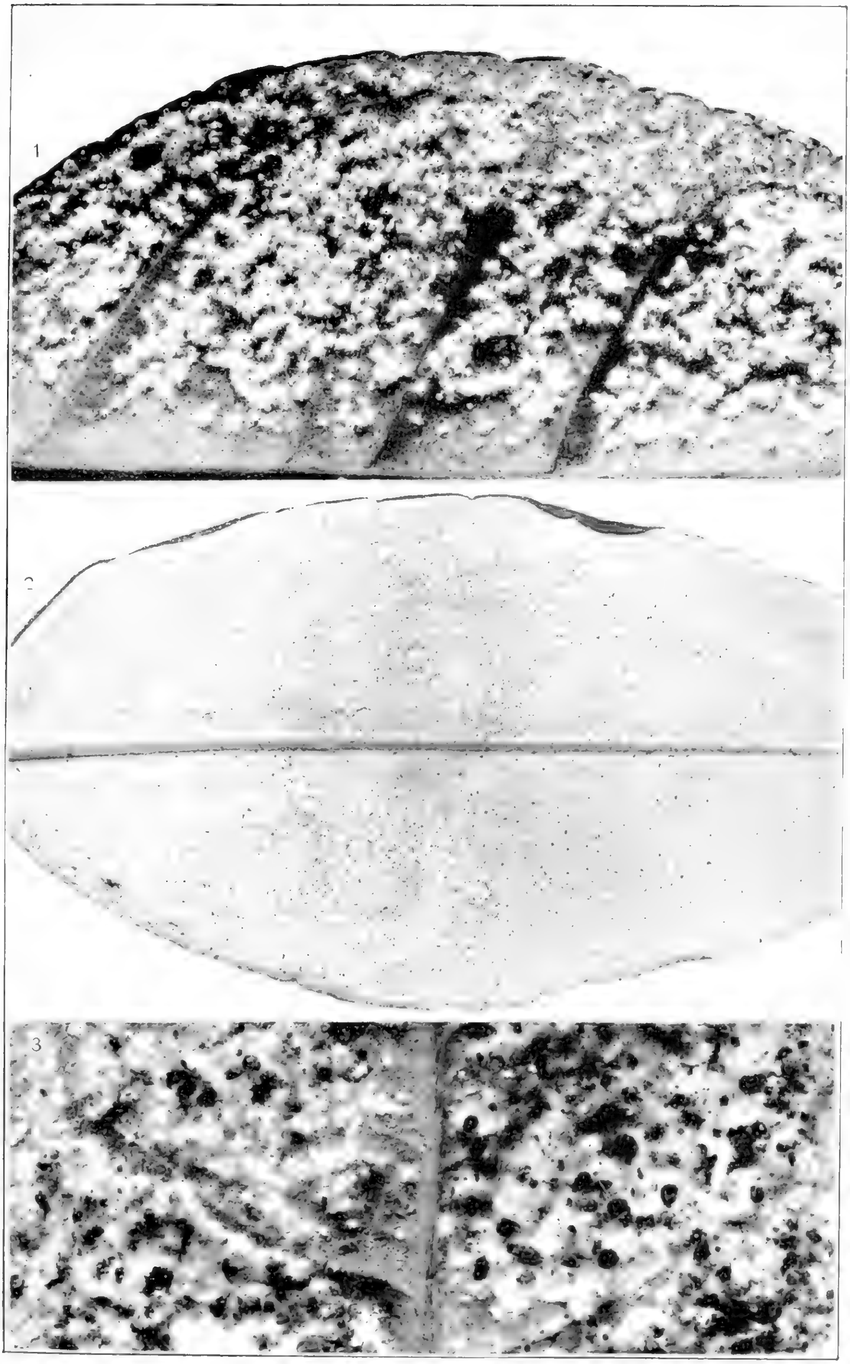
At present very little is known of the capacity for injury possessed by this aleyrodid. Mr. C. L. Marlatt, Assistant Chief of the Bureau of Entomology, found it quite abundant, locally, on several of the old orange trees at Artimisa, Cuba, but at that time (1905) noted that it had spread but slightly into the surrounding younger citrus groves. When describing it for the first time Prof. A. L. Quaintance [a] stated that, judging from its abundance on leaves sent to the Bureau of Entomology from Cuba, it was a very serious pest of the Cuban orange, possibly rivaling the well-known citrus white-fly in Florida. Whatever damage it is causing in Cuba, where it may be partially held in check by parasites and predaceous enemies, it has shown itself capable of rapid multiplication and spread in its new home at Tampa. Notwithstanding the fact that it has not been observed in Florida before, although many trees now heavily infested have been under casual observation during 1907 and 1908, it has become well established over a very large portion of the city, spreading northward beyond Michigan avenue and eastward about 2 miles, into Ybor City. Orange groves in the more elevated portions of the city are thoroughly infested, hence it is safe to presume that the pest is well established in the western section of the city.

From the present infestation it appears that the insect first secured a foothold along the water front, and this points to its possible importation from Cuba. In this section neglected worthless trees along the streets and in dooryards are in many cases heavily infested. While it appears to be rivaling the citrus white-fly in the extent of its attack on some trees, it is improbable that it is capable of causing such widespread disaster; nevertheless, if it becomes abundant in a grove, it will prove a source of no little aggravation and discomfort to those working in the trees because of the large and extremely viscid drops of honeydew which collect over the bodies of the insects, and later become embedded in the copious waxen secretions.

LIFE HISTORY.

Nothing has been published regarding the life history of this aleyrodid aside from the statement made by Professor Quaintance (l. c.) that the eggs lie prostrate on the leaf, and are arranged, more or less, in circles or curves. When discovered in Tampa by the writer on November 14, 1909, adults were abundant and depositing eggs upon both new and old growth, showing the usual preference for the former, and larvæ in all stages, as well as pupæ, were numerous. Later, on December 15, Mr. S. S. Crossman found adults abundant, and examination of material at this time showed that pupæ were still maturing. The last brood of adults of this species is, therefore, on wing later in the year than that of either the citrus or spotted-wing white-fly. Adults were noted by the writer on a visit to Tampa during late January.

[a] U. S. Dept. Agr., Bur. Ent., Tech. Ser. 12, Pt. V, pp. 91–92, 1907. The more important Aleyrodidæ infesting economic plants, with description of a new species infesting the orange.



THE WOOLLY WHITE FLY (ALEYRODES HOWARDI) ON ORANGE.

Fig. 1.—Moderate infestation of leaf, showing many specimens in larval instars. Fig. 2.—Eggs on tender leaf. Fig. 3.—Heavy infestation of leaf, showing globules of honeydew embedded in woolly secretions overgrown by fungi. (Original.)

Unless molested or crowded each female deposits her eggs in a complete circle (Pl. IV, fig. 2), she being always on the inside (fig. 19, *c*). This arrangement she effects by using her mouth parts as a pivot upon which to rotate her body. Since often as many as 3 or 4 rows of eggs are present in one circle, it is evident that the female describes several circles while ovipositing before seeking a new place. Although as few as 27 eggs have been counted in a single circle and as many as 130 in a circle of 4 rows, it is probable that the larger number does not indicate the maximum egg-laying capacity, which, in the case of *A. citri*, has been found to be 222.

The eggs are whitish when deposited but soon turn to a dark-brown or blackish color and become partially covered by waxen secretions rubbed from the bodies of the adults. They are curved, the concave side being upward (fig. 19, *a*, *b*), and in hatching the membranes rupture along the median distal half of the upper surface and do not spring back into place after the larva has escaped.

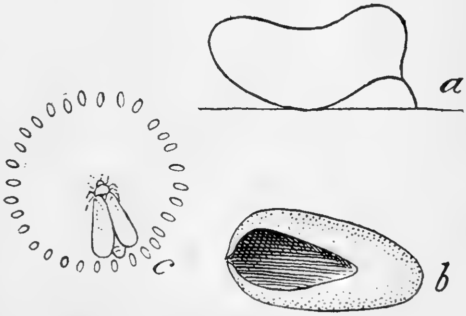


FIG. 19.—The woolly white-fly (*Aleyrodes howardi*): *a*, Egg, showing attachment to leaf; *b*, eggshell, viewed from above; *c*, female depositing eggs in a circle. *c*, Much enlarged; *a*, *b*, highly magnified. (Original.)

The larva after hatching crawls about before settling. It is yellowish, elliptical, with 9 pairs of marginal spines and 4 pairs of short, stout, dorsal spines. Soon after ceasing to crawl, it develops a short, inconspicuous, marginal wax fringe similar to that of the first instar of *A. nubifera* (fig. 20). In the second instar the marginal bristles are lost except one anterior and two posterior pairs, and the legs become unfit for locomotion as is the case with other aleyrodids. During this instar there develop 6 white abdominal cross-bands and a distinct, white, marginal fringe of wax, varying in width with age, often becoming 0.3 mm. wide; aside from these secretions, each of the dorsal spines secretes a long, outstanding waxen rod, of varying length, these rods being at all times characteristic of this instar (see fig. 21). After passing into the third instar the larva, except in point of size, assumes the appearance of the pupa: the marginal fringe and abdominal secretions found in the preceding instar remain practically the same, but these are largely or wholly concealed by the long, white, curling, and variously matted secretions which arise from along, but not on, the margin of the insect, giving to a leaf infested with this species a woolly appearance (Pl. IV, fig. 1) which, when infestation is heavy, entirely conceals the insect beneath. These threadlike secretions are often twice as long as the insect itself. At emergence the pupa case splits at the anterior end, down both the dorsal and ventral sides along the median line, on the dorsal side splitting back to the first abdominal segment. The empty pupa case is white and delicate. The adult insect of either sex is lemon-yellow, with pure-white wings, without darker markings; the ground color of the body being partially obscured by loose particles of waxen secretions. The adult resembles closely *A. citri*, the citrus white-fly, but carries its wings farther away from the body, thus leaving more of the abdomen exposed.

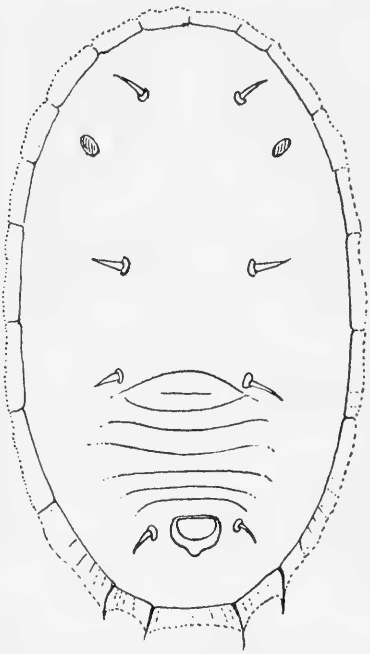


FIG. 20.—The woolly white-fly: Larva of first instar, dorsal view, showing spines and marginal wax fringe. Highly magnified. (Original.)

A very characteristic feature of this species, as compared with any of the Florida Aleyrodidæ now known to the writer, is the globule of honeydew which collects over the vasiform orifice, often becoming so large as to conceal the posterior half of the body, and resembling somewhat the secretions of the persimmon Psylla. These globules are extremely viscid and make the handling of leaves infested with this aleyrodid very disagreeable. They collect in large numbers in the waxen secretions on heavily infested leaves (Pl. IV, fig. 3) and both they and the secretions become grayish and dust-laden with age. The globules frequently become overgrown by a rank growth of greenish-brown fungus resembling the hyperparasitic species attacking the yellow white-fly fungus, *Aschersonia flavocitrina*.

DESCRIPTION.

A detailed description of *Aleyrodes howardi* follows [a]:

The egg.—Length, 0.2 mm. to 0.19 mm.; width, 0.1 mm. to 0.088 mm. Uniformly brownish in color, smooth, without reticulations or waxy secretions; curved, lying prostrate on leaf, with convex side approximating latter, attached by short stalk arising from convex surface about one-fourth distance from base to tip of egg. Eggs deposited more or less in complete circles; spaces between eggs often filled with waxy secretions rubbed from body of adults. (See fig. 19.)

[a] The original description of the pupa by Professor Quaintance has been used but amplified by the writer.

The larva, first instar.—Size about 0.26 mm. by 0.13 mm.; elliptical, yellowish-white, with 9 pairs of short marginal bristles, arranged as in figure 20, the two posterior pairs longest, the relative lengths being as follows:

Pair	1	2	3	4	5	6	7	8	9
Relative lengths	2	2.5	6	4	5	5	4	8	8

After settling, an inconspicuous, transparent, marginal wax fringe develops, but little exceeding in width the length of the marginal spines. Eyes reddish-brown, usual. Dorsum with 4 pairs of short stout spines; 1 pair cephalad and mesad of eyes, 1 pair at vasiform orifice, and 2 pairs on central region between the fifth and sixth, and sixth and seventh pairs of marginal spines, respectively. Legs and antennæ well developed, usual; vasiform orifice similar in shape to that of pupa, but without apparent strong setæ.

The larva, second instar.—Size, about 0.38 mm. by 0.22 mm. All marginal bristles lost except 2 pairs of minute bristles, one at anterior, the other at posterior end of body. Four pairs of bristles on dorsum located as in first instar, but different in that when wax secretions are removed, the first 3 anterior pairs are stout spindle-shaped (fig. 21, *a*), the fourth pair at vasiform orifice, long and slender, as in pupal stage; a fifth dorsal pair at caudal end of body but not on margin, similar to those in pupal stage. Color, brownish or black; margin with narrow white wax fringe, equaling at times 0.3 mm. Instar conspicuous because of long single, stout, outstanding waxen rods secreted by each of the spindle-shaped dorsal spines, and 6 abdominal cross bands of white waxen secretions. Insects well advanced in this instar, after the dorsal waxen rods have developed, present a profile similar to that shown in figure 21, at *b*.

FIG. 21.—The woolly white-fly, second larval instar. *a*, Spindle-shaped spine; *b*, diagrammatic profile, showing characteristic wax secretions. Highly magnified. (Original.)

The larva, third instar.—Size, about 0.58 mm. by 0.38 mm. Except in point of size, this resembles the pupal instar in all respects. The spindle-shaped spines of the previous instar are replaced by ordinary strong bristles.

The pupa.—Size, about 0.9 by 0.55 mm., subelliptical in shape. Many specimens with more or less evident indentures on cephalo-lateral margin of case, with cephalic end obtusely pointed. Color, on leaf, under hand lens, with secretions removed, yellowish-brown varying to blackish; under transmitted light, yellowish to brownish-yellow. There is a distinct marginal rim all around, with wax tubes distinct, the incisions acute and tubes rounded distally. From margin of case all around arises a short rim of wax, composed of individual wax-threads, serrated on margin as seen under a high-power microscope. Pupa usually quite covered by a very copious secretion of whitish, curling wax-rods which is very conspicuous in badly infested leaves, quite hiding the insects beneath (Plate IV, fig. 3); these waxen filaments often much greater in length than the insect's body, spreading outward when insects are not crowded, but upward when crowded; and arising from along the outer portion of the case, but not on the margin itself from which the above-mentioned distinct waxen fringe arises. Dorsum of pupæ with many wax-secreting pores; the secretions very short, irregular upon the cephalothoracic region, and on the abdominal portion arranged in cross bands on each segment, being most dense on the middle of the segments. Denuded of secretions, the pupa case is seen to be at first almost flat, but later becoming rather convex as the insect develops, with segments distinct.

Dorsum with pair (1) of strong setæ on first abdominal segment, a pair (2) at vasiform orifice, and a pair (3) at, but not on, caudal margin extending some distance beyond margin of case. There is also a pair of minute marginal spines (a) at the anterior end, and another (b) at the posterior end of body. The relative lengths of these spines are as follows:

Pair	1	2	3	a	b
Relative lengths	14	16	10	1.5	2.5

There is also a pair of small bristles on the venter beneath the vasiform orifice. Vasiform orifice relatively small, subcordate, the rim dark brown, from 6 to 8 strong setæ or spines arising from caudal margin; operculum largely filling orifice, the distal margin with two faint notches; lingula not distinguishable. (See fig. 22.)

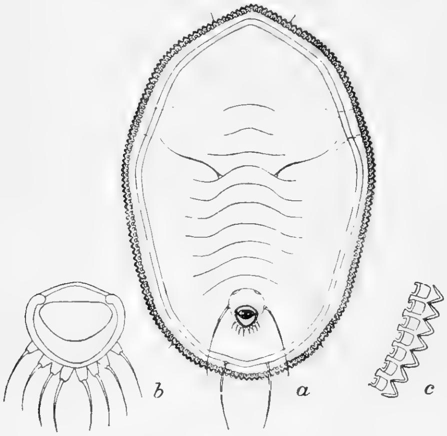


FIG. 22.—The woolly white-fly: Pupa case and details. Greatly enlarged. (From Quaintance.)

The adult.—Usual, lemon-yellow, after emergence becoming coated with white waxen secretions; wings pure white, without darker markings, held along sides of abdomen, but not meeting over the dorsum. A considerable amount of flocculent white wax is secreted, but not as copious a supply as is secreted by the adult of *P. perseæ*. In female: Length of body, 0.42 to 0.47 mm.; length of fore wing, 1.1 mm.; width of fore wing, 0.36 mm.; length of antenna, 0.31 mm.; length of hind tibia, 0.035 mm.; relative lengths of antennal segments as follows:

Segment	1	2	3	4	5	6	7	Spine.
Relative lengths	1.5	3	10	1.3	2.5	2.6	1.5	0.7

FOOD PLANTS.

The woolly white-fly infests the various species of citrus, the guava, and the mango. While found on the mango at Tampa by the writer, its presence on this plant is probably the result of accident. Mr. W. L. Tower is authority for its occurrence on guava in Porto Rico.

DISTRIBUTION.

This species occurs on several islands of the West Indies, but more especially in Cuba. It is now established at Tampa, Fla.

NATURAL ENEMIES.

While no predaceous insects are known to attack this aleyrodid, Cook and Horn[a] have reported it parasitized by the "red fungus,"

[a] Cook, M. T., and Horne, W. T., Cuban Exp. Sta. Bul. 9, p. 31, 1908.

Aschersonia aleyrodis, in Cuba, and Mr. W. L. Tower, entomologist of the Porto Rican Experiment Station, reports that in Porto Rico it is held in check by fungi (undetermined).

REMEDIES.

So far as known to the writer no remedial measures have been adopted against this pest up to the present time. Its recent discovery has not made it possible for experiments leading to its control to be concluded although such experiments are now in progress. From present indications it seems probable that this white-fly will be more easily controlled by fumigation than by spraying, inasmuch as when nearly mature it is very well protected from spray liquids by the secretions mentioned above. Present indications are that during the early larval instars it is as well controlled by spraying as are the citrus and the spotted-wing white-flies, with which it is found associated.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part IX.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON A COLORADO ANT.

BY

H. O. MARSH,
Agent and Expert.

Issued October 17, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*

C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*

R. S. Clifton, *Executive Assistant.*

W. F. Tastet, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work*
Mabel Colcord, *librarian.*

CONTENTS.

U. S. D. A., B. E. Bul. 64, Part IX. Issued October 17, 1910.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON A COLORADO ANT.

(*Formica cinereorufibarbis* Forel.)

By H. O. Marsh,
Agent and Expert.

INTRODUCTION.

A medium-sized ant, known scientifically as *Formica cinereorufibarbis* Forel, is one of the most common species occurring in the vicinity of Rocky Ford, Colo. The nests which it constructs along the fences and irrigation ditches are mounded up very little or not at all, but often cover a considerable area. Sometimes these nests are 3 or 4 feet in length by 2 or 3 feet in width, and they always have several openings.

During the growing season this species of ant is always to be found in attendance on various species of aphides or plant lice. During the summer of 1909 it was most commonly found together with the melon aphis (*Aphis gossypii* Glov.) on cucurbits, and with *Chaitophorus populicola* Thos. on cottonwood. The ants were also observed attending a species of Membracidæ on alfalfa, and late in the season after the leaves had fallen great numbers were found clustered and feeding upon crushed overripe cantaloupes, sometimes out in the field 25 yards from any ant nests.

As the ants were almost invariably to be found on aphis-infested cantaloupe vines, many of the growers are of the opinion that they are responsible, in part at least, for the spread of the aphides from one vine to another. There is also a rather general idea that the ants take the aphides into their nests in the fall, protect them throughout the winter, and then bring them out in the spring and put them upon the plants.

INJURIOUS HABITS.

There appears to be but little foundation for believing that the ants harbor the melon aphis during the winter, and after careful watching the writer has never seen any aphides being carried into the nests. However, these ants do protect the aphides from their natural enemies on the growing plants, and it is a common thing to see the ants busily engaged in killing and carrying off the syrphid larvæ, which were doing good work in destroying the "lice." They were also repeatedly observed carrying away adults of the convergent ladybird (*Hippodamia convergens* Guer.), the nabid bug *Reduviolus ferus* L., and a species of Chrysopa. The ladybird larvæ apparently were not molested, while the beneficial syrphid larvæ were objects of special attack, and it was not unusual to see as many as ten or twelve larvæ being carried away from a single vine at a time. Wherever the ants were abundant the syrphid larvæ were noticeably reduced in number, and the aphides thus had a better chance of increasing. The ants appear to use the syrphid larvæ as food, as they were observed carrying them into their nests, which, in several cases, were 12 or 15 feet from the vines infested by the aphides.

EXPERIMENTS WITH POTASSIUM CYANID AS A REMEDY.

As frequent inquiries were made by the melon growers concerning possible remedies for use against the ants it was decided to conduct a series of experiments. Owing to the large number of nests which occur along practically every fence and ditch, and to the large size of the nests, and particularly to the fact that each nest has several openings, it was obvious that carbon bisulphid would be too expensive for practical use with this species, and it was decided to make the experiments with various solutions of potassium cyanid. The object of these experiments was to determine if repeated applications would materially reduce the number of the ants and, if the ants were thus reduced, what effect it would have on the melon-aphis problem.

In making these experiments a strip about 80 yards in length was selected along a fence at the edge of a cantaloupe field. This strip was bordered along one side by a common road or highway and occupied along the center by a row of elm trees which were too small to cause any shade worth mentioning, as none of them was over 4 inches in diameter at the base. There were at least twenty-five distinct nests in this strip, and the ants occurred by thousands. Cantaloupes had been planted in the field along this strip for several successive years, and each year the first few rows nearest the fence were infested by melon "lice," while the vines which were beyond the convenient range of the ants were not infested, or at least not until later in the season. The owner of the cantaloupes was firmly convinced that the ants were responsible for the infestation of the first few rows and welcomed any attempt to destroy them.

In order to determine the cheapest and most practical solution the following preliminary tests were made:

Experiment No. 1.—One-half ounce of 98 per cent cyanid of potash dissolved in 1 gallon of water was used. On August 31, 1909, at 5 p. m., 2 gallons of this solution were applied to a nest 2½ feet in length by 2 feet in width. The entire outer surface of the nest was soaked and a considerable quantity was poured directly into the openings. Ants which were hit died almost at once and others which returned from the field and ran over the wet surface died within a few seconds. When the nest was examined an hour later the surface was well covered with dead specimens. There was still a fairly strong odor of the cyanid from the wet soil and returning ants were soon killed, although they did not die quite as rapidly as when the application was first made.

Experiment No. 2.—One ounce of 98 per cent cyanid in 1 gallon of water was used. On August 31, between 5.30 and 5.45 p. m., 4 gallons of this solution were applied to two nests, each about 3 feet long and 2 feet wide. The conditions were as in Experiment No. 1 and the immediate results appeared to be about the same.

Experiment No. 3.—Two ounces of 98 per cent cyanid in 1 gallon of water were used. On August 31, at 6 p. m., 2 gallons of this solution were applied to a nest about 3 feet long by 2 feet wide. The immediate results appeared to be about the same as in Experiments Nos. 1 and 2, although there was a somewhat stronger odor of the cyanid from the wet soil.

At the time these three tests were made the sun was warm and shining brightly. The ants were very active and thousands of them were away from the nests and among the aphis-infested cantaloupe vines.

Since the larger lumps of cyanid dissolved rather slowly some time was gained by breaking them up with a hammer.

At 4 p. m. on September 1 an examination was made of the nests treated in these tests. At that time there were hundreds of dead ants lying on the surface of the nests and a comparatively small number of specimens was running about. Most of the living ants had apparently lost interest in the aphides and had gathered on or about the treated nests and some were carrying dead specimens. There appeared to be little difference between the results of Experiments Nos. 1 and 2, but there were certainly fewer live ants about the nest treated in Experiment No. 3 than about the others.

As some fear was felt that a strong solution of the cyanid might kill the small elm trees which occupied the ant-infested strip and as Experiment No. 1 gave comparatively good results, it was concluded to continue the work with that strength. Accordingly, between 4.30 and 6 p. m. on September 1, the remainder of the infested strip, about 65 yards in length and containing 21 nests, was treated with

28 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. At the time of this treatment there were thousands of ants either actually in attendance on the "lice" or running about between the nests and the infested cantaloupe vines.

At 6 p. m. on September 2 the treated strip was examined. Dead ants by thousands, at some places in heaps, were lying on or about the nests. Many dead specimens were also found out in the field from 6 to 10 feet from the nests. However, at every nest there were still a few live ants. Practically all of these survivors had gathered about the nests and it was difficult to find a live ant out in the field, where at the time of the treatment they occurred in surprisingly large numbers.

In order to test the effect of a second treatment applied soon after the first, two nests near the center of the strip were given a second application at 5.30 p. m. September 3. This was considered as Experiment No. 4. In this experiment 2 gallons of solution at the rate of one-half ounce cyanid to each gallon of water were applied to each nest as before.

An examination made of these nests on the following afternoon (September 4) showed that although a few additional ants had been killed no practical advantage had been gained by this treatment, and this conclusion was not altered by frequent later examinations.

Along the entire treated strip the ants which remained alive seemed demoralized for about a week, but by September 11 several small colonies had again started. The cyanid solution does not penetrate very deeply into the nests and it is evident that the pupæ escape destruction unless they are very close to the surface, and on reaching maturity they are able, with the remaining live ants, to reestablish the colonies.

By September 16 one or two of these colonies (nests) had reached fairly good size and although the ants were moderately common they occurred in very much smaller numbers than they did at the time of the first general treatment (September 2). This first treatment left the nests with a "crust" of compact soil over the surface. At two or three nests, just under the crust, the ants had large numbers of pupæ and at a few other nests a considerable number of winged adults had crawled out and was clustered about the openings.

At this date (September 16) all the nests in the entire strip were again treated with 25 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. A particular effort was made to soak the winged specimens and the pupæ. All the adults touched were readily killed, but the pupæ showed no immediate effect from the treatment.

An examination made on the following afternoon showed that although the number of ants had been very considerably reduced there were still some living specimens at each nest. The pupæ at the treated nests seemed to be dead and the living ants paid no attention to them. It was observed that at two places quite a number of pupæ had been overlooked and not soaked by the solution and at another place a moderate number of winged specimens had crawled from an opening of an untreated (overlooked) nest.

By September 27 about a dozen small, weak colonies had started, and on the following day between 4 and 5 p. m. all the inhabited nests were again treated with 25 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. In this treatment all the openings in the nests were enlarged with a pointed stick and from a quart to a gallon of the solution poured into each. At this date many of the cantaloupe vines had been trampled down by the pickers or had died from disease or other cause. As a result there was not a very good supply of aphides in the immediate vicinity of the nests and the ants were mostly close about or in the nests. At two places many pupæ were present and at another nest there were a good many winged specimens.

Examination made on the following day (September 29) showed that there were still a few living ants about the nests, and the pupæ were still light in color and did not appear to be dead. A day later some of the pupæ appeared to be still alive, but as all of these were embedded in the moist soil, where the living ants paid no attention to them, they certainly could not have survived. At this time there was no odor of the cyanid over the nests, but when lumps of the moist soil were picked up the odor from them was quite apparent.

Repeated examinations made of the treated strip during October and November showed that the ants had almost completely disappeared, while at untreated (check) nests they occurred in large numbers. It would be interesting to know what became of the few specimens which survived the last treatment. Possibly they became discouraged and went to less troubled quarters.

It is evident that from experiments of this nature definite or final conclusions can not yet be reached. The work was begun so late in the season that the rather gradual decrease in the number of the ants had no marked effect on the melon aphis. It showed that to keep this species within reasonable bounds repeated applications of the cyanid and constant watching are necessary. As this would require so much more attention than the ordinary farmer can be induced to give, it does not seem probable that this method will ever become very popular for this particular species of ant, unless it can be definitely proved that this species is a more important factor in the melon-aphis problem than it is now known to be. It is very probable that quicker results would have been obtained if a stronger solution had been used.

At Rocky Ford, Colo., 98 per cent potassium cyanid was obtainable in small lots for 50 cents a pound. When used at the rate of a pound in 30 or 32 gallons of water this makes a comparatively cheap solution.

Although this solution is extremely poisonous, there need not be undue risk to human beings from its use if proper care is exercised in preparing and handling it. When leaning over a half barrel of the solution for the purpose of stirring it or dipping out pailfuls, the fumes were quite noticeable and, with the writer, caused a slight dull headache which lasted a short time. Although in applying the solution the writer's hands were frequently wet with it, and no ill effects resulted, yet it would be safer to keep the solution from coming into contact with the skin. Some persons are peculiarly susceptible to this poison, and with some its contact with the skin causes a rash. Persons with weak hearts should be especially careful not to inhale the fumes.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part X.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE PECAN CIGAR CASE-BEARER.

BY

H. M. RUSSELL,

Agent and Expert.

Issued November 12, 1910.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1910.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*
R. S. Clifton, *Executive Assistant.*
W. F. Tastet, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

58772°—10

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE PECAN CIGAR CASE-BEARER.

(*Coleophora caryæfoliella* Clem.)

By H. M. Russell,
Agent and Expert.

INTRODUCTION.

Among the insects of minor importance that affect the pecan, the pecan cigar case-bearer (*Coleophora caryæfoliella* Clem.) is probably met with in groves more than any other species. At times the insect occurs in such numbers as to defoliate entire trees, checking their growth and considerably reducing the crop of nuts. In the future this insect is likely to cause increasing damage as the acreage in pecans increases, and it may become as great a pest to the pecan as *Coleophora fletcherella* Fernald is to the apple. The occurrence of this insect in large numbers at Orlando, Fla., during the spring of 1909 presented the opportunity of studying it, and the results are given in this article. The dates for appearance of the different stages are for that locality. These dates will undoubtedly vary as we go northward.

EARLY HISTORY.

Clemens[1 a] first described this species in 1861, as *Coleophora caryæfoliella*, from larvæ found feeding in their cases on leaves of hickory during the fall. He gave a short description of the larva and case, but did not succeed in rearing the adult.

In 1872 Clemens's original description[2] was republished in his "Tineina of North America," edited by H. T. Stainton.

Chambers,[3] in 1874, described the adult under the name *Coleophora rufoluteella*, from specimens captured in Kentucky in June.

Writing again in 1878, Chambers[4] places his *rufoluteella* as a synonym under *caryæfoliella*. He wrote at that time: "*C. rufoluteella* Cham. is known only from captured specimens. I am, however, utterly unable to distinguish it from specimens bred by me in the latter part of June from larval cases found feeding on hickory leaves

---

[a] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 86.

in the manner described by Doctor Clemens for *caryæfoliella*, and I believe it to be the same species."

During 1882 Lord Walsingham[5] identified a specimen, reared from *Prunus americana*, as *C. rufoluteella* which he thought to be distinct from *caryæfoliella*. Packard,[6] in 1890, wrote of this insect, under insects injurious to hickory: "The larva feeds in a cylindrical case attached to the under surface of the leaves."

During the same year there was published in Insect Life[7] a brief note recording the parasite, *Rhyssalus trilineatus* Ashm., as having been reared from this species on hickory at Washington, D. C., May 5, 1893.

Apparently nothing more was written until 1905, when Gossard,[8] in his bulletin on pecan insects, mentions what is undoubtedly this species as "*Coleophora* sp."

RECENT RECORDS.

May 5, 1901, Mr. L. O. McPherson, of Josephine, Ala., sent in larvæ of this species affecting the pecan. Writing of this attack, October 23, 1905, Mr. McPherson stated that in the year mentioned this insect entirely denuded a number of large trees of their leaves during May and June only.

June 3, 1907, the larval cases of this insect were observed on pecan at Orlando, Fla. March 16, 1908, the winter cases of these larvæ were found clustered together on twigs of pecan in a deserted grove outside of Orlando. April 2 and 7, 1908, the larvæ were again observed at Orlando, Fla. They were just leaving their winter cases for the larger spring cases.

In 1909, during April and May, several large trees in the grove of Mr. C. W. Townsend, of Orlando, Fla., were almost completely prevented from putting out foliage until weeks after other trees had done so, because the larvæ of this species were so numerous on the buds and leaves. May 11 found this insect causing considerable defoliation to pecan trees at the old Standard Oil grove just west of Orlando, now owned by Mr. Long. At the same time it was abundant in all the groves around Orlando. On May 16 Mr. J. D. Mitchell, of this Bureau, reared this insect from leaves of pecan at Victoria, Tex.

DISTRIBUTION.

This species was first described by Clemens in a paper on North American Tineina, but the locality for his specimens is not given. V. T. Chambers records it from larval cases taken in Kentucky and records capture of the adult at Covington, Ky. Prof. H. A. Gossard records what is undoubtedly this species as met with on "almost every tree I examined for the purpose of finding it" in Florida. The author, while working in Florida during the years 1907–1909, found it in every grove examined around Orlando.

In the Bureau of Entomology and the U. S. National Museum there are specimens from McPherson, Ala.; Victoria, Tex.; Pittsburg, Pa.; Hampton, N. H.; Washington, D. C.; Virginia; and New York.

From these records of capture and injury, this insect seems to be distributed throughout the Austroriparian faunal area of the United States and may also extend into the Carolinian and into the lower edge of the Alleghanian areas.

FIG. 23.—Pecan twigs with buds and young leaves killed by pecan cigar case-bearer (*Coleophora caryæfoliella*). (Original.)

FOOD PLANTS.

The pecan cigar case-bearer feeds principally on nut-bearing trees, and of these it has been observed feeding on walnut, pecan, and hickory. It has been doubtfully recorded on dogwood and *Prunus americana*.

CHARACTER OF INJURY.

Damage by the pecan cigar case-bearer occurs during the early spring, principally to budded trees, and is due to the feeding of the larvæ on the tender buds and unfolding leaves. Where this insect is very abundant it causes injury in two ways. If the buds are backward in opening, the larvæ leave the twigs where they have hibernated, and crawling to the swelling buds attack them and eat out the contents, so that the life is destroyed, and before the tree can put out its foliage the dormant buds must develop. Figure 23, taken May 6, 1909, shows pecan twigs with buds destroyed by these larvæ;

the winter cases are still seen attached to sides of the buds. On the other hand, if the trees develop their foliage before the larvæ leave hibernation in injurious numbers, the leaves are riddled by the larvæ as they come from the twigs and the wind soon whips them to pieces. In this way, by feeding on the opening buds and young leaves in great numbers, this insect may delay the trees from coming into foliage for a period of from six to eight weeks. Because of this, young trees are held back during the most important period of their growth, and older trees, owing to this extra demand for nourishment for building leaves, probably have the crop of nuts for the year considerably decreased. Plate V, figure 1, shows a pecan twig with the young leaves ragged and largely destroyed by this insect, and Plate V, figure 2, shows the mines of the larvæ and some of the case-bearers at work. Plate VI is from a photograph of a pecan tree, taken May 6, 1909, showing injury by this insect. Plate VII shows a tree not attacked by this insect, which had been in full foliage for at least four weeks. When the writer left Orlando, June 13, the injured tree shown in Plate VI was still partly bare.

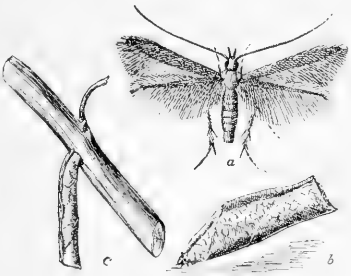


FIG. 24.—The pecan cigar case-bearer (*Coleophora caryæfoliella*): *a*, Adult; *b*, *c*, larvæ in cases. Greatly enlarged. (Original.)

DESCRIPTION.

The adult.—*Coleophora caryæfoliella* is one of the Microlepidoptera belonging to the family Elachistidæ, characterized by narrow, pointed wings with long fringes on the inner margins. The adult is a delicate little moth, ochreous in color, with a wing expanse of about 9 mm. The head is yellowish ochreous, with white scales over the eyes, the palpi and base of the antennæ the same color as the head, and the rest of the antennæ white ringed with brown. The body is the same color as the head, while the fore wings are reddish ochreous with costal margin white and fringe on inner border gray, and the hind wings are gray or whitish. This moth is well illustrated in figure 24 at *a*.

Chambers described the adult as follows:

The species is ochreous; the head and palpi pale or yellowish ochreous; the antennæ white, annulate with brown; fore wings reddish ochreous, darker towards the apex, with the costal margin from base to cilia white.

The ornamentation of the imago is nearer that of *C. limosipennella* than to any of the other species figured in *Nat. Hist. Tin.* Al. ex. 4½ lines.

The egg.—The egg has not been observed by the author, but is probably very similar to that of *C. fletcherella* as described by A. G. Hammar.[a]

[a] United States Dept. Agr., Bur. Ent., Bul. 80, Pt. II, p. 37, June 30, 1909.

Fig. 1.—Twig of pecan, showing injury to foliage. (Original.)

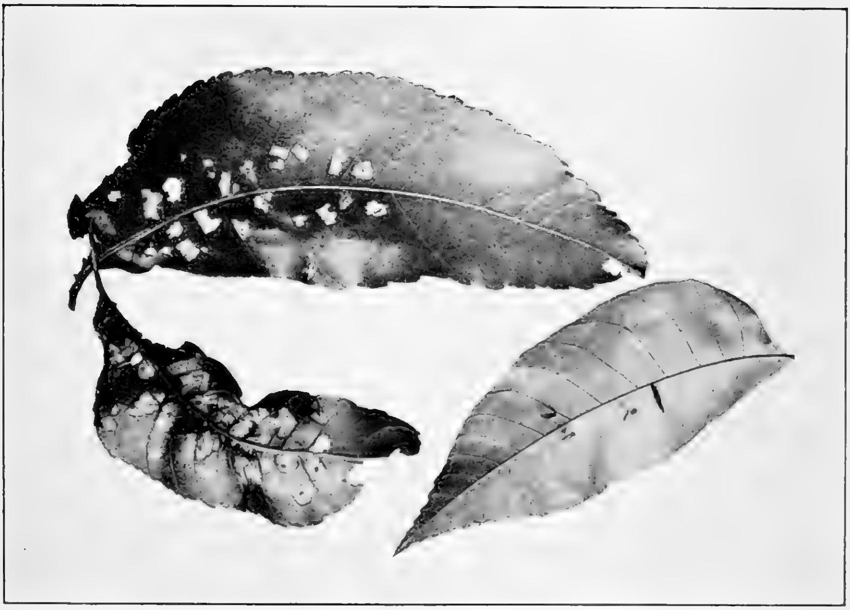


Fig. 2.—Leaves of pecan, showing mines. On upper leaf are larvæ in cases at work. About natural size. (Original.)

WORK OF THE PECAN CIGAR CASE-BEARER (COLEOPHORA CARYÆFOLIELLA).

The larva and larval cases.—The case in which the larva passes the winter is small, 3–3.5 mm. long, very flat, cylinderlike, and by the end of winter has the same color as the twigs or bark on which it rests. In the spring the larva is found in a case that is considerably larger. This is 5–7 mm. long, cylindrical, flattened vertically at the upper end, and slightly rounded at the lower. This case is made from a hollowed portion of leaf and so shows the entire leaf structure. It becomes reddish brown in color, and resembles a minute cigar.

The mature larva is about 5.5 mm. long and 1 mm. wide, the cylindrical body having well-marked segments. The head is one-half as wide as the body, hemispherical, flattened, black in color, with the triangle reddish. The body is light brown, with cervical shield oval, shining black, divided along center by a light brown line. The third segment of the body has a small black shield like the cervical, the anal plate shining black. The surface of the body is finely punctured and bears scattered, short, white hairs. The legs are light brown, while the prolegs are wanting or very small, marked by minute elevations, except the anal pair, which are large and functional. The nearly mature larva is well illustrated in its case in figure 24, *b*, *c*.

The pupa.—The pupa is formed within the larval case, and is about 5.5 mm. long and 1 mm. wide, cylindrical, having nearly the same diameter throughout the entire length. The head and eyes are blackish, while the remainder of the pupa is light yellowish-brown. The leg cases extend beyond the tip of the abdomen.

Clemens described this species from the larval case, but did not rear the adult. His original description is as follows:

1. *C. caryæfoliella.* The larva mines the leaves of hickory in September and October. The head and body is [are] reddish-brown, somewhat darker on the second and third rings.

The case is small, dark brownish, and in form is a flattened simple cylinder. The larva feeds only in small rectangular patches, of which there are usually several in the same leaf. The case is fixed to the under surface and the larva feeds in one patch until it is compelled to remove its entire body from its case, and then removes to another part of the leaf to form a new mine.

HABITS OF THE ADULT.

The moths emerge from the pupæ during May and June and at that time may be found among the pecan trees. When only recently emerged from the pupæ they rest either on the pupal cases or on the leaves or twigs of the host plant, with the fore wings folded back over the hind wings and flat over the abdomen, while the antennæ are held closely together and directed forward. During the day they seem to rest among the leaves.

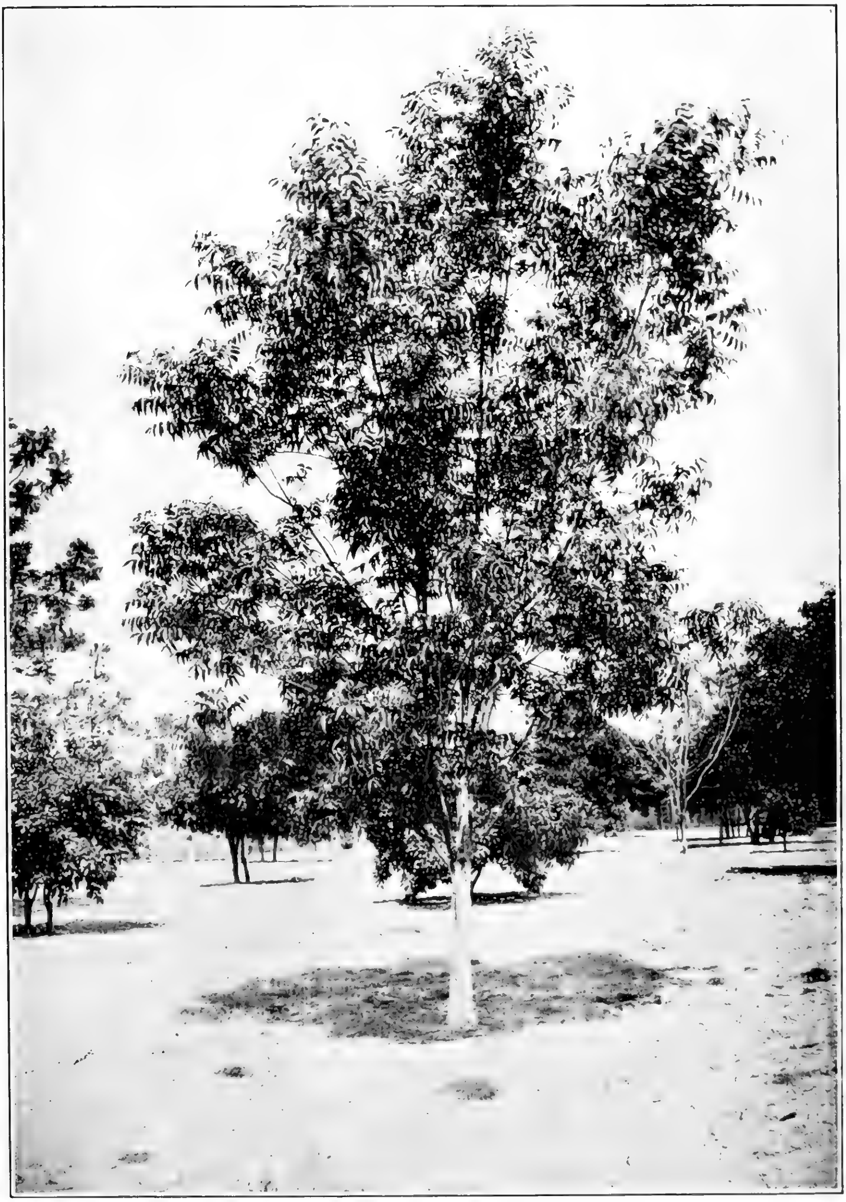
HABITS OF THE LARVA.

The larvæ of *Coleophora caryæfoliella,* upon hatching from the eggs in July, mine the leaves of the host plant, and after feeding there for some time cut out the two skins of the mine and construct the cases within which they live during the fall and winter. After the cases are made the larvæ feed upon the leaves by eating through the lower epidermis and tunneling out the interior of the leaf in all directions until the mine is so large that to mine farther the larvæ would have to leave their cases. Under such conditions they move and begin a new mine, so that the leaves become full of irregular rectangular patches of brown with a small round hole in the center on the underside. In feeding, the larvæ carry the cases nearly perpendicular to the leaf surface. When the larvæ move they extend the head and thorax and crawl along, bearing the case aloft behind. In the fall, some time in October, before the leaves fall, these larvæ move from the leaves to the twigs or to the trunk, where they get behind the bark. Often they get in between the bud and the twig. Here they fasten the cases to the support and hibernate. The writer has seen from fifteen to twenty minute cases on a twig 4 to 5 inches in length, and where very abundant they will cluster together literally in hundreds. Gossard[7] has a photograph of these winter cases completely covering a twig.

In the spring, when the weather becomes warm enough, generally between March 15 and April 1, these larvæ become active and leave the twigs, where they have spent the winter, to commence feeding. If the trees are backward they often begin to feed before the leaves have developed and in such cases attach themselves to the swelling buds. Each larva eats a minute round hole into a bud and feeds as long as it can reach food without leaving its small case. When this becomes impossible the larva changes position and attacks the bud in a new place, so that infested buds are often found with four or five holes in the sides. Under such treatment the buds are killed or the tiny leaves start and are killed, and turning brown drop off. Often the larvæ attack the young tender leaves and mine out rectangular blotches in them. About the first week in April these larvæ outgrow their winter cases and construct larger ones.

Larvæ forming new cases move to the edge of the leaf and mine between the two skins. They then cut out a portion of the leaf, using the edge for one side. The sides are then sealed with silk, an opening being left at one end for the head. From the method of making new nests one edge of the case will often show serrations of the leaf edge. The larvæ then leave the old case attached to the leaf, where the latter has been cut to form a new case. They eat out large mines from 2 to 8 mm. long and 4 to 5 mm. wide (Pl. V,

PECAN TREE, SHOWING FOLIAGE CHECKED AND INJURY BY PECAN CIGAR CASE-BEARER.
(ORIGINAL.)



NORMAL PECAN TREE, SAME SIZE AS THAT SHOWN IN PLATE VI, BUT WITHOUT INJURY BY THE PECAN CIGAR CASE-BEARER. (ORIGINAL.

fig. 2) in the leaves, feeding generally on the under side but sometimes on the upper also. These mines are deserted by the larvæ when they can not reach more of the surrounding tissue without leaving their cases, and new mines are made. In this way badly infested leaves may have from six to twenty mines to each leaflet. Soon the old mines dry up and are broken out by the wind, leaving the leaves full of ragged holes. The larvæ feed during the day and can often be seen with the head and part of the body inserted between the leaf surfaces, eating out the tissues in an ever-enlarging angular mine. If disturbed or in search of fresh food, these larvæ will move around considerably. When making a new mine the end of the case is loosely fastened and held diagonally attached, to the leaf. (See fig. 24.)

HABITS OF THE PUPATING LARVA.

During May most of the larvæ become mature and they then either fasten the case tightly to the leaves and pupate or move to twigs, branches, or bits of bark on the trunk of the tree and fasten the cases there. The larvæ spin a quantity of silk by which they fasten the cases very firmly to the support, after which they reverse their position, so that the head is pointing out toward the unattached end. After remaining quiet for a number of days the pupæ are formed, and the adults emerge during the last of May or the first of June.

SEASONAL HISTORY.

As far as observed, this insect has only one brood during the year, the larvæ hibernating when only partially grown.

In Florida the larvæ of this species become active from the 15th to the 30th of March, when the buds of the pecan are opening, or just after they have opened. Leaving the twigs and sheltered places where they have hibernated, they begin feeding on the buds or tender leaves. In a short time these larvæ outgrow their old winter cases and construct new ones of larger size. During the spring of 1908 this occurred mostly between April 1 and April 7.

The larvæ, after forming new cases, continue feeding and grow rapidly until May, when they become full grown.

By May 4, 1909, a few larvæ pupated and, as others pupated from time to time, by May 19 or 20 the greater part of the brood was in the pupal state. This pupal period occupies about twelve days.

An adult was observed in the cage on May 11, but most of the moths emerge from May 27 to June 5. On June 3 the adults were abundant on the foliage of pecan.

The adult probably lays her eggs on the underside of the leaves during June, and by the middle of July the larvæ are working as miners in the leaves of pecan. After a time they construct their minute cases and feed on the foliage until fall, probably until the last of September or first part of October, when they move to twigs to hibernate, sometimes being packed around them by the hundreds. Others hibernate under bits of bark on the trees or in crotches and other sheltered spots.

RECOMMENDATIONS.

Where this insect becomes abundant enough to be injurious it can with little doubt be controlled by spraying the trees with arsenate of lead (at the rate of 3 pounds to 50 gallons of water) when the buds are swelling—in March in central Florida and in similar climates. When the larvæ attack the foliage, this should be similarly sprayed.

Lime-sulphur mixture applied during the dormant season would undoubtedly give good results.

Where trees are sprayed in spring for the budworm (*Proteopteryx deludana* Clem.) no further treatment will be required for the case-bearer.

A bibliographical list follows:

BIBLIOGRAPHY.

1. CLEMENS, BRACKENRIDGE.—Proceedings of the Entomological Society of Philadelphia, Vol. I, p. 78, 1861.

   Original description of the species from larva and case; adult not reared.

2. CLEMENS, BRACKENRIDGE.—Tineina of North America, p. 166, 1872. Edited by H. T. Stainton.

   Same account as in No. 1.

3. CHAMBERS, V. T.—Canadian Entomologist, Vol. VI, p. 129, 1874.

   Described captured adults as *C. rufoluteella* n. sp.

4. CHAMBERS, V. T.—Canadian Entomologist, Vol. X, p. 112, 1878.

   Made his *rufoluteella* synonym of *caryæfoliella*, giving description of adult, larva, and larval case, and brief account of larval habits.

5. WALSINGHAM, THOS.—Transactions of the Entomological Society of London for 1882, pp. 430–431.

   Regards *rufoluteella* as distinct from *caryæfoliella*.

6. PACKARD, A. S.—Fifth Report U. S. Entomological Commission, p. 316, 1890.

   A brief account of habits.

7. [EDITORIAL].—Insect Life, Vol. II, p. 351, 1890.

   Mention of parasite.

8. GOSSARD, H. A.—Bul. 79, Florida Agricultural Experiment Station, p. 304, 1905.

   Brief account of injury to pecan by an unidentified Coleophora, probably this species, and remedies.

Brief mention has also been made of the occurrence of this species in Florida and Texas in recent Yearbooks of the Department.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 64.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

CONTENTS AND INDEX.

ISSUED JANUARY 27, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 64.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

I. THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.
By A. W. MORRILL, *Special Field Agent.*

II. NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.
By W. DWIGHT PIERCE, *Special Field Agent.*

III. NOTES ON "PUNKIES."
By F. C. PRATT, *Special Field Agent.*

IV. AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

V. INSECTS INJURIOUS TO THE LOCO WEEDS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

VI. THE GREENHOUSE THRIPS.
By H. M. RUSSELL, *Agent and Expert.*

VII. NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.
By E. S. TUCKER, *Special Field Agent.*

VIII. THE WOOLLY WHITE-FLY: A NEW ENEMY OF THE FLORIDA ORANGE.
By E. A. BACK, *Agent and Expert.*

IX. NOTES ON A COLORADO ANT.
By H. O. MARSH, *Agent and Expert.*

X. THE PECAN CIGAR CASE-BEARER.
By H. M. RUSSELL, *Agent and Expert.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*
R. S. Clifton, *Executive Assistant.*
W. F. Tastet, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., November 30, 1910.

Sir: I have the honor to transmit herewith ten papers on miscellaneous insects for publication as Bulletin No. 64 and as No. IX of the series of bulletins entitled "Some Miscellaneous Results of the Work of the Bureau of Entomology." These papers, which were issued separately during 1907, 1908, 1909, and 1910, are as follows: The Mexican Conchuela in Western Texas in 1905, by A. W. Morrill; Notes on the Economic Importance of Sowbugs, by W. Dwight Pierce; Notes on "Punkies," by F. C. Pratt; An Injurious North American Species of Apion, with Notes on Related Forms, by F. H. Chittenden; Insects Injurious to the Loco Weeds, by F. H. Chittenden; The Greenhouse Thrips, by H. M. Russell; New Breeding Records of the Coffee-bean Weevil, by E. S. Tucker; The Woolly White-fly, by E. A. Back; Notes on a Colorado Ant, by H. O. Marsh; the Pecan Cigar Case-bearer, by H. M. Russell.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The present publication comprises ten articles previously published separately as parts and now brought together to form the complete bulletin, which is No. IX of the series entitled "Some Miscellaneous Results of the Work of the Bureau of Entomology." The previous bulletins of this series are Nos. 7, 10, 18, 22, 30, 38, 44, and 54. The articles of the present bulletin relate to species which, although economically important, do not properly come under the scope of any of the other bulletins thus far published in parts, viz, those relating to forest insects, the cotton boll weevil and related and associated insects, truck-crop insects, deciduous fruit insects, cereal and forage insects, and apiculture. The investigations the results of which are here published were, however, conducted coincidently with the various projects of several branches of the Bureau, including those dealing with some of the groups of insects mentioned above.

The first paper treats of the Mexican conchuela, a species investigated in Mexico in 1904, at which time it had not yet been reported to entomologists as of economic importance in the United States. It was predicted at that time that should the pest become abundant in Texas it would cause considerable damage to crops. The results of investigations in Texas in 1905 confirmed the prophecies of 1904.

Part II presents economic notes on three common species of sowbugs encountered during field-crop investigations in Texas and other parts of the South, while Part III, by F. C. Pratt, treats of the biologies of the various biting flies belonging to the genus Ceratopogon, known commonly as "punkies."

Part IV treats of a small weevil (*Apion griseum* Sm.) injurious to beans in Texas and New Mexico and includes biologic notes on a number of related forms.

Part V considers a number of the more important insects which feed upon the loco weeds. This investigation was undertaken in cooperation with the loco-weed investigations of the Bureau of Plant Industry, and as it was conclusively shown that insects of several species were largely responsible for control of the plant on prairies and grass lands a publication covering these insects was deemed desirable.

Part VI considers the greenhouse thrips (*Heliothrips hæmorrhoidalis* Bouché), a species previously recorded as injurious to a number of hothouse plants. This insect was found injuring mango, crotons, and other plants on beds and in parks at Miami, Fla. The results of a series of experiments for its control are given in this number.

Part VII is largely supplemental to an article in Bulletin No. 8 of the Division of Entomology, giving a note on new food materials for the coffee-bean weevil (*Aræcerus fasciculatus* DeG.). This insect was discovered working in chinaberries and cornstalks adjacent to cotton fields during an investigation of cotton insects.

A new and dangerous species of Aleyrodes attacking citrus fruits is the subject of Part VIII. This species (*Aleyrodes howardi* Quaint.), which occurs on several islands of the West Indies, including Cuba and Porto Rico, has recently made its appearance in Florida. Present indications are that this species will be controllable by the same measures used for the citrus white fly, which it much resembles in capacity for damage.

Part IX gives the results of experiments undertaken for the control of a species of ant (*Formica cinereorufibarbis* Forel), which fosters the melon aphis in Colorado, protecting it largely from predaceous enemies. The control of this ant may prove of great value as a measure against the melon aphis.

Part X is a biologic account of a minor pecan pest, the pecan cigar casebearer in the South, and includes suggestions for its control.

CONTENTS.[a]

[a] The ten papers constituting this bulletin were issued in separate form on April 2, 1907 (Pts. I to III), January 14 and May 29, 1908 (Pts. IV and V), August 4 and 5, 1909 (Pts. VI and VII), and May 7, October 17, and November 12, 1910 (Pts. VIII to X).

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

ERRATA.

Page 25, line 11 from bottom, for *C.* read *Ceratopogon.*
Page 41, line 9 from bottom, for *virginica* read *virginiana.*
Page 43, between lines 4 and 5 insert (*Heliothrips hæmorrhoidalis* Bouché).
Page 51, lines 10 and 17, for *azalia* read *azalea.*
Page 51, line 11, for *lauristina* read *laurestina.*
Page 51, line 17, for *catleyia* read *cattleya.*
Page 51, line 17, for *dendrobuim* read *dendrobium.*
Page 80, line 12, for *1893* read *1883.*

X

INDEX.

○

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 64.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

I. THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.
By A. W. MORRILL, *Special Field Agent.*

II. NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.
By W. DWIGHT PIERCE, *Special Field Agent.*

III. NOTES ON "PUNKIES."
By F. C. PRATT, *Special Field Agent.*

IV. AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

V. INSECTS INJURIOUS TO THE LOCO WEEDS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

VI. THE GREENHOUSE THRIPS.
By H. M. RUSSELL, *Agent and Expert.*

VII. NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.
By E. S. TUCKER, *Special Field Agent.*

VIII. THE WOOLLY WHITE-FLY: A NEW ENEMY OF THE FLORIDA ORANGE.
By E. A. BACK, *Agent and Expert.*

IX. NOTES ON A COLORADO ANT.
By H. O. MARSH, *Agent and Expert.*

X. THE PECAN CIGAR CASE-BEARER.
By H. M. RUSSELL, *Agent and Expert.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 64.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

I. THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.
By A. W. MORRILL, *Special Field Agent.*

II. NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.
By W. DWIGHT PIERCE, *Special Field Agent.*

III. NOTES ON "PUNKIES."
By F. C. PRATT, *Special Field Agent.*

IV. AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

V. INSECTS INJURIOUS TO THE LOCO WEEDS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

VI. THE GREENHOUSE THRIPS.
By H. M. RUSSELL, *Agent and Expert.*

VII. NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.
By E. S. TUCKER, *Special Field Agent.*

VIII. THE WOOLLY WHITE-FLY: A NEW ENEMY OF THE FLORIDA ORANGE.
By E. A. BACK, *Agent and Expert.*

IX. NOTES ON A COLORADO ANT.
By H. O. MARSH, *Agent and Expert.*

X. THE PECAN CIGAR CASE-BEARER.
By H. M. RUSSELL, *Agent and Expert.*

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1911.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*
R. S. Clifton, *Executive Assistant.*
Chas. J. Gilliss, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., November 30, 1910.

Sir: I have the honor to transmit herewith ten papers on miscellaneous insects for publication as Bulletin No. 64 and as No. IX of the series of bulletins entitled "Some Miscellaneous Results of the Work of the Bureau of Entomology." These papers, which were issued separately during 1907, 1908, 1909, and 1910, are as follows: The Mexican Conchuela in Western Texas in 1905, by A. W. Morrill; Notes on the Economic Importance of Sowbugs, by W. Dwight Pierce; Notes on "Punkies," by F. C. Pratt; An Injurious North American Species of Apion, with Notes on Related Forms, by F. H. Chittenden; Insects Injurious to the Loco Weeds, by F. H. Chittenden; The Greenhouse Thrips, by H. M. Russell; New Breeding Records of the Coffee-bean Weevil, by E. S. Tucker; The Woolly White-fly, by E. A. Back; Notes on a Colorado Ant, by H. O. Marsh; the Pecan Cigar Case-bearer, by H. M. Russell.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The present publication comprises ten articles previously published separately as parts and now brought together to form the complete bulletin, which is No. IX of the series entitled "Some Miscellaneous Results of the Work of the Bureau of Entomology." The previous bulletins of this series are Nos. 7, 10, 18, 22, 30, 38, 44, and 54. The articles of the present bulletin relate to species which, although economically important, do not properly come under the scope of any of the other bulletins thus far published in parts, viz, those relating to forest insects, the cotton boll weevil and related and associated insects, truck-crop insects, deciduous fruit insects, cereal and forage insects, and apiculture. The investigations the results of which are here published were, however, conducted coincidently with the various projects of several branches of the Bureau, including those dealing with some of the groups of insects mentioned above.

The first paper treats of the Mexican conchuela, a species investigated in Mexico in 1904, at which time it had not yet been reported to entomologists as of economic importance in the United States. It was predicted at that time that should the pest become abundant in Texas it would cause considerable damage to crops. The results of investigations in Texas in 1905 confirmed the prophecies of 1904.

Part II presents economic notes on three common species of sowbugs encountered during field-crop investigations in Texas and other parts of the South, while Part III, by F. C. Pratt, treats of the biologies of the various biting flies belonging to the genus Ceratopogon, known commonly as "punkies."

Part IV treats of a small weevil (*Apion griseum* Sm.) injurious to beans in Texas and New Mexico and includes biologic notes on a number of related forms.

Part V considers a number of the more important insects which feed upon the loco weeds. This investigation was undertaken in cooperation with the loco-weed investigations of the Bureau of Plant Industry, and as it was conclusively shown that insects of several species were largely responsible for control of the plant on prairies and grass lands a publication covering these insects was deemed desirable.

Part VI considers the greenhouse thrips (*Heliothrips hæmorrhoidalis* Bouché), a species previously recorded as injurious to a number of hothouse plants. This insect was found injuring mango, crotons, and other plants on beds and in parks at Miami, Fla. The results of a series of experiments for its control are given in this number.

Part VII is largely supplemental to an article in Bulletin No. 8 of the Division of Entomology, giving a note on new food materials for the coffee-bean weevil (*Aræcerus fasciculatus* DeG.). This insect was discovered working in chinaberries and cornstalks adjacent to cotton fields during an investigation of cotton insects.

A new and dangerous species of Aleyrodes attacking citrus fruits is the subject of Part VIII. This species (*Aleyrodes howardi* Quaint.), which occurs on several islands of the West Indies, including Cuba and Porto Rico, has recently made its appearance in Florida. Present indications are that this species will be controllable by the same measures used for the citrus white fly, which it much resembles in capacity for damage.

Part IX gives the results of experiments undertaken for the control of a species of ant (*Formica cinereorufibarbis* Forel), which fosters the melon aphis in Colorado, protecting it largely from predaceous enemies. The control of this ant may prove of great value as a measure against the melon aphis.

Part X is a biologic account of a minor pecan pest, the pecan cigar casebearer in the South, and includes suggestions for its control.

CONTENTS.[a]

[a] The ten papers constituting this bulletin were issued in separate form on April 2, 1907 (Pts. I to III), January 14 and May 29, 1908 (Pts. IV and V), August 4 and 5, 1909 (Pts. VI and VII), and May 7, October 17, and November 12, 1910 (Pts. VIII to X).

ILLUSTRATIONS

PLATES.

TEXT FIGURES.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.

(*Pentatoma ligata* Say.)[a]

By A. W. Morrill,
Special Field Agent.

INTRODUCTION.

In a recent bulletin of the Bureau of Entomology[b] the writer gave an account of the Mexican conchuela (*Pentatoma ligata* Say, fig. 1), based upon an investigation conducted in northern Mexico in September, 1904. It was predicted that should the pest ever become very abundant in this country, where more diversified farming is usually practiced, it would be likely to affect a wide range of farm crops instead of confining its attacks to cotton alone. Almost unknown in 1903, the conchuela, as it is called by the natives of Mexico, first became of considerable importance as a cotton pest in the leading cotton district of Mexico—the "Laguna"—and in 1904 established its reputation as an enemy of alfalfa in western Texas by ruining in specific instances seed valued at over $1,000, representing the loss to the crops of two growers from whom definite reports were obtained. This loss in western Texas was, however, first made known to entomologists in July of the following year (1905), through correspondence of a resident of Barstow, Tex., with Mr. W. D. Hunter, in charge of the investigations on cotton insects conducted by this Bureau. As the writer was at that time in Mexico, continuing his investigations of this pest, Mr. J. C. Crawford was sent to Barstow to investigate the economic status of the insect there. His preliminary observations were made on July 20 to 22, inclusive, and were followed by visits to Barstow by the writer on August 11 and 12 and September 12, and by Mr. Crawford on October 13 and November 14. The reports of Mr. Crawford, which were duly submitted to Mr. Hunter, have been freely used by the writer in preparing this paper.

---

[a] Order Hemiptera, family Pentatomidæ.

[b] Bul. 54, Bur. Ent., U. S. Dept. Agric., pp. 18–34, 1905.

AN ASSOCIATED SPECIES.

An allied pentatomid, the grain bug[a] (*Pentatoma sayi* Stål), was found at Barstow associated with the conchuela. In 1905 this species was not plentiful enough to cause much damage to crops by itself, but as the character of its injury and that of the conchuela is the same it is necessary to consider the two species together when they are found on the same food plant. In this case they were found together only on alfalfa and Milo maize, although the grain bug is known to have a wide range of food plants and probably is fully as general in its feeding habits as is the conchuela. The history of the former species as a pest antedates, even in western Texas, that of the latter, for as long ago as December, 1895, specimens of *Pentatoma sayi* were received by this Bureau from Toyahvale, Reeves County, Tex., with a report that they had destroyed 40 acres of peas and 2 acres of lima beans on the correspondent's farm. It is interesting to note that this report came from a point not 50 miles from Barstow. Since that time this species has earned a bad reputation by its destructiveness to wheat and oats in Colorado and elsewhere.

GENERAL AGRICULTURAL CONDITIONS AT BARSTOW, TEX.

Ward County, of which Barstow is the county seat, is situated in western Texas, a short distance south of the southeastern corner of New Mexico. With the exception of a narrow valley along the river the country consists of high rolling prairie covered in large part with a short growth of mesquite and sage. Being in the arid region the rainfall is too light to be depended on for agricultural purposes and all crops are grown under irrigation, a practice which began with the settlement of the county in 1891. Water for irrigation is obtained from the Pecos River, and at present about 10,000 acres are under cultivation in the county. Of this area, in 1905, about 5,000 acres were devoted to cotton and the greater part of the remainder to grapes, peaches, and alfalfa. The elevation of Barstow is about 2,500 feet above the sea level.

DAMAGE TO CROPS PREVIOUS TO 1905.

According to residents of Barstow who are best informed concerning the conchuela, the insect never, previous to 1904, attacked crops of any kind in sufficient numbers to attract attention. As far as can be learned there had been, previous to that time, no attempt to produce a seed crop of alfalfa. The occurrence of this pest on cotton in moderate numbers is not likely to be associated with the

[a] In using this common name for this species the writer follows Prof. C. P. Gillette. Bul. 94, Colo. Exp. Sta., p. 3, Dec., 1904.

injury which usually first becomes apparent upon the opening of the bolls. The most notable losses in 1904, which with little doubt were due to the conchuela, were on the farms of Mr. C. E. Pierce and Miller Brothers. The former had 120 acres of alfalfa which was cut for the seed crop about the middle of July, from 150 to 200 pounds of seed per acre being expected. It was noticed that this insect was very abundant in the field, but the extent of the damage was fully realized only when an average of $83\frac{1}{3}$ pounds of seed per acre was obtained. At the prevailing value of 12 cents per pound the estimated loss was from $8 to $14 per acre, or from $960 to $1,680 for the entire field. The 10 acres of alfalfa belonging to Miller Brothers should have produced at least 150 pounds of seed per acre, according to general estimates, but so much of the seed was ruined, supposedly by the conchuela, that the yield was reduced to 60 pounds per acre. The average loss per acre was estimated as at least $10. Other losses of this kind occurred in Ward County during 1904, but the information obtainable concerning them is less definite. According to one report, alfalfa growers at two other points in the Pecos River Valley—Grand Falls and Toyah Creek—experienced a failure with a seed crop of alfalfa in that year which they attributed to "weevil," a term commonly applied to the cause of such losses even before an insect has been located upon which to place the responsibility. In this case the writer believes that at least the greater part of the losses in question can be safely considered as due to the work of *Pentatoma ligata*, together with the grain bug, *P. sayi*.

CROPS DAMAGED IN 1905.

ALFALFA.

Direct observations, both in western Texas and northern Mexico, showed that fields devoted to alfalfa are capable of harboring the conchuela in enormous numbers. In the Laguna district in Mexico alfalfa has been grown for several years, but only for hay and forage, and in comparatively small quantities on the cotton plantations. As far as could be learned, previous to 1905 the pest here considered never attracted attention on account of its occurrence in the alfalfa fields, but in that year it became so abundant that at Tlahualilo, State of Durango, upon the cutting of a crop, adjacent cotton fields and a small vineyard were overrun by myriads of the insects, while several miles distant at another plantation it was first brought to the notice of the managers by appearing in large numbers in the troughs in which green alfalfa was fed to stock. In these cases, no seed crop being grown, the attack was limited to the leaves and stems. The effect of the extensive feeding on these parts can not be definitely stated, as in all cases where plants without seed were heavily infested the cutting was made before the writer had an opportunity to make an examination. According to report, however, no marked effect upon the plant was produced in the instances here recorded, and, accordingly, until more is known, we may assume that where it is not intended to produce seed the principal danger incident to the occurrence of the conchuela in alfalfa fields lies in the fact that a choice breeding place is furnished the insects, which may multiply to enormous numbers and spread to other crops. This phase of the subject will be discussed elsewhere in this paper and also in a report on Heteroptera attacking the cotton plant.

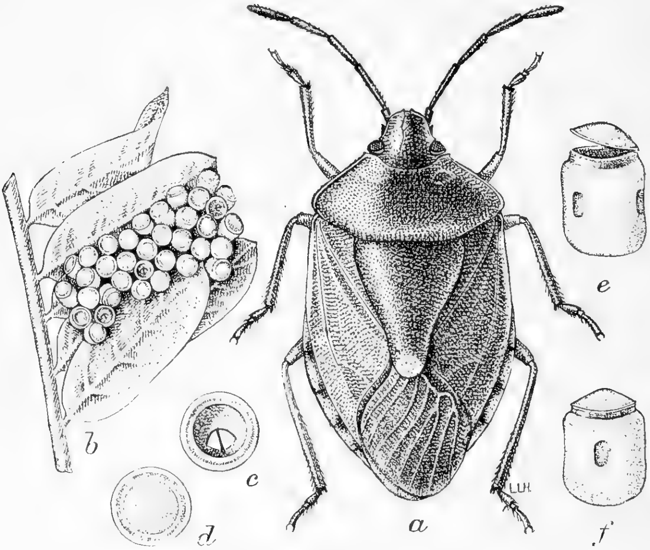


FIG. 1.—The conchuela (*Pentatoma ligata*): *a*, adult bug; *b*, egg mass on leaves; *c*, egg after hatching, lid removed showing egg burster; *d*, egg before hatching, from above; *e*, egg from side, showing lid above exit hole; *f*, egg before hatching, from side; *a*, enlarged 4 diam.; *b*, enlarged 2⅔ diam.; *c-f*, enlarged 9 diam. (Author's illustration.)

In infested fields when the seed is present the bugs may be seen clinging to the seed clusters extracting the rich juices by means of their thread-like setæ. The seed pod, when once fed upon, shrivels and turns dark and is readily distinguished from uninjured seed pods. No attempt has been made to determine how rapidly a bug progresses with its destructive feeding, but as these insects are usually observed to be engaged in this way as long as desirable food remains, and as the individual seed is small, undoubtedly each one of the insects is capable of destroying a very large number of the seed pods during its existence.

Cutting of the alfalfa checks the multiplication of the pest, but also has the effect of driving the bugs elsewhere in search of food, often with more or less serious results to neighboring crops. It should also be noted that the longer time required to produce a seed crop is favorable to the production of large numbers of the insects. Windrows of alfalfa hay, originally intended for thrashing for the seed, in the field of Mr. Carson, at Barstow, were found to harbor many adult conchuelas which were for the most part busily engaged in destroying the last few seed clusters. It would thus appear that the danger is not over with the cutting of the alfalfa, and that thrashing should be attended to as soon as possible if the insects are present and injury is to be avoided.

The only extensive damage to alfalfa by this insect at Barstow during 1905 was on the farm of Mr. J. P. Carson. Other growers, owing to their experience of the previous year, decided to grow no seed crop; thus indirectly many suffered a loss which should be charged up to the insect, as an average crop of seed has a value equal to several times that of a single cutting for hay. Mr. Carson had 55 acres ready for cutting for the seed the last week in July, but the damage by the bugs amounted to complete destruction, for although the land was originally heavily seeded, there was not sufficient uninjured seed to defray the expense of thrashing. The loss was considerably more than $1,500, in addition to the partial loss of a hay crop in the extra time allowed for the maturity of the seed.

Miller Brothers in 1905 fortunately avoided the destructive work of the insects and made a fair seed crop. At Barstow the interval between cuttings for hay is on the average about four and one-half weeks, while for the maturity of the seed an additional period of about three and one-half weeks is necessary. Other farm work prevented Miller Brothers from cutting their alfalfa when it was in prime condition for cutting for hay. As the seed began to mature, the scarcity of the pest which had proven so destructive the previous season caused the owners to anticipate a successful seed crop. On September 13 the writer, who made a careful examination of the condition of the alfalfa field referred to, found the bugs scarce, as reported, and the damage to the seed, which was already mature, very slight. The yield of seed reported by Miller Brothers for the 10 acres was 1,499 pounds.

MILO MAIZE.

On August 11 a field of Milo maize was examined at Barstow, and it was found that in certain spots a considerable proportion of the seed was ruined, while more or less ruined seed could be found throughout the field. According to the owner, Mr. Carson, the conchuelas had been very abundant a week previous, as many as 25 of the insects frequently being noted on a single seed head. They were found to be generally distributed throughout the field on August 11.

but in small numbers, the largest number found on a single seed head being five—two adults, two fourth-instar nymphs, and one fifth-instar nymph. On the Milo maize, as on the alfalfa, *Pentatoma ligata* was accompanied by *P. sayi*, but in more nearly equal numbers; this is not necessarily of any special significance, though possibly it may indicate a preference of the latter species for the seed of the grains.

COTTON.

The first examination for the conchuela in the cotton fields at Barstow was on August 11, when of the five fields visited specimens of the insect were found in all except one. In every case the number of damaged bolls, although in small proportion, gave evidence of the occurrence of the insect in somewhat larger numbers some weeks previous. In one field an examination of 100 plants showed an infestation of 5 per cent of the plants, with 12 adults per 100 plants. The damage to the bolls in this field amounted approximately to 15 per cent. Another field of about 10 acres was found to be damaged to a less extent except for about one-half an acre near one side where, of 60 bolls selected at random, 30 per cent were destroyed by bugs. The writer estimates, as a result of personal examinations in many fields at and near Barstow, that the average damage to cotton by the conchuela in 1905 was about 10 per cent.

PEACHES.

Although peaches have been grown at Barstow for several years we have no report of damage to the fruit by the conchuela or other bugs until 1905, when the matter was reported by Mr. C. E. Pierce and investigated, as stated in the introduction, by Mr. Crawford and the writer. The attack was confined to the fruit of the earliest varieties in their first fruiting season. The trees were located on the side of the orchard adjacent to the 120-acre alfalfa field, the damage to the seed crop of which in the previous year has already been mentioned. Shortly after the 10th of July, coincident with the cutting of the alfalfa, the bugs were noticed on the fruit of these trees, which was just beginning to ripen. The trees soon became very heavily infested, and on July 20 it was not uncommon to observe from 10 to 15 on a single peach and in one instance 20 were counted. The tendency of the conchuelas to congregate on certain individual peaches was very marked, as has likewise been observed in their occurrence upon cotton bolls.[a] On the most heavily infested trees, owing to this habit, many peaches at any given time seemed neglected, but all on the attacked trees were ultimately destroyed. The injured fruit became shrunken in spots and sponge-like to the touch, finally

[a] Bul. 54, Bur. Ent., U. S. Dept. Agric., p. 26, 1905.

falling to the ground. It was apprehended that the pests would transfer their attention to the late peaches when these began to ripen, and a few were observed to do so, but apparently when the supply of early peaches was exhausted or rendered unfit for further feeding, the late peaches were not mature enough to be attractive, and consequently suffered practically no injury from this source.

GRAPES.

In 1905 at Barstow the fruit in the vineyards was in general only slightly affected by *Pentatoma ligata*. The principal damage was in the small gardens in town, where in certain instances the destruction was practically complete. Probably owing to the large area occupied by the vineyards and to the fact that the fruit of the different varieties ripens at about the same time, no especial concentration of the insects in the large vineyards was noticed, and there was no indication that any such concentration occurred. The ripe fruit is preferred, although when the food supply is short it may be attacked when immature. The injured berry shrivels and under the influence of the hot sun soon becomes raisin-like.

At Tlahualilo, Durango, Mexico, on July 17, 1905, a vineyard of about 10 acres with vines heavily loaded with fruit became thoroughly infested by direct migration from an adjacent alfalfa field of adults and of nymphs in the last two instars. Each cluster of grapes was attacked by several bugs, the maximum noted on a single cluster being 25. Without consultation with the writer the grapes were picked immediately upon discovery of the infestation, the presumption being that the removal of their food would serve as a check to the insects, to the benefit of the cotton fields. This step was, however, inadvisable, since the fruit, which was of comparatively small value, would have served as a trap at which the bugs could have been easily destroyed when so thickly congregated. As it was, the bugs gathered in groups of hundreds on the trellis posts and on the vines, principally at the forks, where they were destroyed, partly by spraying and partly by use of a gasoline-blast torch. The last-mentioned method, while effective in its destruction of the pest, injured the vines to a certain extent in nearly all cases.

GARDEN VEGETABLES.

Between the middle of July and the middle of August garden crops at Barstow were affected to a considerable extent by this destructive pest. Owing to the comparatively small amount of land devoted to such crops, the actual money equivalent of the loss was not great. The crops which suffered most were peas, beans, and tomatoes. In each case the attack was restricted almost entirely to the seed or fruit, thus accomplishing a maximum of damage. Under another heading the writer has referred to the destruction of peas and beans in Western Texas, not far from Barstow, by the grain bug. Among other cases on record which give further evidence of the losses pentatomid bugs may cause by their attacks on vegetables is one quoted by H. G. Hubbard[a] from the report of a Florida correspondent on his experience with a species commonly called the green tree bug (*Nezara hilaris* Say). According to the report, this species attacked cowpea vines before any seed was developed and completely ruined 35 acres of this crop, so that no good seed was obtained. A garden crop of tomatoes was also reported to have been entirely destroyed, the ground under the vines being almost covered by the fallen fruit. The injured fruit was described as reddish-yellow in color at the point punctured, and when cut was found to be "full of lumps and totally devoid of flavor." These records of the damage by other pentatomid bugs to general garden crops show the extent to which the conchuela is capable of affecting these crops when they are grown on a more extensive scale than was the case at Barstow at the time the observations recorded in this paper were made.

OTHER FOOD PLANTS.

The principal natural food plants of the conchuela are the mesquite and related leguminous plants, the beans being the object of attack. It would require more than one season's observations to determine how important is the connection between the abundance of mesquite beans and the abundance of the insects on cultivated plants. It is presumable that during the period when the insects are multiplying most rapidly the abundance of rich food such as the mesquite bean provides is an important factor in determining the amount of subsequent injury to crops. At Barstow, in addition to the mesquite and the crops which have been separately discussed, the conchuela has been found feeding on the fruit of peppers, on squash vines, and on the leaves of yucca. It has also been reported on good authority to have been observed in considerable numbers on corn, and the writer has in Mexico found egg batches of this species attached to the green leaves of corn. In general, the species may be said to be almost omnivorous, showing a preference, however, for fruits and seeds.

SEASONAL HISTORY.

The multiplication of the conchuela in western Texas seems to follow the same course as has been observed in northern Mexico; in other words, the maximum number is reached between the middle and

[a] Report on Insects Affecting the Orange. Div. Ent., U. S. Dept. Agric., p. 160, 1885.

last of July, after which the number diminishes rapidly. The bugs are strong fliers, which accounts for their sudden appearance on a given crop, and in some cases for their sudden disappearence from it.

On July 20–22 no eggs or young could be found on the infested peach trees, nor could any of these stages be found on August 11 and 12 after the adults had entirely disappeared from the trees. If any eggs were deposited by the bugs when the latter were attacking the peaches the resulting nymphs were probably carried to the ground with the falling of the fruit, for the interval between the examinations was not sufficiently long for them to have reached the winged or adult stage. The only breeding places of consequence found at Barstow were in the alfalfa fields. Here eggs and nymphs were found in large numbers on August 11 and 12. A month later the insects had been reduced by at least one-half, and their scarcity was noticeable everywhere except in small areas in some fields of alfalfa and along the borders near fences and ditches where the cuttings had not been made at regular intervals. Of 32 adult pentatomids collected in the alfalfa fields September 12, 26 were *P. ligata* and 6 *P. sayi*. At the next examination, on October 13, it was evident that the insects were still decreasing in numbers, but the nymphs in the last two stages were proportionally more abundant than before. In the lot of 16 adults and 49 nymphs collected at that time, *P. sayi* was not represented. The last examination, made on November 14, showed that the conchuelas had almost entirely disappeared; a half hour's search where, at the time of previous examinations, they had been found most abundant, resulted in the capture of only 6 adults, no nymphs being seen.

NATURAL ENEMIES.

EGG PARASITES.

Minute egg parasites belonging to the family Proctotrypidæ are generally known among entomologists to play an important rôle in checking the multiplication of many insects, so that anything which affects the numbers of these parasites frequently results in a corresponding benefit or injury to the crops attacked by the host insects. If these parasites of the eggs of pentatomids were eliminated, many of the pentatomids would undoubtedly be ranked among our most important insect pests. The importance of these parasites in checking the multiplication of the conchuela at Barstow in 1905 can be best emphasized by summarizing the results obtained by rearing parasites from eggs collected at that place.

Summary of results obtained by rearing parasites from eggs of Pentatoma ligata collected at Barstow, Tex., in 1905.

When collected.	Number of egg batches.	Total number of eggs.	Number of eggs hatched.	Per cent hatched.	Number of parasites emerged.	Per cent producing parasites.	Number of eggs destroyed by other agencies.	Per cent failing to produce nymphs.
August 11-12	6	181	35	19	41	22	0	81
September 12	13	246	20	8	148	54	*a* 35	92
Total	19	427	55	13	189	44	35	87

a Representing two batches of 13 and 22 eggs, respectively. Presumably destroyed by ants, the broken eggshells remaining.

Shrinking of the eggs, indicating infertility, occurred in no case among the eggs included above. From the fact that adult parasites frequently fail to emerge from the egg of the host even after

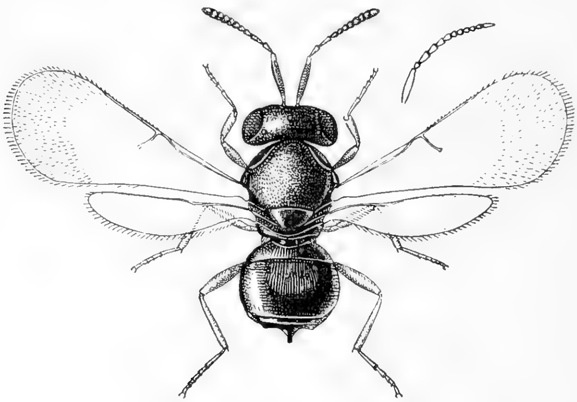


FIG. 2.—*Telenomus ashmeadi*, an important egg parasite of *Pentatoma ligata*: Adult female and antenna of male. Highly magnified (original).

breaking through the shell—and as far as observed it seldom occurs in nature that eggs of the conchuela fail to hatch when not destroyed by outside agencies—it may be concluded that practically all the eggs appearing intact which failed to hatch were destroyed by the parasites. In support of this supposition 10 eggs which neither hatched nor from which live parasites emerged, selected at random from the 19 batches above mentioned, were opened and each was found to contain a dead adult parasite. The specimens bred from the eggs of *P. ligata* and also of *P. sayi* from Barstow were all of the same species and identified by Dr. William H. Ashmead, of the U. S. National Museum, as a new species of the genus Telenomus (fig. 2). The writer will describe the species under the name *Telenomus ashmeadi*. An egg batch of the conchuela containing hatched and unhatched eggs is shown in Plate I, figure 1, and a parasitized egg batch in Plate I, figure 2.

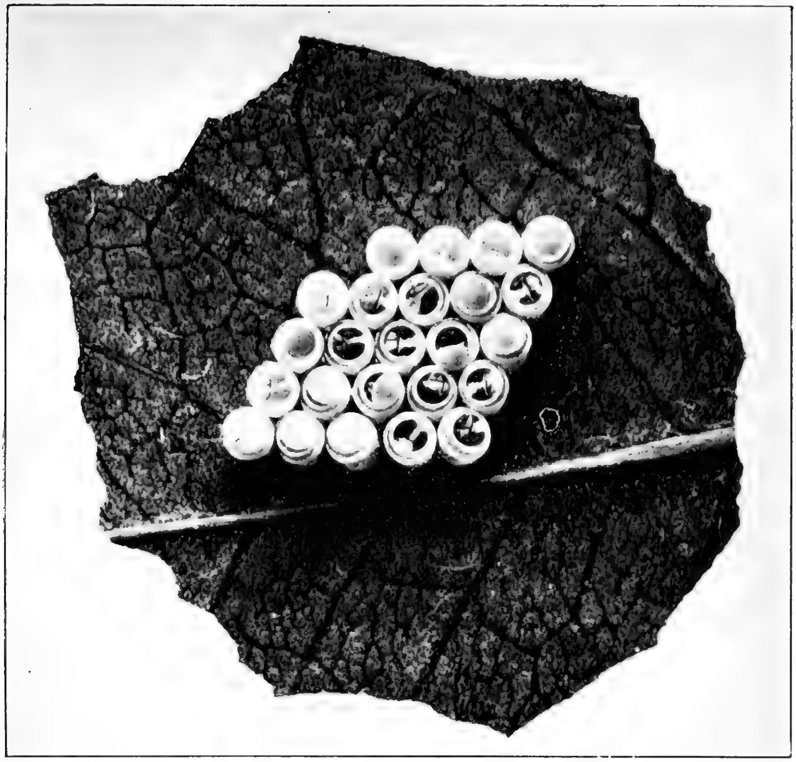


FIG. 1.—EGG BATCH OF CONCHUELA (PENTATOMA LIGATA), SHOWING HATCHED AND UNHATCHED EGGS. ENLARGED 6⅔ DIAMETERS (ORIGINAL).

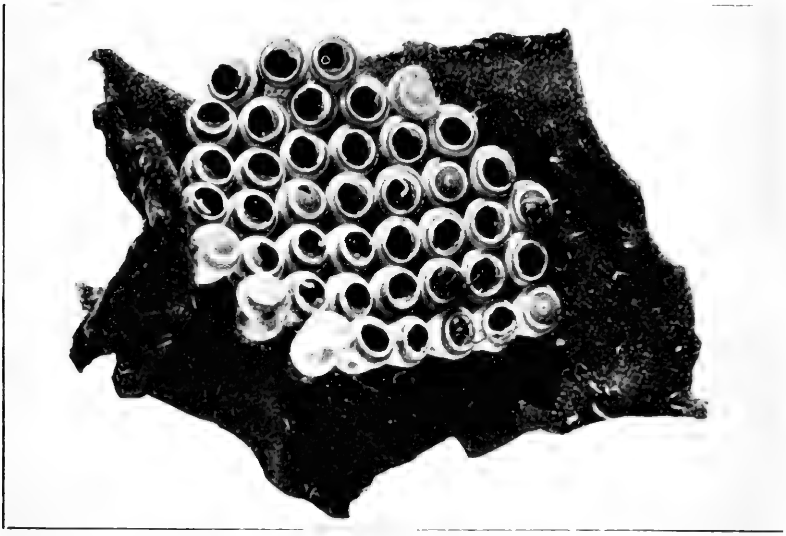


FIG. 2.—EGG BATCH OF CONCHUELA (PENTATOMA LIGATA) FROM WHICH 32 PROCTOTRYPID PARASITES (TELENOMUS ASHMEADI) HAVE EMERGED. ENLARGED 6⅔ DIAMETERS (ORIGINAL).

The illustration shows three parasites, including male and female, ready to emerge; also an egg destroyed, probably by an ant.

TACHINID PARASITES.

A species of the very useful family Tachinidæ, *Gymnosoma fuliginosa* Desv., has been reared from adults of the conchuela. The victims of this parasitic fly are distinguished by the yellowish-white egg or eggshell which remains attached to the thorax of the host unless it happened to have been attached to a nymph in the fifth instar, which afterwards molted. On August 11 and 12 only three parasitized specimens were discovered, two in the fifth nymphal instar and one an adult. An adult of this species of Tachinidæ was bred from one of these bugs. On September 12 parasitism by these tachinids was found to be more common than at the time of the previous visit. Of 24 adults examined at that time, 4 were found to be parasitized. On October 13, of 18 adults and 31 nymphs in the fifth nymphal instar, 2 only had been parasitized, both nymphs. While these parasites are decidedly beneficial and may be more useful under some conditions, they were not sufficiently abundant at Barstow in 1905 to explain the rapid decimation of the numbers of the conchuela which has been described under the subject of seasonal history.

PREDACEOUS ENEMIES.

Although no observations on the subject of predaceous enemies were made at Barstow, it seems important to refer briefly to the records of observations by others along this line, in order that it be not inferred that because pentatomids in general are characterized by their ability to produce an offensive odor they are immune to the attacks of insectivorous birds and of toads. On the contrary the crow [a] is believed to be especially fond of bugs of this group, and many other birds,[b] as well as the common toads,[c] seem to find them unobjectionable as food. If we accept the evidence of definite reports and observations during three successive seasons as indicative of the usual seasonal history of the conchuela, the period of maximum abundance is followed closely by a marked reduction in the numbers of the pest. In this it is not unlikely that birds will prove to be an important if not the leading factor.

METHODS OF CONTROL.

Under some conditions farm practices, such as the destruction of weeds in the fall and otherwise hindering the sucessful hibernation of the conchuelas, would be of unquestioned value in control, but under

---

[a] Bul. 6, Div. Orn. and Mam., U. S. Dept. Agric., p. 63.

[b] Buls. 13, Biol. Surv., Dept. Agric., U. S., pp. 25, 62, 70; 15, p. 23; 21, p. 43; 23, p. 26. Yearbook U. S. Dept. Agric. for 1895, pp. 417, 423, 429; Yearbook U. S. Dept. Agric. for 1900, p. 414, Plates L, LI.

[c] Bul. 46, Hatch (Mass.) Exp. Sta., p. 26. Bul. 91, Ky. Exp. Sta., pp. 62, 64.

the conditions in western Texas, such as those obtaining at Barstow, probably little good could be accomplished by such measures. With the mesquite-covered surrounding districts as a stronghold these insects probably will become established in the alfalfa fields each year and become more or less numerous as the season progresses, their numbers being governed by conditions which for the most part exert their influence secondarily through the natural enemies of the species. The question of control at Barstow, and where similar conditions prevail, resolves itself into: First, avoidance of damage to the seed crop of alfalfa; second, methods tending to prevent the insect's spread from alfalfa to other crops, or otherwise preventing infestations; third, direct remedies applicable for use when crops other than alfalfa become infested.

AVOIDANCE OF INJURY TO THE SEED CROP OF ALFALFA.

At Barstow the experience of alfalfa growers for two successive seasons, supported by direct observation by Mr. Crawford and the writer at regular intervals during 1905, has shown that the conchuelas are so numerous during July and August that an attempt to produce a seed crop during this period would be inadvisable. In northern Mexico observations extending over three seasons have shown the insects both to reach a maximum in numbers and to show a marked decrease therefrom during the last two weeks of July. This corresponded with the history of the pest at Barstow, and it is believed that the danger limits above given are sufficiently wide to cover all but exceptional cases under the present conditions. If a crop intended for seed promised to mature before July 1, probably but little damage would be accomplished by the conchuela, but this is entirely a surmise which it is hoped will be thoroughly tested when an opportunity presents itself. The same probabilities hold for a crop of seed which would mature after the 1st of September. This, moreover, has been substantiated by the experience of Miller Brothers at Barstow, which has been described under the subject of damage to alfalfa in 1905. Avoidance of the injury as here outlined is undoubtedly simpler than actually defending the seed in the field from attack.

A SUGGESTION AS TO MECHANICAL CONTRIVANCES FOR COLLECTING THE INSECTS.

Between the conchuela (*P. ligata*) and its near relative, the grain bug (*P. sayi*), whose reputation as a pest has already been mentioned, it may be anticipated here that in the course of time remedies will be demanded for use against such insect enemies of alfalfa in other sections of the country. In a field with ripening seed an experiment with an insect-collecting net in one hand and a stick in the other, simulating the action of an imaginary specially constructed hopperdozer with a revolving fan, convinced the writer of the practicability of collecting these insects mechanically. The great majority of the insects, when undisturbed, may be found near the tops of the plants, on the seed clusters when these are present. They drop to the ground when slightly disturbed, much more readily, in fact, than when they have a footing on a more substantial object like a cotton boll. It is safe to predict that a contrivance for collecting will be devised when the necessity arises. It should be light, operated from behind, and consist essentially of an elongate metallic pan suspended below a revolving fan geared to the supporting wheels.

PREVENTIVE AND PROTECTIVE MEASURES.

If, as advised in one of the preceding paragraphs, no attempt is made to produce a seed crop during the period of the year when the conchuelas are dangerously abundant, an important factor in their multiplication and spread will be eliminated. But the shorter period required for the hay crop is sufficient to permit the insects to reach the enormous numbers indicated in the writer's reference to the occurrence on alfalfa in northern Mexico in 1905. Uusually the greater number of the insects will not reach maturity during the interim between cuttings, and the work of preventing the spread will be in part the checking of the migration of the crawling nymphs. This can be readily accomplished when necessary by leaving an uncut border around the field, where the insects when trapped can be destroyed by spraying with kerosene emulsion. As the insects show a marked tendency to concentrate in certain limited areas rather than to spread evenly over the fields, this can be taken advantage of by making a general examination of the field, before cutting, to locate the colonies. A few small boys in a few hours might pick up several quarts [a] of the adults when these are abundant and well concentrated. If this is not feasible, small heavily infested areas may be treated with kerosene emulsion, although adult pentatomids are apt to be quite resistant to this insecticide. At Tlahualilo, Durango, Mexico, on July 11, 1905, after the alfalfa hay had been made and stacked, countless hosts of the insects still remained in the alfalfa field in spite of the extensive migration to neighboring crops. Those that remained were largely concentrated near one corner of the field and, as suitable spraying apparatus was not available, destruction of the pest was accomplished by respreading about 3 or 4 tons of alfalfa hay over the ground and then burning it. This operation for the protection of the surrounding cotton fields against further invasion from this source was effective, but would be unnecessarily costly under ordinary

[a] One quart contains approximately 1,500 adult specimens of *P. ligata*.

circumstances. In the case of the chinch bug a practice of destruction by burning similar to the one here mentioned has been recommended for use under certain conditions.[a] Cooperation among the owners of adjoining farms is necessary in order to obtain the best results in the attempt to check the spread of the conchuela, as well as in the case of the chinch bug and many other insects.

A protective measure which may in some cases be recommended, especially for use in small gardens, consists in screening such crops as tomatoes with a cheap quality of mosquito netting.

REMEDIES WHEN CROPS OTHER THAN ALFALFA ARE ATTACKED.

The subject of remedies for use in protecting cotton against damage by the conchuela and related pests will be reserved for a future publication. When this insect attacks the seed of Milo maize and related grains little can be done except when the bugs are concentrated in large numbers in limited areas; then hand collecting or jarring from the plants may be advisable, particularly as a protective measure when such an infestation is an element of danger to neighboring crops. For remedial measures against the insect when it attacks garden vegetables and grapes we can suggest spraying with kerosene emulsion and collecting by hand, or, if it is necessary to carry on operations on a large scale, the bugs may be jarred into convenient receptacles containing kerosene and water, so arranged that they can be dragged between the rows if desired.

When attacking peaches a certain proportion of the bugs can be jarred from the fruit and killed on the ground, but this is at the best far from satisfactory, as the fruit itself is likely to be shaken off or otherwise injured and many of the bugs will escape by flying. Peach trees when pruned in accordance with the practice of the leading growers are low enough to permit hand picking of all the fruit and are correspondingly easy of fumigation. A light tent made of ordinary cotton sheeting can be placed over an infested tree by the use of poles and held in place at the bottom by dirt or stones. The burning of tobacco stems, pyrethrum, or buhach powder inside the tent will soon stupefy the insects and cause them to fall to the ground, where they can be easily and quickly killed. The fumes can be prevented from escaping too readily through the cloth by lightly painting it with linseed oil thinned with turpentine. This method of fumigation is inexpensive and has the further advantage of requiring but a few minutes' work for each tree.

[a] Bul. 17, old series, Div. Ent., U. S. Dept. Agric., p. 37, 1888.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.

By W. Dwight Pierce,
Special Field Agent.

Having been detailed to investigate certain injuries attributed to sowbugs, the writer presents the following notes concerning the life history and habits of three species of these isopods, namely, *Armadillidium vulgare* Latr., *Porcellio lævis* Latr., and *Metoponorthus pruinosus* Brandt. The first species, at least, is capable of doing considerable injury to garden crops, flower gardens, vines, and field crops in the vicinity of buildings, although it is also found to be a valuable scavenger. The scavenger habit, however, makes it an undesirable intruder in the house owing to the possibility that it may convey disease.

ARMADILLIDIUM VULGARE Latr.

The sowbug *Armadillidium vulgare* Latr. is commonly known as the "pill-bug," on account of its habit of rolling into a ball whenever disturbed. Ordinarily it is found only in the vicinity of habitations, in dark, damp places, such as woodsheds and cellars, under boards and rubbish, and around wells, cisterns, and water barrels. The open foundations under houses in the South give very favorable locations for breeding.

For several years the Department of Agriculture has received reports of injury from sowbugs to one or another crop in various parts of Texas. The sowbugs seem to have been on the increase from year to year. In 1905 the spring rains, although at times occasioning a natural check to these pests, brought about a series of conditions favorable to a rapid increase in their numbers. Moisture is a requisite to their life, and it also seems that vegetation is a standard article of food. The bad conditions of the ground throughout Texas during that year made all crops very late, so that by the time the succulent cotton and garden crops were coming up the new broods of young sowbugs were everywhere engaged in finding delicate, tender food.

At Dallas the cotton patch of the boll-weevil laboratory furnished ample evidence of the capacity of these crustaceans in devouring vegetation (see Pl. II). By April 14 the cotton was sending up the second, and in some cases the third, pair of leaves. At this time Mr. Springer Goes noticed that the growing tips in rows adjacent to buildings were badly eaten, although the injury extended over the entire patch to a greater or less degree. All plants which were tipped died very shortly, with the result that seven rows had to be entirely replanted. A great many of the seedlings of the second planting also were killed. Many gardens had suffered through attacks on the young sprouts of beans, peas, and tomatoes, and on rose bushes and other cultivated flowers. In December Mr. R. C. Howell found the sowbugs doing serious damage to roots of palmetto, one large plant being entirely killed. From Austin there came a note published in Farm and Ranch, dated April 29, 1905, which enumerated the following plants as subject to the attacks of this species: Butter beans, radishes, lettuce, mustard, potted plants, and also flower seed. The earlier planting of beans was untouched, while the late planting, owing to the favorable conditions for multiplication afforded the sowbugs, was seriously injured.

From economic literature the writer finds the following records of injury attributed to this species:

Miss Richardson [a] cites injuries to cucumbers and hothouse vegetables at New Orleans, La., to various plants at Fort Worth, Tex., and to date palms from Algeria, located at Washington, and states that these sowbugs are a most serious pest on mushrooms at Berkley, Va.

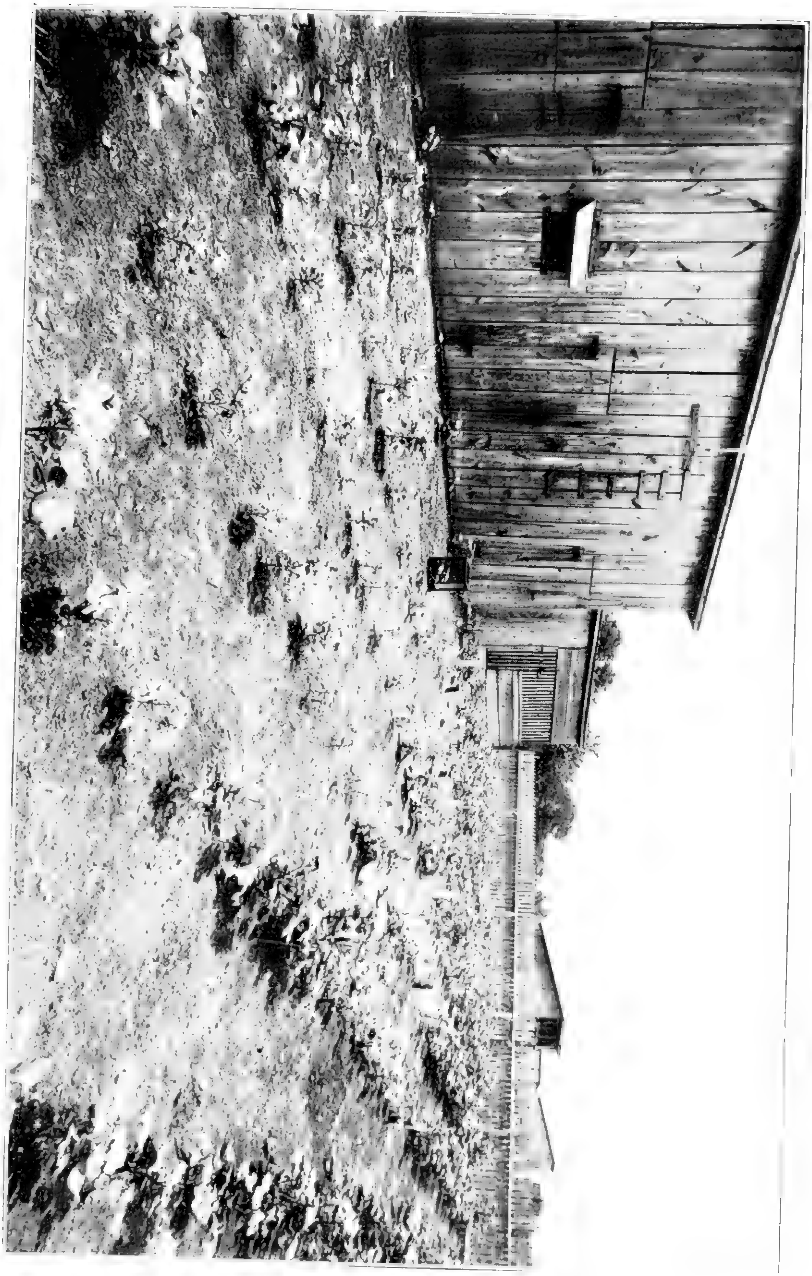
Mr. H. Garman [b] cites this species as very injurious to young cucumbers and lettuce in greenhouses, and recommends carbon bisulphid as a remedy.

With this information in hand, a series of seventy-five experiments was conducted in the laboratory in order to compare various conditions and foods in their effects upon this species. Over 900 individuals were involved in the experiments, of which the results may be here summarized.

The most favorable condition under which to keep the sowbugs was found to consist of a mixture of gumbo and sand kept moist, and a supply of fresh cotton leaves, leaving some old ones to decay and mold. Moisture is absolutely essential. With such conditions, sowbugs were carried through the entire period of the investigation, e. g., 10 females and 1 male were kept alive eighty days, and 4 of these

[a] Monograph on the Isopods of North America. By Harriet Richardson. Bul. 54, U. S. Nat. Mus., 1905.

[b] Bul. 91, Ky. Agric. Exp. Sta., 1901.



WORK OF ARMADILLIDIUM VULGARE ON COTTON.

[This shows the center of the injured area, which was replanted, and also the source of the infestation—the sheds. (Original.)]

females were still alive one hundred and sixty days after the beginning of the experiment. The cotton leaves, when tender, were eagerly eaten.

Fungous growth was favorable only under certain conditions. In the experiments cited above the leaves in contact with the earth decayed and accumulated a rich growth of mold. Upon these decayed leaves the sowbugs seemed to thrive, although there was always evidence of feeding on green leaves when such were present. Fungous growths on dry leaves, on decaying fruit, and on moist dead wood were only capable of sustaining them as long as the moisture was conserved. Fungus found on earth moistened with molasses sustained 9 sowbugs thirty-six days, and 2 survived as long as seventy-five days. Green cotton leaves alone will sustain the life of these crustaceans longer than any other simple condition tried—thirty-two days being the longest any remained alive under these conditions. The other vegetation provided was not favorable, and the sowbugs seemed rather to keep alive on the moisture from the blotter or on the fungus-covered decayed leaves; thus, rose buds and leaves, and the leaves of violet, mint, and chrysanthemum were untouched by the sowbugs. These leaves did not retain their moisture long after picking. When moist earth alone was provided, some found sufficient food to sustain life eighteen days. Additional proof that nourishment is sought in the soil was obtained by mixing London purple or Paris green with the earth. Death always resulted very quickly. When other conditions were unfavorable it was often found that some were sustained by feeding upon the bodies of their dead associates, which were completely devoured. The molted skins were generally devoured.

Experiments with the cattle tick (*Boophilus annulatus* Say) and its eggs evidenced the fact that the sowbugs fed on the dead ticks and ate the eggs when no other food was present. Thirty-eight sowbugs were furnished with a large number of eggs of the tick, and it was found that in several instances as many as 13 tick eggs each were eaten per day for a series of days. This, however, was a maximum, the average during the conduct of the experiment being about 3 eggs per day each. Experiments to find whether the sowbugs fed upon the pupæ of a cutworm (*Prodenia ornithogalli* Guen.) proved futile.

A series of outdoor tests was also conducted with baits to find what substances might be used to attract these crustaceans, and finally a series of poison tests to ascertain the most advisable remedy.

Bread proved attractive, but as every piece tried was carried away by some mammal or bird its use seemed inadvisable. Flour, bacon, potatoes, radishes, and sugar proved to be good baits. To ascertain the relative value of different insecticides several poison tests were conducted with pyrethrum, Paris green, London purple, and arsenic. Few dead sowbugs were found, however, and it was noticed that a less number approached the poisoned baits than those not poisoned. A series of tests with repellents showed that barriers of powder—whether pyrethrum, arsenic, London purple, or Paris green—proved obnoxious, the sowbugs quickly turning away to avoid the danger, and showing, by the frantic waving of the antennæ, that they had a perception of something wrong. London purple seemed the least repellent and yet practically as effective as any of the others. Sowbugs placed in a jar with a biscuit rolled in arsenic became frantic and died in a few minutes, as did others placed in jars with earth mixed with either London purple or Paris green.

After sprinkling Paris green under boards which had been favorite haunts of the sowbugs, no more live specimens could be found, although each day several dead ones were discovered. In April, when the sowbugs were doing considerable damage to the cotton, a mixture of Paris green and lime was dusted on and around the sprouts with the result that under the poisoned plants great numbers of dead sowbugs were found. No dead could be found around the unpoisoned plants. The dusting was harsh treatment for the plants, being in many cases fatal. It is, however, as proved by other tests, unnecessary to dust the plants. The poison will be picked up by the sowbugs in foraging over the ground.

Under a roll of wire matting in his back yard the writer found the sowbugs so abundant that they crawled over each other in their haste to get away. Having very little poison on hand, he sprinkled what he had of Paris green, London purple, and arsenic over the ground in an area of about 1 square yard and rolled back the matting. Next morning he found 21 sowbugs alive and over 800 dead. Those alive died in a few days, apparently from the effects of the poisoning. The poison washed from these dead sowbugs and used to saturate the soil in jars in several experiments proved fatal to all sowbugs placed in the jars.

Kerosene emulsion as a contact spray was fatal. In spraying a water barrel with kerosene the writer generally sprayed the ground around it also, with the result that the sowbugs were always killed.

These experiments and tests were supplemented by numerous observations of actual conditions from which also data may be derived regarding means of control.

Concerning the plant-feeding habits, definite proofs were obtained as follows:

May 25, at 7.30 a. m., sowbugs were noted at various distances above the ground feeding on the foliage of weeds and honeysuckle. On June 30, at 7 a. m., three sowbugs were discovered feeding on weeds, and one at 8 feet above the ground feeding on a honeysuckle leaf. Nine others were found on the honeysuckle vine at various heights up to 3 feet; also two on grass blades and seven on the ground under the honeysuckle. On July 3, at 7.30 p. m., the sowbugs were just commencing to climb the various plants, and none were feeding as yet. On the honeysuckle 19 were seen at various heights up to 3 feet, and all but two on the stems and moving upward.

The following definite proofs of the scavenger habits of this sowbug were obtained: May 17 a dead rat near the house was found covered with a great number of sowbugs and almost entirely eaten, even the skin being eaten in places. At another time several sowbugs were discovered diligently cleaning a peach pit.

Concerning the haunts of these animals the following observations were made: In April and May there was considerable moisture, and under every shaded, moist board, cinder, and clod, and under straw, refuse, garbage, and carrion, one could easily find many adult sowbugs and multitudes of young. In the cotton patch, at the base of each plant, the ground became cracked, and here sheltered great numbers of sowbugs, which very likely did injury to the roots. May 17, under the trees and in shady places, the sowbugs were so plentiful that at every step numbers were crushed. July 3, at 8 p. m., sowbugs to the number of 14 were found on an oak tree, the highest being 5 or 6 feet above the ground. July 26, in the late afternoon and early evening, some five dozen sowbugs were found in cracks and holes on three trees, many of them as high as could be seen.

Regarding the effect of natural and field conditions upon these crustaceans certain notes were made. Susceptibility to varying weather conditions was very noticeable. May 25, at 7.30 a. m., a large number of sowbugs had gathered at baits. At 8 o'clock a sudden storm commenced to rise. The sowbugs seemed immediately conscious of danger and hastened in all directions for the highest shelter possible, gaining protection on the fence and beneath the clapboards of the house. All were out of sight when the first drops of water fell. In April and May there was considerable rain, and during the periods of sunshine, at whatever time of day, the sowbugs were to be seen everywhere, crawling over the sidewalks and pavements. April 23 and 24 the ground was drenched with water, and on the 25th dead sowbugs were to be found everywhere on the ground and on the sidewalks. On June 3 a similar observation was made in a spot where the water had stood for several days. By June 15 the intense heat had driven the sowbugs from the open so that few could be found in unprotected places.

The writer's notes upon the biology of the isopods are based on observations of about a thousand individuals in the large series of experiments that has been already referred to.

Copulation was frequently noted out of doors during April and May. The males may be distinguished from the females by their colors as well as by the specific sexual characters. They are a dark slaty blue, while the females are lighter and have yellow markings.

The period of incubation in this species is long, between fifty-six and ninety-three days, according to the varying results obtained. As no individuals were secured in copula, the exact time of its duration was not recorded. The development of the eggs may be watched from the exterior. The females should be treated very carefully, but with a lens one may see on the ventral side, in the marsupium, the distinct form of the eggs, and may notice the increase in size and finally note the young embryos and the little white young. One experiment with 10 females was most fruitful in giving data on this point. On May 8, June 16, and July 8 young had been produced, and on examination on July 26 all were found to be unfertilized except one, which had eggs apparent. On August 7 the fertile female produced a brood of young. This was ninety-three days after being placed in captivity. A male was admitted on July 26, and on September 30 a brood of young was produced. This would indicate a period of incubation of, at the most, sixty-eight days. In another experiment a female which had just produced a brood of young was placed with 3 males on August 7. On October 2 a brood of young was produced, making the period of incubation fifty-seven days. The number of young in a brood varied from 29 to 79.

The little isopods are pure white when they leave the marsupium. They have six pairs of legs. Within twenty-four hours of birth they molt, and still have only six pairs of legs. Between the fourteenth and eighteenth days another molt takes place and the resulting third instar has seven pairs of legs. The young continue to grow and molt, having been observed in the act of molting on the twenty-eighth, thirty-sixth, fifty-eighth, and sixty-eighth days. After the first molt there is no regularity as to times of molting in the brood, all depending on the food supply. After the first molt a slight darkening of the intestines is noted, and by the twenty-first day the sowbugs are of a gray color throughout and under 3 mm. in length. In fifty-eight days they have not increased beyond 4 mm. in length. The greatest size of any found was 15 mm. This specimen was probably several years old. Females not over 7 mm. long are capable of reproduction.

Before molting, the body of all sowbugs becomes a very dirty gray color. The act of molting is peculiar. At first a white border indicating the loosening of the old skin appears at the front edge of the fifth free thoracic segment, then another on the sixth, and still another on the seventh. Finally the entire posterior half of the skin is free and the isopod steps out of it. This process consumes about twenty-four hours, and when completed the posterior part of the body is of fresh slate color, while the old anterior part appears very dull. Following the first stage of the molt the anterior segments commence to loosen and are slid forward. The dorsum of the third and fourth thoracic segments is loosened before the legs of these segments are released. From then on the last two pairs of legs in the very young and the last three in later stages are used to hold the animal in position. The anterior legs are not available for use for some time after they are free. The antennæ are withdrawn last.

Regeneration of parts takes place in the antennæ and legs. Several times individuals with aborted members were noticed. These latter would gradually attain full length, then budding of the succeeding segment would be noted and finally this member would be normal. The regenerated part is white for some time.

REMEDIES.

In the treatment of sowbugs poisoned baits are standard remedies. The great fondness of sowbugs for potatoes long ago led to these being used, poisoned either with Paris green or London purple. The potatoes are sliced and a thin covering of powder applied. Sprinkling the soil around an injured plant with Paris green, or dusting the same under boards and other haunts of the sowbugs is also very effective. If the sowbugs are injurious in a garden patch—after treating the ordinary haunts—it is best to keep the ground well broken and raked to prevent clodding and cracking, which gives them protection. Old boards, cans, and rubbish should not be allowed to accumulate. Such precautions will tend greatly to prevent any great damage or annoyance.

Carbon bisulphid has been recommended for the treatment of sowbugs in greenhouses and dwellings, but no special experiments along this line have been tried by the writer.

PORCELLIO LÆVIS Latr.

Porcellio lævis Latr. is a lighter colored sowbug than the preceding, and does not roll up in a ball when disturbed, but instead runs rapidly away to cover. The only definite point in favor of considering it as naturally a plant feeder was the discovery of one dead specimen under cotton dusted with Paris green. It was found, however, that the best way to keep this species alive in the laboratory was to furnish it with fresh cotton leaves and loose mixed soil. Sowbugs of this species were not found far from the barns, and were not numerous in the laboratory cotton patch. They were generally under moist, dark objects and seemed to prefer damp wood piles. Several were found with Armadillidium in crevices and in trees at various heights. One Porcellio was found in the skeleton of a carabid beetle, which was entirely eaten out. In numerous cases this species was found devouring those of its own kind. The molted skin is usually eaten. A chest of old clothes, which had been wet in a flood, was found to be literally alive with this sowbug. Experiments with eggs of the cattle tick (*Boophilus annulatus* Say) gave the following results: Four sowbugs provided with over 300 eggs devoured 153 at the rate of between 5 and 6 a day each.

The broods of this species are small, numbering from 8 to 30. Metamorphosis is more rapid than in Armadillidium. The seventh pair of legs is attained before the twelfth day. Molting is as in Armadillidium.

The same remedies as recommended for Armadillidium were found to be effective.

METOPONORTHUS PRUINOSUS Brandt.

Metoponorthus pruinosus Brandt is a much rarer sowbug than either of the two preceding species. It is also more delicate and more agile. The color is a beautiful blue-gray in the male and somewhat tinged with red in the female. Its haunts are damp, earthy places in sheds, etc.

These sowbugs feed very eagerly on cotton leaves and were kept under the same condition as the two preceding species. Forty tick eggs were eaten by two individuals at the rate of about 7 per day each. They may be poisoned by dusting the soil in their haunts with arsenicals.

Reproduction and development is very rapid, much more so than in either Armadillidium or Porcellio. One pair produced four broods of young in sixty-two days, there being seventeen, sixteen, and twenty-one days between broods. The broods are small. The young grow so rapidly that in two months they are one-half as large as their parents. They molt frequently. It is very difficult to observe this species closely because of its rapidity of movement.

CONCLUSIONS.

In conclusion it may be said that (1) in a damp year the sowbugs may do considerable damage to the young growing vegetable crops; (2) they serve at all times as scavengers; (3) their exclusion from houses is advisable because of the scavenger habit, there being a possibility of the transmission of diseases; (4) in the case of the cattle-tick problem they may be beneficial by eating such eggs as are deposited in barns, sheds, pens, in the woods near the watering places, and in moist meadows. Finally, cleanliness is probably the best preventive against sowbug inroads, arsenical compounds the best outdoor remedies, and carbon bisulphid the best indoor remedy.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON "PUNKIES."

(*Ceratopogon* spp.)

By F. C. Pratt,
Special Field Agent.

INTRODUCTION.

While in the Blue Ridge Mountains near Bluemont, Va., a few years ago the writer heard reports concerning "biting gnats," which were said to bite furiously before rains. At that time his stay was of short duration, and a dry summer prevented him from securing specimens. In 1904, however, during another visit to the same locality one rainy week, July 21–28, he was harassed by myriads of these minute flies, which were extremely numerous and active after as well as before rains. They proved to be *Ceratopogon guttipennis* Coq., one of the smaller Chironomidæ. Mr. D. W. Coquillett has recently made a careful systematic study of the specimens belonging to the genus Ceratopogon contained in the United States National Museum collection, including those reared at the insectary of this Department and by the writer, and the determinations of the species here mentioned are his. The records of these rearings are brought together in the present paper with the addition of such data as have been communicated by collectors and correspondents.

Prior to 1902 little had been published on any of these pernicious insects beyond scattered notices such as were furnished in a previous bulletin[a] of this Bureau, on the bite of *C. stellifer* Coq. in Texas. As the bibliographic references have never been collected, the writer has brought together all data and accompanying illustrations, with such references to the biting and other habits of this group as he has been able to find.

CERATOPOGON GUTTIPENNIS Coq.

The flies of the species *Ceratopogon guttipennis* will bite any exposed part of the body, preferring, however, the hairy parts. At one time 25 individuals were counted in the hair on the head of the writer's 8-year-old boy guide at Bluemont, Va. They are persistent in their endeavors to obtain blood, piercing the skin and filling up with blood so as almost to lose semblance to flies. In many cases an itching

[a] Bul. 44, Div. Ent., U. S. Dept. Agric., p. 92, 1904.

pimple results from the punctures, the eruptions, in appearance,

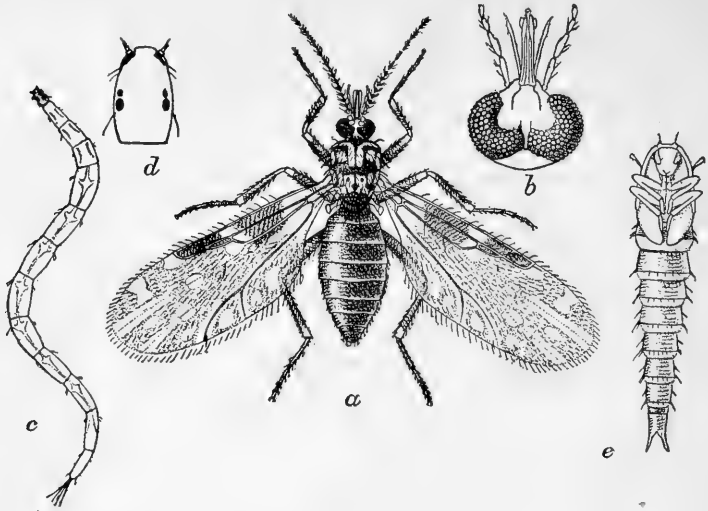


FIG. 3.—*Ceratopogon guttipennis: a*, adult; *b*, head of same; *c*, larva; *d*, head of same; *e*, pupa. All greatly enlarged (original).

being very much like the vesicles caused by contact with poison ivy. The adult is a minute fly 1 mm. in length, appearing blackish to the naked eye, but under a lens seen to be of a deep gray hue, with mottled wings (fig. 3). Its mouth parts are illustrated in figure 4. The species was described by Mr. D. W. Coquillett,[a] to whose paper the reader is referred for descriptions of many species of this genus. The Virginia punkie is the name which the writer would suggest for this particular species, as it may possibly be distinct from the one occurring in Maine which the Indians called "no-see-um," and which is popularly known as "punkie," the latter name being corrupted according to locality. The flies of this species are very troublesome to man and domestic animals. If milking is put off later than usual in the morning, they drive the cows almost frantic by their persistence, and while that process is going on the operator, having both hands engaged, is at their mercy.

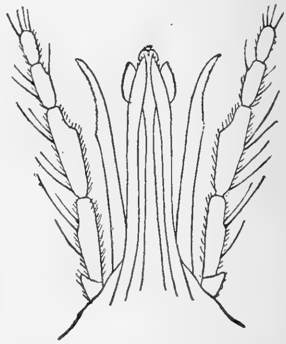


FIG. 4.—*Ceratopogon guttipennis:* Mouth parts of adult. Highly magnified (original).

THE LARVA.

Larvæ were found in the very dirty water in holes in the middle of poplar stumps, in company with larvæ of mosquitoes (*Anopheles bar-*

[a] Proc. U. S. Nat. Mus., Vol. XXIII, No. 1225, p. 603, 1901.

beri Coq., *Culex signifer* Coq., and *C. triseriatus* Coq.), larvæ of the dascyllid beetle *Prionocyphon discoideus* Say, and a rat-tailed maggot related to Eristalis. Eggs could not be found on account of the dirty condition of the water. The larval food seems to be the débris at the bottom of the holes, as well as dead mosquito and other larvæ, and cast larval and pupal skins. In one instance the larvæ had accomplished the complete disintegration of a rat-tailed maggot, and the writer has seen them render the skin of the beetle larva just referred to transparent. On several occasions larvæ were seen inside the skin. They were taken also at Woodstock under similar conditions, that is, in holes containing water in living trees.

The larva (fig. 3, *c*), when full grown, is 4.7 mm. in length and very slender. It has 12 segments exclusive of the head, the two segments following the head together being about the length of each of the other segments. It is white in color, threadlike, and has a brownish head. Locomotion is undulatory. The larvæ frequently come to the surface and then descend, squirming along the bottom of a jar and apparently never remaining quiet, as does the larva of Culex at times. Some of the larvæ were carried through the winter in a room which was moderately cool, but seldom near freezing. From these over-wintered larvæ adults issued April 27 to May 8, 1905. Later investigation may prove that the larvæ freeze up just as do the larvæ of some mosquitoes, then thaw out in the spring and complete their life cycle.

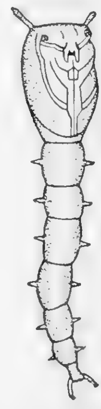


Fig. 5. Pupa of *Ceratopogon varicolor.* Much enlarged (after Dyar).

THE PUPA.

The pupa (fig. 3, *e*) is 3.01 mm. in length and 0.84 mm. in breadth. It is of a brown color, a little more than half as long as the mature larva, but much stouter, and has eight abdominal segments, each succeeding segment being narrowed to the last, which is bifurcated, the claspers being 0.35 mm. in length. It is provided with two short breathing tubes. In this stage the insect does not move frequently, remaining in a perpendicular position in the water just below the surface. For comparison the figure of an allied species, *Ceratopogon varicolor* Coq. (fig. 5), from Bellport, N. Y., is reproduced from Plate I, Volume V, of the Proceedings of the Entomological Society of Washington.

The known distribution, gathered from specimens in the U. S. National Museum collection, is as follows: Plummers Island, Md., June 6 (H. S. Barber); Medina, Ohio, August 5 (J. S. Hine); Bluemont, Va., July 29 and 30, and Woodstock, Va., August 8 and 9 (F. C. Pratt); Santa Rita Mountains, Arizona, July 8 (E. A. Schwarz).

A specimen of *Ceratopogon guttipennis* has recently (April 13, 1906) been reared from a larva collected from water in a hollow living tree at Dallas, Tex., April 9, 1906, under conditions similar to those at Bluemont and Woodstock, Va. This water had been frozen during the winter.

OTHER SPECIES OF CERATOPOGON.

There are nearly one hundred known species of Ceratopogon represented in the U. S. National Museum collection, and several species besides the one under discussion are known to bite, among them

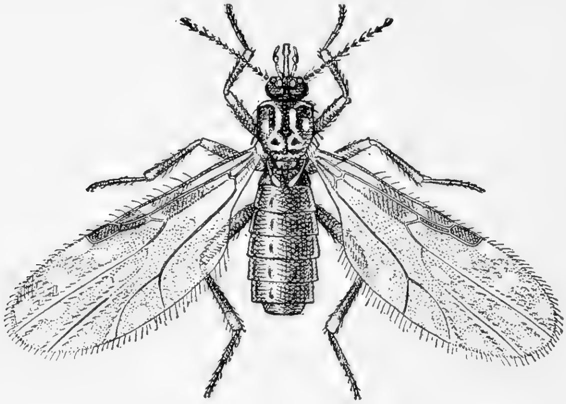


FIG. 6.—*Ceratopogon stellifer:* Adult. Highly magnified (original).

C. sanguisuga Coq., *C. stellifer* Coq., *C. variipennis* Coq., *C. unicolor* Coq., and *C. cinctus* Coq. Many others will undoubtedly be found to have similar habits.

C. sanguisuga Coq. has been collected at the following localities: Marlboro, Md., May 13 (H. S. Barber); Woodside, Md., October 12 (J. E. Benedict, jr.); Kaslo, British Columbia, June 29 (H. G. Dyar).

C. stellifer Coq. (fig. 6) is a little smaller than *C. guttipennis* and is a most notorious biter. Its distribution, as shown by specimens in the U. S. National Museum, is as follows: District of Columbia, May 12, June 6, September 9 (H. S. Barber, collector); Fairfax County, Va., August 18 (J. E. Benedict, jr.); Corinth, Miss., August 19, and Athens, Tenn., August 22 (H. S. Barber); Las Vegas Hot Springs, N. Mex., August 7, 11, and 19, and Hot Springs, Ariz., June 27 (H. S. Barber).

C. variipennis Coq. A female of this species was collected while sucking blood by W. P. Cockerell at Las Vegas, N. Mex., May, 1902, and has been collected at Westville, N. J., in June, by J. B. Smith and on July 2 by C. W. Johnson; also at Richmond, Va., by Mrs. A. T. Slosson, and at Mexico City, Mexico, by O. W. Barrett.

C. unicolor Coq. has been taken at Eureka and Fieldbrook, Humboldt County, Cal., by H. S. Barber in May and June.

C. cinctus Coq. was found at Lake Worth and Biscayne Bay, Fla., by Mrs. A. T. Slosson, who braved its biting in order to collect specimens of it.

C. websteri Coq. was collected April 17, 1887, by Prof. F. M. Webster at Ashwood, La., on bushes in company with a species of Simulium.

C. mutabilis Coq., reared from human excrement by the writer in the District of Columbia June 17, occurs also at Jacksonville, Fla. (Mrs. A. T. Slosson, collector).

C. griseus Coq. was captured on human excrement by the writer at Travilah, Md., in June. It has been collected also in Florida and Arizona, and Prof. T. D. A. Cockerell found it on a horse at Pecos, N. Mex. This species, as well as *C. mutabilis*, were recorded by Dr. L. O. Howard in an article on the insect fauna of human excrement as "Ceratopogon species." [a]

C. specularis Coq. was reared by Mr. C. L. Marlatt from horse and cow manure during his investigation on the horn fly (*Hæmatobia serrata* R.-D.) in Virginia in 1889. It has been collected also at Springfield, Mass. (Dimmock); Philadelphia, Pa., June 28, and Natrona, Pa., July 30 (C. W. Johnson); District of Columbia, August 11 (F. C. Pratt); Woodside, Md., October 12 (J. E. Benedict, jr.); Warrenton, Va., August 23, and Rosslyn, Va., December 30 (C. L. Marlatt), and in Colorado.

W. H. Long[b] found larvæ of this species on the under side of dry cow dung from August to December, but more abundantly during November and December, in company with *C. brumalis* at Austin, Tex.

C. brumalis Long. Mr. W. H. Long writes of this species as follows: [c]

> During November, December, and January the larvæ of this species were found in immense numbers on the under side of nearly dry cow dung. They seem to feed on the dung, never penetrating very far into the substance. No eggs were found. The duration of the larval stage seems to be several weeks, that of the pupal stage seven to ten days. * * * Several hundred larvæ of all ages were found on the under surface of a piece of moist rotting elm wood; similar larvæ and puparia were also found in the nests of the common foraging ant (*Eciton cæcum*) on several different occasions.

Mr. Long states that he reared imagines from larvæ taken in these various situations and they proved to be the same species. It is known from Austin, Tex.

C. stenammatis Long. Long writes of this species as follows:[d]

> The specimens were received from Dr. W. M. Wheeler, who found them in the nest of an ant (*Stenamma fulvum* subsp. *aquia*) at Colebrook, Conn., August, 1900. They were moving about in the refuse heaped up by the ants in certain portions of their nests. The species seems to be a genuine myrmecophile like the European species (*C. Braueri* Wasmann).

---

[a] Proc. Wash. Acad. Sci., Vol. II, p. 559, 1900.

[b] Biol. Bul., Vol. III, pp. 7–10, figs. 3–6 (in part), 1902.

[c] L. c., Vol. III, pp. 3–7, figs. 1, 2, 6 (in part).

[d] L. c., p. 10, figs. 4, 6 (in part).

C. texanus Long.

The larvæ of this species are gregarious in small numbers beneath the bark of old dead trees in moist places, or on the under side of very damp rotting wood during December and January. Rare.[a]

Austin, Tex.

C. wheeleri Long. Adults of this species have not been reared on account of a proctotrypid parasite (*Adeliopria longii* Ashm.).

The Ceratopogon puparia were found December 15, 1900, beneath a stone, in what seemed to be an abandoned ant's nest. The parasites issued, one from the thoracic dorsum of each of the Ceratopogon puparia December 31 and lived eight or ten days.[b]

Austin, Tex.

The late Dr. O. Lugger[c] calls attention to the "cussedness" of an unidentified species and gives a figure which may possibly be *C. stellifer*. Ceratopogon has also been recorded as breeding under leaves and in flowing sap from trees; thus the group is seen to have diversified habits.

In Europe, Professor Mik[d] described as *Ceratopogon hippocastani* a hairy-winged species having a footless larva, found in the very moist or wet ulcerous parts of stems of horse-chestnut (*Æsculus hippocastanum*).

OTHER BLOOD-SUCKING CHIRONOMIDÆ.

A related form which may be mistaken for Ceratopogon is *Œcacta furens* Poey, taken in June at Cardenas, Cuba, by Mr. E. A. Schwarz, and at Montserrat, West Indies, April 8, by Mr. H. G. Hubbard. It was also taken at Perihueta and Laguna Carmen, Mexico, by Dr. Alfredo Dugès.

Another related form, *Tersesthes torrens* Towns., described by Prof. C. H. T. Townsend[e] with notes on habits, has been collected at the following localities: Filmore Canyon, and Las Vegas Hot Springs, N. Mex. (Townsend); Fort Grant, Ariz., July 19 (H. G. Hubbard); Ash Fork, Ariz., June 18 (H. S. Barber); Lake Worth, Fla. (Mrs. A. T. Slosson); Salt Lake, Utah (H. S. Barber), and Baracoa, Cuba, August (A. Busck).

Mr. Barber has collected from thirty to forty species of Ceratopogon and states that Tersesthes is much worse as a pest than any Ceratopogon he has ever encountered.

---

[a] Long. L. c., pp. 10-12, figs. 5, 6 (in part).

[b] Long. L. c., pp. 12–14, fig. 5 (in part).

[c] Second Rept. Ent. of Minn. Exp. Sta., pp. 171–172, fig. 142, 1896.

[d] Wiener Ent. Ziet., Vol. VII, pp. 183–192, Pl. II, 1888.

[e] Psyche, Vol. VI, pp. 369–371, pl. 8, 1893.

U. S. D. A., B. E. Bul. 64, Part IV. Issued January 14, 1908.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

In economic works of European authors a very considerable number of species of Apion are mentioned in connection with injuries to cultivated plants, and particularly to the Papilionaceæ, for which a large proportion of species show a preference. Certain European forms are sufficiently abundant to receive common English names, among which are the clover weevil, the Dutch-clover yellow-legged weevil, the cinquefoil weevil, the tare or vetch weevil, and others, the popular name being indicative of each insect's food habits.

None of our native species, so far as known to the writer, has hitherto been recorded as injuring useful plants; hence a note received from Mr. James K. Metcalfe, Silver City, N. Mex., of injuries to forage plants by *Apion griseum* Sm. is of interest.

APION GRISEUM Sm.

September 25, 1899, our correspondent sent seedpods of the Metcalfe bean (*Phaseolus retusus*), together with specimens of the beetle. This weevil was stated to be very destructive to this plant, which has been mentioned by Dr. Jared G. Smith as one of the most promising of our native forage plants.[a] The weevil was said to be also destructive to the "Raphael" bean (*Phaseolus wrightii*), and we have received the same species from Phaseolus beans from Tolima, Mexico.

This species has also been observed by the writer to develop in the seedpods of a wild bean, *Phaseolus polystachyus* (*perennis*). Eighteen individuals were found on opening a pod of this plant at Rosslyn, Va., April 22. One seed had harbored eleven Apions, all of which perished owing to their inability to escape from the pod.

[a] Yearbook, U. S. Department of Agriculture, for 1897, p. 506.

which had evidently died prematurely as a result of overinfestation by the weevils. Pods were examined during the first week of October, and at this time half of those gathered were infested. The sound pods may be easily separated from the infested ones, since the latter are flattened, discolored, and sometimes even distorted, while sound and fully matured pods are full and round like a diminutive pea-pod. Most individuals were in the pupal condition at the last-mentioned period. The adults, like others of the genus, feed upon the leaves, piercing them with innumerable holes, from 20 to as many as 60 such punctures being sometimes visible on a single small leaf.

The insect hibernates in the beetle condition, escapes from the pod about May or June, or earlier if the pod happens to crack, and the punctures made upon the early appearance of the insect are plainly visible in October.

Careful comparison of the writer's reared material of *Apion griseum* with typical specimens in the U. S. National Museum (some of which appear to be types) of *A. fraternum*, identified as such by Dr. J. B. Smith, who described that species, shows that this is the same insect which was found by Dr. C. V. Riley on *Strophostyles* (*Phaseolus*) *pauciflora* as cited by Smith. The identity of these two forms has also been recognized by Fall in his revision of the genus.[a]

The chalcidid fly *Catolaccus incertus* Ashm. was reared from infested pods, and is undoubtedly parasitic on this Apion.

APION COLON Sharp.

February 6, 1903, Dr. Edward Palmer furnished specimens of this species collected at Alvarez, San Luis Potosi, Mexico, on a species of wild bean with scarlet flowers and tuberous roots, which is used as a cure for hydrophobia (Palmer's No. 63).

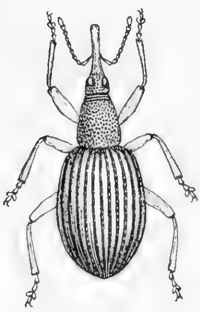


FIG. 7.—*Apion assimile*, greatly enlarged.

This species is not known to occur in our limits, but is mentioned because of possible economic importance.

The accompanying illustration (fig. 7) represents a European species, and will assist the average student of entomology in recognizing weevils of the genus. Upward of 100 species of the genus Apion have been recognized in America north of Mexico, and most of these are minute or almost microscopic. It follows, therefore, as there is considerable generic resemblance throughout, that these many different forms are difficult of differentiation, both sexes being frequently required to make specific determination. The body is

[a] Trans. Amer. Ent. Soc., Vol. XXV, p. 147, 1898.

elongate pyriform, or pear-shaped; the rostrum or beak is more or less prolonged in front of the eyes, and the head back of the eyes is usually constricted, forming a neck. The antennæ are delicate and elbowed.

NOTES ON RELATED FORMS.

The following observations on other species of Apion are chiefly from the writer's personal experience, and all rearings should be so credited, with the exception of those where the collector or observer is mentioned:

Apion æneipenne Sm.—During the first two weeks of June numerous examples of this species were obtained at Rosslyn, Va., by beating a common tick-trefoil (Meibomia [Desmodium]). When the beetles were confined with leaves they riddled them with minute holes after the manner of the commoner *A. nigrum* on locust.

Apion turbulentum Sm.—This species was observed during the latter half of September in and near Cabin John, Md., and in considerable numbers on *Meibomia marylandica.* The beetles were numerous, occurring on the seeds, in which they undoubtedly live, although they were not reared.

Apion cribricolle Lec.—We have, among the Department notes, one on the rearing of this beetle from a species of lotus (*Lotus* [*Hosackia*] *glabra*) from Henwood, Santa Cruz County, Cal.

Apion proclive Lec.—July 18, 1898, Mr. E. M. Ehrhorn reported that this species was infesting the pods of *Lupinus arborea* at Pacific Grove, Cal., where nearly every pod showed signs of attack. A similar attack to lupine was reported by Mr. Ehrhorn in 1907 at San Francisco, Cal. The beetles issued September 5–19. The species proves to be parasitized by a chalcidid.

Apion patruele Sm.—This species was found abundantly on a climbing wild legume at Cold Spring Harbor, Long Island, N. Y., in July. The plant at this time was in bloom, and there is little doubt that the larva inhabits the pods.

Apion segnipes Say.—The writer has reared from this species, found in its well-known food plant, the goat's rue (*Cracca* [*Tephrosia*] *virginiana*), the chalcidid parasite *Eurytoma tylodermatis* Ashm., in August, in Maryland, near the District of Columbia. The writer has also reared this species from its larva found in the cells of *Tyloderma foveolatum* in October. There is fair indication, therefore, of two generations.

Apion decoloratum Sm.—This species breeds in the seed pods of the genus Meibomia. Beetles have been reared from *M. paniculata* and *M. grandiflora*, and exit holes have been observed in pods of all of the species of this genus of plants that have come under observation in Maryland and Virginia about Washington. The beetles began issuing from the pods September 21, and most of those in the field had escaped by the end of the month. Stragglers, however, continued to issue from the material gathered until the end of October. Mr. Fall states that "Mr. Wickham has found the species in some abundance on Desmodium in Iowa City." *Catolaccus incertus* Ashm. was reared with this species.

Apion herculanum Sm. was reared July 24–28 from the dried fruit of sheepberry (*Viburnum lentago*), and beetles were taken in the same locality, Marshall Hall, Md., in May on *V. acerifolium* in bloom. At Ithaca, N. Y., it was taken in fair abundance on the flowers of this same plant, collected May 28, June 5–20, and July 2–6 several years previously. Mr. Schwarz informs the writer that he has reared the species also from dogwood (*Cornus* sp.).

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

INSECTS INJURIOUS TO THE LOCO WEEDS.

By F. H. Chittenden, Sc. D.,
Entomologist in Charge of Breeding Experiments.

For many years the Bureau of Entomology has conducted correspondence in regard to insects found on the loco weeds of the semiarid regions of the West. In earlier years these insects were found chiefly on purple or woolly loco, *Astragalus mollissimus*, and more recently on the white loco, *Aragallus lamberti*. It was at one time supposed by stockmen that the insects might be the cause of the poisoning to sheep, cattle, and other stock, but such is not the case.

The general subject of loco poisoning to stock has been treated in various publications, but the insect inhabitants of the weeds have never received mention in this connection, with the exception of the false-indigo gall-moth,[a] which is apparently the principal insect destroyer of the loco. Numbers of correspondents and observing botanists have noticed that the caterpillar of this insect, which feeds at the roots and crowns of locos, is quite instrumental in reducing their abundance. Recently Dr. C. Dwight Marsh, Bureau of Plant Industry, has collected many insects on locos and expresses the opinion that several other species are concerned in this work. Chief among these are the fickle midge,[b] the loco root-maggot,[c] the four-lined loco weevil,[d] and the spotted root fly.[e] Of these the root-maggot, midge, and root fly are probably in the main attracted to the plants after the gall-moth has first caused injury, but the weevil also attacks living roots, usually, however, according to observations, after the plant has produced its quota of seed.

The following account of loco insects has been prepared from the records of the Bureau of Entomology, much of the material having also been supplied by Doctor Marsh, and in the list which follows it

[a] *Walshia amorphella* Clem.

[b] *Sciara inconstans* Fitch.

[c] *Pegomya lupini* Coq.

[d] *Cleonus quadrilineatus* Chevr.

[e] *Euxesta notata* Wied.

will be understood that the locality Hugo, Colo., is the one in which he collected specimens for identification. This account does not pretend to be an exhaustive one, but is more in the nature of a list, with notes on such species as appear to be concerned in killing out the weed. Considering the toxic qualities of the locos, the insects which affect them, with some exceptions, may be classified as highly beneficial, since the species which have just been mentioned have in some cases completely rid large areas of loco weeds.

THE FALSE-INDIGO GALL-MOTH.

(*Walshia amorphella* Clem.)

Prior to 1886 the larva of this species was known only as a gall maker on the stems of false indigo (*Amorpha fruticosa*) and was described from moths reared from that plant in 1864. An account of the species and its habits was afterwards given by Riley in 1870.[a] He stated that as the twigs invariably withered and died above the gall, and as the shrub was of no special value, the species might be placed among our harmless insects. In early records of the Bureau of Entomology there are numerous references to this species and its occurrence on false indigo. In 1886 a second food plant, *Astragalus mollissimus*, was recorded.[b]

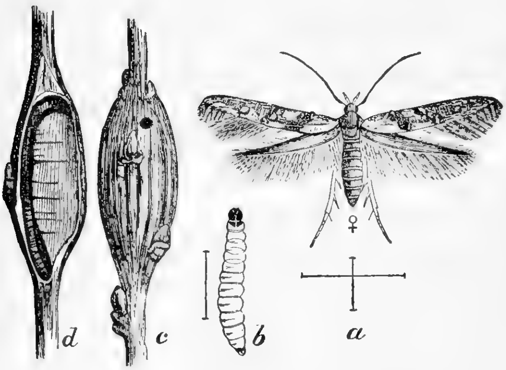


FIG. 8.—False-indigo gall-moth (*Walshia amorphella*): *a*, Female moth; *b*, larva; *c*, gall in false indigo, showing exit hole near top; *d*, gall opened, showing larva *in situ*. *a*, *b*, 3 times natural size; *d*, *c*, natural size. (After Riley.)

This moth (fig. 8, *a*) belongs to the family Tineidæ and has a wing expanse of about half an inch. It is grayish yellow, spotted with dark brown, and both wings are provided, as in others of this group, with very long posterior fringes, longer than the wings themselves. The larva or caterpillar (fig. 8, *b*) is yellowish white, with the head and thoracic plate dark brown. It measures from a third to two-fifths of an inch in length.

Our records of the distribution of this species show that it has been observed most commonly from Iowa and Missouri westward to California, although it occurs also in the Atlantic region. It is quite

[a] 2nd Rept. State Ent. Mo., pp. 132–133.

[b] Proc. Ent. Soc. Wash., Vol. I, p. 30.

singular that the larva should have the dual habit of forming galls on a shrub, as in the case of its occurrence eastward, and at the same time boring into the roots of weeds, as is its western habit. From the experience of many persons who have been in correspondence with this office in regard to the habits of this insect, there can be no hesitation in reiterating that it is the most potent element in the destruction of the loco weed of the West. In this connection it may be well to mention briefly what some of our correspondents have reported. Mr. Thomas J. Quillian, Birmingham, Colo., wrote, April 9, 1889, that from observations conducted by himself and a fellow stockgrower he was led to believe that possibly the "worms" eaten by the stock produced the craziness (and sometimes death) instead of the plant, as was generally supposed, this conclusion being more plausible because upon opening the dead animals many "worms" were always found. Mr. D. H. Marum, Woodward, Okla., has written that in that vicinity the plants begin to die about the last week in May. At that time the small "worms" are found in the roots, which they hollow out completely, leaving practically nothing but a shell. He suggested the possibility of propagating these and other loco insects with a view to destroying the weed. Mr. Thomas Carson, Bovina, Tex., writing of the great loss in cattle in that section, stated that this insect, which he had observed devouring the heart of the loco, was very efficient in reducing the abundance of this noxious weed and had proved very beneficial to the cattle interests. In closing, it should be added that in the extreme west, as, for example, at Alameda, Cal., this species has been observed breeding on *Lupinus arborea*.

THE LOCO ROOT-MAGGOT.

(*Pegomya lupini* Coq.)

The loco root-maggot has been prominent among insects found feeding on the roots of *Astragalus mollissimus* for a number of years. Doctor Marsh says that in the neighborhood of Hugo, Colo., it is apparently the most important agent in the suppression of the purple loco. It is probable that it will rank second to the false-indigo gall-moth as a destroyer of this plant. On this head Mr. George Hochderffer, Flagstaff, Ariz., who, on April 7, 1907, sent specimens found at the roots of the plant, stated that hundreds of acres of loco had been destroyed by this insect, and he believed not only that it might prove to be a valuable friend to stockmen, but that it had already proven so.

It is the larva of a species of anthomyiid fly closely related to the seed-corn maggot,[a] the adult being readily distinguished from that

[a] *Pegomya fusciceps* Zett.

of the latter by the long bristles on the underside of the posterior femora or hind thighs. It was described in 1901 from flies obtained from the stems of *Lupinus alba* from Los Angeles, Cal.[a] This species resembles the common house fly, though more slender and of a more distinctly gray color. The larvæ are white maggots and resemble the seed-corn maggot. They infest chiefly the crown of the plant, seldom, if ever, entering the roots, but penetrating into the larger stems; sometimes, it is reported, going as far as the base of the flowers.

We have records of the rearing of this species from *A. mollissimus* from material collected at Sherlock, Kans., and from *Lupinus arborea* at Alameda, Cal., in April. In June, 1887, it was received from New Mexico with statement by Dr. V. Havard that it was breeding in the roots of *A. mollissimus*. At this time we were conducting considerable correspondence with Doctor Havard in regard to the insect enemies of this plant in Kansas, New Mexico, and Texas. Doctor Havard stated, among other things, that at that time it was somewhat generally believed that " locoism " on the part of stock animals was due, not to any deleterious property of the plants, but to the larvæ of insects found abundantly in the stems and roots. In all specimens received by him from New Mexico the stems, without exception, were bored by the larvæ of this species. Flies from this last lot began issuing June 10. In May, 1905, and January, 1908, this species was again received from locos from Hugo, Colo. In that locality it was associated with *Euxesta notata* and *Sciara inconstans*.

THE FICKLE MIDGE.

(*Sciara inconstans* Fitch).

This minute gnat-like fly was reared from purple loco received from Hugo, Colo., in 1906, the adults issuing May 24. During 1907–8 additional specimens were received from the same source. Doctor Marsh has expressed the belief that this species, with the larger maggot, *Pegomya lupini* Coq., is one of the chief causes of the destruction and apparent temporary extermination of this loco weed in that section of Colorado. The members of the family to which it belongs, the Mycetophilidæ, are for the most part scavengers, feeding on decomposing vegetable matter, including fungous growths, whence their name of " fungus gnats." Taken as a whole, however, the family displays great diversity in habits and the present species is the most widely distributed and most nearly omnivorous of its kind. It feeds on vegetation of almost all forms, occurring destructively in greenhouses, as also in the open, in cultivated and uncultivated regions. It appears to be most abundant in the Northern States.

[a] Ent. News, September, 1901, pp. 206–207.

The insect is shown in its different stages, highly magnified, in figure 9. The size is indicated by the hairlines at the right of the figure. It will be noticed that the female fly (*c*) is larger than the

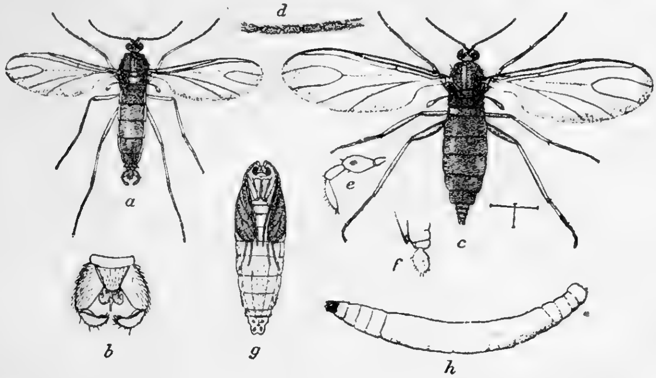


FIG. 9.—Fickle midge (*Sciara inconstans*) : *a*, Male fly ; *b*, external genital organs of male ; *c*, female ; *d*, enlarged antennal joints of same ; *e*, maxillary palpus of same ; *f*, tip of abdomen of female from side ; *g*, pupa, ventral view ; *h*, larva, dorsal view. *a*, *c*, *g*, *h*, Much enlarged ; *b*, *d*, *e*, *f*, more enlarged. (Author's illustration.)

male. The latter (*a*) is recognized by its claspers, shown much enlarged at *b*. The larva is a delicate, thread-like maggot of milk-white color with a jet-black head. On account of its minute size—about $\frac{1}{5}$ of an inch in length—its presence is very frequently unnoticed in greenhouses, although the flies are more conspicuous, from their habit of flying about on the "glass." In some cases this species is confused with nematodes or eel-worms.[a]

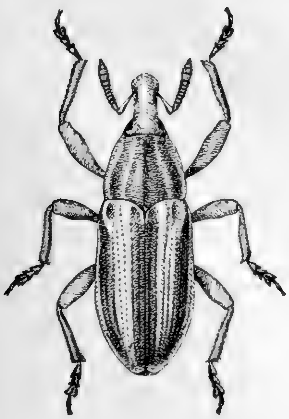


FIG. 10.—Four-lined loco weevil (*Cleonus quadrilineatus*): Adult. Much enlarged (original).

THE FOUR-LINED LOCO WEEVIL.

(*Cleonus quadrilineatus* Chevr.)

This curculionid weevil was found breeding in considerable numbers on *Aragallus lamberti* at Hugo, Colo., during 1907, by Dr. C. D. Marsh, who reports very appreciable injury. As a rule, however, this species does not occur in numbers until after the plants have made good growth and have seeded.

This beetle, (fig. 10) measures about half an inch in length; has a stout rostrum or beak, a little shorter than the thorax; is black, and densely coated with gray pubescence alternating with two pairs of longitudinal black lines, one subsutural and the other submarginal.

[a]A more complete account of this insect appeared in Bul. 27, n. s., Div. Ent., U. S. Dept. Agric., pp. 108–113, 1901.

Practically nothing is known of the life history of any species of the genus, of which there are quite a number. The beetles are partial to Astragalus and Aragallus and feed also on lupines and related plants. The larvæ are undoubtedly root or stalk feeders. The present species in the larval stage affects the roots and transforms in the ground in comparatively large earthen cocoons, such as are shown in the illustration (fig. 11).

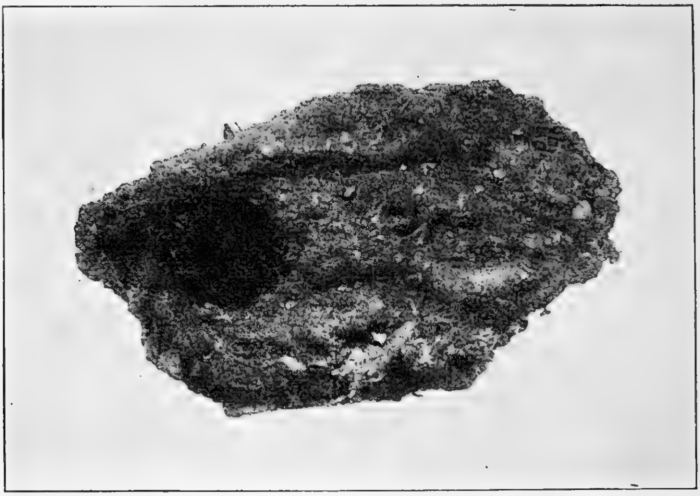


FIG. 11.—Four-lined loco weevil (*Cleonus quadrilineatus*): Cocoon. (Original.)

THE YELLOW LOCO FLY.

(*Tritoxa incurva* Loew.)

This species was collected at Hugo, Colo., on *Aragallus lamberti*. It is a two-winged fly of the family Ortalidæ and is recorded as having the same habits as the black onion fly (*Tritoxa flexa* Wied.), whose larva or maggot lives in the bulbs of onions; indeed, it was at one time considered a color variety of the latter. The wing markings are almost identical, but the face, thorax, and most of the abdomen are brownish yellow, whereas in the onion fly these parts are black. Its body is about one-third of an inch long, each wing having a little shorter measurement. Neither species under consideration is, as a rule, especially abundant, but both are capable of being very destructive to plant life when they multiply in numbers, as may happen any year in some localities.

THE SPOTTED ROOT FLY.

(*Euxesta notata* Wied.)

This pretty little fly of omnivorous habits was reared from *Astragalus mollissimus* from Hugo, Colo., in June and July, 1905, being associated with the fickle midge and the loco root-maggot. In its larval stage it displays a remarkable diversity of habits, although it is evidently by choice a root feeder and is also, with the seed-corn maggot and many related insects, a scavenger by nature, following in some cases original attack by some other form of insect. It has been recorded by Dr. L. O. Howard as having been bred from larvæ in human excrement in houses and out of doors. Mr. E. G. Titus has reared it from sugar beet collected at Olney, Colo., and from cocklebur collected at St. Matthews, S. C., where it was feeding in the cells of a weevil, *Baris transversa*. In September, 1905, it was reared by the writer from onions infested by *Tritoxa flexa* from Williamson School, Pa., and there is positive evidence that it had fed on the onion bulbs, as neither stems nor leaves were present. Dr. J. B. Smith also has reared it from onions. In 1906 it was reared from corn on the farm of Dr. B. T. Galloway near the District of Columbia, where it was reported injurious, the injury being at first attrib-

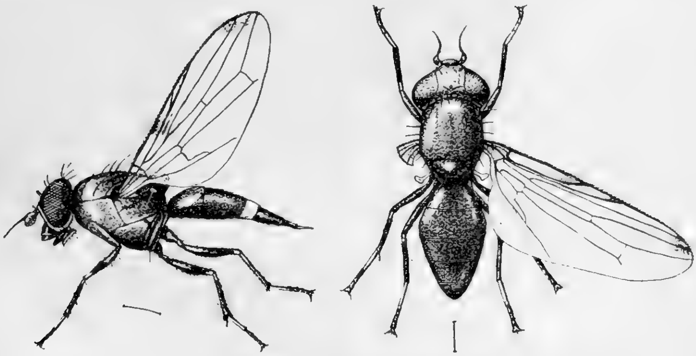


FIG. 12.—Spotted root fly (*Euxesta notata*): Adult male at right; female at left. Much enlarged (original).

uted to the seed-corn maggot, as attack was to seed corn and resembled the work of the latter species. From cabbage it has been reared on two occasions, viz, from the roots collected at Washington, D. C., and from maggot-infested roots received from Bethel, Alaska. It has also been bred from the pulp of Osage orange, from apples infested by the codling moth, from sumach fruit, from the bolls of cotton, and from Solanum. It is not rare in diseased cotton bolls.

This fly belongs to the same family as the preceding, the Ortalidæ, and is shown in figure 12, where it will be seen that it has a large head and flat body. Each wing is marked with two black spots. The female is distinguished from the male by its more slender form, smaller head, and pointed abdomen, which bears near the anal extremity a distinct white transverse band. The body is metallic blue.

Our rearings show that larvæ have come under observation from May 27 to as late as October 2 and that flies have issued from various sources June 10–July 30, September 8–21, and throughout October.

THE BUR-CLOVER APHIS.

(*Aphis medicaginis* Koch.)

This species is well known to attack both Astragalus and Aragallus, as well as various other related plants, including clover, cowpea, alfalfa, coffee bean (Cassia), bur-clover, *Caragana arborescens*, *Robinia viscosa*, *Melilotus italica*, and *Glycyrrhiza lepidota*. It has also been observed on oxalis, and on cotton associated with the common and more destructive cotton or melon aphis.

Certain of our correspondents have remarked on the occurrence of ladybirds and ants on infested loco plants, conclusive evidence in the case of the ladybirds, *Hippodamia convergens* Guér., that aphides were present.

The present species has a considerable literature, having been described in 1857 and afterwards treated more or less fully by Monell, Thomas, Oestlund, Cowen, Osborn, Hunter,[a] and Sanderson.

A somewhat complete account of this aphis was given by Sanderson in 1906,[b] including a consideration of its food plants and descriptions of different stages as well as references to literature. Still other bibliographical references have been given by Hunter.[a] This species is evidently of foreign origin and was first noticed in this country at St. Louis, Mo., by Monell in 1879.

THE MEAL SNOUT-MOTH.

(*Pyralis farinalis* L.)

During July, 1907, a colony of the larva of this beautiful pyralid moth was observed by the writer breeding in the roots of *Astragalus mollissimus* received from Hugo, Colo. Since the species is of cosmopolitan distribution and commonly found in most barns, storehouses, and even in dwellings, it can not be positively stated that it attacks loco roots in the open, but it quite likely infests the dead roots. Frequently this species breeds in clover hay, after the manner of the clover-hay worm,[c] to which it is related. As a rule the larva requires for its development a certain amount of moisture, feeding on dry material which has become heated, as in the case of stored grain or stacked hay. This species is shown natural size, the moth at *a* and the larva at *b* of figure 13. More complete accounts of the meal snout-moth are given elsewhere.[d]

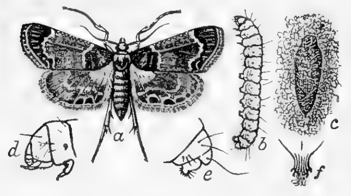


FIG. 13.—Meal snout-moth (*Pyralis farinalis*): *a*, Moth; *b*, larva; *c*, chrysalis, natural size; *d*, head of larva; *e*, anal segment of larva; *f*, tip of pupa. Enlarged (author's illustration).

[a] Bul. 60, Iowa Agr. Exp. Sta., The Aphididæ of North America, 1901, p. 101.

[b] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 26–29.

[c] *Hypsopygia* (*Asopïa*) *costalis* Fab.

[d] See Yearbook U. S. Department of Agriculture for 1894, p. 286, and Farmers' Bulletin 45, pp. 10, 11.

PLANT-BUGS, LEAFHOPPERS, ETC.

Numerous plant-bugs, leafhoppers, and related insects were observed and collected at Hugo, Colo. As a considerable portion of these were in the nymph or immature stages, comparatively few were identified specifically. The list follows:

Alydus eurinus Say and A. *pluto* Uhl., coreid plant-bugs bearing some relation to the squash bug, were among the number. The former has been recorded attacking Lima beans and cowpeas; hence, it is quite probable that both feed on loco and lupines, which are of the same botanical family.

Dasycoris humilis Uhl., another coreid of unknown habits.

Geocoris griseus Dall., a plant-bug of the family Lygæidæ.

Hadronema militaris Uhl., a small capsid or leaf-bug. It infests Amaranthus and beets. Probably accidental.

Stiphrosoma atrata Uhl., also a capsid, of unknown habits.

Philænus bilineatus Say, a cercopid leafhopper which probably feeds on grasses.

Deltocephalus flexulosus Ball, a jassid leafhopper.

Bruchomorpha dorsata Fitch, a fulgorid.

Nabis ferus L., a predatory form. It doubtless destroys many of the other bugs, especially in their immature stages.

MISCELLANEOUS INSECTS.

Agromyza æneiventris Fallen, a small fly, was reared from pupæ at the roots of Aragallus from Flagstaff, Ariz., received in April, 1907, from Mr. Geo. Hochderffer. We have office records of the rearing of this species from the roots of clover and from larvæ found in burrows in the stems of Ambrosia. The fly was reared by the writer from mines in garden peas collected at Washington, D. C., August 10, 1904. The insects issued July 30. Pea leaves are, in fact, quite often infested by this miner.

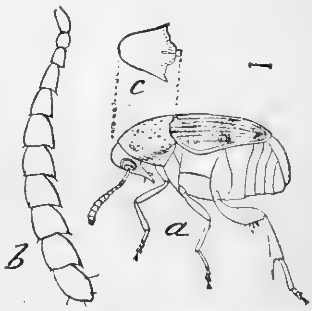


FIG. 14.—*Bruchus obsoletus*: *a*, Beetle; *b*, antenna; *c*, prothorax. *a*, *c*, Much enlarged; *b*, more enlarged. (From Riley.)

Unknown leaf-beetle.—December 14, 1901, Mr. D. P. Marum, Woodward, Okla., wrote of an insect which fed upon the leaves of *Astragalus mollissimus*. During April of that year he noticed that a few stems in each hill of loco were stripped of leaves, and found on the plants a small beetle which he believed to be a ladybird, although it did not have the bright spots known to be present on Coccinellidæ inhabiting that region.

Bruchus obsoletus Say (fig. 14) was stated by its describer to have been found on a species of Astragalus, but recent researches show that the plant in question was a related one, the goats' rue, *Cracca* (*Tephrosia*) *virginiana*.[a]

Bruchus aureolus Horn.—Recorded as occurring on the flowers of Astragalus in Owens Valley, Cal. (Insect Life, Vol. V., pp. 166, 167).

Unknown hymenopterous gall.—Among other material collected at Hugo, Colo., were stems of *Aragallus lamberti* containing elongated fusiform galls one-half to one inch in length and about one-third that in width. Each of these contained a single large hymenopterous larva; these, however, were not reared.

[a] An illustration of this insect and its food plant were furnished in the Annual Report of the Department of Agriculture for 1892, p. 172, Pl. VII.

Rusticus (*Lycæna*) *acmon* Doubl. & Hew. This very pretty blue butterfly was reared from *Astragalus mollissimus* from Hugo, Colo., the adult issuing July 20, 1906. Nothing has been published in regard to the natural habits of this species, and it is not known if it plays any important part in the reduction of the loco weeds.

Grasshoppers and related insects were collected in some numbers at Hugo, Colo., on *Aragallus lamberti*. They were mostly in the nymph condition and therefore could not be readily identified. There were two species of grasshoppers (*Melanoplus* spp.), each occurring in about equal numbers, and a smaller grasshopper (*Opeia obscura* Scudd.), a walking stick (*Parabacillus coloradus* Scudd.) and a tree-cricket (*Œcanthus* sp.). Probably none of these accomplishes much in the line of defoliation of the loco with the exception of the two Melanopli, which are allied to the pernicious Rocky mountain locust.

Aphiochæta pygmæa Zett.—This small fly, which belongs to the Phoridæ, was reared from *Astragalus mollissimus*, from Hugo, Colo., July, 1906, from roots in which other species were breeding. This is a European species known from Texas westward to California.

In the compilation of the above list the writer is indebted to Mr. D. W. Coquillett for assistance in identifying some of the Diptera mentioned, to Mr. Otto Heidemann for the identifications of the plant-bugs, leafhoppers, etc., and to Mr. A. N. Caudell for naming the grasshoppers and related insects.

U. S. D. A., B. E. Bul. 64, Part VI. Issued August 4, 1909.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE GREENHOUSE THRIPS.

(*Heliothrips hæmorrhoidalis* Bouché.)

By H. M. Russell,

Agent and Expert.

INTRODUCTION.

This insect has been known since 1833 to have been the cause of much injury to greenhouse plants; but its life history has never been fully worked out.[a] The writer, while engaged in field work in the State of Florida during 1907, had his attention called to a "diseased" condition of crotons in one of the greenhouses at Orlando. This condition was found to be caused by the extreme abundance of a species of thrips feeding on the foliage. Specimens of the adult were sent to Dr. W. E. Hinds, who determined them to be *Heliothrips hæmorrhoidalis* Bouché. While working under the direction of Dr. F. H. Chittenden during the winter of 1907–8, the writer made a study of this insect's life history and the means by which it might be controlled.

HISTORY.

The species was first described by Bouché,[1] in 1833, as *Thrips hæmorrhoidalis* from specimens taken in a greenhouse in Europe. At that time he wrote that he believed the native land of the species to be America. That this supposition was correct appears evident at the present time.

Packard,[10] writing in 1870, described this species for the first time from this country. He wrote: "This is one of the greatest pests in our hothouses. It is the *Heliothrips hæmorrhoidalis* of Burmeister." Packard called it the greenhouse thrips and gave a meager description of the larva and adult, and an illustration of the latter, but neither descriptions nor drawing are exact enough to identify specimens. He furnished a list of food plants, a description of injury, and recommended washing plants with soapsuds as a remedy.

[a] The external and internal anatomy of this insect has been fully worked out by several European entomologists, while others have made incomplete studies of the life history on the Continent.

Under the name *Thrips adonidum*, A. J. Cook,[11] writing of this species, in 1874, said: "Around Detroit, here at Adrian, and in our southern counties they are likewise a serious pest."

In 1882 Mr. Th. Pergande[13] recorded this insect as taken out of doors at Washington, D. C., on apple late in November. J. A. Lintner,[15] in 1885, on this authority, lists it as an insect affecting the apple.

Nothing more was written about this species in this country until 1896, when G. C. Davis[21] wrote of "a black species, *Heliothrips hæmorrhoidalis*, which we have found most common on croton plants. As far as noticed its work is confined to the underside of the leaves, where the spots are eaten, so that the work clearly resembles that of the red spider."

Dr. F. H. Chittenden,[24] in 1902, predicted that this species, which he called the "greenhouse thrips," would probably increase in numbers and destructiveness with time.

Hinds[25] wrote of this insect the same year: "It has been very injurious in some places." He also added that it was called the "black fly" in Germany and that its life history was unknown.

RECENT RECORDS.

This species, determined by Mr. Pergande, was sent in to the Bureau of Entomology, January 8, 1908, by Mr. P. J. Wester, of Miami, Fla., who collected it on mango (*Mangifera indica*). He wrote: "It has never appeared to do serious damage until this year." Mr. I. J. Condit, a collaborator of this bureau, at San Luis Obispo, Cal., reported it injurious in a greenhouse at that place in September, 1908, and again reported it on November 2, 1908, as injurious to ornamentals in one of the parks at Santa Barbara, Cal.

NATURE AND EXTENT OF INJURY.

The damage caused by the greenhouse thrips is confined to the foliage of ornamental plants entirely, in so far as the author is aware, for he knows of no recorded injury to the blossoms of plants nor has he noticed any. Injury effected by the thrips is due to the method of feeding on the plants. Adults and larvæ both obtain their food by puncturing the epidermis of the leaf with their sharp mouth-parts,[a] and after lacerating the tissue they suck out tissue and plant juices at the point of attack. The insects then attack the leaf in a new place, so that in time it becomes full of tiny, pale-colored spots where the tissue and chlorophyll have been extracted.

In the case of croton plants, upon which this insect was studied, injury was noticed first on the older leaves and gradually, as these became badly infested, the injury spread until the young leaves were

[a] For structure of mouth-parts see "The Pear Thrips," by Dudley Moulton, Bul. 68, Part I, Bur. Ent., U. S. Dept. Agr., pp. 2–3, 1907.

attacked, soon after unfolding. The infested leaves first showed injury on the underside, where the surface appeared full of minute white spots. As attack continued, these spots became more numerous and united, forming blotches where the leaf was devoid of tissue. The injury then became apparent from the upper side, as the surface developed a twisted and distorted aspect between the lateral veins, and was finally evidenced by wilted and dead areas around the edges of the leaf. In severe attacks the insects spread to the upper surface of the leaves, and in a short time this as well as the underside is nearly devoid of color. Both surfaces become thickly covered with minute drops of reddish fluid voided by the thrips, which gradually change to black. As the attack continues, the leaves become limp and yellow and eventually drop off, so that plants that were not treated to prevent injury in many cases lost their entire foliage. The injury is similar on other ornamentals.

This insect injures plants in two ways: First, it causes a serious drain on the vitality of the plant from the feeding of thousands of thrips, so that the growth is seriously checked and in neglected cases would cause the death of the plant. Secondly, it destroys the beauty of the plants for ornament by despoiling them of their foliage.

ORIGIN AND DISTRIBUTION.

Although this insect was first described from Europe and is there widely distributed, it is without doubt indigenous to tropical America. Pergande[19] writes that this insect was "probably introduced with ornamental plants from the warmer regions of America;" and that it "is found upon wild and cultivated plants in Brazil." Franklin[27] records it in Barbados as follows: "This species is found in the open in St. Vincent and Barbados. It is evidently a tropical species." This insect has been collected at Miami, Fla., on plants growing in the open in midwinter. Moulton[26] says, "out of doors it feeds and becomes very destructive to Laurestinas." Mr. Condit, writing of this species from Santa Barbara, Cal., November 2, 1908, said that it was doing considerable damage to ornamentals in one of the parks.

These records of occurrences at several localities in the Tropical and Lower Austral life zones of this country point strongly to tropical America as its original home. This is further strengthened because of its well-known habit of living in greenhouses, in many localities, upon exotic plants from the Tropics. From this habit it has become widely distributed in Europe and North America. In Europe, Walker and Cameron record it from several places in England, Bouché and others from Germany, Heeger and Löw from Vienna, and Reuter from Finland. It has also been recorded from France and Italy.

In this country it has been recorded from Massachusetts, from several places in Michigan, and from Washington, D. C., Florida, and

California. It has been collected in Iowa and Pennsylvania and recently in the Barbados and the island of St. Vincent.

Because of the fact that it has been collected in such widely distant places in all sections of the country, we can safely say that *Heliothrips hæmorrhoidalis* is generally distributed in greenhouses throughout the United States.

DESCRIPTION.

Heliothrips hæmorrhoidalis belongs to the family Thripidæ, the genus being characterized by having antennæ with 8 segments and the body with a markedly reticulated surface. This is especially

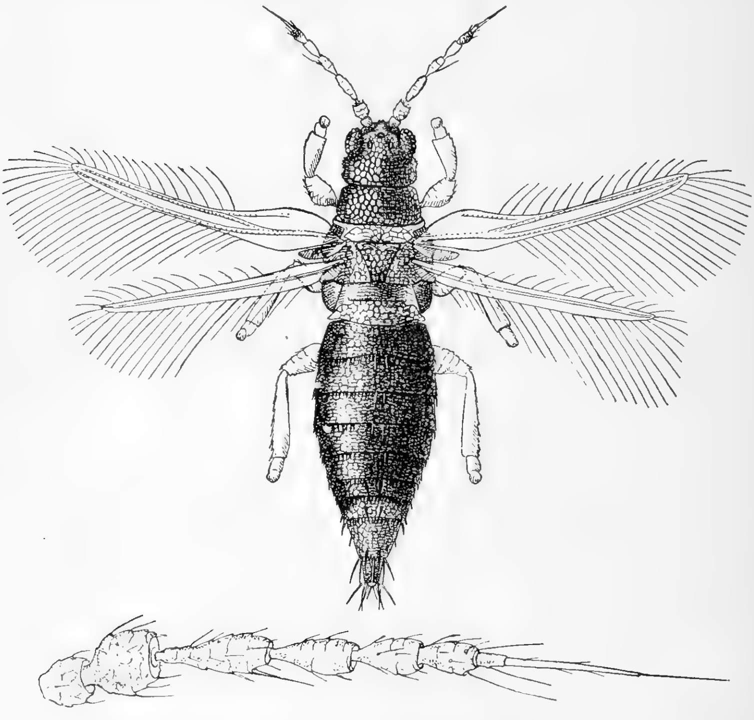


FIG. 15.—Greenhouse thrips (*Heliothrips hæmorrhoidalis*): Adult female, enlarged about 50 diameters, and greatly enlarged drawing of antenna underneath. (Original.)

pronounced on the head and thorax. The legs are unarmed and the wings are characterized by having the fore-wings broad at the base, with 2 longitudinal veins.

The adult (fig. 15).—When the adult first emerges the abdomen is pale yellow, with the head and thorax darker, and the antennæ, legs, and wings appearing white. In the course of several hours, however, the insect becomes fully colored. The head and thorax are then dark brown, the abdomen yellowish brown, fading at the apex to brownish-yellow. In the female the antennæ are twice as long as the head. The total length is about 1.25 mm. and the greatest width, across the mesothorax, is about 0.30 mm.[a]

The male has not been described, and this species is without question parthenogenetic for many generations.

The egg.—The egg (fig. 16, *a*) is bean-shaped, 0.296 mm. in length and 0.088 mm. in width, very delicate, with a thin shell, and colorless. Eggs are laid in the leaf tissue of the host plant, generally on the underside.

The larva, first stage (fig. 16, *b*).—[Description made while larva was very young and before it had commenced to feed on the plant.] Length, 0. 31 mm.; width of mesothorax, 0.10 mm. General shape fusiform; antennæ, head, and legs very large in proportion to the rest of the body. Color translucent white. Head large, quadrate; eyes reddish, ocelli absent. Antennæ 0.16 mm. in length; 7-segmented;[b] basal segment cylindrical, short, with spine on inner side; second segment twice as long as basal one and not as wide, with 4 or 5 spines; third pedunculate, ringed, as long as segments 1 and 2 combined, 2 long spines near tip of segment; fourth pedunculate, nearly twice as long as third, tip more slender than third, ringed, a number of prominent spines near tip; fifth, sixth, and seventh slender, equal in length, and together equaling the length of the fourth, each with one or two small spines near the tip. Legs translucent white, long. Abdomen tapering posteriorly; with 10 segments, the first 8 nearly equal in length, ninth and tenth somewhat longer than others. Each abdominal segment with longitudinal rows of setæ, the ninth with 2 and tenth with 4 spines that are three or four times the length of the setæ.

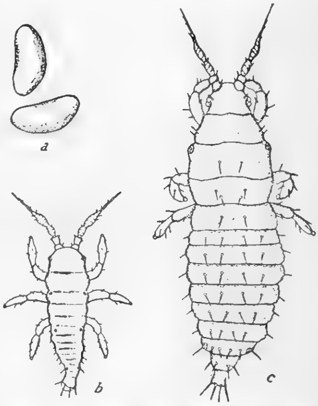


FIG. 16.—Greenhouse thrips: *a*, Egg; *b*, larva, first stage; *c*, larva, full grown. All enlarged about 40 diameters. (Original.)

The larva, second stage.—Length, 0.90 to 0.97 mm.; width of mesothorax, 0.22 to 0.23 mm.; shape about same as in first stage; body long, cylindrical, sides nearly parallel until fifth abdominal segment, where they begin to taper to blunt point. Color of thorax and abdomen slightly yellowish, last two segments of abdomen translucent white; alimentary tract plainly indicated by the brownish color given to it by inclosed food; this extends from the metathorax to the sixth abdominal segment. Surface of the body covered with minute granulations. Head quadrate, but with notch behind the eyes on each side; eyes reddish, ocelli absent. Antennæ 7-segmented, third and fourth distinctly spindle-shaped and annulated, fifth and sixth slightly annulated, and together with seventh segment quite slender. Legs translucent white. Abdomen 0.50 mm. in length, fusiform, ovipositor not formed; segments with rows of fine setæ, similar to those in adult, increasing in length toward posterior end, ninth and tenth segments equal in length (0.059 mm.).

The young nymph or prepupa (fig. 17, at left).—Length, 1.184 mm.; width of mesothorax, 0.3404 mm. Shape similar to adult. Head, length, 0.148 mm.; width at eyes, 0.1628 mm. Head translucent white, vertex slightly yellowish, ocelli absent, head

[a] For a full characterization of the genus and of the species see Hinds's Monograph of the Thysanoptera, pp. 168–170.

[b] After careful search the writer has been able to make out what he considers 7 segments in the antennæ.

deeply notched behind eyes; eyes red, made up of a few large facets, surface faintly reticulated; head rounded in front; a pair of setæ over rear angle of eyes, another pair in front of the eyes, and a third over the antennæ. Antennæ translucent, extending forward about twice the length of the head and composed of 7 segments; first segment cylindrical, broader than long; second cylindrical, nearly twice as long as segment 1 and not so broad; third longer than second, base constricted but not pedunculate, and with constriction at third and two-thirds length from base, so that it appears to be made up of 3 segments; fourth spindle-shaped, about as long as third; 5, 6, and 7 short and slender and not very clearly defined. Segments bear few spines on sides.

Prothorax nearly one-half again as wide as long, sides rounded, posterior edge broadest, semitranslucent white to faint yellow, a few prominent setæ around edges. Mesothorax with prominent rounded angles, translucent white to faint yellow, surface faintly reticulated, wing-cases translucent white, distinct from each other, those of fore-wings extending to second abdominal segment and those of hind-wings extending to middle of second abdominal segment. Legs translucent white to faint yellow, strong. Abdomen shaped as in adult, white to faint yellow, last few segments translucent, eight rows of setæ in pairs, increasing in length from anterior to posterior end. Length of abdomen, 0.5956 mm.

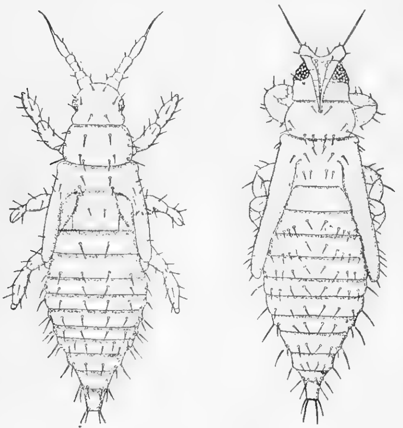


FIG. 17.—Greenhouse thrips: Prepupa on the left and pupa on the right. Enlarged about 40 diameters. (Original.)

The full-grown nymph or pupa (fig. 17, at right).—Length, 1.25 mm.; width at mesothoracic angles, 0.2812 mm. Shape similar to that of adult. Color translucent white to slightly yellowish. Head, length, 0.1628 mm.; width, 0.1924 mm.; translucent white, distinctly reticulated, eyes dark red, larger than in prepupal stage, facets large. Three ocelli present in close triangle between eyes, color chitinous yellow. Antennæ laid backward on head and reaching to near middle of prothorax, segments indistinct, translucent white. Segments 1 and 2 projecting in front of the head and 2 with a long spine extending forward, 0.1332 mm. in length. Thorax plainly reticulated, translucent white to faint yellow. Prothorax more than twice as broad as long. Wing cases 0.4736 mm. long, extending to near middle of fifth abdominal segment, translucent white to faint yellow. Length from head to end of wing-pads, 0.6512 mm. Legs translucent white to pearly white. Abdomen broader and shorter than in adult, contracted, but of same general shape, surface plainly reticulated, setæ well developed, the longest ones at posterior end. Length of abdomen, 0.6956 mm.; width, 0.3552 mm.; length of posterior setæ, 0.0888 mm.

HABITS OF THE ADULT.

After emerging from the pupæ, the mature thrips feed on the underside of the leaves for several weeks. They are not, as a rule, as abundant on the upper surface. One plant, on which there were about 150 adults, had only 3 or 4 of this number feeding on the upper surface of the foliage.

Adults walk over the leaf quite rapidly, and if disturbed they raise the tip of the abdomen and move rapidly away, walking in any direction. In a few cases they have been observed to jump when disturbed, but generally they simply move rapidly. The writer has never observed adults in flight, but that they do fly is certain, as he has found that plants free from thrips and at a distance from infested plants after a time will become infested by adults. As the study of the life history of this species was carried on in an unheated greenhouse with low temperature, it is quite possible that the adults were rendered sluggish. It seems strange that the writer has not observed their flight, for in studying this thrips he has examined a large number on plants and has purposely disturbed them to induce flight. Adults often remain motionless for long periods, and in such cases rest close to the veins of the leaf.

The eggs are laid singly in the tissues of the leaf, the female first making an incision with her ovipositor and then pushing the egg into the incision. She probably lays only 1 or 2 eggs in a day, as the eggs are large and the ovaries will hold only a few matured eggs at one time. One female examined had 6 eggs partly formed in her ovaries and 3 of these were quite small. As the leaves become exhausted from the feeding of larvæ and adults, the latter leave them and oviposit in fresh young leaves, so that in time the exhausted leaves are deserted and fall off and gradually the remainder of the plant becomes infested.

HABITS OF THE LARVÆ.

On March 5 larvæ were observed hatching from the eggs about 10 a. m. In all cases where larvæ emerged the leaf was marked by a dark spot and the surface was slightly swollen.

When first observed the head of the larva was projecting slightly out of a slit in the leaf epidermis, probably the same one that was made in depositing the egg, and the light red eyes were very conspicuous. Little by little the body is worked more and more out of the opening, and as it projects in the air, working vigorously back and forth, with its limbs folded against the body and invisible, it has the appearance of a minute worm in motion. When all but the tip of the abdomen is free the tiny larva remains quiet for a very short time, then one by one, beginning with the antennæ, but the legs in no regular order, the appendages unfold. The larva moves them around freely for a time and then, bending over, grasps the leaf surface and commences to pull, in an effort to free the end of the abdomen. After considerable work the larva frees itself and after a short rest moves around in search of a place to feed. Some only travel a few inches, others travel over a considerable portion of the leaf surface before settling down to feed. The time required for the larva to emerge varies from 6 to 12 minutes.

As a rule the larvæ are found on the underside of the leaves, but when crowded, as in severe infestations, they attack the upper surface.

While they will feed anywhere on the leaf, in many cases they will cluster together in colonies between two veins of the leaf. In one case observed by the author a number of larvæ hatched from eggs on one edge of the leaf and the next day were all feeding together on the opposite edge. In another case a colony of 85 larvæ was observed collected in a circle between two veins near the edge of the leaf. Many of the larvæ in this colony were moving around, but would not separate from the colony.

The larvæ when first hatched are minute and colorless, but as soon as they begin feeding the alimentary tract becomes plainly marked from the dark reddish fluid contained in it. This fluid is excreted and collects in globules on the tip of the abdomen, being held in place by the terminal setæ. The tip of the abdomen is elevated, and it is an interesting sight to see numbers of these larvæ moving over the leaf with globules of red liquid suspended in the air on the tips of the abdomen. When disturbed they become excited and move around rapidly, jerking the abdomen from side to side. The globule of liquid gradually increases in size until it is too large to carry, and is then left on the surface of the leaf, where it dries as a small reddish spot.

As long as the food supply in the leaf is fresh and abundant these arvæ will remain on it, and thus the number becomes very large. One leaf was found with about 250 larvæ, besides a number of pupæ and adults. If disturbed, or if the leaf is beginning to wilt and lose its vitality, the larvæ become restless, separate, and move around over the leaf in search of fresh food, but eventually many will collect again in colonies. They feed unprotected on the leaf, as far as their own efforts are concerned, but in many cases they secrete themselves under a slight web made by red spiders and are protected by it. Upon leaves exposed in part to sunlight the larvæ seek that part of the leaf which is the least exposed. They molt unprotected in the midst of the feeding colony. These larvæ are delicate little creatures, and if for any reason they are knocked from the plant most of them soon die, not being able to travel far in returning to the food plant.

HABITS OF THE PREPUPA AND PUPA.

The larvæ change to prepupæ in the midst of the feeding colony without seeking protected quarters, but nearly always on the underside of the leaf. The prepupæ move around a little on the underside of the leaf and generally are clustered in groups of from 4 to 10 prepupæ and pupæ. In many cases they are under the web of red spiders, but if no red spiders have been on the plant they are then unprotected.

The pupæ are associated with the prepupæ, but do not move about unless disturbed. Not only are the prepupæ more active than the pupæ, but they carry the antennæ in front of the head and frequently move them, while the pupæ have the antennæ laid back on the head and motionless. Neither prepupæ nor pupæ take any nourishment.

FOOD PLANTS.[a]

Heliothrips hæmorrhoidalis feeds on a large number of ornamental plants. In this country it has been recorded as feeding on the following: Liliaceous plants, azalea, *Pellea hastata*, aspidium, crotons, dahlias, phlox, verbena, pink, ferns, vines, cherry laurel, laurestina, palms, ficus, and fuchsia.

This year this thrips damaged the mango (*Mangifera indica*) at Miami, Fla., and was recorded [27] from St. Vincent and the Barbados Islands on cacao, kola, and the date palm. In Europe the following list includes most of the ornamentals preyed upon by this thrips: Ærides, azalea, begonia, camarotes, cattleya, crinums, dendrobium, eucharis, ficus, grape, lælia, lefortia, marcintacia, pancratium, phalenopsis, and viburnum.

LIFE HISTORY.

In order to study the life history of this insect, solitary females were put on isolated plants that were previously uninfested and carefully watched. An attempt to study isolated females, in small vials with bits of leaves, failed of results and after 2 weeks was discontinued.

Life cycle.—The life cycle, as detailed, is probably very near the maximum length, as the studies were conducted with the temperature of the house quite low, frequently falling to 50° F. at night. With these conditions the length of the egg stage is about 8 days, but possibly in a well-heated greenhouse this would be cut almost in half. The larvæ molt twice, the last time transforming to prepupæ, and during the cool weather require from 16 to 20 days to obtain full growth. The prepupal period is of short duration, occupying only from 10 to 15 hours, while the pupal period is from 4 to 5 days. This gives a total of 33 days as a maximum, and with favorable conditions this is probably reduced to 20 days or less.

Longevity.—The greenhouse thrips, for such a minute insect, has quite an extended duration of life and evidently feeds on the leaves for a number of days before starting egg-deposition. In one case ob-

---

[a] Since the above was submitted for publication some new food plants for this species have been reported. Dr. E. A. Back found it feeding on maples at Orlando, Fla., and on alligator pear (*Persea gratissima*). The fact that this insect feeds on the mango and alligator pear serves to indicate that at some time in the future it may be of great importance in Florida, as both are valuable fruits in that State.

served, no larvæ hatched until 19 days after the female was placed on a plant. This insect was about 1 day from the pupa when placed on the plant. Another female was observed for 4 weeks, when she disappeared, quite probably dying of old age. Probably this thrips lays from 10 to 20 eggs during her lifetime. The writer observed 10 larvæ on 1 plant with a single adult, and possibly some were killed by mites, etc.

Generations.—In greenhouses this insect is active during the entire year, so that the number of generations is quite large. Taking the maximum life cycle, this thrips might produce as many as 12 generations a year, provided that the species breeds continuously and conditions are favorable to rapid growth.

NATURAL CONTROL.

Rain.—In its native home this thrips is probably kept under control by frequent rains. At Miami, Fla., where hundreds of crotons are planted on hotel and private grounds, the author could find no traces of injury and collected only 1 adult. Crotons that were badly infested by this insect, kept in a greenhouse at Orlando, Fla., during the winter of 1907, were placed outside in June and by the end of the summer it was almost impossible to find specimens of the thrips on them. In times of drought this insect may increase in such numbers as to cause serious injury where it occurs in the open.

Natural enemies.—Frequently a mite is found on plants infested with the greenhouse thrips. On a few occasions the author has found thrips with one of these mites fastened to its dorsum. Specimens of this predaceous enemy were determined by Mr. Nathan Banks as *Lælaps macropilis* Bks.

ARTIFICIAL CONTROL.

EXPERIMENTS WITH REMEDIES.

FUMIGATION EXPERIMENTS.

A series of fumigation experiments was conducted against this insect in its occurrence on croton at Orlando, Fla. All were made in a small, fairly tight room, containing 660 cubic feet.

Experiment No. 1.—April 27, 1908, at 4 p. m., a plant was fumigated all night with one sheet of nico fume. It was a cloudy, cool day, just after a rain, and a good breeze was blowing. On opening the room at 8.15 a. m. there was quite a pronounced odor of nicotine.

April 28, the paper below the plant was covered with this insect in all stages, and many were also found on the plant.

Result of the fumigation, counting the thrips on the plant:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	109	30	436	575
Alive	10	26	10	46
Per cent killed	91.6	53	97.6	92+

May 2, the plant was in fine condition and uninjured. About 10 live adults remained. No live larvæ were seen, but the leaves were covered with hundreds of dead ones.

Experiment No. 2.—May 16, at 5.45 p. m., a plant was fumigated overnight with one-half sheet of nico-fume paper. At 5.45 p. m. it was dark from rain clouds.

May 17, the plant was uninjured. Red spiders and mealy bugs were alive. Few thrips were on the plant.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	2	5	10	17
Alive	0	13	0	13
Per cent killed	100	27+	100	$56\frac{2}{3}$

Experiment No. 3.—April 28, at 5.15 p. m., fumigated a plant overnight with one sheet of aphicide. The sky was cloudy and there was a strong breeze. The plant had a few thrips on it.

April 29, when examined at 8.45 a. m., the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	30	1	6	37
Alive	3	0	2	5
Per cent killed	90	100	75	88+

May 2, the plant was in fine condition.

Experiment No. 4.—May 24, at 7 p. m., fumigated a plant with one sheet of aphicide. There was a strong breeze.

May 25, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	10	67	80
Alive	0	2	0	2
Per cent killed	100	$83\frac{1}{3}$	100	97+

Experiment No. 5.—May 22, at 6 p. m., fumigated a plant overnight with one-half sheet of aphicide. There was a strong breeze.

May 23, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	6	15	31	52
Alive	2	21	11	34
Per cent killed	75	$41\frac{2}{3}$	73.8	60.4+

Experiment No. 6.—April 30, at 8.30 a. m., a plant was fumigated with one sheet of aphis punk (=2 sheets of nico fume or aphicide) all day; cloudy. Toward the end of the fumigation the punk began to burn in strips, so it was not all consumed. It gave a very dense smoke. The room was opened late in the afternoon.

May 1, the plants were uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	0	3	10
Alive	14	11	18	43
Per cent killed	$33\frac{1}{3}$	0	14.2	18.8

May 2, live thrips were abundant on the plants.

Experiment No. 7.—April 30, fumigated with one-half sheet of aphis punk (equal to 1 sheet of other kinds), but as it did not burn up, the house was opened at 5.30 p. m. and a fresh piece put in. The fumigation lasted all night. This piece also burned in strips and a third was not consumed.

May 1, the plants were uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	0	2	3	5
Alive	11	13	15	39
Per cent killed	0	$13\frac{1}{2}$	$16\frac{2}{3}$	11+

It seems that the thrips that drop to the ground have a better chance to recover than those on the plant.

Experiment No. 8.—May 1, at 5.15 p. m., fumigated all night with one-half sheet of aphis punk (fresh box from the factory). This was entirely consumed and the room well filled with smoke.

May 2, the plants were uninjured; red spiders were alive.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	68	1	42	111
Alive	4	24	1	29
Per cent killed	94.4	5	97+	86.4

Experiment No. 9.—May 26, at 7 p. m., fumigated with one-half sheet of aphis punk (fresh box). Fumigation lasted all night. The sky was cloudy.

May 27, the plant was uninjured. The condition of the thrips was as follows:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	2	2	11
Alive	0	7	0	7
Per cent killed	100	22+	100	61⅑

Experiment No. 10.—May 20, at 5.50 p. m., fumigated with nico-fume liquid (1 tablespoonful = ½ ounce + 1 ounce water, vaporized over an alcohol lamp). The sky was partly cloudy. Sprinkled the plant with water.

The vapor rose slowly until 6 p. m., when small flies on the window began to drop. House flies were still flying around the room at 6.15 p. m., when the liquid was all evaporated.

May 21, the plant was uninjured. Red spiders were apparently all alive. A very careful examination of the plant failed to show a live thrips.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	74	12	8	94
Alive	0	0	0	0
Per cent killed	100	100	100	100

Experiment No. 11.—May 27, at 3.50 p. m., fumigated with nico-fume liquid (½ tablespoonful to 2 tablespoonfuls of water, vaporized). Sky clouded, breeze strong.

May 28, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	2	1	6
Alive	0	2	0	2
Per cent killed	100	50	100	75

Experiment No. 12.—May 21, at 6 p. m., fumigated with rose-leaf insecticide (29 c. c. + 25 c. c. water, vaporized over an alcohol lamp). The sky was cloudy, with rain falling.

May 22, the plants were apparently uninjured. Red spiders were alive.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	2	4	13
Alive	0	0	0	0
Per cent killed	100	100	100	100

Experiment No. 13.—May 18, fumigated with potassium cyanid (0.00$\frac{2}{3}$ gram per cubic foot. In 660 cubic feet used 4.4 grams potassium cyanid, 7.92 c. c. sulphuric acid, and 15 c. c. water). Time, 5.30 p. m. Sky clouded; temperature 82° F; breeze strong; length of fumigation, overnight.

May 19, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	8	0	1	9
Alive	2	17	54	73
Per cent killed	80	0	1.8	10.9

This strength was entirely too weak.

Experiment No. 14.—May 19 fumigated with potassium cyanid (0.02 gram per cubic foot. In room used 13.2 grams potassium cyanid, 26.8 c. c. sulphuric acid, and 53.6 c. c. water). Time, 6 p. m. Length of fumigation, all night. Temperature, 78° F.; breeze strong.

May 20, the plants were uninjured. Flies and bees in the room were all dead. Red spiders were alive. The thrips were all dead.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	10	28	41
Alive	0	0	0	0
Per cent killed	100	100	100	100

May 25, the plant was uninjured.

SPRAYING EXPERIMENTS.

Experiment No. 15.—February 25, sprayed very thoroughly with rose-leaf insecticide (1 part to 48 parts water) a large croton infested with this thrips in all stages. Gave the upper and under sides a very thorough spraying so as to cover entirely the surface and be sure to hit nearly all of the thrips. The spraying was done in the afternoon when the house became shaded from the sun. A fine spray from a small hand pump, common in greenhouses, was used.

February 26, examined the plant at 9.30 a. m. and find results as follows:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	34	5	5	44
Alive	1	2	2	5
Per cent killed	97.1	71.4	71.4	90

May 12, 1908, this plant had then a number of young thrips upon it again and a lot of adults that had flown onto it.

Experiment No. 16.— February 20, 1908, sprayed with cold water. Took hose and washed off all of the plants in the greenhouse with cold water. The next morning found the adults still common and also many larvæ on the crotons, but many leaves badly infested before washing were then entirely free from them. Probably the spraying with cold water washed away and killed 40 to 50 per cent of young thrips.

SUMMARY OF EXPERIMENTS.

The fumigation and spraying experiments in the control of the greenhouse thrips may be summarized as follows:

No. of experiment.	Date.	Method.	Material.	Amount per 660 cubic feet.	Per cent killed.	Injury to plant.	Status of red spider after treatment.
1	Apr. 27	Fumigation	Nico-fume paper.	1 sheet	92	None	Alive.
2	May 16	do	do	½ sheet	56.6	do	Do.
3	Apr. 28	do	Aphicide	1 sheet	88	do	Do.
4	May 24	do	do	do	97	do	Do.
5	May 22	do	do	½ sheet	60.4	do	Do.
6	Apr. 30	do	Aphis punk	1 sheet	18.8	do	Do.
7	do	do	do	½ sheet	11+	do	Do.
8	May 1	do	do	do	86.4	do	Do.
9	May 26	do	do	do	61+	do	Do.
10	May 20	do	Nico-fume liquid.	½ ounce	100	do	Do.
11	May 27	do	do	¼ ounce	75	do	Do.
12	May 21	do	Rose-leaf insecticide.	29 c. c.	100	do	Do.
13	May 18	do	Potassium cyanid.	0.00⅓ gram per cubic foot.	10.9	do	Do.
14	May 19	do	do	0.02 gram per cubic foot.	100	do	Do.
15	Feb. 25	Spray	Rose-leaf insecticide.	1 part to 48 parts water.	90	do	Do.
16	Feb. 20	do	Water in hose	Drenching	40-50	do	Do.

REMEDIES RECOMMENDED.

For the treatment of this pest there are a number of good remedies. The question as to the best method to employ depends upon the size of the house infested and upon the experience of the person engaged in treating the insect.

Fumigation with nicotine papers.—Any of the standard fumigating papers will give good results against this pest if they are strictly fresh and kept tightly sealed. Fumigation should be done at night in a moist atmosphere and the papers should be used at the rate of about 2 sheets for every 1,000 cubic feet of space. Early in the morning the house should be opened and thoroughly aired.

Fumigation with nicotine liquid extracts.—Liquid extracts of nicotine offer one of the best methods of greenhouse fumigation and against this pest are very successful. Those made up of 40 per cent nicotine should be used at the rate of 1 ounce to every 1,000 cubic feet of space and the weaker solutions at greater strengths. The preparation should be evaporated over small lamps or stoves, and to prevent scorching should be diluted with water, approximately two-thirds. Fumigation should be carried on at night in a moist atmosphere, and the house should remain closed all night.

Fumigation with hydrocyanic-acid gas.[a]—*When fumigating with hydrocyanic-acid gas great care should be taken, as this gas is fatal to all animal life.* The work must be conducted at night and *the plants should have dry foliage.* In treating this insect, use from 0.01 to 0.05 grams of potassium cyanid per cubic foot for from 2 hours to all night, the strength and length of exposure varying according to the tightness of the house and the kind of plants being treated, as there is considerable difference between various plants as to their resisting power to this gas.

Spraying with nicotine liquids.—Nicotine extracts diluted with water, if carefully applied to plants, will kill large numbers of the greenhouse thrips, but the great objection is that many are not hit by the spray, and therefore the plants become infested again in a short time.

Spraying with kerosene emulsion.[b]—It is quite possible that kerosene emulsion spray will be effective against the greenhouse thrips when used at the strength of 1 part of stock to 10 parts of water and it costs considerably less and is more readily obtained than the nicotine preparations. It should be very carefully prepared and used experimentally at first until the effect on the foliage of the different plants is noted. Care should also be taken to prevent a quantity of emulsion from collecting around the roots.

Water spray.—Frequent treatment with a stiff spray of water from a garden hose will tend to keep this insect down, but unless there are only a few plants it would be better to use one of the other remedies.

Any treatment for this insect should be repeated in from 7 to 10 days to destroy the young larvæ that have hatched from the eggs. This should be sufficient, but it may be best to give a third treatment in another week or two.

BIBLIOGRAPHY.

1. Bouché, P. F.[c]—Schädliche Garten Insecten, p. 42, 1833.
   Original description of the species.

2. Haliday, A. H.—Entomological Magazine, Vol. III, p. 443, 1836.
   Description of the female as *Heliothrips adonidum*.

3. Burmeister, H.—Handbuch der Entomologie, Vol. II, p. 412, 1838.
   Description of adult female and habits of insect.

---

[a] For complete directions for the use of hydrocyanic-acid gas, see Cirs. 37 and 57, Bur. Ent., U. S. Dept. Agr.

[b] For the method of making emulsions, see Farmers' Bulletin 127, pp. 22–23, or Cir. 80, Bur. Ent., U. S. Dept. Agr.

[c] Not seen by author.

4. Burmeister, H.—Genera Insectorum, Fasc. 5, 1838.
Short description and excellent colored plate of the adult female.

5. Haliday, A. H.—Walker, Homopt. Ins. Brit. Mus., p. 1102, Pl. VI, fig. 13, 1852.
Short description and figures of parts of head.

6. Heeger, E.—Fünfte Fortsetzung Sitzungsb. Kais. Akad. Wiss., Wien, IX, p. 473, Pl. XVII, 1852; separate, Wien, Gerold, VIII, pp. 3–4, 1852.
Description of egg and young stages and adult with account of habits.

7. Bremi-Wolf, J. J.—Stett. Ent. Zeit., pp. 313–315, 1855.
Reprinted from Abh. Zurick Gartenbau-Geselle, 111, pp. 260–261. Short description and account of habits.

8. Löw, F.—Verhandl. k. k. zool.-bot. Ges., Wien, XVII, p. 747, 1867.
Brief account of injury.

9. Boisduval, J. A.—Essai sur Entomologie Horticole, pp. 233–235, fig. 32, 1867.
Description of adult, account of habits with long list of host plants, and figure of leaf injured by this insect.

10. Packard, A. S.—17th Ann. Rep., Mass. Bd. Agr., p. 263, pl. 1, fig. 2, 1870.
Short account of habits of this insect and a poor illustration of adult.

11. Cook, A. J.—3rd Ann. Rep. Pom. Soc. Mich., 1873–74, p. 501, 1874.
Brief notice in which this insect, mentioned as *Thrips adonidum*, is called a serious pest in Michigan.

12. Packard, A. S.—Half Hours with Insects, pp. 118–119, fig. 86, 1881.
This account is nearly identical with No. 10.

13. Pergande, Th.—Psyche, Vol. III, p. 381, 1882.
Brief note on occurrence out of doors, at Washington, D. C., Nov. 14.

14. Lefevre, E.—Entomologist, Vol. XV, p. 240, 1882.
Mentioned as injurious to greenhouse plants.

15. Lintner, J. A.—2nd Rep. Ins. N. Y., pp. 29, 31, 38, 56, 1885.
There is some doubt as to whether this insect or a leaf-hopper is referred to in the first, second, and third references.

16. —— ——.—Ann. Soc. Ent. Belg., Vol. XXIX, p. lxx, 1885.
Note on use of tobacco as a fumigant.

17. Jordan, K.—Zeitschrift für Wiss. Zool., XLVII, pp. 541–620, Pls. XXXVI–XXXVIII, 1888.
Anatomy and biology of Thysanoptera, with frequent mention of this insect.

18. Uzel, J.—Monographie der Ordnung Thysanoptera, pp. 168–170, Pl. VI, figs. 90–92, 1895.
Description of adult and figures of head, antenna, and wing.

19. Pergande, Th.—Insect Life, Vol. VII, p. 390, 1895.
Observations on this and other thrips.

20. Frank, A.—Die tierparasitären Krankheiten der Pflanzen, p. 134, 1896.
Short account of habits and advice as to remedies.

21. Davis, G. C.—Special Bull. No. 2, Mich. Agr. Exp. Sta., p. 13, 1896.
Brief note on occurrence in Michigan.

22. Buffa, P.—Estratto dalla Rivista di Patologia Vegetale, VII, Nos. 1–4, pp. 94–108; continued, VII, Nos. 5–8, pp. 129–135, 136–142, 1898.
Study of the external and internal anatomy of the species. Illustrated by 5 plates.

23. Tümpel, R.—Die Geradflügler Mitteleuropas, p. 290, 1901.
Description of female and poor figure in colors.

24. Chittenden, F. H.—Weekly Florists' Review, April 17, p. 739, 1902.
Short popular article on thrips in greenhouses.

25. Hinds, W. E.—Proc. U. S. Nat. Mus., vol. 26, p. 168, 1903. Issued as separate No. 1318, 1902.

Description of adult and account of habits as far as known.

26. Moulton, Dudley.—Tech. Ser. 12, Part III, Bur. Ent., U. S. Dept. Agr., pp. 43, 51–52, 1907.

Brief notes on characters and habits. Destructive to laurestinas out of doors.

27. Franklin, H. J.—Proc. U. S. Nat. Mus., Vol. XXXIII, p. 719, 1908.

Notes on occurrence out of doors in the Barbados.

U. S. D. A., B. E. Bul. 64, Part VII. Issued August 5, 1909.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.

(*Aræcerus fasciculatus* De Geer.)

By E. S. Tucker,
Special Field Agent.

INTRODUCTION.

While making field observations upon the cotton boll weevil during the past season (1908), a large plantation situated 6 miles south of Alexandria, La., was visited on September 18 and again on December 4. On my first visit at this place the overseer directed my attention to the work of strange weevils occurring in dried cornstalks in fields adjacent to cotton. Upon examination the larval and pupal stages and sometimes a few adults of the insects were found in the pith, at or close to the joints (Pl. III). These specimens were identified as the coffee-bean weevil (*Aræcerus fasciculatus* De Geer) (fig. 18), and the selection of cornstalks for breeding purposes places the species on record as a new enemy to be encountered in cornfields.

NATURE OF INJURY TO CORN.

According to the statements of the overseer, the working of these weevils in cornstalks during the past year was more noticeable than in the preceding season, when he first detected the insects at work. He claimed that the attacks began in green stalks before the corn matured and thus caused stunted ears. Being a close observer, he first noticed their attacks during the last week of August, while the stalks were still fresh and sappy, although the leaves had begun to dry. These facts prove beyond question that the larvæ were hatched within living tissues of the plants. Furthermore, he expressed a firm belief that the holes made by these insects for emergence from the stalks afterwards offer a retreat for cotton boll weevils, which may enter and hibernate in the pith. His opinion in this respect was supported by the claim that he had found boll weevils in such places at the time the land was being prepared for spring planting.

In the course of such work many old cornstalks were dragged out of the dirt that had been thrown over them by means of a "middle-buster" plow used for breaking the ground during November and December; and in two or three instances, which he remembered as having occurred in February, he found stalks with boll weevils secreted in the cavities evidently formed by the stalk pests.

At the time of my first examination the emergence holes and other signs of work by *Aræcerus fasciculatus* were not visible unless the leaves were stripped from the stalks as they stood in the fields. Centers of infestation were then located in different parts of the fields by breaking open a number of stalks to ascertain the extent of depredations. As most of the ears had been gathered, inspection of the greater part of the fields was freely made and infested sections of the stalks were collected. The damaged stalks broke easily at the joints where larvæ had worked, and usually but one injured place was found on a stalk. All attacks by the weevils at this time were

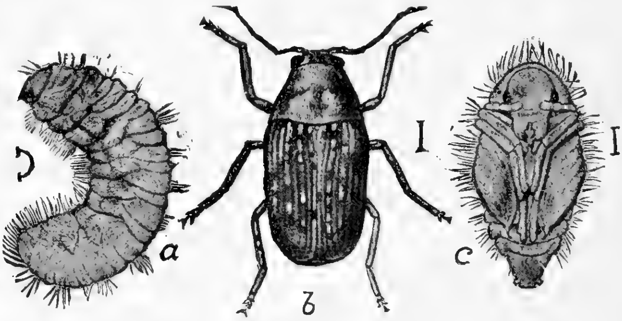
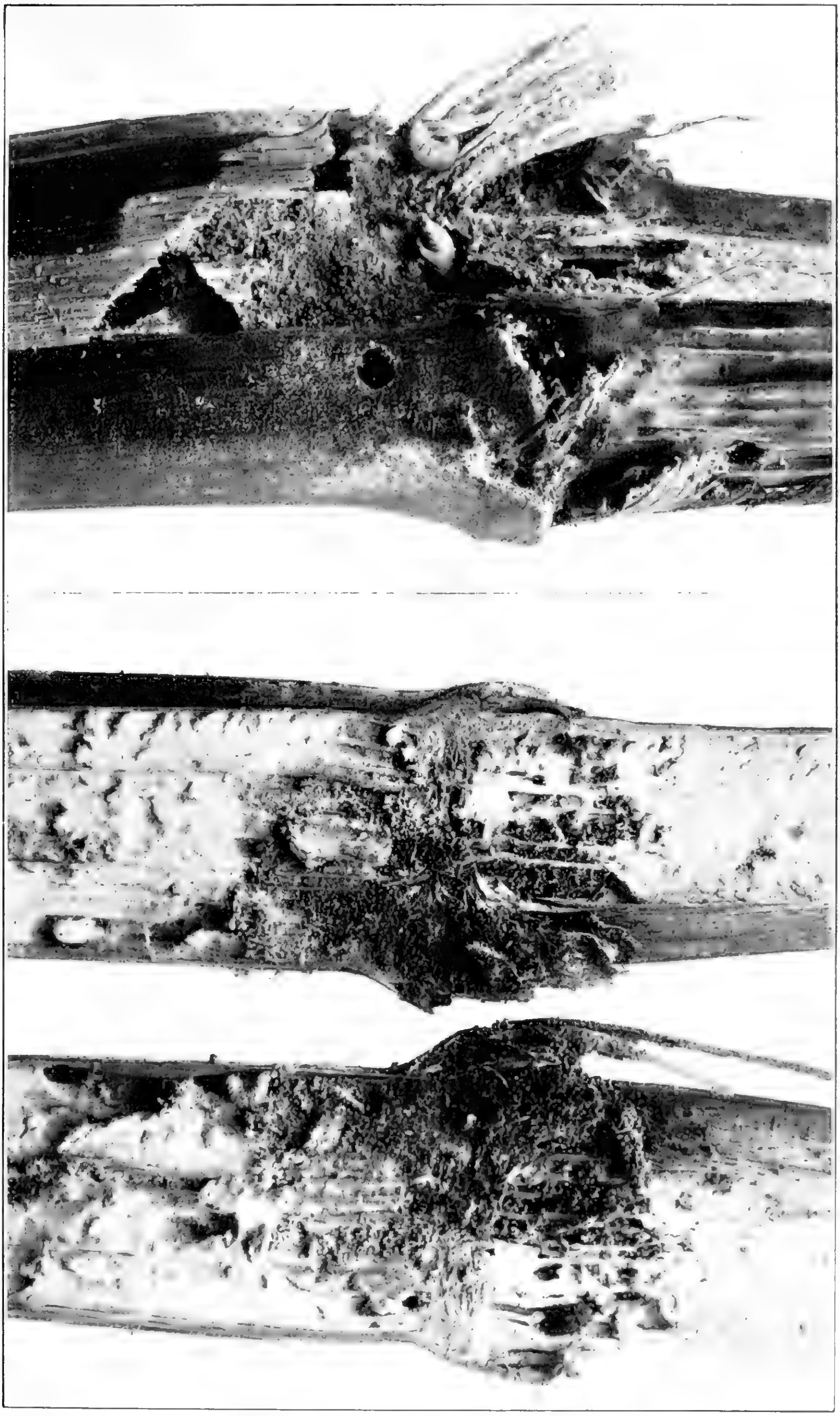


FIG. 18.—Coffee-bean weevil (*Aræcerus fasciculatus*): *a*, Larva; *b*, adult or beetle; *c*, pupa. Greatly enlarged. (From Chittenden.)

confined to the upper joints. These damaged joints varied in thickness from a little more than an inch to slightly less than one-half inch. The extra thick and hard structure of the lower joints was then thought to present unsuitable conditions for the breeding of the weevils, at least where the pith incompletely filled the stem. Further developments which were noted on my second examination showed, however, that the insects had bred extensively and worked downward into the lowest joints, their tunnels running through the pith from one joint to another. Since all stages were found again, the prospect for continual breeding of the weevils, which perhaps depends upon mild weather, seemed to be assured as long as the stalks were not destroyed. As previously observed, the effects of their work were most noticeable at the joints. The common occurrence of damaged stalks, which were readily detected on account of the emergence holes being exposed to view by reason of the partial loss of the leaves, indicated that the infestation was widespread.



WORK OF THE COFFEE-BEAN WEEVIL (ARÆCERUS FASCICULATUS) IN CORNSTALKS. (ORIGINAL.)

NOTES ON LIFE HISTORY IN CORN.

Judging from the appearance of damaged stalks when split open, the larvæ evidently begin work at a joint and form wide cavities, mainly in a crosswise direction, as they progress into the pith. All examples of their injuries showed that irregular portions of the pithy substance, excepting most of the fibers, had been reduced to a discolored, powdery condition, which was usually more pronounced above the joint than below it. The greater part of the time necessary for the growth of the grubs is probably spent in the excavation of these spaces to satisfy their demands upon the pith as a food supply. In preparation for the pupal stage the grown or nearly grown larvæ manifest a tendency to burrow into fresh pith some distance from the area of early operations. A considerable proportion of them does this; though few grubs proceed farther than 2 inches upward or downward. These burrows run in somewhat deflective courses, but when finished always terminate just under the hard surface of the stem and afford a convenient position at the far end for each insect upon attaining maturity to gnaw its way out, as was proved in many cases by an emergence hole being already cut to afford means of escape to the tenant. Nearly every closed burrow contained either a grown larva, a pupa, or an adult. These stages commonly occurred also in or close to the large primary cavities, indicating that not all the larvæ undertake special measures for pupation away from their original place of development, though all apparently provide for facility of emergence as adults, and the greater number perhaps complete their transformations in the same relative position. In fact, the greater number of openings appearing through the surface immediately surrounding the worst damaged places close to the joints shows that emergence is most frequently effected there.

OCCURRENCE IN CHINABERRIES; PARASITES.

The further records on the habits of *Aræcerus fasciculatus* are obtained from the notes on file at the laboratory of the Bureau of Entomology at Dallas, Tex., all of which pertain to the breeding of the species in berries of the chinaberry tree (*Melia azedarach*). Several larvæ and pupæ and one adult were found in the pulp of old chinaberries collected at Victoria, Tex., April 24, 1907, by Mr. R. A. Cushman. From other collections of similarly infested berries, made at the same place on May 12, by Mr. A. C. Morgan, adult weevils first emerged seven days later, and on the 27th and 28th of the same month the first rearings of parasites were recorded. These parasites represented a species which was later described by Mr. J. C. Crawford as *Cerambycobius cushmani*, and further developments not only proved it to be the most important enemy of *Aræcerus fascicu-*

latus, but highly inimical to the cotton boll weevil. Numbers of these parasites, together with *Eurytoma tylodermatis* Ashm., which also attacks the boll weevil, matured during the following June and July from another lot of old berries infested by the immature stages of *Aræcerus fasciculatus*, the material having been collected by Mr. Cushman on June 11. Other species of parasites were reared from these lots, but so far remain undetermined. The latest date recorded for the emergence of weevils in confinement was July 11, but under natural conditions these insects probably breed continuously throughout the season in berries which are apt to be hanging on trees or falling from them at all times of the year.

During the past year opportunities permitted me to make personal observations upon the work of these weevils in chinaberries. While at San Augustine, Tex., on March 22, my attention was drawn to an infestation occurring in both fallen and hanging berries. Fallen berries in a soft, shriveled, or rotting condition frequently contained well advanced larval stages. Seldom were more than one or two grubs found in a berry. The larvæ in hanging berries were generally younger. Some of the hanging berries contained very small grubs, evidently newly hatched, that had scarcely begun working in the firm pulp. The falling of infested berries seemed to be induced by the softened condition resulting from the more advanced work of the larvæ, and the pupal stage must necessarily be passed in fallen berries. Collections of these berries were placed in breeding boxes, and adult weevils emerged from April 16 until June 16, but no parasites appeared, probably because of the earliness of the collection. On March 25, at Longview, Tex., the species was again taken by me, but only fallen berries were examined. A live adult was removed from one berry.

At Monroe, La., on the 21st of the same month, Mr. R. A. Cushman made an interesting find in regard to a new enemy of the coffee-bean weevil. In a number of infested berries one weevil larva was found to be attacked by a new species of mite belonging to the genus Pediculoides. This mite is also known as an enemy of boll weevil larvæ.

HABITS IN GENERAL.

Previously published records of *Aræcerus fasciculatus* show it to be a common insect in warm climates, and that it has no particular food preferences. It is as likely to be found breeding in beans or any stored dry vegetable products, including dried fruits, as in dry pithy stalks, and is commonly found breeding as a scavenger in dry decayed cotton bolls. In common with most other weevils, the adults feign death for a short time when disturbed, and then suddenly become active and seek to escape.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE WOOLLY WHITE-FLY: A NEW ENEMY OF THE FLORIDA ORANGE.

(*Aleyrodes howardi* Quaintance.)

By E. A. Back, Ph. D.
Agent and Expert.

INTRODUCTION.

The attention of entomologists is called, for the first time, to the discovery in this country of a new species of *Aleyrodes* which attacks citrus trees. In view of the widespread havoc played among the orange groves of Florida by the citrus white-fly (*Aleyrodes citri* Riley and Howard) and the spotted-wing white-fly (*Aleyrodes nubifera* Berger), the appearance among the orange trees at Tampa of another aleyrodid which has already demonstrated itself to be of economic importance is of interest, if not, indeed, a subject for considerable concern.

During a recent examination of orange trees along several of the streets in the business section of Tampa in connection with government white-fly investigations that are being carried on in Florida by the Bureau of Entomology, the attention of the writer was attracted to dense white and grayish woolly secretions on the under surface of many leaves. At first this was supposed to be a heavy infestation of the rather scarce *Paraleyrodes perseæ* Quaintance, but on closer examination proved to be *Aleyrodes howardi* Quaintance, up to the present time known only to infest orange trees on several of the West Indian islands, especially Cuba.

INJURY AND EXTENT OF INFESTATION.

At present very little is known of the capacity for injury possessed by this aleyrodid. Mr. C. L. Marlatt, Assistant Chief of the Bureau of Entomology, found it quite abundant, locally, on several of the old orange trees at Artimisa, Cuba, but at that time (1905) noted that it had spread but slightly into the surrounding younger citrus groves. When describing it for the first time Prof. A. L. Quaintance [a] stated that, judging from its abundance on leaves sent to the Bureau of Entomology from Cuba, it was a very serious pest of the Cuban orange, possibly rivaling the well-known citrus white-fly in Florida. Whatever damage it is causing in Cuba, where it may be partially held in check by parasites and predaceous enemies, it has shown itself capable of rapid multiplication and spread in its new home at Tampa. Notwithstanding the fact that it has not been observed in Florida before, although many trees now heavily infested have been under casual observation during 1907 and 1908, it has become well established over a very large portion of the city, spreading northward beyond Michigan avenue and eastward about 2 miles, into Ybor City. Orange groves in the more elevated portions of the city are thoroughly infested, hence it is safe to presume that the pest is well established in the western section of the city.

From the present infestation it appears that the insect first secured a foothold along the water front, and this points to its possible importation from Cuba. In this section neglected worthless trees along the streets and in dooryards are in many cases heavily infested. While it appears to be rivaling the citrus white-fly in the extent of its attack on some trees, it is improbable that it is capable of causing such widespread disaster; nevertheless, if it becomes abundant in a grove, it will prove a source of no little aggravation and discomfort to those working in the trees because of the large and extremely viscid drops of honeydew which collect over the bodies of the insects, and later become embedded in the copious waxen secretions.

LIFE HISTORY.

Nothing has been published regarding the life history of this aleyrodid aside from the statement made by Professor Quaintance (l. c.) that the eggs lie prostrate on the leaf, and are arranged, more or less, in circles or curves. When discovered in Tampa by the writer on November 14, 1909, adults were abundant and depositing eggs upon both new and old growth, showing the usual preference for the former, and larvæ in all stages, as well as pupæ, were numerous. Later, on December 15, Mr. S. S. Crossman found adults abundant, and examination of material at this time showed that pupæ were still maturing. The last brood of adults of this species is, therefore, on wing later in the year than that of either the citrus or spotted-wing white-fly. Adults were noted by the writer on a visit to Tampa during late January.

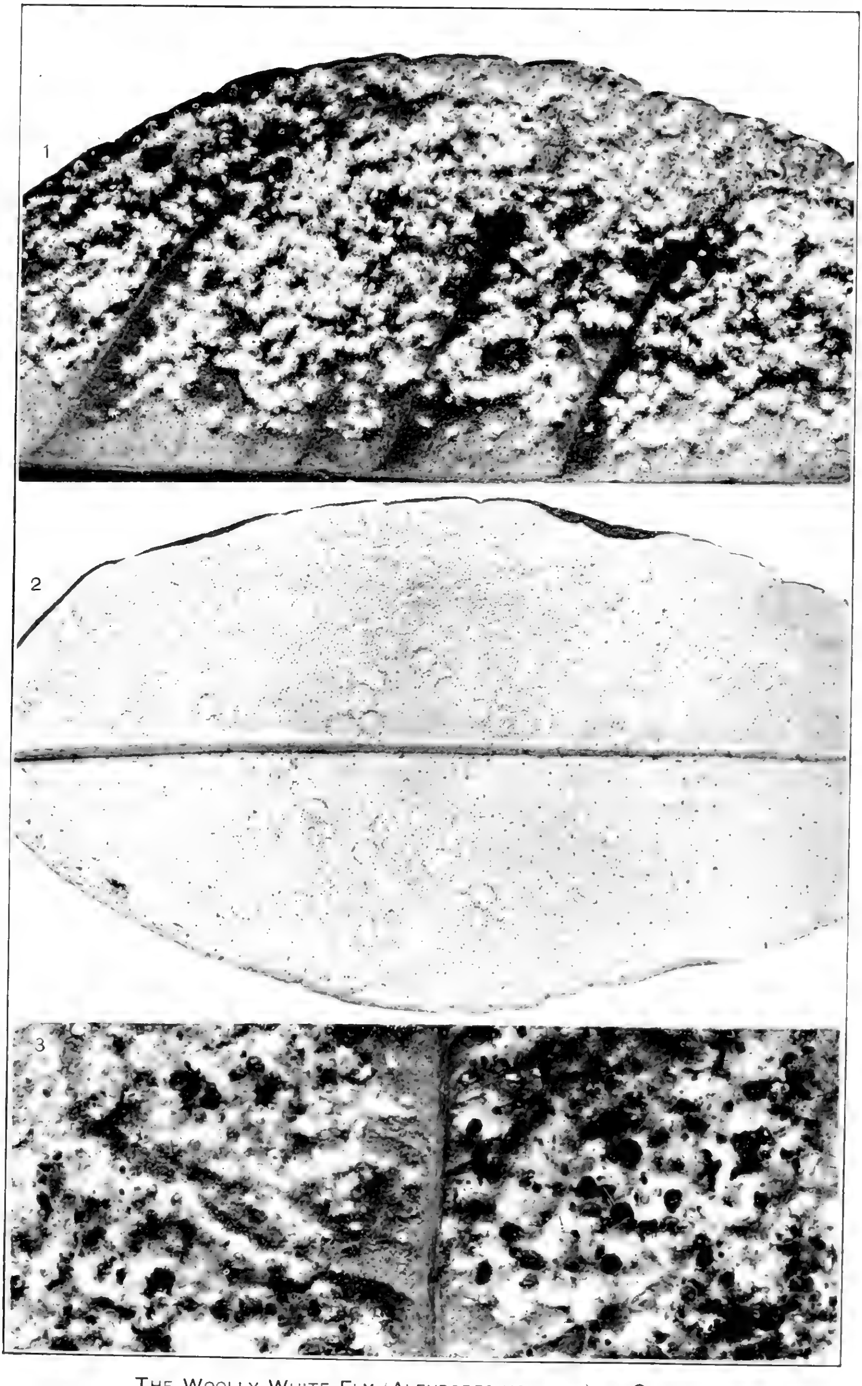
---

[a] U. S. Dept. Agr., Bur. Ent., Tech. Ser. 12, Pt. V, pp. 91–92, 1907. The more important Aleyrodidæ infesting economic plants, with description of a new species infesting the orange.

1

2

3



THE WOOLLY WHITE FLY (ALEYRODES HOWARDI) ON ORANGE.

Fig. 1.—Moderate infestation of leaf, showing many specimens in larval instars. Fig. 2.—Eggs on tender leaf. Fig. 3.—Heavy infestation of leaf, showing globules of honeydew embedded in woolly secretions overgrown by fungi. (Original.)

Unless molested or crowded each female deposits her eggs in a complete circle (Pl. IV, fig. 2), she being always on the inside (fig. 19, *c*). This arrangement she effects by using her mouth parts as a pivot upon which to rotate her body. Since often as many as 3 or 4 rows of eggs are present in one circle, it is evident that the female describes several circles while ovipositing before seeking a new place. Although as few as 27 eggs have been counted in a single circle and as many as 130 in a circle of 4 rows, it is probable that the larger number does not indicate the maximum egg-laying capacity, which, in the case of *A. citri*, has been found to be 222.

The eggs are whitish when deposited but soon turn to a dark-brown or blackish color and become partially covered by waxen secretions rubbed from the bodies of the adults. They are curved, the concave side being upward (fig. 19, *a*, *b*), and in hatching the membranes rupture along the median distal half of the upper surface and do not spring back into place after the larva has escaped.

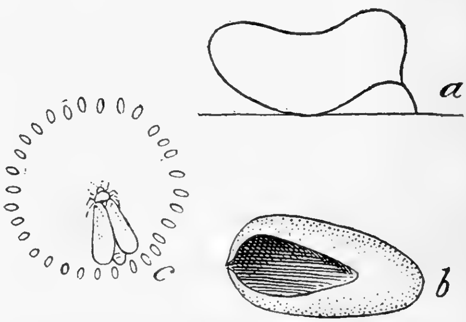


FIG. 19.—The woolly white-fly (*Aleyrodes howardi*): *a*, Egg, showing attachment to leaf; *b*, eggshell, viewed from above; *c*, female depositing eggs in a circle. *c*, Much enlarged; *a*, *b*, highly magnified. (Original.)

The larva after hatching crawls about before settling. It is yellowish, elliptical, with 9 pairs of marginal spines and 4 pairs of short, stout, dorsal spines. Soon after ceasing to crawl, it develops a short, inconspicuous, marginal wax fringe similar to that of the first instar of *A. nubifera* (fig. 20). In the second instar the marginal bristles are lost except one anterior and two posterior pairs, and the legs become unfit for locomotion as is the case with other aleyrodids. During this instar there develop 6 white abdominal cross-bands and a distinct, white, marginal fringe of wax, varying in width with age, often becoming 0.3 mm. wide; aside from these secretions, each of the dorsal spines secretes a long, outstanding waxen rod, of varying length, these rods being at all times characteristic of this instar (see fig. 21). After passing into the third instar the larva, except in point of size, assumes the appearance of the pupa; the marginal fringe and abdominal secretions found in the preceding instar remain practically the same, but these are largely or wholly concealed by the long, white, curling, and variously matted secretions which arise from along, but not on, the margin of the insect, giving to a leaf infested with this species a woolly appearance (Pl. IV, fig. 1) which, when infestation is heavy, entirely conceals the insect beneath. These threadlike secretions are often twice as long as the insect itself. At emergence the pupa case splits at the anterior end, down both the dorsal and ventral sides along the median line, on the dorsal side splitting back to the first abdominal segment. The empty pupa case is white and delicate. The adult insect of either sex is lemon-yellow, with pure-white wings, without darker markings; the ground color of the body being partially obscured by loose particles of waxen secretions. The adult resembles closely *A. citri*, the citrus white-fly, but carries its wings farther away from the body, thus leaving more of the abdomen exposed.

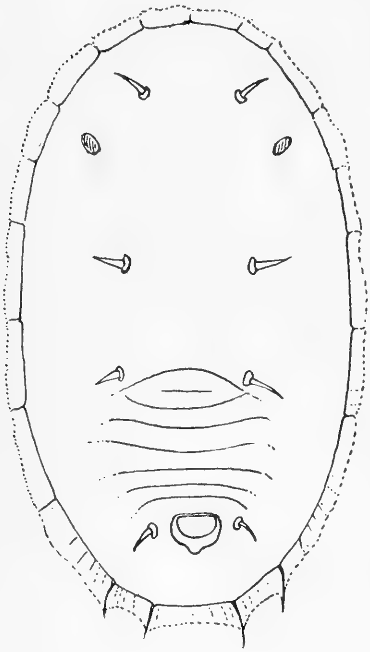


FIG. 20.—The woolly white-fly: Larva of first instar, dorsal view, showing spines and marginal wax fringe. Highly magnified. (Original.)

A very characteristic feature of this species, as compared with any of the Florida Aleyrodidæ now known to the writer, is the globule of honeydew which collects over the vasiform orifice, often becoming so large as to conceal the posterior half of the body, and resembling somewhat the secretions of the persimmon Psylla. These globules are extremely viscid and make the handling of leaves infested with this aleyrodid very disagreeable. They collect in large numbers in the waxen secretions on heavily infested leaves (Pl. IV, fig. 3) and both they and the secretions become grayish and dust-laden with age. The globules frequently become overgrown by a rank growth of greenish-brown fungus resembling the hyperparasitic species attacking the yellow white-fly fungus, *Aschersonia flavocitrina*.

DESCRIPTION.

A detailed description of *Aleyrodes howardi* follows [a]:

The egg.—Length, 0.2 mm. to 0.19 mm.; width, 0.1 mm. to 0.088 mm. Uniformly brownish in color, smooth, without reticulations or waxy secretions; curved, lying prostrate on leaf, with convex side approximating latter, attached by short stalk arising from convex surface about one-fourth distance from base to tip of egg. Eggs deposited more or less in complete circles; spaces between eggs often filled with waxy secretions rubbed from body of adults. (See fig. 19.)

[a] The original description of the pupa by Professor Quaintance has been used but amplified by the writer.

The larva, first instar.—Size about 0.26 mm. by 0.13 mm.; elliptical, yellowish-white, with 9 pairs of short marginal bristles, arranged as in figure 20, the two posterior pairs longest, the relative lengths being as follows:

Pair	1	2	3	4	5	6	7	8	9
Relative lengths	2	2.5	6	4	5	5	4	8	8

After settling, an inconspicuous, transparent, marginal wax fringe develops, but little exceeding in width the length of the marginal spines. Eyes reddish-brown, usual. Dorsum with 4 pairs of short stout spines; 1 pair cephalad and mesad of eyes, 1 pair at vasiform orifice, and 2 pairs on central region between the fifth and sixth, and sixth and seventh pairs of marginal spines, respectively. Legs and antennæ well developed, usual; vasiform orifice similar in shape to that of pupa, but without apparent strong setæ.

The larva, second instar.—Size, about 0.38 mm. by 0.22 mm. All marginal bristles lost except 2 pairs of minute bristles, one at anterior, the other at posterior end of body. Four pairs of bristles on dorsum located as in first instar, but different in that when wax secretions are removed, the first 3 anterior pairs are stout spindle-shaped (fig. 21, *a*), the fourth pair at vasiform orifice, long and slender, as in pupal stage; a fifth dorsal pair at caudal end of body but not on margin, similar to those in pupal stage. Color, brownish or black; margin with narrow white wax fringe, equaling at times 0.3 mm. Instar conspicuous because of long single, stout, outstanding waxen rods secreted by each of the spindle-shaped dorsal spines, and 6 abdominal cross bands of white waxen secretions. Insects well advanced in this instar, after the dorsal waxen rods have developed, present a profile similar to that shown in figure 21, at *b*.

FIG. 21.—The woolly white-fly, second larval instar: *a*, Spindle-shaped spine; *b*, diagrammatic profile, showing characteristic wax secretions. Highly magnified. (Original.)

The larva, third instar.—Size, about 0.58 mm. by 0.38 mm. Except in point of size, this resembles the pupal instar in all respects. The spindle-shaped spines of the previous instar are replaced by ordinary strong bristles.

The pupa.—Size, about 0.9 by 0.55 mm., subelliptical in shape. Many specimens with more or less evident indentures on cephalo-lateral margin of case, with cephalic end obtusely pointed. Color, on leaf, under hand lens, with secretions removed, yellowish-brown varying to blackish; under transmitted light, yellowish to brownish-yellow. There is a distinct marginal rim all around, with wax tubes distinct, the incisions acute and tubes rounded distally. From margin of case all around arises a short rim of wax, composed of individual wax-threads, serrated on margin as seen under a high-power microscope. Pupa usually quite covered by a very copious secretion of whitish, curling wax-rods which is very conspicuous in badly infested leaves, quite hiding the insects beneath (Plate IV, fig. 3); these waxen filaments often much greater in length than the insect's body, spreading outward when insects are not crowded, but upward when crowded; and arising from along the outer portion of the case, but not on the margin itself from which the above-mentioned distinct waxen fringe arises. Dorsum of pupæ with many wax-secreting pores; the secretions very short, irregular upon the cephalothoracic region, and on the abdominal portion arranged in cross bands on each segment, being most dense on the middle of the segments. Denuded of secretions, the pupa case is seen to be at first almost flat, but later becoming rather convex as the insect develops, with segments distinct.

Dorsum with pair (1) of strong setæ on first abdominal segment, a pair (2) at vasiform orifice, and a pair (3) at, but not on, caudal margin extending some distance beyond margin of case. There is also a pair of minute marginal spines (a) at the anterior end, and another (b) at the posterior end of body. The relative lengths of these spines are as follows:

Pair	1	2	3	a	b
Relative lengths	14	16	10	1.5	2.5

There is also a pair of small bristles on the venter beneath the vasiform orifice. Vasiform orifice relatively small, subcordate, the rim dark brown, from 6 to 8 strong setæ or spines arising from caudal margin; operculum largely filling orifice, the distal margin with two faint notches; lingula not distinguishable. (See fig. 22.)

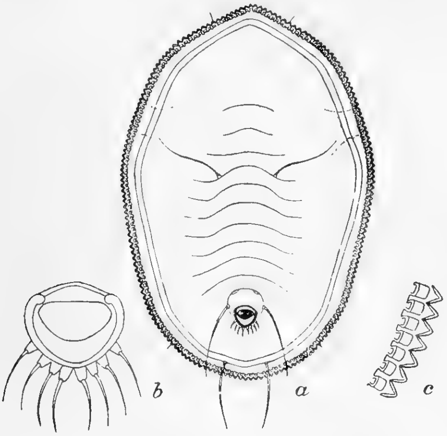


Fig. 22.—The woolly white-fly: Pupa case and details. Greatly enlarged. (From Quaintance.)

The adult.—Usual, lemon-yellow, after emergence becoming coated with white waxen secretions; wings pure white, without darker markings, held along sides of abdomen, but not meeting over the dorsum. A considerable amount of flocculent white wax is secreted, but not as copious a supply as is secreted by the adult of *P. perseæ*. In female: Length of body, 0.42 to 0.47 mm.; length of fore wing, 1.1 mm.; width of fore wing, 0.36 mm.; length of antenna, 0.31 mm.; length of hind tibia, 0.035 mm.; relative lengths of antennal segments as follows:

Segment	1	2	3	4	5	6	7	Spine.
Relative lengths	1.5	3	10	1.3	2.5	2.6	1.5	0.7

FOOD PLANTS.

The woolly white-fly infests the various species of citrus, the guava, and the mango. While found on the mango at Tampa by the writer, its presence on this plant is probably the result of accident. Mr. W. L. Tower is authority for its occurrence on guava in Porto Rico.

DISTRIBUTION.

This species occurs on several islands of the West Indies, but more especially in Cuba. It is now established at Tampa, Fla.

NATURAL ENEMIES.

While no predaceous insects are known to attack this aleyrodid, Cook and Horn[a] have reported it parasitized by the "red fungus,"

[a] Cook, M. T., and Horne, W. T., Cuban Exp. Sta. Bul. 9, p. 31, 1908.

Aschersonia aleyrodis, in Cuba, and Mr. W. L. Tower, entomologist of the Porto Rican Experiment Station, reports that in Porto Rico it is held in check by fungi (undetermined).

REMEDIES.

So far as known to the writer no remedial measures have been adopted against this pest up to the present time. Its recent discovery has not made it possible for experiments leading to its control to be concluded although such experiments are now in progress. From present indications it seems probable that this white-fly will be more easily controlled by fumigation than by spraying, inasmuch as when nearly mature it is very well protected from spray liquids by the secretions mentioned above. Present indications are that during the early larval instars it is as well controlled by spraying as are the citrus and the spotted-wing white-flies, with which it is found associated.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON A COLORADO ANT.

(*Formica cinereorufibarbis* Forel.)

By H. O. Marsh,
Agent and Expert.

INTRODUCTION.

A medium-sized ant, known scientifically as *Formica cinereorufibarbis* Forel, is one of the most common species occurring in the vicinity of Rocky Ford, Colo. The nests which it constructs along the fences and irrigation ditches are mounded up very little or not at all, but often cover a considerable area. Sometimes these nests are 3 or 4 feet in length by 2 or 3 feet in width, and they always have several openings.

During the growing season this species of ant is always to be found in attendance on various species of aphides or plant lice. During the summer of 1909 it was most commonly found together with the melon aphis (*Aphis gossypii* Glov.) on cucurbits, and with *Chaitophorus populicola* Thos. on cottonwood. The ants were also observed attending a species of Membracidæ on alfalfa, and late in the season after the leaves had fallen great numbers were found clustered and feeding upon crushed overripe cantaloupes, sometimes out in the field 25 yards from any ant nests.

As the ants were almost invariably to be found on aphis-infested cantaloupe vines, many of the growers are of the opinion that they are responsible, in part at least, for the spread of the aphides from one vine to another. There is also a rather general idea that the ants take the aphides into their nests in the fall, protect them throughout the winter, and then bring them out in the spring and put them upon the plants.

INJURIOUS HABITS.

There appears to be but little foundation for believing that the ants harbor the melon aphis during the winter, and after careful watching the writer has never seen any aphides being carried into the nests. However, these ants do protect the aphides from their natural enemies on the growing plants, and it is a common thing to see the ants busily engaged in killing and carrying off the syrphid larvæ, which were doing good work in destroying the "lice." They were also repeatedly observed carrying away adults of the convergent ladybird (*Hippodamia convergens* Guer.), the nabid bug *Reduviolus ferus* L., and a species of Chrysopa. The ladybird larvæ apparently were not molested, while the beneficial syrphid larvæ were objects of special attack, and it was not unusual to see as many as ten or twelve larvæ being carried away from a single vine at a time. Wherever the ants were abundant the syrphid larvæ were noticeably reduced in number, and the aphides thus had a better chance of increasing. The ants appear to use the syrphid larvæ as food, as they were observed carrying them into their nests, which, in several cases, were 12 or 15 feet from the vines infested by the aphides.

EXPERIMENTS WITH POTASSIUM CYANID AS A REMEDY.

As frequent inquiries were made by the melon growers concerning possible remedies for use against the ants it was decided to conduct a series of experiments. Owing to the large number of nests which occur along practically every fence and ditch, and to the large size of the nests, and particularly to the fact that each nest has several openings, it was obvious that carbon bisulphid would be too expensive for practical use with this species, and it was decided to make the experiments with various solutions of potassium cyanid. The object of these experiments was to determine if repeated applications would materially reduce the number of the ants and, if the ants were thus reduced, what effect it would have on the melon-aphis problem.

In making these experiments a strip about 80 yards in length was selected along a fence at the edge of a cantaloupe field. This strip was bordered along one side by a common road or highway and occupied along the center by a row of elm trees which were too small to cause any shade worth mentioning, as none of them was over 4 inches in diameter at the base. There were at least twenty-five distinct nests in this strip, and the ants occurred by thousands. Cantaloupes had been planted in the field along this strip for several successive years, and each year the first few rows nearest the fence were infested by melon "lice," while the vines which were beyond the convenient range of the ants were not infested, or at least not until later in the season. The owner of the cantaloupes was firmly convinced that the ants were responsible for the infestation of the first few rows and welcomed any attempt to destroy them.

In order to determine the cheapest and most practical solution the following preliminary tests were made:

Experiment No. 1.—One-half ounce of 98 per cent cyanid of potash dissolved in 1 gallon of water was used. On August 31, 1909, at 5 p. m., 2 gallons of this solution were applied to a nest 2½ feet in length by 2 feet in width. The entire outer surface of the nest was soaked and a considerable quantity was poured directly into the openings. Ants which were hit died almost at once and others which returned from the field and ran over the wet surface died within a few seconds. When the nest was examined an hour later the surface was well covered with dead specimens. There was still a fairly strong odor of the cyanid from the wet soil and returning ants were soon killed, although they did not die quite as rapidly as when the application was first made.

Experiment No. 2.—One ounce of 98 per cent cyanid in 1 gallon of water was used. On August 31, between 5.30 and 5.45 p. m., 4 gallons of this solution were applied to two nests, each about 3 feet long and 2 feet wide. The conditions were as in Experiment No. 1 and the immediate results appeared to be about the same.

Experiment No. 3.—Two ounces of 98 per cent cyanid in 1 gallon of water were used. On August 31, at 6 p. m., 2 gallons of this solution were applied to a nest about 3 feet long by 2 feet wide. The immediate results appeared to be about the same as in Experiments Nos. 1 and 2, although there was a somewhat stronger odor of the cyanid from the wet soil.

At the time these three tests were made the sun was warm and shining brightly. The ants were very active and thousands of them were away from the nests and among the aphis-infested cantaloupe vines.

Since the larger lumps of cyanid dissolved rather slowly some time was gained by breaking them up with a hammer.

At 4 p. m. on September 1 an examination was made of the nests treated in these tests. At that time there were hundreds of dead ants lying on the surface of the nests and a comparatively small number of specimens was running about. Most of the living ants had apparently lost interest in the aphides and had gathered on or about the treated nests and some were carrying dead specimens. There appeared to be little difference between the results of Experiments Nos. 1 and 2, but there were certainly fewer live ants about the nest treated in Experiment No. 3 than about the others.

As some fear was felt that a strong solution of the cyanid might kill the small elm trees which occupied the ant-infested strip and as Experiment No. 1 gave comparatively good results, it was concluded to continue the work with that strength. Accordingly, between 4.30 and 6 p. m. on September 1, the remainder of the infested strip, about 65 yards in length and containing 21 nests, was treated with

28 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. At the time of this treatment there were thousands of ants either actually in attendance on the "lice" or running about between the nests and the infested cantaloupe vines.

At 6 p. m. on September 2 the treated strip was examined. Dead ants by thousands, at some places in heaps, were lying on or about the nests. Many dead specimens were also found out in the field from 6 to 10 feet from the nests. However, at every nest there were still a few live ants. Practically all of these survivors had gathered about the nests and it was difficult to find a live ant out in the field, where at the time of the treatment they occurred in surprisingly large numbers.

In order to test the effect of a second treatment applied soon after the first, two nests near the center of the strip were given a second application at 5.30 p. m. September 3. This was considered as Experiment No. 4. In this experiment 2 gallons of solution at the rate of one-half ounce cyanid to each gallon of water were applied to each nest as before.

An examination made of these nests on the following afternoon (September 4) showed that although a few additional ants had been killed no practical advantage had been gained by this treatment, and this conclusion was not altered by frequent later examinations.

Along the entire treated strip the ants which remained alive seemed demoralized for about a week, but by September 11 several small colonies had again started. The cyanid solution does not penetrate very deeply into the nests and it is evident that the pupæ escape destruction unless they are very close to the surface, and on reaching maturity they are able, with the remaining live ants, to reestablish the colonies.

By September 16 one or two of these colonies (nests) had reached fairly good size and although the ants were moderately common they occurred in very much smaller numbers than they did at the time of the first general treatment (September 2). This first treatment left the nests with a "crust" of compact soil over the surface. At two or three nests, just under the crust, the ants had large numbers of pupæ and at a few other nests a considerable number of winged adults had crawled out and was clustered about the openings.

At this date (September 16) all the nests in the entire strip were again treated with 25 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. A particular effort was made to soak the winged specimens and the pupæ. All the adults touched were readily killed, but the pupæ showed no immediate effect from the treatment.

An examination made on the following afternoon showed that although the number of ants had been very considerably reduced there were still some living specimens at each nest. The pupæ at the treated nests seemed to be dead and the living ants paid no attention to them. It was observed that at two places quite a number of pupæ had been overlooked and not soaked by the solution and at another place a moderate number of winged specimens had crawled from an opening of an untreated (overlooked) nest.

By September 27 about a dozen small, weak colonies had started, and on the following day between 4 and 5 p. m. all the inhabited nests were again treated with 25 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. In this treatment all the openings in the nests were enlarged with a pointed stick and from a quart to a gallon of the solution poured into each. At this date many of the cantaloupe vines had been trampled down by the pickers or had died from disease or other cause. As a result there was not a very good supply of aphides in the immediate vicinity of the nests and the ants were mostly close about or in the nests. At two places many pupæ were present and at another nest there were a good many winged specimens.

Examination made on the following day (September 29) showed that there were still a few living ants about the nests, and the pupæ were still light in color and did not appear to be dead. A day later some of the pupæ appeared to be still alive, but as all of these were embedded in the moist soil, where the living ants paid no attention to them, they certainly could not have survived. At this time there was no odor of the cyanid over the nests, but when lumps of the moist soil were picked up the odor from them was quite apparent.

Repeated examinations made of the treated strip during October and November showed that the ants had almost completely disappeared, while at untreated (check) nests they occurred in large numbers. It would be interesting to know what became of the few specimens which survived the last treatment. Possibly they became discouraged and went to less troubled quarters.

It is evident that from experiments of this nature definite or final conclusions can not yet be reached. The work was begun so late in the season that the rather gradual decrease in the number of the ants had no marked effect on the melon aphis. It showed that to keep this species within reasonable bounds repeated applications of the cyanid and constant watching are necessary. As this would require so much more attention than the ordinary farmer can be induced to give, it does not seem probable that this method will ever become very popular for this particular species of ant, unless it can be definitely proved that this species is a more important factor in the melon-aphis problem than it is now known to be. It is very probable that quicker results would have been obtained if a stronger solution had been used.

At Rocky Ford, Colo., 98 per cent potassium cyanid was obtainable in small lots for 50 cents a pound. When used at the rate of a pound in 30 or 32 gallons of water this makes a comparatively cheap solution.

Although this solution is extremely poisonous, there need not be undue risk to human beings from its use if proper care is exercised in preparing and handling it. When leaning over a half barrel of the solution for the purpose of stirring it or dipping out pailfuls, the fumes were quite noticeable and, with the writer, caused a slight dull headache which lasted a short time. Although in applying the solution the writer's hands were frequently wet with it, and no ill effects resulted, yet it would be safer to keep the solution from coming into contact with the skin. Some persons are peculiarly susceptible to this poison, and with some its contact with the skin causes a rash. Persons with weak hearts should be especially careful not to inhale the fumes.

U. S. D. A., B. E. Bul. 64, Part X. Issued November 12, 1910.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE PECAN CIGAR CASE-BEARER.

(*Coleophora caryæfoliella* Clem.)

By H. M. Russell,
Agent and Expert.

INTRODUCTION.

Among the insects of minor importance that affect the pecan, the pecan cigar case-bearer (*Coleophora caryæfoliella* Clem.) is probably met with in groves more than any other species. At times the insect occurs in such numbers as to defoliate entire trees, checking their growth and considerably reducing the crop of nuts. In the future this insect is likely to cause increasing damage as the acreage in pecans increases, and it may become as great a pest to the pecan as *Coleophora fletcherella* Fernald is to the apple. The occurrence of this insect in large numbers at Orlando, Fla., during the spring of 1909 presented the opportunity of studying it, and the results are given in this article. The dates for appearance of the different stages are for that locality. These dates will undoubtedly vary as we go northward.

EARLY HISTORY.

Clemens[1][a] first described this species in 1861, as *Coleophora caryæfoliella*, from larvæ found feeding in their cases on leaves of hickory during the fall. He gave a short description of the larva and case, but did not succeed in rearing the adult.

In 1872 Clemens's original description[2] was republished in his "Tineina of North America," edited by H. T. Stainton.

Chambers,[3] in 1874, described the adult under the name *Coleophora rufoluteella*, from specimens captured in Kentucky in June.

Writing again in 1878, Chambers[4] places his *rufoluteella* as a synonym under *caryæfoliella*. He wrote at that time: "*C. rufoluteella* Cham. is known only from captured specimens. I am, however, utterly unable to distinguish it from specimens bred by me in the latter part of June from larval cases found feeding on hickory leaves

[a] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 86.

in the manner described by Doctor Clemens for *caryæfoliella*, and I believe it to be the same species."

During 1882 Lord Walsingham[5] identified a specimen, reared from *Prunus americana*, as *C. rufoluteella* which he thought to be distinct from *caryæfoliella*. Packard,[6] in 1890, wrote of this insect, under insects injurious to hickory: "The larva feeds in a cylindrical case attached to the under surface of the leaves."

During the same year there was published in Insect Life[7] a brief note recording the parasite, *Rhyssalus trilineatus* Ashm., as having been reared from this species on hickory at Washington, D. C., May 5, 1883.

Apparently nothing more was written until 1905, when Gossard,[8] in his bulletin on pecan insects, mentions what is undoubtedly this species as "*Coleophora* sp."

RECENT RECORDS.

May 5, 1901, Mr. L. O. McPherson, of Josephine, Ala., sent in larvæ of this species affecting the pecan. Writing of this attack, October 23, 1905, Mr. McPherson stated that in the year mentioned this insect entirely denuded a number of large trees of their leaves during May and June only.

June 3, 1907, the larval cases of this insect were observed on pecan at Orlando, Fla. March 16, 1908, the winter cases of these larvæ were found clustered together on twigs of pecan in a deserted grove outside of Orlando. April 2 and 7, 1908, the larvæ were again observed at Orlando, Fla. They were just leaving their winter cases for the larger spring cases.

In 1909, during April and May, several large trees in the grove of Mr. C. W. Townsend, of Orlando, Fla., were almost completely prevented from putting out foliage until weeks after other trees had done so, because the larvæ of this species were so numerous on the buds and leaves. May 11 found this insect causing considerable defoliation to pecan trees at the old Standard Oil grove just west of Orlando, now owned by Mr. Long. At the same time it was abundant in all the groves around Orlando. On May 16 Mr. J. D. Mitchell, of this Bureau, reared this insect from leaves of pecan at Victoria, Tex.

DISTRIBUTION.

This species was first described by Clemens in a paper on North American Tineina, but the locality for his specimens is not given. V. T. Chambers records it from larval cases taken in Kentucky and records capture of the adult at Covington, Ky. Prof. H. A. Gossard records what is undoubtedly this species as met with on "almost every tree I examined for the purpose of finding it" in Florida. The author, while working in Florida during the years 1907–1909, found it in every grove examined around Orlando.

In the Bureau of Entomology and the U. S. National Museum there are specimens from McPherson, Ala.; Victoria, Tex.; Pittsburg, Pa.; Hampton, N. H.; Washington, D. C.; Virginia; and New York.

From these records of capture and injury, this insect seems to be distributed throughout the Austroriparian faunal area of the United States and may also extend into the Carolinian and into the lower edge of the Alleghanian areas.

FIG. 23.—Pecan twigs with buds and young leaves killed by pecan cigar case-bearer (*Coleophora caryæfoliella*). (Original.

FOOD PLANTS.

The pecan cigar case-bearer feeds principally on nut-bearing trees, and of these it has been observed feeding on walnut, pecan, and hickory. It has been doubtfully recorded on dogwood and *Prunus americana*.

CHARACTER OF INJURY.

Damage by the pecan cigar case-bearer occurs during the early spring, principally to budded trees, and is due to the feeding of the larvæ on the tender buds and unfolding leaves. Where this insect is very abundant it causes injury in two ways. If the buds are backward in opening, the larvæ leave the twigs where they have hibernated, and crawling to the swelling buds attack them and eat out the contents, so that the life is destroyed, and before the tree can put out its foliage the dormant buds must develop. Figure 23, taken May 6, 1909, shows pecan twigs with buds destroyed by these larvæ;

the winter cases are still seen attached to sides of the buds. On the other hand, if the trees develop their foliage before the larvæ leave hibernation in injurious numbers, the leaves are riddled by the larvæ as they come from the twigs and the wind soon whips them to pieces. In this way, by feeding on the opening buds and young leaves in great numbers, this insect may delay the trees from coming into foliage for a period of from six to eight weeks. Because of this, young trees are held back during the most important period of their growth, and older trees, owing to this extra demand for nourishment for building leaves, probably have the crop of nuts for the year considerably decreased. Plate V, figure 1, shows a pecan twig with the young leaves ragged and largely destroyed by this insect, and Plate V, figure 2, shows the mines of the larvæ and some of the case-bearers at work. Plate VI is from a photograph of a pecan tree, taken May 6, 1909, showing injury by this insect. Plate VII shows a tree not attacked by this insect, which had been in full foliage for at least four weeks. When the writer left Orlando, June 13, the injured tree shown in Plate VI was still partly bare.

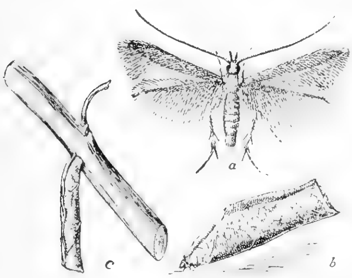


FIG. 24.—The pecan cigar case-bearer (*Coleophora caryæfoliella*): *a*, Adult; *b*, *c*, larvæ in cases. Greatly enlarged. (Original.)

DESCRIPTION.

The adult.—*Coleophora caryæfoliella* is one of the Microlepidoptera belonging to the family Elachistidæ, characterized by narrow, pointed wings with long fringes on the inner margins. The adult is a delicate little moth, ochreous in color, with a wing expanse of about 9 mm. The head is yellowish ochreous, with white scales over the eyes, the palpi and base of the antennæ the same color as the head, and the rest of the antennæ white ringed with brown. The body is the same color as the head, while the fore wings are reddish ochreous with costal margin white and fringe on inner border gray, and the hind wings are gray or whitish. This moth is well illustrated in figure 24 at *a*.

Chambers described the adult as follows:

> The species is ochreous; the head and palpi pale or yellowish ochreous; the antennæ white, annulate with brown; fore wings reddish ochreous, darker towards the apex, with the costal margin from base to cilia white.
>
> The ornamentation of the imago is nearer that of *C. limosipennella* than to any of the other species figured in *Nat. Hist. Tin.* Al. ex. 4½ lines.

The egg.—The egg has not been observed by the author, but is probably very similar to that of *C. fletcherella* as described by A. G. Hammar.[a]

[a] United States Dept. Agr., Bur. Ent., Bul. 80, Pt. II, p. 37, June 30, 1909.

Fig. 1.—Twig of pecan, showing injury to foliage. (Original.)

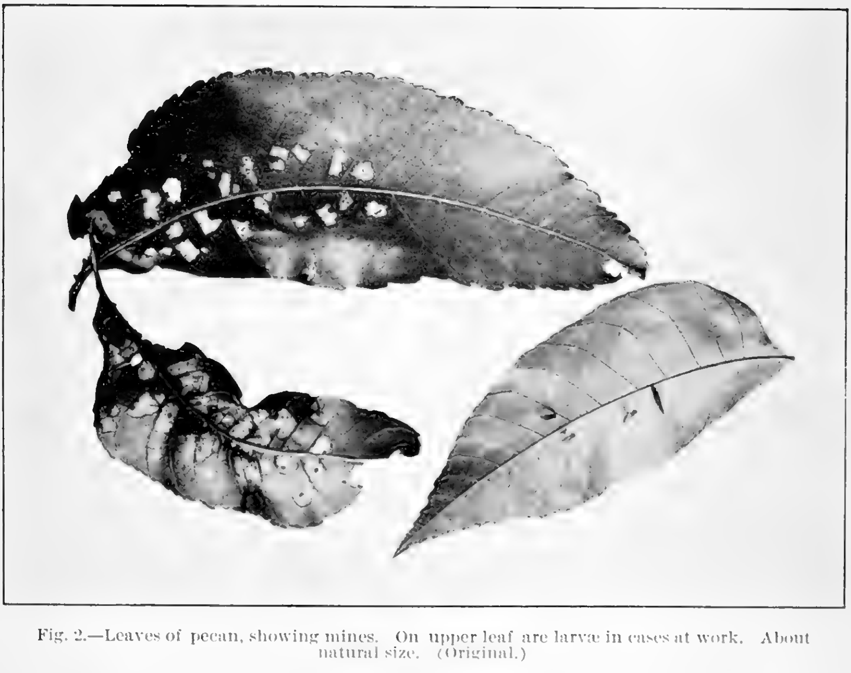


Fig. 2.—Leaves of pecan, showing mines. On upper leaf are larvæ in cases at work. About natural size. (Original.)

WORK OF THE PECAN CIGAR CASE-BEARER (COLEOPHORA CARYÆFOLIELLA).

The larva and larval cases.—The case in which the larva passes the winter is small, 3–3.5 mm. long, very flat, cylinderlike, and by the end of winter has the same color as the twigs or bark on which it rests. In the spring the larva is found in a case that is considerably larger. This is 5–7 mm. long, cylindrical, flattened vertically at the upper end, and slightly rounded at the lower. This case is made from a hollowed portion of leaf and so shows the entire leaf structure. It becomes reddish brown in color, and resembles a minute cigar.

The mature larva is about 5.5 mm. long and 1 mm. wide, the cylindrical body having well-marked segments. The head is one-half as wide as the body, hemispherical, flattened, black in color, with the triangle reddish. The body is light brown, with cervical shield oval, shining black, divided along center by a light brown line. The third segment of the body has a small black shield like the cervical, the anal plate shining black. The surface of the body is finely punctured and bears scattered, short, white hairs. The legs are light brown, while the prolegs are wanting or very small, marked by minute elevations, except the anal pair, which are large and functional. The nearly mature larva is well illustrated in its case in figure 24, *b*, *c*.

The pupa.—The pupa is formed within the larval case, and is about 5.5 mm. long and 1 mm. wide, cylindrical, having nearly the same diameter throughout the entire length. The head and eyes are blackish, while the remainder of the pupa is light yellowish-brown. The leg cases extend beyond the tip of the abdomen.

Clemens described this species from the larval case, but did not rear the adult. His original description is as follows:

1. *C. caryæfoliella.* The larva mines the leaves of hickory in September and October. The head and body is [are] reddish-brown, somewhat darker on the second and third rings.

The case is small, dark brownish, and in form is a flattened simple cylinder. The larva feeds only in small rectangular patches, of which there are usually several in the same leaf. The case is fixed to the under surface and the larva feeds in one patch until it is compelled to remove its entire body from its case, and then removes to another part of the leaf to form a new mine.

HABITS OF THE ADULT.

The moths emerge from the pupæ during May and June and at that time may be found among the pecan trees. When only recently emerged from the pupæ they rest either on the pupal cases or on the leaves or twigs of the host plant, with the fore wings folded back over the hind wings and flat over the abdomen, while the antennæ are held closely together and directed forward. During the day they seem to rest among the leaves.

HABITS OF THE LARVA.

The larvæ of *Coleophora caryæfoliella,* upon hatching from the eggs in July, mine the leaves of the host plant, and after feeding there for some time cut out the two skins of the mine and construct the cases within which they live during the fall and winter. After the cases are made the larvæ feed upon the leaves by eating through the lower epidermis and tunneling out the interior of the leaf in all directions until the mine is so large that to mine farther the larvæ would have to leave their cases. Under such conditions they move and begin a new mine, so that the leaves become full of irregular rectangular patches of brown with a small round hole in the center on the underside. In feeding, the larvæ carry the cases nearly perpendicular to the leaf surface. When the larvæ move they extend the head and thorax and crawl along, bearing the case aloft behind. In the fall, some time in October, before the leaves fall, these larvæ move from the leaves to the twigs or to the trunk, where they get behind the bark. Often they get in between the bud and the twig. Here they fasten the cases to the support and hibernate. The writer has seen from fifteen to twenty minute cases on a twig 4 to 5 inches in length, and where very abundant they will cluster together literally in hundreds. Gossard[7] has a photograph of these winter cases completely covering a twig.

In the spring, when the weather becomes warm enough, generally between March 15 and April 1, these larvæ become active and leave the twigs, where they have spent the winter, to commence feeding. If the trees are backward they often begin to feed before the leaves have developed and in such cases attach themselves to the swelling buds. Each larva eats a minute round hole into a bud and feeds as long as it can reach food without leaving its small case. When this becomes impossible the larva changes position and attacks the bud in a new place, so that infested buds are often found with four or five holes in the sides. Under such treatment the buds are killed or the tiny leaves start and are killed, and turning brown drop off. Often the larvæ attack the young tender leaves and mine out rectangular blotches in them. About the first week in April these larvæ outgrow their winter cases and construct larger ones.

Larvæ forming new cases move to the edge of the leaf and mine between the two skins. They then cut out a portion of the leaf, using the edge for one side. The sides are then sealed with silk, an opening being left at one end for the head. From the method of making new nests one edge of the case will often show serrations of the leaf edge. The larvæ then leave the old case attached to the leaf, where the latter has been cut to form a new case. They eat out large mines from 2 to 8 mm. long and 4 to 5 mm. wide (Pl. V,

PECAN TREE, SHOWING FOLIAGE CHECKED AND INJURY BY PECAN CIGAR CASE-BEARER.
(ORIGINAL.)

NORMAL PECAN TREE, SAME SIZE AS THAT SHOWN IN PLATE VI, BUT WITHOUT INJURY BY THE PECAN CIGAR CASE-BEARER. (ORIGINAL.)

fig. 2) in the leaves, feeding generally on the under side but sometimes on the upper also. These mines are deserted by the larvæ when they can not reach more of the surrounding tissue without leaving their cases, and new mines are made. In this way badly infested leaves may have from six to twenty mines to each leaflet. Soon the old mines dry up and are broken out by the wind, leaving the leaves full of ragged holes. The larvæ feed during the day and can often be seen with the head and part of the body inserted between the leaf surfaces, eating out the tissues in an ever-enlarging angular mine. If disturbed or in search of fresh food, these larvæ will move around considerably. When making a new mine the end of the case is loosely fastened and held diagonally attached, to the leaf. (See fig. 24.)

HABITS OF THE PUPATING LARVA.

During May most of the larvæ become mature and they then either fasten the case tightly to the leaves and pupate or move to twigs, branches, or bits of bark on the trunk of the tree and fasten the cases there. The larvæ spin a quantity of silk by which they fasten the cases very firmly to the support, after which they reverse their position, so that the head is pointing out toward the unattached end. After remaining quiet for a number of days the pupæ are formed, and the adults emerge during the last of May or the first of June.

SEASONAL HISTORY.

As far as observed, this insect has only one brood during the year, the larvæ hibernating when only partially grown.

In Florida the larvæ of this species become active from the 15th to the 30th of March, when the buds of the pecan are opening, or just after they have opened. Leaving the twigs and sheltered places where they have hibernated, they begin feeding on the buds or tender leaves. In a short time these larvæ outgrow their old winter cases and construct new ones of larger size. During the spring of 1908 this occurred mostly between April 1 and April 7.

The larvæ, after forming new cases, continue feeding and grow rapidly until May, when they become full grown.

By May 4, 1909, a few larvæ pupated and, as others pupated from time to time, by May 19 or 20 the greater part of the brood was in the pupal state. This pupal period occupies about twelve days.

An adult was observed in the cage on May 11, but most of the moths emerge from May 27 to June 5. On June 3 the adults were abundant on the foliage of pecan.

The adult probably lays her eggs on the underside of the leaves during June, and by the middle of July the larvæ are working as miners in the leaves of pecan. After a time they construct their minute cases and feed on the foliage until fall, probably until the last of September or first part of October, when they move to twigs to hibernate, sometimes being packed around them by the hundreds. Others hibernate under bits of bark on the trees or in crotches and other sheltered spots.

RECOMMENDATIONS.

Where this insect becomes abundant enough to be injurious it can with little doubt be controlled by spraying the trees with arsenate of lead (at the rate of 3 pounds to 50 gallons of water) when the buds are swelling—in March in central Florida and in similar climates. When the larvæ attack the foliage, this should be similarly sprayed.

Lime-sulphur mixture applied during the dormant season would undoubtedly give good results.

Where trees are sprayed in spring for the budworm (*Proteopteryx deludana* Clem.) no further treatment will be required for the case-bearer.

A bibliographical list follows:

BIBLIOGRAPHY.

1. CLEMENS, BRACKENRIDGE.—Proceedings of the Entomological Society of Philadelphia, Vol. I, p. 78, 1861.

   Original description of the species from larva and case; adult not reared.

2. CLEMENS, BRACKENRIDGE.—Tineina of North America, p. 166, 1872. Edited by H. T. Stainton.

   Same account as in No. 1.

3. CHAMBERS, V. T.—Canadian Entomologist, Vol. VI, p. 129, 1874.

   Described captured adults as *C. rufoluteclla* n. sp.

4. CHAMBERS, V. T.—Canadian Entomologist, Vol. X, p. 112, 1878.

   Made his *rufoluteclla* synonym of *caryæfoliella*, giving description of adult, larva, and larval case, and brief account of larval habits.

5. WALSINGHAM, THOS.—Transactions of the Entomological Society of London for 1882, pp. 430–431.

   Regards *rufoluteclla* as distinct from *caryæfoliella*.

6. PACKARD, A. S.—Fifth Report U. S. Entomological Commission, p. 316, 1890.

   A brief account of habits.

7. [EDITORIAL].—Insect Life, Vol. II, p. 351, 1890.

   Mention of parasite.

8. GOSSARD, H. A.—Bul. 79, Florida Agricultural Experiment Station, p. 304, 1905.

   Brief account of injury to pecan by an unidentified Coleophora, probably this species, and remedies.

Brief mention has also been made of the occurrence of this species in Florida and Texas in recent Yearbooks of the Department.

INDEX.

○

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 65.

L. O. HOWARD, Entomologist and Chief of Bureau

THE TOBACCO THRIPS,

A NEW AND DESTRUCTIVE ENEMY OF SHADE-GROWN TOBACCO.

BY

W. A. HOOKER,

Special Field Agent.

ISSUED APRIL 19, 1907.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1907.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Entomologist and Acting Chief in absence of Chief.*
R. S. Clifton, *Chief Clerk.*

F. H. Chittenden, *in charge of breeding experiments.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of cotton boll weevil investigations.*
F. M. Webster, *in charge of cereal and forage-plant insect investigations.*
A. L. Quaintance, *in charge of deciduous-fruit insect investigations.*
E. F. Phillips, *acting in charge of apiculture.*
D. M. Rogers, *in charge of gipsy and brown-tail moth work.*
A. W. Morrill, *engaged in white fly investigations.*
E. S. G. Titus, *in charge of gipsy moth laboratory.*
C. J. Gilliss, *engaged in silk investigations.*
R. P. Currie, *assistant in charge of editorial work.*
Mabel Colcord, *librarian.*

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 65.

L. O. HOWARD, Entomologist and Chief of Bureau

THE TOBACCO THRIPS,

A NEW AND DESTRUCTIVE ENEMY OF SHADE-GROWN TOBACCO.

BY

W. A. HOOKER,

Special Field Agent.

ISSUED APRIL 19, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., January 31, 1907.

SIR: I have the honor to transmit herewith a manuscript by Mr. W. A. Hooker, special field agent in this Bureau, on the tobacco thrips, an insect which has, during the last two or three years, caused great damage to shade-grown tobacco in Florida, Texas, and Georgia. This paper contains a general account of this thrips, and gives recommendations for applying remedial measures, and I recommend its publication as Bulletin No. 65 of the Bureau of Entomology.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

THE TOBACCO THRIPS, A NEW AND DESTRUCTIVE ENEMY OF SHADE-GROWN TOBACCO.[a]

(*Euthrips nicotianæ* Hinds.)

INTRODUCTION.

In accordance with the authorization of the Secretary of Agriculture and the instructions of Dr. L. O. Howard, the writer left Washington, D. C., April 14, 1905, to investigate certain injury to shade tobacco at Quincy, Fla. He arrived at Quincy April 16 and spent the following two months in the work. Having reached what seemed to be a satisfactory result, he left there on June 16. June 27 was spent at Palestine, Tex., and June 28 and 29 at Nacogdoches, Tex., in examination of tobacco fields. At Quincy the writer was associated with Mr. W. W. Cobey, tobacco-breeding expert of the Bureau of Plant Industry, from whom valuable advice and suggestions were received. The writer again visited Quincy in October, 1905, and spent two weeks in a further examination. A continuation of the work was planned for 1906, but could not be carried out, although a visit was made at Quincy in November to determine the results obtained where remedial measures had been employed.

HISTORY.

The first report of thrips injuring tobacco in this country, so far as the writer is aware, was made by Dr. F. H. Chittenden in 1904,[b] the species concerned being considered as *Euthrips tritici* Fitch. As will be seen from the following pages, additional material showed that the insect concerned is a new species, *Euthrips nicotianæ* Hinds.

A Russian, Lindeman,[c] first described scientifically in 1888 a species of thrips, *Thrips tabaci*, which he reported as doing great damage to tobacco in that country. While this same species is generally distributed in our own country and although its list of food plants is large, it is not recorded as having attacked tobacco here.

Several communications were received by this Bureau during the

[a] Circular No. 68, published February, 1906, gives a brief account of the insect and remedies recommended by the writer.

[b] Yearbook of the U. S. Department of Agriculture for 1904, p. 605, 1905.

[c] Die Schädlichsten Insekten des Tabak in Bessarabien, Bull. Soc. Imp. Natur., Moscow, pp. 51–65. 1888. See also Targioni-Tozzetti, Animali ed insetti del Tabacco, pp. 222–224, 1891.

summer of 1904, with inquiries concerning an injury to shade-grown tobacco in Florida. The insect causing this injury was variously described as "a little parasite," "a flea," "an unknown insect," etc. Not until the winter of 1904 could anything definite be learned. At that time a report was received from Mr. W. W. Cobey, tobacco-breeding expert, of the Bureau of Plant Industry, describing the nature of the injury.

It seems that on tobacco grown in the South, and under shade especially, insect enemies of the crop are found at their worst. Of the many insects with which the planter has had to deal in the past, the budworm, requiring two and three applications a week of arsenicals, has been far in the lead in the amount of damage done. It often happens, when a crop is introduced into a new locality, that insects previously unknown, finding in it a desirable food, leave their natural food plant, multiply rapidly through new and more favorable conditions, and thus become serious pests. This is what has happened to shade-grown tobacco in the South. The suckfly (*Dicyphus minimus* Uhl.), which first appeared on tobacco in 1888, has made the raising of a second crop of shade-grown tobacco in Florida unprofitable. The leaf miner or splitworm (*Phthorimæa operculella* Zell., formerly known as *Gelechia solanella* Boisd.) also has attacked and become injurious to tobacco. And now comes a new pest in this new tobacco thrips, which has threatened to surpass the destructive budworm in actual injury.

Injury by the tobacco thrips was first observed in 1902, on tobacco grown in the field on which the first shade was erected in 1896. Since that time the insect seems to have increased rapidly, until, during the summer of 1905, the thrips was found in all shade tobacco fields examined, and the opinion is expressed by several planters that, if allowed to continue its ravages, it is on a fair road to completely check the production of the shade crop.

The history of shade-grown tobacco in this country dates back to the year 1896, when one-fourth of an acre of slat shade was put up at Quincy, Fla. It was found that Sumatra wrapper tobacco grown in this way nearly, if not altogether, equals the quality of the imported article. So successful has been the raising of this tobacco that to-day over 3,000 acres are grown under shade in Florida and the adjoining counties of Georgia, while Texas has a smaller acreage.

NATURE AND EXTENT OF INJURY.

The injury occasioned by the tobacco thrips is known as "white vein," which, as the term indicates, is due to a white appearance of the veins (see Pl. I, fig. 2). These veins show in the wrapper when manufactured into cigars. The injury is brought about by the removal of the sap by the adult thrips in feeding on the upper surface of the leaf. The thrips feed on the space between the veins as well as

FIG. 1.—SLAT-SHADE FIELD, SHOWING IRON COWPEAS GROWN BETWEEN TOBACCO CROPS. (ORIGINAL.)

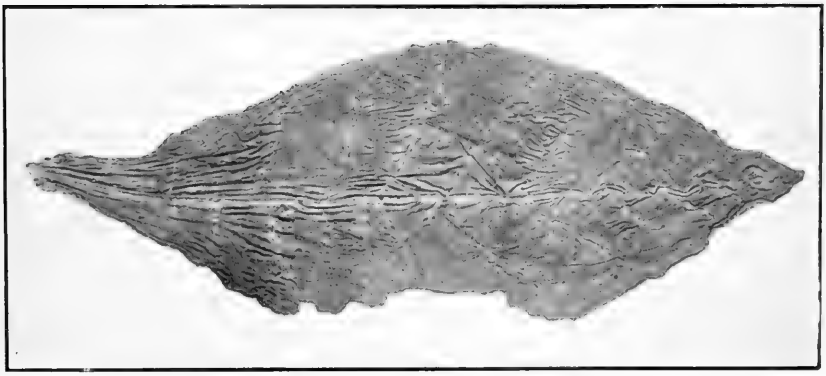


FIG. 2.—LEAF OF TOBACCO, SHOWING "WHITE VEINS" CAUSED BY THE TOBACCO THRIPS (EUTHRIPS NICOTIANÆ). (ORIGINAL.)

on the veins, but except on the veins themselves the indications of their feeding disappear in the fermentation process.

The work of the pest should not be confused with the so-called "white vein" that sometimes occurs in tobacco grown in the North and which seems to be due to a physiological disorder of the plant.

As a result of the thrips's work, when the crop is affected to any extent, all the white-vein tobacco must be sorted into a grade by itself and sold as such, the expense of grading being thereby largely increased. The value of the crop also is greatly reduced, as there is no demand for this grade at present. There seems to be quite a variation in the estimates of the depreciation of tobacco thus affected, one packer estimating the value as decreased from $1.50 to 30 cents, or a loss of $1.20 per pound, while another packer places the decrease at from $1 to 50 cents, or a loss of 50 cents per pound. These seem to be maximum and minimum estimates.

For the year 1904 it is estimated that 20 per cent of the crop grown under slat shade was damaged to such an extent by white veins that it was thrown into a grade by itself.

The injury for 1905 was decreased to a great extent by the heavy rainfall in the latter part of June and in July. In the crop of tobacco sprayed with emulsion there were practically no white veins to be found, and this was the case in 1906. Early tobacco was especially affected by white veins in 1905, the injury having taken place previously to the rains. One crop of tobacco is estimated by the planter as containing 33 per cent of affected wrappers, practically one-half of which must necessarily be placed in a separate grade. Another crop is estimated as containing 20 per cent of affected wrappers, 10 per cent being placed in a separate grade. The amount of injury will vary from year to year, depending upon the period and amount of rainfall.

In the past the greatest damage has been to that particular section near the original shade, but the thrips now seem to be disseminated throughout all the fields of shade tobacco.

ORIGIN AND DISTRIBUTION.

As soon as possible after reaching Quincy, specimens of the tobacco thrips were collected and sent to Dr. W. E. Hinds, an authority on this group of insects. He found that they represented a new species and has named and described them.[a]

This insect was taken by the writer at Nacogdoches, Tex., on shade tobacco, as well as at Quincy, Fla. In April adults and larvæ were taken in large numbers on cocklebur (*Xanthium glabratum*) growing in the shade fields and in smaller numbers on dewberry, mustard, and shepherd's purse blossoms. It has been taken by the writer at Dallas,

[a] Proc. Biol. Soc. Washington, Vol. XVIII, pp. 197–199, September, 1905.

Tex., in both winged and wingless forms, on Johnson grass (*Sorghum halepense*) in March. It would seem, therefore, to be a general feeder and widely distributed through the Southern States.

DESCRIPTION.

Adult.—Doctor Hinds describes the adult as follows:

EUTHRIPS NICOTIANÆ sp. nov.

Average length, 1.05 mm. (0.95 to 1.13 mm.); average breadth at middle of abdomen, 0.27 mm. (0.225 to 0.285 mm.). General color of head and thorax light brown or tawny yellow-brown; abdomen dark brown.

Head about one and one-half times as wide as long, frequently slightly retracted under anterior margin of prothorax; occiput transversely wrinkled, posterior margin strongly thickened and darker in color; anterior margin slightly bisinuate, cheeks approximately straight and parallel. Eyes dark red in color, not protruding, occupying together fully one-half the width of the front of the head and being one half as long as the head; margins around eyes pale yellow in color; surface of eyes finely faceted and slightly pilose; three ocelli present, well separated, posterior ones contiguous with yellow borders to eyes, pale yellow in color and margined inwardly with pale-orange crescents; one moderately stout dark spine in front of each posterior ocellus; postocular spines weak and inconspicuous. Mouth cone reaching nearly to posterior edge of the prosternum, tapering abruptly; maxillary palpi slender, three-segmented. Antennæ inserted slightly below front margin, approximate at base, about two and one-half times as long as the head and approximately equal to breadth of mesothorax; relative length of segments: [a]

FIG. 1.—The tobacco thrips (*Euthrips nicotianæ*): Adult insect. Much enlarged (author's illustration).

1	2	3	4	5	6	7	8
6.2	11.4	13.5	13.6	12.2	16.2	3.0	4.5

Segment 1 is rounded, three-fourths as long as broad; 2 is as broad as 1; following segments about three-fourths as thick; segments 3 to 6 are constricted at bases, becoming more stout successively. Color of segments 1 and 2 uniform light brown; 3 to 5 pale yellow at bases, shading to brown at outer ends, each succeeding segment from 3 to 6 becoming darker in color; 6 to 8 are

[a] The number of the segment is given above the line and below it the number of spaces covered upon an eye-piece micrometer by an average of the segments of 10 antennæ.

dark brown. Spines upon segments 2 to 5 are of medium size, but not very conspicuous. Color of head varying from gray-brown to yellow-brown.

Prothorax about five-ninths as long as broad and slightly longer than the head; sides rounded, slightly wider at hind than at fore angles; one stout spine at each anterior, and two stouter spines of equal size at each posterior angle; anterior marginal pair of spines about one-half as long as those at front angles; usual row of five spines on each side of hind margin, of which number 4 is equal in strength to those on the front margin. Mesothorax nearly one and one-third times as wide as the prothorax, broadest posteriorly, sides curving outward; mesonotum without conspicuous spines, posterior margin forming an obtuse angle in middle. Metathorax slightly narrower than mesothorax, sides nearly parallel, broader than prothorax at posterior edge; metanotum bears two pairs of spines at front edge, the inner pair being as strong as those at front angles of prothorax. Wings present (probably reduced at some season of year), average length about 0.68 mm., not reaching to the tip of the abdomen, breadth equal to about one-thirteenth of their length; fore wing has two longitudinal veins, each bearing stout spines set at regular intervals; fore wings shaded ash gray, hind wings gray only along basal three-fourths of midvein; spines on wing veins dark brown and conspicuous; costa bears 19 to 24 spines; fore vein, 13 to 18; hind vein, 10 to 12; scale, 5; interior of scale, 1; fringe of hairs on costa of fore wing quite heavy, in length exceeding the breadth of the wing. Legs of medium length, lighter than body in color, pale yellow, shaded more or less with brown on upper side at middle of femora and tibiæ; a pair of stout brown spines at inside of tip of each tibia, small brown spines scattered along femora and tibiæ; spines standing in two rows on inner side of hind tibiæ are weak and only about four in each row.

Abdomen nearly cylindrical to eighth segment, then tapering abruptly to an acute tip; color uniformly dark brown; a still darker-colored narrow chitinous thickening extends across dorsal side of segments 2 to 8 near anterior edge. Three or four quite stout and rather conspicuous dark-brown spines stand at each side of dorsal plates on 2 to 8; six rather prominent spines stand in a row on posterior edge of ventral plates 2 to 7; terminal spines stout and prominent; tenth segment split open along dorsal median line.

Described from 10 females.

Male specimens of this species have not been found.

Three cotypes (three slides) deposited in the U. S. National Museum. Type No. 8434, U.S.N.M. Three cotypes (three slides) deposited at the Massachusetts Agricultural College. Four cotypes (two slides) retained.

Habitat.—Quincy, Fla.; Nacogdoches, Tex.; Climax, Ga.

Wingless females appear in May and seem to predominate by the latter part of that month.

This species may be readily distinguished from *Euthrips tritici* Fitch by its color, which is brown, that of *tritici* being yellow. Differences in structure by which the species may be readily separated are found in the postocular spines, those of *nicotianæ* being weak and inconspicuous, while those of *tritici* are quite prominent. On the wings prominent differences are found in the number of spines on the veins, the costa of *nicotianæ* bearing from 19 to 24, the fore vein 13 to 18, and the hind vein 10 to 12, while in *tritici* the costa bears from 26 to 28, the fore vein 20 to 22, and the hind vein 15 to 18.

Egg.—The eggs are deposited in the tissues of the stem and leaves.

Larva, first stage.—Length about 0.23 mm.; width of mesothorax 0.11 mm.

General shape fusiform. Color of posterior part of thorax and entire abdomen pale yellow; elsewhere pearly white. Head quadrate; eyes reddish. Antennæ 0.15 mm. in length; distinctly four-segmented; basal segment cylindrical, short; second ovate, slightly shorter than the third; third slightly conical, the apex joining the second; fourth fusiform, widest near the basal fourth, about equal in length to the other three. The fourth segment is distinctly annulated, the second and third indistinctly so; setæ are present on all segments, most numerous on the fourth. Legs translucent white, stout. Abdomen tapering posteriorly; with ten segments, the first eight nearly equal in length, the ninth twice and tenth three times the length of the preceding. Each abdominal segment with longitudinal rows of setæ, the ninth with two and tenth with four spines that are four times the length of the setæ.

Larva, second stage.—Length from 0.6 to 1.17 mm.; width of mesothorax from 0.14 to 0.2 mm.; shape same as in first stage. Color of thorax and abdomen yellowish, with exception of the last abdominal segment. Head quadrate; antennæ with four segments, the fourth being more distinctly annulated than in the first stage. Abdomen with the setæ increasing in length posteriorly; ninth and tenth segments about equal in length, each less than twice the length of the others.

The young nymph or prepupa.—Length, 0.52 to 0.62 mm.; width of mesothorax, 0.10 to 0.12 mm. Antennæ translucent, extending forward, much shortened and composed of five segments, first two cylindrical and very short, third and fourth globose, fifth tapering to the apex. The last segment of the abdomen is set with four spines by use of which the young nymph seems to protect itself, when approached by another the abdomen being turned upon it. The wing sheaths are very noticeably separated, the upper one extending to the middle of the second segment, the lower one to the middle of the third segment. The legs are translucent white, stout.

The full-grown nymph or pupa.—Length, 0.68 to 1.22 mm.; width of mesothorax, 0.15 to 0.20 mm. Shape similar to the adult. Color yellowish; head, antennæ, wing pads, legs, and caudal segments of the abdomen varying to pearly white. Antennæ extending to the middle of the prothorax. Three yellowish ocelli between the eyes, the latter dark red. Wing pads so closely applied as to appear single, extending to the middle of the fifth abdominal segment; length from head to tip of wing pads 0.39 mm. The abdomen is noticeably contracted longitudinally; greatest width, 0.24 mm.; longest setæ, 0.078 mm.

HABITS.

Feeding.—When examinations were first made, April 17, the adult thrips were found feeding in the seed beds on the upper surface of the young tobacco plants, and in the field on the upper surface of the leaves of young cocklebur weeds. In the larval stage they feed on the lower surface of the leaves of tobacco and weeds, but as they become adult seem to prefer the upper surface, a habit which is very favorable for remedial treatment, as they can then be reached much more readily by sprays. To determine the attractiveness of tobacco the experiment was tried of transplanting young tobacco plants into a field that had been prepared ready for transplanting, but in which weeds, consisting of cockleburs and grass, were to be found.

In order that thrips might not be accidentally taken from the seed bed on the plants, the latter were dipped in a solution of kerosene emulsion and this washed off with water. Fifteen plants were set in a 2-acre field at intervals of 4 and 8 rods. The day following was rainy and unfavorable to movement of the thrips, but the second following day was pleasant. In the afternoon of the second day an examination was made, and four plants were found to have been covered with dirt in the ridging for setting the field. Of the eleven remaining, four plants were found without thrips, five with one each, one with two, and one with three. From this it would seem that the thrips are quite strongly attracted from the weeds in the field to the tobacco.

As the thrips commence feeding and breeding on the young plants the lower or sand leaves receive the greatest amount of injury. From the lower leaves they gradually work up the stalks to the leaves above, until at harvesting time they have reached more than half way up. In attacking a leaf they first appear feeding near the tip, and gradually work toward the stem. It may be well to note here that the leaves are harvested by picking—called "priming"—as they ripen, and that the stalks often reach the slats or cloth 9 feet from the ground. In the early stages of the tobacco the thrips are found on that grown in sun and shade alike, but as the sun tobacco thickens up they seem to leave it and are found in numbers only on the shade-grown tobacco. In a field in which Cuba and Sumatra varieties were grown together the thrips were found to be equally injurious to both.

Jumping.—When disturbed, the adults have the habit of jumping, and have thus been mistaken by some for small fleas. This characteristic is typical of the genus to which the tobacco thrips belongs. The motion seems to be produced by a combined movement of the wings and abdomen.

Flight.—The closely related wheat thrips takes flight readily, but the tobacco thrips apparently does not do so. Notwithstanding all the observations he has made, the writer has as yet failed to see it take wing, and its power of flight must be limited.

FOOD PLANTS.

The tobacco thrips seems to be a general feeder, as adults were taken in April on blooms of dewberry (*Rubus* sp.), shepherd's purse (*Bursa bursa-pastoris*), and mustard (*Brassica* sp.). Adults and larvæ were taken on oats, wheat, and cocklebur as well as on tobacco.

LIFE HISTORY.

Methods of study.—In order to determine the life cycle, adult thrips were confined in small wide-mouth vials on parts of tobacco leaves for periods of twelve and twenty-four hours, but repeated attempts failed to induce them to oviposit. The parts of tobacco leaves were thereupon replaced by small bean pods, with the result that oviposition soon took place. Absorbent cotton was used as a stopper for the vial in order to keep the moisture from forming on the inside and thus catching the young thrips, which readily succumb when so caught.

Life cycle.—The life cycle of this species is found to be quite short and very similar to that of the closely related wheat thrips, *Euthrips tritici.* In May and June only twelve or thirteen days are required for its completion. In the tobacco field the eggs appear to be deposited in the tissues on the under surface of the leaf. In May and June the incubation period for eggs laid in confinement in young bean pods seems to average about four days. The larvæ, upon hatching, feed on the under surface of the leaf; during this stage, which lasts seven days, and before changing to pupæ, they molt twice. When about to pupate the larvæ crawl to some obscure nook; there they remain inactive, without feeding, during the pupal stage, which lasts two days. The adults, on emerging, have a yellowish color, which in a few hours turns to the normal brown. As adults the thrips crawl to the upper surface of the leaf and commence feeding.

Hibernation.—The tobacco thrips appears to hibernate in the adult stage. When the fields were visited, the latter part of October, not a specimen could be found, although another thrips (*Chirothrips crassus* Hinds), which was taken in large numbers in sheaths of grass found growing in the tobacco fields, was at first mistaken for the tobacco thrips. Mr. W. W. Cobey informed the writer that he had observed the tobacco thrips on the leaves of cocklebur about October 10, previous to a cold spell. Thus it would seem that the thrips goes into hibernation after the first approach of cold weather.

OTHER THRIPS THAT MAY BE MISTAKEN FOR THE TOBACCO THRIPS.

While the tobacco thrips is the only species commonly found on tobacco, yet a number of other thrips which may be mistaken for this pest are found in the vicinity of the tobacco fields, or even accidentally upon the tobacco itself. Among those that may be so mistaken are the following species:

Euthrips tritici Fitch, the "wheat thrips," is a species generally distributed throughout the South. It has a wide range of food plants and can be found during a large part of the year in almost any blossom. In Florida it has been reported as injuring the orange and strawberry by attacking the blossoms. At Quincy, Fla., during the summer of 1905, it was found in large numbers associated with the tobacco thrips in oat fields bordering the tobacco fields. It was also found seriously injuring roses, causing the outer petals to wither before the flowers opened. It may be distinguished from the tobacco thrips by the yellowish color of the adult or winged form, which in the tobacco thrips is dark brown.

Thrips tabaci Lind., the "onion thrips," has been reported by Prof. A. L. Quaintance as quite abundant in Florida, attacking onions, cabbage, and cauliflower. It may be distinguished from the tobacco thrips by its color, which is yellowish.

Anthothrips niger Osborn is another species which was very abundant at Quincy the summer of 1905. In oats and wheat bordering the tobacco fields it was found breeding in vast numbers with the wheat and tobacco thrips. It was also occasionally taken on tobacco and tomato. It is a strong flyer, and may be further distinguished from the tobacco thrips by its much larger size and black color.

A few specimens of *Æolothrips bicolor* Hinds were taken on oats and wheat in the vicinity of tobacco fields. This species may be distinguished by the white or yellowish pigmentation of the first three segments of the abdomen.

Chirothrips crassus Hinds was taken in October and November in large numbers in the sheaths of grass growing in tobacco fields. It was at first mistaken for the tobacco pest, because of the similarity in color, but may be easily distinguished, as it does not have the jumping habit of the tobacco thrips.

NATURAL CONTROL.

Rains.—Of the natural checks, rain is the most important. It is known that nearly all thrips thrive during warm and dry weather, and that they are washed from their food plants and destroyed in numbers by rain. This is true of the tobacco thrips in that it is washed off by heavy rains, yet unless the rain continues for several days few seem to be destroyed, for at the end of the first or by the second clear day following the writer has found it on the leaves in as large numbers as ever.

The influence of rain upon the pest, however, was very noticeable in its effect during the summer of 1905. Up to the latter part of June very little rain had fallen, and the drought was showing its effect on the unirrigated fields. At this time the dry spell was broken and rains were heavy and frequent. The June, 1905, rainfall, which was nearly three times that of the preceding June, yet still below the normal, nearly all fell during the latter part of the month and was followed by the heavy July rainfall, which was the greatest since 1900, and more than twice that of 1904. As a result the thrips were kept off the leaves, the plants grew rapidly, and priming was forced into twenty days where it usually takes thirty. The sand leaves were lost in large part because of this rapid ripening and the leaves affected to the greatest extent by white vein were thus eliminated from the crop. As the result of these weather conditions, white veins in the late tobacco were reduced to a very small percentage.

The great amount of injury in 1904 was undoubtedly due to the exceptionally droughty season. This will be shown by the accompanying chart (fig. 2) of total monthly precipitation for the last seven years. That during 1905 and 1906 the injury was so much less than in 1904 must have been due to the greater precipitation. As before stated, it is quite evident that the amount of injury by thrips will vary from year to year, depending upon the period and amount of rainfall. The total precipitation in inches at Tallahassee, Fla., during April, May, June, and July of the years 1898-1906 is shown in the following table:

Precipitation in inches at Tallahassee.

Year.	April.		May.		June.		July.		Length of record (years).
	Total.	Departure from normal.	Total.	Departure from normal.	Total.	Departure from normal.	Total.	Departure from normal.	
1898	0.87	−1.89	1.55	−2.65	4.49	− 1.25	10.00	+1.71	14
1899									
1900	4.05	+1.05	2.06	−1.60	16.47	+10.72	10.31	+1.87	15
1901	2.72	−0.27	5.07	+1.59	5.61	− 0.75	8.25	+0.02	16
1902	0.84	−1.15	2.86	−0.62	9.94	+ 3.58	5.83	−2.40	17
1903	0.11	−1.88	5.59	+2.11	10.01	+ 3.65	7.09	−1.14	18
1904	1.65	−0.34	1.05	−2.43	1.33	− 5.03	3.95	−4.28	19
1905	0.92	−1.07	7.55	+4.07	3.50	− 2.86	8.76	+0.53	20
1906	0.15	−2.43	2.92	+0.70	5.17	− 1.23	8.88	+1.00	21

Insects.—Specimens of a small bug, *Triphleps insidiosus* Say, were found very commonly upon oats, where they seemed to be quite destructive to the thrips. When captured with the thrips by sweeping the oats with a net, they were shortly found with a thrips impaled upon their beaks, sucking out the juices. While this insect may assist in decreasing the tobacco thrips that breed on oats, it has not as yet been found on tobacco.

A fungus also was found growing upon dead thrips taken from tobacco in the seed bed; but this may be, and probably is, a form attacking the insect after its natural death.

REMEDIES.

Remedies may be considered under two heads, namely, cultural methods and insecticide applications.

CULTURAL METHODS.

It is the practice of many tobacco growers to start the seed bed in the shade-tobacco field (see Pl. II), and, after the plants are removed, to plant it with the rest of the field. This practice is unquestionably a bad one, not alone from its furnishing a breeding place for the thrips, but also because it becomes a center of infestation for many other pests, particularly flea-beetles. It was noticed during the summer of 1905 that insect pests, and especially flea-beetles, were the most numerous in transplanted seed beds and in that part of the field adjoining the seed bed. It seems advisable, therefore, that the seed bed be located outside and at some distance from the tobacco field. Where it is necessary that the seed bed be located in the field, the thrips can be largely overcome by frequent applications of kerosene emulsion, as hereinafter described. Applications of Paris green also

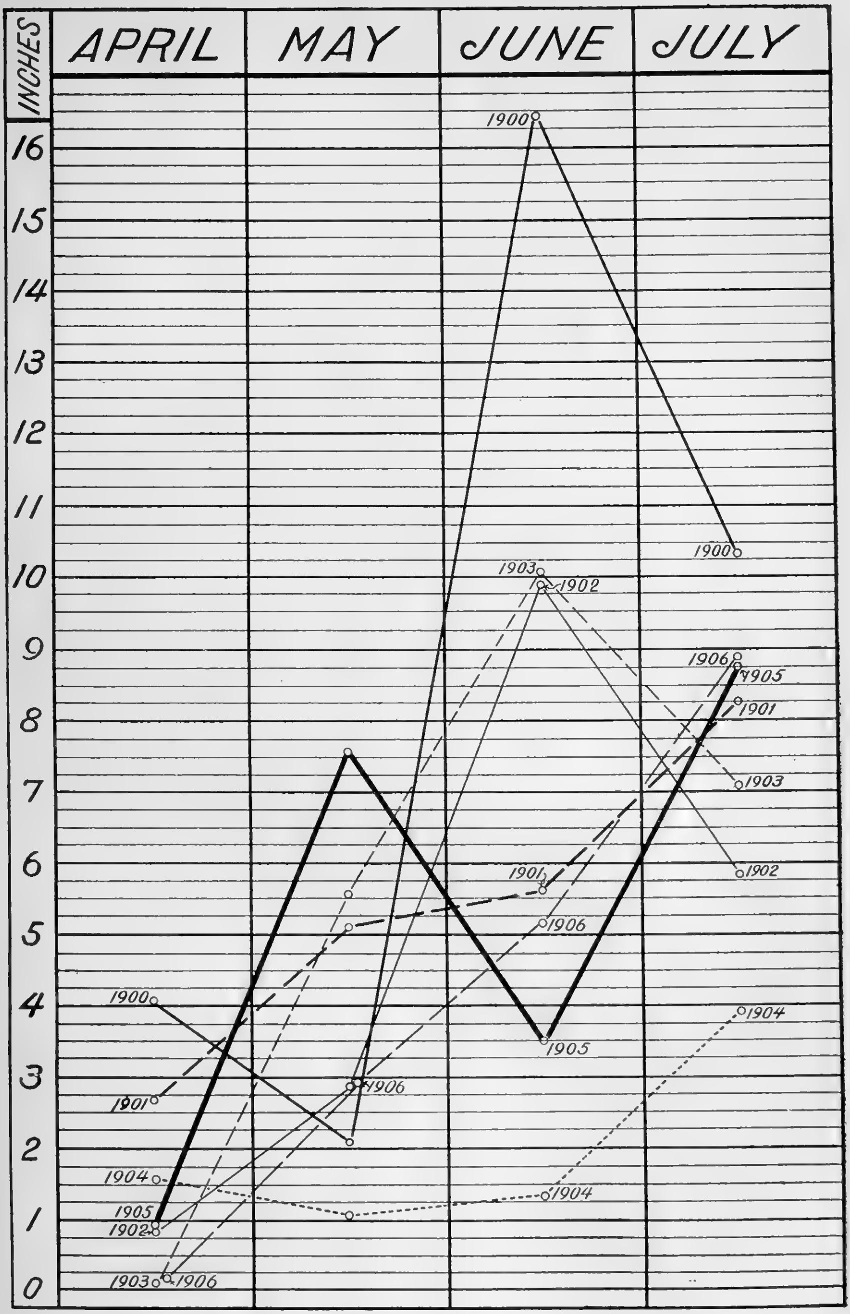


FIG. 2.—Diagram showing total monthly precipitation at Tallahassee, Fla., during April, May, June, and July, 1900–1906, to illustrate relation of rainfall to amount of injury by the tobacco thrips. (Original.)

should be made to check other insects. This will apply to the seed bed wherever it be located.

Since it is evident that the thrips pass the period between crops in the tobacco field feeding upon catch crops that follow, as rye, wheat, etc., or upon weeds which have been allowed to grow, it seems advisable that thorough and clean cultivation be practiced. While it is possible that the employment of the kerosene emulsion treatment, as recommended, may prove so effective as to permit the growing of catch crops (Pl. I, fig. 1) without injurious effect, yet a thorough cultivation of the soil after the crop is harvested is strongly advised, for besides its effect on the thrips it will result in the destruction of budworm and hornworm pupæ and grasshopper eggs.

As soon as priming is finished the stalks should be plowed under, together with all other vegetation in the field. Although cockleburs were observed repeatedly during the summer of 1905, coming up the day following cultivation, and although the seed may lie in the soil two and three years before germinating, yet if the weeds are prevented from fruiting in the fall by keeping the soil well plowed the effect will soon become apparent.

The practice followed by some planters of keeping a space of 10 feet bordering the shade field free from all vegetation is quite desirable as affecting the thrips.

It is the general practice to grow oats in fields bordering the shade tobacco, but as the tobacco thrips is found breeding in vast numbers in oats it would seem advisable to replace oats with corn in these border fields.

The part that irrigation may take in controlling the thrips seems to be of importance. Somewhat less than one-fourth of the shade tobacco in Florida is irrigated. This is carried out by one of two methods, namely, surface or overhead delivery. Surface irrigation, which is largely practiced, does not seem to affect the pest. In the overhead method piping is employed, provided at intervals with laterals that extend 4 or 5 feet above the cover and to which are attached nozzles that give a fountain spray. In this way an artificial rain is produced. This overhead irrigation seems to have quite a noticeable effect in decreasing the numbers of thrips. Three irrigations weekly seem to be much more effective than two. One firm estimates a decrease in injury of 10 per cent in a field thus irrigated in 1904. The great expense of piping and damage from freezing has kept the method from being installed to any great extent as yet.

In growing wrapper tobacco, shade is produced by the use of either slats (Pl. I, fig. 1; Pl. II, fig. 1) or cheese cloth. (Pl. II, fig. 2.) The temperature in the shade produced by the former is reduced about 10° from the normal, while by the latter it is increased 10°. From information received it is found that the thrips have, up

FIG. 1.—SLAT-SHADE TOBACCO FIELD, SHOWING SEED BED. (ORIGINAL.)

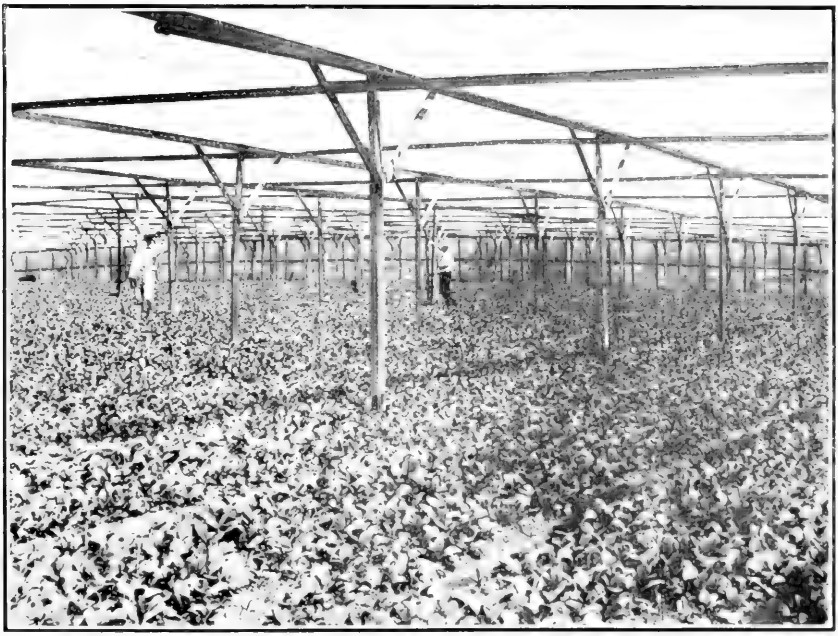


FIG. 2.—CHEESECLOTH-SHADE TOBACCO FIELD, SHOWING SEED BED. (ORIGINAL.)

to the present time, caused a much larger percentage of injury to tobacco grown under the slat shade. During the summer of 1905, however, they were found causing no small amount of injury to tobacco under cheese cloth. Whether or not the meteorological differences between cheese-cloth and slat shade have an influence on the thrips's work, can not be told at present, but the matter is important and should be watched closely.

INSECTICIDES.

In carrying on experiments to determine the most effective and practical insecticides, reference was made to Professor Quaintance's bulletin entitled "The Strawberry and the Onion Thrips."[a] The insecticides which Professor Quaintance found to be most effective on *Euthrips tritici* were given repeated trials. As a result it was found that the resistance of the tobacco thrips to insecticides is far greater than that of *Euthrips tritici.*

In experimenting with insecticides three important points, aside from their effect upon the insect, were to be considered: First, their relative cost; second, the expense involved in their application; and, third, their effect, if any, upon the foliage. From the nature of the mouth parts of thrips, which are fitted for piercing and sucking, stomach poisons were not available and contact insecticides were necessarily used. These latter, as is generally known, kill by entering through the breathing pores and setting up an irritation, or by closing them and bringing about the death of the insect from suffocation. It has been found that the adult feeds largely on the upper surface of the leaves. In this habit, therefore, lies our opportunity to treat the pest successfully with insecticides.

Among the insecticides experimented with are the following, the sprays being applied with a knapsack sprayer:

Rose-leaf insecticide.—This is a high-grade extract of tobacco. Professor Quaintance, in his experiments with the wheat thrips, finds this insecticide to be the most effective and practical remedy for use against the thrips affecting strawberries, and recommends for that species 1 part to 48 of water. This strength, when used upon the tobacco thrips, has but little effect. Various strengths were tried. When 1 part of the insecticide to 20 parts of water is used, the thrips seem to be paralyzed, remaining immovable for about an hour and a half, after which they commence to show life, and soon become as active as ever. Further experiments with this insecticide show it to be effective when used with whale-oil soap in the following proportions:

Rose-leaf insecticide	1 quart.
Whale-oil soap	½ pound.
Water	20 quarts.

[a] Bul. 46, Fla. Agric. Exp. Sta., July, 1898.

Nikoteen.—This is a preparation advertised as containing 40 per cent of nicotine. It was applied in various strengths. Sprayed at the rate of 1 part to 144 of water, 38 per cent of the thrips were found to be dead when the examination was made, twenty-four hours later. No greater strengths were tried, as the cost of the insecticide would not allow its use.

Tobacco decoction.—This was made by boiling 1 pound of tobacco, stems and leaves, in 1 gallon of water for a half hour. This strength was very effective, practically all of the thrips that were fairly hit by the spray being killed. Weaker strengths were less efficient. As other forms of nicotine were found to be more effective in combination with whale-oil soap, the latter was used with the decoction. When so used, however, the mixture, owing apparently to some chemical change which had taken place, burned the leaf.

Whale-oil soap.—This was used in the proportion of 1 pound of soap to 6 gallons of water. When examined shortly after spraying the thrips were seemingly as lively as ever. A strength of 1 pound to 5 gallons killed about 50 per cent of the thrips, but seemed to burn the leaf slightly.

Glucose and molasses.—It was thought that possibly the thrips might be caught or prevented from working on the leaf by means of a sticky spray. A proportion of 1 quart of glucose to 6 quarts of water was tried. While a few thrips were caught and killed by the spray, others had escaped and were found, after the water had evaporated, walking about over the leaf without trouble. Molasses, also, was tried, but found to be even less effective than the glucose.

Dusting with lime or other powders seems to be of little value, as the thrips are found making their way about through the dust without trouble. Lime also has the disadvantage that it is not entirely washed off by rains.

Arsenicals were tried, but, as expected, seem to be of little value when used for the thrips.

Kerosene emulsion.—Since this is our strongest contact poison it was thought from the first that if it could be used in sufficient strength to kill the thrips without injury to the tobacco leaf, it would furnish a satisfactory remedy. Experiments were made with the following formula for the stock solution:

Kerosene	2 gallons.
Hard soap	½ pound.
Water	1 gallon.

A strength of 1 part of stock solution to 10 parts of water proved quite satisfactory in killing the thrips. This spray was found to burn the leaves when used in the sun, but further experiments have demonstrated that it can be used on a cloudy day or late in the evening without danger of injury.

THE BEST TREATMENT.

Of the many insecticides used, kerosene emulsion has been found to be the most satisfactory remedy for the tobacco thrips. Tobacco decoction in a concentrated strength seems to be effective, but, because of the amount of material necessary and the labor involved in its preparation, its use is less satisfactory. Rose-leaf insecticide, while effective in concentrated strengths, is impractical because of its greater expense as compared with the emulsion. The advantages of kerosene emulsion are its destructive power against the insects and its low cost when compared with other possible remedies. Its one disadvantage lies in the fact that it can not be applied while the sun is shining. This has been overcome by night applications, as herein described.

It was suggested that the kerosene might affect the aroma of the cigar. Cigars wrapped with sprayed tobacco, however, fail to give evidence of any such effect. Very particular attention was paid to this point, but no traces whatever of the kerosene in either the leaf or the cigar could be detected.

HOW TO MAKE KEROSENE EMULSION.

The formula heretofore given, namely, 2 gallons of kerosene, 1 gallon water, and one-half pound of soap, is followed when hard soap is used. The soap should be cut into fine shavings and dissolved in the gallon of boiling water. The water should then be added to the kerosene while still hot and churned by means of a force pump, pumping it back into the same vessel for ten minutes. When thoroughly emulsified it has a creamy appearance and upon cooling becomes much thicker.

A certain naphtha soft soap is now manufactured that will dissolve readily and by the use of which the emulsion can be made without heat. When this soap is used, a pint will replace the hard soap in the formula. This naphtha soap has the advantage that it can be made up at short notice and at any place needed. In lots of 100 pounds it can be obtained at 3½ cents per pound. Whale-oil soap has been used to replace hard soap in the formula, but seems to have very little advantage over hard soap.

When making the emulsion, care should be taken that it is completely emulsified. Each particle of the kerosene must be surrounded by a film of soap, and unless this be brought about by thorough churning with the force pump the kerosene, being free, will not mix with the water, but will rise to the surface and, as the sprayer becomes nearly empty, will be forced out in the spray and burn the foliage.

WHEN TO APPLY THE EMULSION.

The emulsion should be applied first when the plants are in the seed bed. A number of applications will be advisable in order that the hibernated thrips may be killed and not carried to the field on the plants when set out. Spraying in the field should be commenced as soon as the plants are transplanted. Two applications a week, when possible, seem advisable. By starting when the plants are in the seed bed and spraying regularly, it seems probable that the pest can be almost entirely checked.

In combating the budworm of tobacco it is necessary to apply Paris green in the leaf bud (1 tablespoonful to a peck of corn meal) two or three times weekly to prevent serious injury. The moisture furnished by the kerosene spray, when it comes in contact with the Paris green, has a tendency to slightly burn the bud, and care should be taken not to spray into the bud more than is necessary. As the plants get larger this can be easily prevented. It will be found well to apply the Paris green and meal on the morning following the spraying, when possible.

HOW TO USE THE EMULSION.

After experimenting with different strengths it was found that 1 part of the stock emulsion to 10 parts of water is effective. The emulsion may be handily diluted to the required strength in large quantities, in barrels or casks set near the rows to be sprayed. If left standing for longer than two days, the kerosene separates from the soap and therefore should not be diluted until the day it is to be applied or day before. The tobacco has been sprayed with emulsion during the day until it was 6 inches high without burning. Even if burning does occur in this early stage it is not objectionable, as the leaves drop from the stalk before priming commences.

The emulsion is best applied by means of a knapsack sprayer. While the plants are small the insecticide can be properly applied by spraying one row at a time, but as the plants get larger it has been found best to spray a row twice, going down on one side and back on the other. It has been found that spraying can be commenced shortly after 5 o'clock in the evening, except it be a very bright, hot day, when it will be necessary to wait until a little later. On large plantations this gives insufficient time during daylight, and spraying after dark becomes necessary. In so spraying after dark the use of two hands to a row, one on each side, preceded by a boy with a lantern or a torch, is a very satisfactory and economical method of application. Care should be taken that the spray is distributed over all the leaves, as it must come in contact with the thrips when sprayed in order to be effective.

COST OF SPRAYING.

Supplies and labor.—The applications necessary to keep the pest in check will be found to vary considerably, depending upon the rainfall. It seems improbable that spraying for the maximum period of ten weeks will be found necessary when regular spraying is started while the plants are still in the seed bed. The amount of spray necessary and the labor required in spraying varies with the growth of the plant. It was found in June, when the plants were about 2 feet high, that 8 acres were sprayed in four hours by nine men and three boys, using six spray pumps and applying 50 gallons of the diluted emulsion per acre. This was at a cost of about 55 cents an acre for labor and 50 cents for spray. It is roughly estimated that the expense will not exceed $20 an acre, even if found necessary to spray twice weekly for the maximum period of ten weeks.

Apparatus.—In applying the emulsion it is necessary, from the nature of the crop, to use a knapsack sprayer. These sprayers can be purchased for from $5 to $15. The writer would recommend the the purchase of the better grades, as they will be found the most satisfactory and in the end the cheapest.

SUMMARY OF RECOMMENDATIONS.

The following recommendations are made as a result of the experiments carried on in 1905, and the success following their practice:

1. Practice clean cultivation of the field between crops.
2. Plant fields bordering the shade to other than cereal crops.
3. Locate the seed bed outside the tobacco field.
4. Apply kerosene emulsion (1 part to 10 parts of water) with a knapsack sprayer twice a week regularly, commencing while the plants are in the seed bed.

It is very important that the spray be regularly and carefully applied during the first few weeks after transplanting, in order that the adult thrips which have passed the winter in the tobacco field be killed before depositing their eggs on the tobacco or weeds in the field.

CAUTION.

The kerosene emulsion must be churned until thoroughly emulsified, else burning will follow the application.

The emulsion should not be made up to the 1 to 10 strength until shortly before using, as when left standing for longer than two days the excess of water has a tendency to dissolve the soap surrounding the oil globules, setting the oil free.

Spraying must be done in the evening (after 5 o'clock), else the sun's rays will cause a burning of the leaves, following the spray. Spraying may be done on a cloudy day, but only when there is no danger of the clouds breaking away and allowing the sun to appear.

Spraying should not follow an application of Paris green, and when preceding it the plants should be allowed to dry before the Paris green is applied. Care should be taken not to spray into the leaf bud, so far as that can be avoided.

ADDENDA.

THE TOBACCO THRIPS IN 1905–6.

Although the writer was unable to continue the work in Florida the past year (1906), as planned, he took advantage, in November, of the opportunity offered to visit Quincy. An interview with several planters was sufficient to further convince him of the practicability of spraying with the kerosene emulsion and the efficiency of this spray when carefully applied.

The injury produced by the thrips the past year has been only about 60 per cent of that of 1905. This is undoubtedly due to the variation in the period and the amount of precipitation, as before stated by the writer.

EFFECT OF THE SPRAY.

As previously stated, the writer was associated during the work on this insect with Mr. W. W. Cobey, tobacco-breeding expert of the Bureau of Plant Industry. During the past two years Mr. Cobey has had opportunity to observe the results obtained from the use of the kerosene-emulsion spray and at the request of the writer has prepared the following statement in relation to its effect on the character of the tobacco and the desirability of its use:

It is the opinion of the writer, after a careful comparative study of the treated and untreated tobacco, that the use of kerosene emulsion on tobacco, when carefully prepared and applied at the proper time under favorable conditions, is in every way practicable and can be profitably employed by tobacco growers in preventing almost wholly the ravages of this insect. There was considerable apprehension among the tobacco growers at first regarding the probable injurious effects of the kerosene emulsion on the character of the tobacco. However, a careful study of the cured and fermented tobacco from the sprayed plants showed that the spraying with kerosene emulsion had not injured the quality or reduced the value of the crop. It has been impossible to discover any difference in the color, elasticity, or aroma of the treated and untreated tobacco after curing and fermenting. On the other hand, the prevention of injury to the tobacco by the thrips, by means of the kerosene-emulsion spray, prevented a serious loss to the grower.

The injured tobacco may be fermented sufficiently to even up the color of the leaves and darken the white or discolored veins so that the injury will not be noticeable, but this severe sweating will darken the leaves to such an extent that they can only be classed as dark wrapper.

The use of the spray was quite general during the season of 1906, and serious injury to the tobacco from the thrips was thus prevented. It was found by those who commenced to apply the spray early in the season and were forced to discontinue it after the tobacco was about 2 feet high, that there was but very little injury by the thrips, while those who did not use it suffered a loss to an extent of about one-fourth of that of 1904. During the year the injury under slat shade was very slight.

For those who may apprehend injury to the quality of the tobacco it may be said that the experiments conducted during the last two seasons indicate that when spraying is begun very early in the season it will not be necessary to continue it after the crop is about half grown.

INDEX.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part I.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE ASPARAGUS MINER.
NOTES ON THE ASPARAGUS BEETLES.

BY

F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

ISSUED MARCH 16, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

CONTENTS.

ILLUSTRATIONS.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE ASPARAGUS MINER.

(*Agromyza simplex* Loew.)

The stalks of asparagus are frequently attacked by insects, and in recent years have been reported considerably injured by the larva or maggot of a minute black fly to which the name asparagus miner has been given. The larva mines under the epidermis of the stalk, and when it has transformed to the puparium or "flaxseed" stage the thin outer skin becomes more or less ruptured and the presence of the insect is easily detected. It operates more abundantly near the base of the stalks and penetrates below the surface of the ground to a depth of 7 or 8 inches. During the year 1906 this species attracted considerable attention by its abundance in some of the principal asparagus-growing sections of New England and it bids fair to become a pest of considerable importance. It was first noticed on asparagus

FIG. 1.—*Agromyza simplex:* Fly, dorsal view at left, lateral view at right. Highly magnified (original).

in 1896, ten years earlier than the present writing, prior to which time nothing was known of its habits. It is a native species and evidently restricted to asparagus as a food plant. Until the year 1906 it had not been recognized as doing injury to cutting beds, although attack had been observed in various sections. The mines of the larvæ about and below the bases of the stalks are frequently so abundant that they have the effect of girdling, so that the injured stalks can be readily pulled from the ground.

DESCRIPTIVE.

The parent insect is a two-winged fly (fig. 1), metallic black, with large prominent head and eyes, and clear wings, the wing expanse being about one-sixth of an inch (4 mm.).

The larva (fig. 2, *a*) is about one-fifth of an inch long and milk-white in color. Like other maggots, it is footless, large at the posterior extremity, and tapering toward the head.

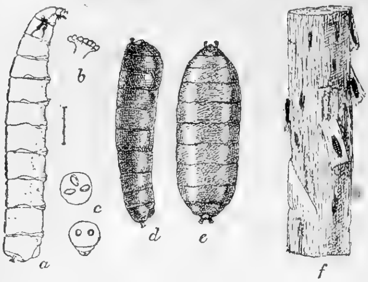


FIG. 2.—*Agromyza simplex:* *a*, larva, lateral view; *b*, thoracic spiracles; *c*, anal spiracles; *d*, puparium from side; *e*, same from above; *f*, section of asparagus stalk, showing injury and location of puparia on detached section; *a-e*, much enlarged; *f*, slightly reduced (original).

The puparium (fig. 2, *d*, *e*) is not unlike the "flaxseed" of the pernicious Hessian fly, with which it has been aptly compared. At a little distance, also, it suggests a Lecanium scale. This stage is remarkable because of its peculiar flattened and curved position, as seen from the side. It is red in color, and measures about 3.5 mm. in length and about 1 mm. in width.

The egg has not been observed.

This species belongs to the dipterous family Agromyzidæ, and was described by Loew in 1861,[a] the locality being given as "Middle States."

DISTRIBUTION.

In its injurious occurrences this species appears to be limited to the eastern United States, from New England to Tennessee. From available data it is quite obvious, however, that it may be destructive over a considerable territory, including a large portion of Massachusetts and Connecticut, Long Island, the District of Columbia, Pennsylvania, and Tennessee. As it is recorded from New Jersey, it is probably injurious there, although no reports of injury in that State have reached this office. In time it will doubtless attract attention in intermediate points and in States farther north and west. It has also appeared in asparagus beds in California.

HISTORICAL AND BIOLOGICAL NOTES.

In May, 1897, and afterwards this fly was observed in abundance by the writer on terminal shoots of asparagus, particularly at Cabin John, Md. Two weeks later no more flies were seen, but June 26 they reappeared and were then usually seen *in copula*. It was surmised at the time that this second appearance indicated the first new generation of the year and its abundance on asparagus seemed to show that it lived in some manner at the expense of that plant. Examination of asparagus plants at that time, however, failed to show attack. The facts which have just been narrated were published in 1898.[b]

---

[a] Diptera Americæ septentrionalis indigena, Centuria octava 84, p. 160.

[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., p. 62, 1898.

In 1900 we received complaint of injuries in the District of Columbia, and from Knoxville, Tenn., and in the meantime the species came under the observation of Mr. F. A. Sirrine, who has stated[a] that work was first observed in asparagus fields on Long Island in 1896. This statement is made in a bulletin of six pages, which represents all that was known of the species at that time.

Late in September, 1900, word was received from Mr. Frederic Voigt, Tennallytown, D. C., of injury to the stalks of asparagus on his and a neighboring truck farm. When the writer visited the field, however, although injury was apparent on the outer skin of some stalks, no living specimens could be obtained, only the dried puparia being in evidence at this time. October 2 of the same year, Mr. Samuel M. Bain, University of Tennessee, Knoxville, Tenn., sent a stalk of asparagus showing the work of this miner upon the skin, and, October 27, specimens of the dried puparia.

February 18, 1901, Mr. T. Miles Brous, Bustleton, Philadelphia, Pa., wrote that this insect, which he accurately described, seemed to cause much greater trouble than the common asparagus beetle. A neighbor had lost two or three new beds of asparagus on account of its ravages.

By the writer's direction, Mr. F. C. Pratt visited a large truck farm at Brookland, D. C., where asparagus was one of the main crops, June 18, 1902. Asparagus was still being cut for market, but volunteer plants were growing here and there in fields of corn, cantaloupe, and potatoes, between rows. A few flies were seen on terminal shoots of asparagus that showed wilting, and many volunteer plants were found badly infested, most individuals having transformed to pupæ. Although stems break off just below the ground, the entire colony of insects below that point is left with sufficient moisture and nourishment for their maintenance. The puparia were present in great numbers underneath the outer skin of the root, and as many as nine puparia were counted in a space only an inch long on one stalk. The stalks below the point of injury appeared to be perfectly sound. Larvæ also were found in rotting stalks that broke off just below ground.

During 1905 Mr. Ralph E. Smith reported this species as becoming abundant in California, though not of any great importance at that time. His description of the insects' manner of work leaves no doubt as to the identity of the species.[b]

RECENT INJURY.

During September, 1906, Messrs. J. B. Norton and A. D. Shamel, of the Bureau of Plant Industry, furnished stems of asparagus from Concord, Mass., showing severe infestation by this species, many

---

[a] Bul. 189, N. Y. Agric. Exp. Sta., p. 277, Geneva, 1900.

[b] Bul. 165, Univ. of Cal. Agric. Exp. Sta., p. 96, 1905.

puparia being present under the mined outer skin. In the neighborhood of Concord, a very important asparagus-growing region where hundreds of acres are devoted to this crop, the infestation was practically absolute, the insect being found even as abundantly as the common asparagus beetle, being present wherever rust was found, as also where no rust was present. The specimens submitted were about the average as regards the degree of infestation, some plants showing injury 7 inches below the surface.

Severe injury was reported on the farms of Mr. Frank Wheeler and Mr. Charles W. Prescott, at Concord, Mass. The growers in that region had never noticed this insect until Mr. Shamel's examination showed that its injuries were extensive. Later Mr. Shamel reported finding infestation in every field and patch of asparagus which he visited in Massachusetts and Connecticut, particularly at Suffield, Granby, and Hartford, Conn., and he believed attack to be widespread.

October 26, 1906, Mr. Ralph E. Smith wrote, by request, that the conditions under which this asparagus miner was found in abundance in the yellow stalks of asparagus in California, as reported by him in an article on Asparagus Rust Control,[a] had prevailed for two or three years. The insect was always very abundant at the base of these yellow, dying stalks, although the injury was attributed to the "centipede," reported as wireworms on a previous occasion.[b]

REMEDIAL MEASURES.

With our present knowledge of the life economy of this species, two methods of control suggest themselves as of greatest value, and it may be that they will prove all that is necessary under ordinary conditions.

(1) In spring permit a few volunteer asparagus plants to grow as a trap crop, to lure the fly from the main crop or the cutting beds for the deposition of her eggs. After this has been accomplished the trap crop should be destroyed by pulling the infested plants and burning them with their contained puparia. The time to pull the plants will vary according to locality and somewhat according to season also. The second and third week in June would be about the right time in and near the District of Columbia. On Long Island this work should be done a week or two later. In the northernmost range of this insect—for example, in Massachusetts—the last of June and the first of July would probably be a suitable time.

(2) The second generation can be destroyed in like manner by pulling old infested asparagus stalks as soon as attack becomes manifest and promptly burning them also.

---

[a] Bul. 172, Univ. Cal. Agric. Exp. Sta., p. 21; [b] Bul. 165, l. c.

If this work were carefully done over a considerable area, it would leave little necessity for other methods, since it would do away with these insects in the vicinity and leave few to be dealt with another season; unless, indeed, this insect has an alternate food plant. The cooperation of neighboring asparagus growers and thoroughness are essential for success.

This method will operate also against the rust which is now present in many fields infested by the miner.

NOTES ON THE ASPARAGUS BEETLES.

Since the publication of the writer's general article on the asparagus beetles in the Yearbook for 1896,[a] many notes on their distribution and destructive occurrences have been published. Some additional data were published soon afterward.[b] The following brief review of the subject is submitted as a sequel to those articles and a summary of the further dissemination of these pests in a decade of years.

THE COMMON ASPARAGUS BEETLE.

(*Crioceris asparagi* L.)

The predictions made by the writer in regard to the future distribution of the common asparagus beetle have been completely fulfilled as regards its western spread, although it has not as yet been reported as far south as Kentucky. Mr. J. G. Sanders, however, informs the writer that it has been established about Columbus, Ohio, since 1903, and Mr. Charles Dury, Cincinnati, Ohio, reported this species at Indian Hill, about 7 miles from that city, on asparagus beds in 1905. Hundreds were observed during June. The customary injury was noticed, and plants appeared as though scorched with fire. In 1897 the species was observed to have continued its spread westward along Lake Erie, and was then known in nine counties in northeastern Ohio. The following year it was first noticed in western Virginia. In 1898 also it was reported to have been present at Benton Harbor, Mich., since 1896. By 1899 it had made its appearance in Canada, accompanied by the twelve-spotted species, in the Niagara River region.

It is interesting to note that in 1900 the present species, which had been rapidly increasing its range in the East, including New York, after occurring in injurious numbers in Maryland, was apparently totally destroyed by the hot spell of July and August that occurred in the District of Columbia and neighboring parts of Virginia and Maryland; whence the conclusion that this condition prevailed to a considerably larger extent than came to the writer's personal notice. In 1901 Dr. James Fletcher noted that the species, though present in the Niagara district, had not increased to the extent that was feared. It had spread to Guelph, Ontario, that year, and did much damage about St. Catharines. In 1904 its occurrence around Toronto was

[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 341–352.

[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., pp. 54–59, 1898.

noticed. It was reported also 40 miles west of Chicago, Ill. It has become very generally distributed in asparagus-growing districts in New York State, and has reached Glens Falls, which approximates its northernmost limit in this country. In 1905 we received complaint of this insect as a pest in Illinois, at Park Ridge, and of its occurrence about Chicago. Reports from Michigan showed that it had been present there in 1904 in the vicinity of Ada, about 10 miles from Grand Rapids, and that it was a pest in that vicinity.

Although the data given above indicate that the species is now well distributed throughout the Upper Austral region, for some reason its occurrence in Indiana has not yet come to our knowledge; nevertheless although there are naturally many uninvaded localities, it is undoubtedly established in that State, most probably near Lake Michigan.

As an example of its manner of distribution, it might be noted that in May, 1905, the beetle was found for the first time in Warrenton, Fauquier County, Va., a little farther inland than it had ever been noticed in that section. Yet this species has been permanently established in the adjoining Alexandria County for many years.

August 8, 1905, Mr. Ralph E. Smith wrote of the occurrence of this species in California, stating that during two seasons it had been very abundant at Bouldin Island, the principal asparagus center of that region. As Mr. Smith was familiar with this insect and its occurrence on the Atlantic coast, there is little doubt that his identification is correct. In the winter of 1904 to 1905 Bouldin Island was flooded and remained under water for over a year. It had just been reclaimed and there were no signs of the beetles. There is, therefore, a possibility that the insect was exterminated in that region, and this includes the State, if the occurrence of the species was only local.

The dying out of this asparagus beetle in small localities where it has not become thoroughly established is not without precedent, as its recorded occurrence at Rock Island, Ill., many years ago, has been verified by specimens now in a Chicago museum, properly labeled as collected there by the late A. Bolter, an experienced collector of Coleoptera. Indeed, it would seem that few vegetable-feeding insects are more subject to extermination in a limited locality not contiguous to one also infested than is the present species.

October 26, 1906, Mr. Ralph E. Smith, at the writer's request, reported the status of this species in California. He wrote that during the summer he found the beetles again, and that they were very abundant in fields near Oakley, Cal. It could not be stated that the insect was of general occurrence in the State, but apparently it existed only in a few scattered colonies. As previously reported the colony at Bouldin Island appears to have been exterminated by flood, and the Oakley occurrence was the first that Mr. Smith had noted since. In most of the asparagus acreage of the State the insect was not yet present.

Mr. Franklin Sherman, jr., has kept a careful record of the occurrence of this species in North Carolina, and informed the writer, on the occasion of a visit in 1906, that it is common in the east-central part of the State in the trucking belt, and especially abundant at Raleigh, Wake County, Goldsboro, Wayne County, and Warsaw, Duplin County.

In order to make the present account of the known distribution of this species as complete as possible, inquiry was made of the official entomologists of the States of Kentucky, Iowa, Missouri, Nebraska, and Minnesota, all of whom reported that the occurrence of this species in their States had not been brought to their attention. Mr. James G. Moore, however, assistant in horticulture at the University of Wisconsin, Madison, Wis., stated that the asparagus beetle had been found in Wisconsin, but he had no special data on its distribution.

REMEDIES.

With regard to remedies good results have followed the experimental use of arsenate of lead. This insecticide has come into very general favor in recent years, and in the correspondence of this office we have for some time advised its employment against most leaf-feeding beetles, like the asparagus beetles. In Connecticut Dr. W. E. Britton [a] has made a practical test of this remedy on asparagus plants, spraying them from all four sides in succession because of the slight leaf exposure as compared with most other plants. The day following treatment (June 4) many dead beetles and larvæ were found on and under the plants. A few had survived and were feeding, but ten days later only a few living larvæ could be found, and the beetles did not again become abundant on the plants during the summer. The same amount of good might be accomplished with scarcely greater expense by spraying from opposite sides and repeating just before the time for the last generation to develop and in time to check the beetles before they go into winter quarters.

In Pennsylvania Prof. H. A. Surface,[b] in a series of experiments with Paris green and arsenate of lead, applied to asparagus plants the first week of June, 1905, found that not more than 50 per cent of the insects were killed when Paris green and lime were used. With lead arsenate 90 per cent were killed, while in one experiment, by the addition of resin soap, which is used as an addition to an insecticide to

---

[a] Rept. Conn. Agric. Exp. Sta. f. 1903 (1904), pp. 275, 276.

[b] Monthly Bulletin, Div. of Zool., Pa. State Dept. Agric., Vol. IV, May, 1906, p. 8.

enable the poison to adhere better to smooth plants, 100 per cent of the insects were killed on the 50 plants treated. In this case the arsenate of lead was used at the rate of about 1 pound to 24 gallons of water, and 2½ pounds of soap were added.

Arsenate of lead has been used with satisfactory results on asparagus at the rate of 1 pound in 16 to 24 gallons of water. Additional experiments are necessary to ascertain the exact amount of the poison that can be used economically to produce the best effect. In Professor Surface's experiments evidently only a single spray was applied.

THE TWELVE-SPOTTED ASPARAGUS BEETLE.

(*Crioceris 12-punctata* L.)

Nearly every year since 1896, when the distribution of the twelve-spotted asparagus beetle was recorded by the writer,[a] the appearance of this species has been noted in new localities in the United States, until it is now well distributed westward and especially northward.

In 1898 Dr. J. B. Smith stated that it then occurred throughout the State of New Jersey "south of the shale from the Atlantic coast to the Delaware." The following year (1899) it was recorded by Dr. E. P. Felt from different counties in New York, and as far west as Buffalo. In some places the species was abundant, while in some near-by localities it could not be found, showing that it was still locally distributed through New York. It was afterwards recorded present in Albany, Batavia, Leroy, Syracuse, Riverhead, Oswego, Center, Glendale, Richmond Hill, Penfield, Elmira, Geneva, Ithaca, and about Brooklyn, N. Y. It was also stated to occur in the Niagara district in Canada as far back as Hamilton, Ontario.

An interesting point in regard to the occurrence of asparagus beetles in the Niagara peninsula was that the two species appeared to have arrived almost simultaneously in that region, but that the twelve-spotted form was by far the more common one. In after years different observers noted its further spread in Canadá, commenting upon the fact that it led the common species in becoming diffused by natural means. By 1902 it had appeared in Connecticut, at New Haven, and later in other parts of that State.

Since some writers on these asparagus beetles have overlooked the author's second article[b] it may be well to mention that facts additional to those printed in the writer's original article are given therein, including a description and illustration of the egg and its manner of deposition, and what is practically a complete account of the life history of the species, the insect being found to develop and to feed where possible almost exclusively on the berry, although the beetles attack young asparagus shoots before the berries appear.

[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 350–351.

[b] Bul. 10, Div. Ent., U. S. Dept. Agric., pp. 57–59, 1898.

The young larva.—The freshly hatched larva has not hitherto been described. It may be briefly described as follows:

Head rounded, nearly twice as wide as long as seen from above; thoracic plates distinctly separated at the middle, with the intervening space yellow; legs infuscated, clear whitish at sutures. General color very pale yellowish, nearly white, and the surface much wrinkled. Length 1 mm., width 0.35 mm.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part II.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE WATER-CRESS SOWBUG.

THE WATER-CRESS LEAF-BEETLE.

BY

F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

ISSUED APRIL 23, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

CONTENTS.

ILLUSTRATIONS.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE WATER-CRESS SOWBUG.

(*Mancasellus brachyurus* Harger.)

During the past three years this isopod has attracted very considerable attention because of its occurrence in troublesome numbers in water cress (*Nasturtium officinale*) grown for market in portions of Virginia, West Virginia, and Pennsylvania. The species is purely aquatic, thus differing from our common dooryard sowbugs, which, although most abundant in moist locations, are strictly terrestrial. It belongs to an entirely different family, the Asellidæ, which contains three genera, mostly fresh-water forms, inhabitants of streams, wells, pools, and lakes.

DESCRIPTIVE.

This species is so distinct from the more common sowbugs (Oniscidæ) that a brief description will suffice. Its general appearance is shown, dorsal view, in figure 3. The body is much depressed, and the legs are long and strong. Seen from the side, it is decidedly shrimplike. The peculiar structure of the antennæ may be noticed in the illustration. They terminate in long flagella, composed of many joints. When mature this sowbug attains a length of 13 or 14 millimeters, or a little upward of half an inch, and is a little more than twice as long as wide, and gray in color. This creature is not an insect, but a crustacean, and therefore classed with crayfish and crabs. A detailed description is given by Miss Richardson,[a] who briefly mentions McKees Spring, Gaylord, and Lexington, Va., as localities where this sowbug was "reported injurious to water cress."

By recent correspondence we have obtained necessary information in regard to the habits and manner of operation of this sowbug, and we have also been successful in ascertaining what promises to be a very perfect remedy for the pest in its occurrence in streams and in spring water. It appears to affect cress only below the surface of the water, attacking the roots and lower leaves, and cutting off the stems

[a] Monograph of the Isopods of North America. By Harriet Richardson. Bul. 54, U. S. National Museum, Washington, 1905, pp. 411–412, figs. 460–461.

near the bottom, causing bunches of the plant to float. In portions of streams where these sowbugs have been found most abundantly they are frequently seen crawling in a thick mass at the bottom. They feed, so far as known, exclusively on cress, not being reported as attacking any other form of vegetation.

REPORTS OF INJURIOUS OCCURRENCES.

This sowbug has been observed as a pest since 1902. Our first report of its pernicious habits was made in 1904, when we received specimens through Mr. J. W. Bryan, Anacostia, D. C., from Halltown, W. Va., where it was very injurious to water cress.

In March, 1905, Mr. Powell Arnette reported injury at Gaylord, Va., to cress grown in spring water. The sowbugs were always found in the water and did not attack cress above the surface. After destroying the last vestige of cress in one of his ponds they remained on the bottom "a foot deep," crawling about on the mud.

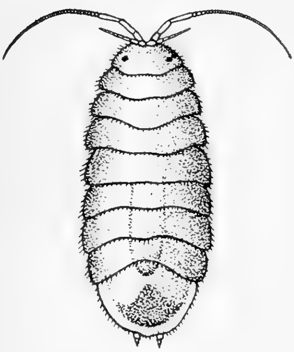


FIG. 3.—The water-cress sowbug (*Mancasellus brachyurus*). Enlarged (after Richardson).

During 1906 (June 18) Mr. John H. Reed, Carlisle, Pa., wrote in regard to this species and its destructive work on water cress in his locality. Specimens were received August 11. The sowbug was observed principally on the roots and lower leaves, crawling up along the stem and cutting off the leaves. August 10 Mr. George C. Jordan, Washington, D. C., sent specimens from Basic City, Va., stating that this "water bug" was devouring his cress beds, and, since a million or more were colonized on the plants, there would be no crop at the rate they were reproducing. When the plants were lifted the sowbugs were observed to drop from them.

METHODS OF CONTROL.

Three ways of controlling this species are suggested. The first and most important consists in a method of growing the water cress so as to eliminate injuries by the sowbug. The second falls under the head of direct remedies, and none of these has as yet given satisfactory results. The third consists in the use of fish or fowls as destroyers. This last means of eradicating the pest has not yet had a fair trial.

The following description of a successful method of disposing of the cress sowbug has been placed at our disposal by Messrs. B. Bryan

& Son, who are practical cress growers and have had several years' experience with the pest:

A METHOD OF GROWING WATER CRESS TO DISPOSE OF THE SOWBUG.

The damage done by the sowbug to water cress has made it our greatest enemy in cress growing, and only after fighting it for four years have we succeeded in finding a way to keep down its numbers so as to be sure of a crop. As cress is ordinarily grown—in lakes or streams of spring water anywhere from 6 inches to 3 feet in depth—it seems impracticable to apply any insecticide. At first we tried to catch the bugs with wire-netting traps placed where the whole stream of water had to pass through them, but the bugs remained among the cress, and we caught only about 20 per cent.

Later, in using copper sulphate to kill moss in the cress, we found that it also killed the sowbugs, snails, etc., when applied freely. Further experiments, however, proved that bluestone could not be applied in deep running water any better than the insecticides previously tried, and when applied in shallow or still water it injured the cress.

The method we are employing at present to fight the sowbug is largely a matter of arrangement of cress beds (see fig. 4), and can be used only where the bottoms of the beds can be graded and drained or where level land adjoins

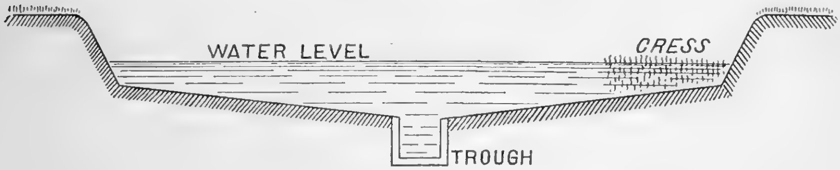


FIG. 4.—Cross section of cress pond showing arrangement for avoiding damage by the water-cress sowbug.

the source of the water supply. We dug long trenches in level land, making them 16 feet wide and about 15 inches deep. Lengthwise they were graded to give a fall of 3 inches in 100 feet, and crosswise to make the center of the trench several inches deeper than the sides. In the center and running the full length of the trench a trough made of three 10-inch boards was sunk below the bottom of the trench in such a way that all of the water might be drained out of the trench through it. Then, with the upper and lower ends of the trench and trough arranged to be opened or closed, the trench could be filled or emptied at will and the flow of water regulated up to 8 inches in depth over the cress. Of course fertile soil was put in the trenches and the cress could be planted either before or after the water was turned in.

With cress beds arranged as above, manipulation to dispose of the sowbugs is simple. By cutting off the water supply and allowing the water to pass out at the lower end of the trench, the sowbugs will collect in the trough, following the receding water, as they can live only in water. No little puddles should remain among the cress, as the bugs will collect in them instead of in the trough. It will be found necessary, also, to use boards to walk on in gathering the cress, as prints of one's boots in the beds would make holes for the bugs to shelter in. The bugs do not move until nearly all of the water is drawn out of the trench. Thus they are collected in a small amount of water in the trough and can then be readily killed with a liberal amount of bluestone, either solid or in solution.

To make the work thorough, water should not be turned into the trench again for twelve or twenty-four hours, in which time the few bugs left among the cress stems will die or find their way to the trough. The trenches can be cleared of bugs in warm weather as frequently as desired, but less danger is done the cress crop if the work is done just after gathering the cress.

The same method of disposing of the sowbugs could be used in greenhouses in the winter, but cress grown in the open air could not be exposed in freezing weather, making the remedy inapplicable in cold weather.

We have not used water in these trenches deeper than 10 inches, and are not able to say how a larger or more rapidly flowing supply of water would act, nor have we grown winter cress in them, as our water supply is insufficient for that purpose.

OTHER REMEDIES.

About the only other remedies which we have been able to suggest are the use of a substance, such as sulphate of copper or chlorid of lime, which might be placed in the water to destroy the pest. As the former has already been tested by Messrs. B. Bryan & Son (see page 13), it need not be mentioned further.

Mr. John H. Reed states that a grower at Healing Springs, Va., has a remedy consisting of a poisonous material which is placed in the water, but he does not know the ingredients nor whether there would be danger to stock drinking the water below the spring. He writes also of the possible use of chlorid of lime. A tank of bleach composed principally of chlorid of lime ran into a creek at Mount Holly Springs, Pa., killed everything that was living in that stream for about half a mile downward, but did not poison stock that drank the water. The bleach came from a paper-mill tank which had burst. If chlorid of lime is tested it should be used on a very small scale at first to note the effect on plant life. It is apt to be harmful to trout and other fish present.

Mr. Reed also suggested the employment of ducks to destroy the pest, but this would necessitate the abandonment of cress culture for a season, as the ducks would injure the condiment both by eating it and by fouling the water.

Among other remedies, we have recommended draining off the water where possible and exposing the sowbugs to the drying effects of the sun.

FISHES AS A POSSIBLE MEANS OF DESTROYING THIS ISOPOD.

In response to inquiry, the following information was received from the Bureau of Fisheries, through Mr. Lawrence O. Murray, Acting Secretary, Department of Commerce and Labor, in regard to the fishes which might be found useful in the destruction of this aquatic isopod in its occurrence on water cress:

Among the fishes which would probably prove most useful for this purpose and with which it is suggested that the Department may wish to experiment are the fresh-water killifishes *Fundulus notatus*, *F. diaphanus*, and *F. dispar*. The first occurs from Michigan to Alabama, Mississippi, and Texas, and is rather common in small lowland ponds. The second is found from Maine to North Carolina in river mouths, in the Great Lakes, and in practically all of the small lakes in the upper Mississippi Valley. The third occurs in smaller lakes and ponds from northern Ohio to Illinois and south to Mississippi. Specimens of each of these species could be obtained at any one of several small lakes in the northern part of Indiana.

It is probable that some of the catfishes might also be useful in this connection, and it is suggested that it might be worth while to try one or more of the small species known as "mad Toms," belonging to the genus *Schilbeodes*. One or more species of this genus can be found in almost any small, sluggish stream in Pennsylvania, Virginia, and West Virginia.

The writer believes that carp should prove of value in keeping down this cress sowbug, there being one drawback, however, that the carp must be watched to see that they do not develop too rapidly and that they do not attack the cress or make the water muddy. Catfish have been tried and found wanting in the case of the water-cress leaf-beetle, which will be considered elsewhere (pp. 16–20).

THE WATER-CRESS LEAF-BEETLE.

(*Phædon æruginosa* Suffr.)

INJURIOUS OCCURRENCE.

Among plant-feeding native insects which have recently appeared in new rôles is a little blackish leaf-beetle, *Phædon æruginosa* Suffr., which was reported for the first time as injurious to water cress (*Nasturtium officinale*) in Pennsylvania, in 1903.

During September Mrs. Hannah B. Hannum, Brandywine Summit, Pa., sent larvæ and adults of this species, with statement that they were devastating her water-cress pond. Both larvæ and beetles fed chiefly on the lower side of the leaves. In confinement they continued feeding, attacking the stalks also. The larvæ all reached development about the same time, being fully matured September 11 and 12, on the last of these two days crawling about the rearing jar and ceasing to feed. The pupal period was not observed, but it probably lasted ten days or a fortnight, as the weather was cool. The beetles continued for some time in our rearing cages, frequently pairing, but depositing no eggs.

August 19, 1904, Mrs. Hannum sent additional specimens of this species in the beetle and nearly grown larval stages. It was noticed that the beetles did not swim rapidly, but steadily, and they were seemingly not discomposed by being somewhat out of their natural element. It seems probable that they fly from plant to plant, and like most beetles undoubtedly are able to float for many hours, and perhaps even swim short distances until they reach a landing place. September 13 our correspondent sent still another lot of this species, mostly beetles, but a number of larvæ were included.

Specimens of the larvæ of a syrphus fly accompanied this sending and probably fed at times on the small larvæ of the beetle.

DESCRIPTIVE.

The beetle.—This species belongs to the tribe Chrysomelini of the family Chrysomelidæ. It is classified in our publications on the Coleoptera of America north of Mexico with Plagiodera, but European systematists place allied forms in the genus Phædon Latr., which now comprises seven species occurring in our country. They are very small semiglobose forms. The outline is oval, with the thorax narrowed anteriorly and the apex margined. The elytra have eight punctate striæ, with a short subsutural and submarginal row of punctures. The third joint of the tarsi is emarginate apically.

The present species measures a scant one-eighth of an inch in length (3 mm.), is shining bronzy black, and has the elytral intervals apparently smooth, but in reality faintly rugulose when highly magnified, while the thorax is microscopically reticulate. The original description appeared in 1858.[a]

The egg.—The eggs have not come under observation. They probably resemble those of the European *Ph. armoraciæ* L., described by Fryer as "elongated oval and of a dark orange color."

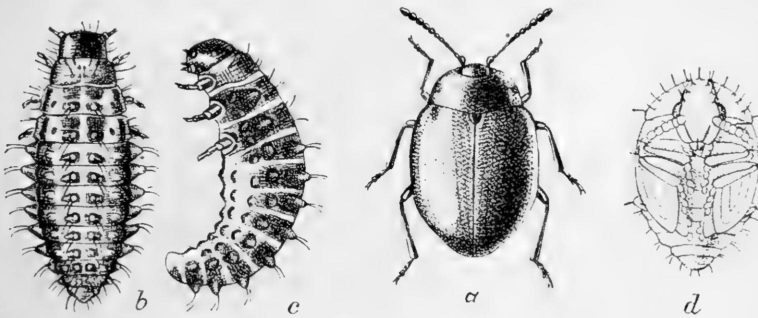


FIG. 5.—The water-cress leaf-beetle (*Phædon æruginosa*): *a*, adult; *b*, larva, from above; *c*, same, from side; *d*, pupa. Enlarged twelve times (original).

The larva.—The larva appears somewhat like that of a related genus, Galerucella, only that it is very much smaller. It is about three or four times as long as wide, depending upon whether it is somewhat contracted or fully extended. The head is subtruncate in front, with the antennæ lateral (in preserved specimens). The head is shining black, and the remainder of the body very dark brown or brownish black relieved by lighter areas between the segments. The first thoracic segment is a little wider than the head: the second considerably wider than that, and the third widest, being nearly as wide as the first two abdominal segments. The second abdominal is widest, and at the same time the widest part of the body. The surface is sparsely covered with long hairs placed on piliferous tubercles, which are arranged some distance apart, as shown in figure 5, *b*. The tubercles on the sides of the dorsum are sometimes very prominent, and the larva is able to extend these, possibly, at will. From the abdominal segments large tubercular sections bearing hairs at their summit extend on each side. The anal segment is pale, like the ventral surface, which bears dark piliferous tubercles. Length, 5 mm.; width, 1.2–1.5 mm.

[a] Ent. Zeitung, Stettin, Vol. XIX, pp. 395, 396, 1858.

The pupa.—The pupa is illustrated by figure 5, *d*, which will answer better than a verbal description. The color is yellow, and the length is slightly less than that of the adult.

The distribution of this species is probably moderately wide and additional study must be given this subject. At present we know of its occurrence in the District of Columbia, in Massachusetts, and probably in West Virginia.

LITERATURE.

Brief mention of the occurrence of this leaf-beetle as an enemy of water cress in Pennsylvania in 1893 was made by the writer,[a] but Mr. Frederick Knab, of this office, mentioning the same species as *Plagiodera viridis*, has recorded[b] its occurrence in great abundance upon water cress near Springfield, Mass., in 1902. The identity of the species in question has been verified by the comparison of specimens, and Mr. Knab's record was evidently made on the assumption of Crotch[c] that *æruginosa* was merely a variety of *viridis*.

HABITS OF THIS AND A RELATED SPECIES.

We can not at the present writing give an approximate statement of the life history of *Phædon æruginosa*, and hence must depend on what is known of the related *Ph. armoraciæ*, which is common to both continents.[d] This letter has evidently been introduced into this country, but its habits have apparently not been studied here. It is known in England as the blue beetle and mustard beetle,[e] and is of considerable importance locally, in some seasons ravaging entire fields of mustard, cress, cabbage, and kohlrabi. It passes the winter as adult, reappearing in spring on cruciferous plants. Fryer stated that in the three years prior to 1881 the Isle of Ely, England, suffered from the ravages of this species, entire fields being injured. Mustard was attacked at about the time of the formation of the seed pod and after the stalks were stripped nearly to the cuticle the beetles transferred their attention to kohlrabi, which they completely consumed, at first attacking the leaves and afterwards the bulbs, leaving nothing but bare stalks.

The water-cress leaf-beetle is doubtless no exception to the general rule among most Chrysomelidæ and other species of Phædon, in laying its eggs on the under side of the leaves. Both larvæ and

[a] Ybk. U. S. Dept. Agric. f. 1903 (1904), p. 564; [b] Entomological News, March, 1903, p. 89; [c] Crotch, Proc. Acad. Phila., 1873, pp. 54, 55; [d] *Phædon armoraciæ* L. syn.: *Plagiodera cochleariæ* Panz., Gyll.; *Phædon betulæ* Küst. It is not the same as *cochleariæ* Fab. [e] Fryer and others have given accounts of this species in The Entomologist (Vol. XIV, pp. 44, 187, etc.).

adults attack the cuticle of the stem after feeding on the leaves, as has been noticed in the case of *armoraciæ*. E. A. Fitch has observed the partiality of the latter for water cress and other crucifers which grow in watery places and mentions the destruction of an entire crop of horseradish.

Kaltenbach[a] records, according to Gyllenhall and his own observations, *Veronica beccabunga*, *Cardamine amara*, and *Cochlearia armoracia* or horseradish as food plants, and states that the larva undergoes metamorphosis in the earth, the pupa state lasting fourteen days. Cornelius[b] is cited as having observed two generations, the spring generation being found in May and June and the second in September. Thomas H. Hart records the water starwort of England (*Callitricha verna*) as another host plant. T. R. Billups,[c] an entomologist as well as truck grower, mentioning this species as *Phædon betulæ*, states that it is "one of the greatest insect pests the market gardeners around London have to contend with." Our American species undoubtedly hibernate as adults and appear in early spring under boards and similar shelter.

METHODS OF CONTROL.

How to successfully control this insect under ordinary conditions is quite a problem. Paris green was tried by our correspondent, mixed with flour and sprinkled over the plants when the dew was on, and this reduced the numbers of the insect somewhat. Owing to the moist condition of the plants, however, the flour formed a paste which stuck like glue, and it was therefore abandoned. Applied in water it rolled off the plants. We were not informed if this application was made with a spraying machine. If the plants were sprayed lightly with a fine spray, it might answer, or, better, Paris green dry with only 20 parts of flour, or plaster or air-slaked lime. An arsenical should not be used within about a week of the time of cutting the cress for market. In the case of Paris green there is practically no danger of poisoning even if it were used later, as the washing which is given the cress will carry away all perceptible traces of the poison.

If conditions should be such that the pond or stream in which water cress infested by this species is growing could be completely overflowed, it would cause the insects to rise to the surface, and in the case of running water would wash them downstream. Flooding alone might not entirely solve the problem, as these beetles are able to survive considerable immersion.

When the cress is grown in sufficiently large bodies of water ex-

---

[a] Pflanzenfeinde, p. 26; [b] Stett. Ent. Zeit., 1863, p. 123; [c] The Entomologist, Vol. XIV, 1881, p. 236.

periments should be made with some of the fish mentioned on page 15 as possibly useful for destroying cress insects. Ducks might also be found valuable. Catfish were tried, but without avail.

Mrs. Hannum has recently written that she attained the greatest success by growing the water cress in running water which carried the beetles away. In cold weather it was necessary to plant in houses where the cress did well until the coming of warm and dry weather, when the beetles would sometimes clean it out almost entirely, leaving only the roots. By tearing the cress out of the houses and in ponds which were not exposed to running water she could replant her beds, and hoped in time to get rid of the pest.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part III.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE CRANBERRY SPANWORM.

THE STRIPED GARDEN CATERPILLAR.

BY

F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

ISSUED AUGUST 31, 1907.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1907.

CONTENTS.

ILLUSTRATIONS.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE CRANBERRY SPANWORM.

(*Cleora pampinaria* Guen.)

A brownish spanworm has been observed by the writer during recent years on asparagus in the District of Columbia in such numbers as to indicate that it is especially attached to this crop, at least in this region. In consideration of the fact that so few insects attack asparagus, the accompanying account has been prepared. The species appears to have attracted no attention since 1884,[7][a] when it was considered in relation to its appearance in cranberry bogs. From material recently collected, several facts hitherto unrecorded have been gained, and there are a number of unpublished notes of the Bureau showing a tendency on the part of the species to become omnivorous. At any rate it is not confined to cranberry, as the name given above would imply, nor to strawberry, as might be inferred from another name, "brown strawberry spanworm," which has also been given it. The list of food plants which will presently be furnished shows a considerable range. Owing to the fact that the insect has not often been observed concentrated on any single crop, little mention of it has been made in literature by economic writers. Cranberry is a favorite food plant, and is sometimes injured to a considerable extent, especially in Massachusetts.

DESCRIPTIVE.

This insect belongs to the lepidopterous family Geometridæ, the larvæ of which are well known under the common names of spanworms, measuring-worms, inch-worms, and loopers.

The moth which produces this spanworm is quite variable in color and markings. The average expanse of wing is from a little less than an inch to upward of an inch and a fourth (22–32^{mm}), but may exceed this, attaining, according to Dr. A. S. Packard,[1] a measurement of an inch and a half. The ground color of living specimens is pale

[a] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 27.

leaden gray, and of old mounted material a duller gray, thickly diffused with black and brown dots and other markings more or less constant, forming irregular lines across both fore-wings and hind-wings. On both there is a marginal regular scalloped black line and within this a strongly dentate or zigzag white line. The general pattern of the wings varies considerably from that shown in figure 6, *a*, which represents the female. The color of the body is similar to that of the wings. The first abdominal segment is white above.

The sexes can be readily distinguished by the antennæ. Those of the female are filiform and tessellated and those of the male rather strongly pectinate, or feathered. The structure of the latter is shown at *e* and *f*, figure 6.

"It may be known," says Packard, "by the very distinct line at the base of the abdomen, the basal wing beyond being usually white, and the underside of the wings having a broad marginal shade, while the third line on the fore-wing is deeply but quite regularly sinuate and near the costa acutely dentate."

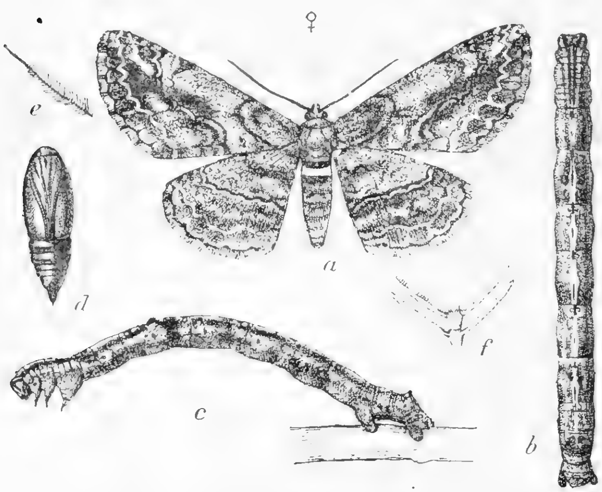


FIG. 6.—The cranberry spanworm (*Cleora pampinaria*): *a*, Female moth; *b*, larva, dorsal view; *c*, larva, lateral view; *d*, pupa; *e*, male antenna; *f*, enlarged joints of same. All enlarged; *e*, *f*, more enlarged (original).

A number of synonyms are credited to *Cleora pampinaria*. It has indeed received five specific names. As three of these were given by Guenée, it is of itself indicative of the variation of the moth. The list follows:

Boarmia sublunaria Gn., Spec. & Gen., IX, 248 (1857); *B. frugallaria* Gn., Spec. & Gen., IX, 246 (1857); *B. collecta* Wlk., Cat. Brit. Mus., XXI, p. 397 (1860); *Cleora tinctaria* Wlk., Cat. Brit. Mus., XXI, p. 486 (1860); *Boarmia fraudulentaria* Zeller, Verh. zool.-bot. Ges. Wien, XXII, p. 492 (1872); *Cymatophora pampinaria* Pack., Mon. Geom., p. 432 (1876).

The egg appears not to have been described.

The larva.—The larva resembles those of other geometrids in being of elongate form, about nine times as long as wide, with the three pairs of thoracic or front legs bunched closely together near the head, and in having only two pairs of prolegs, or unjointed legs, at the opposite extremity. The color varies to a considerable extent from mottled pale yellowish to brown, often with an olivaceous or greenish tint. Those which have been recently captured in the District of Columbia are reddish brown, mottled, streaked, and lined with lighter yellowish, red, and black. The head is strongly marked with transverse irregular black bands. The thoracic segments are marked above by a pair of thin median longitudinal lines. The second abdominal segment bears on the dorsal surface a pair of prominent, widely separated, mostly black tubercles, but in some individuals these are wanting. The penultimate segment also bears above a smaller pair of black tubercles. The larva when full grown measures an inch to upward of an inch and a fourth in length ($25–33^{mm}$) and the greatest diameter is about one-eighth of an inch (3^{mm}). The singular construction of the legs, or rather the lack of the intermediate legs usually present in caterpillars of other families, is the cause of the peculiar motions of the spanworms in crawling about in search of food, which have given them their popular names. When in motion a larva extends its body to full length, then brings the posterior legs close to the anterior ones, causing the body to loop in the center. The body is then stretched out again, these actions being repeated alternately.

When this spanworm is in repose it attaches itself to the foliage—for example, to the stem of asparagus—by means of its anal pair of legs and stretches out its body rigidly and at an angle so that its natural colors harmonize with the foliage or with the landscape. On this head Doctor Smith has remarked that on a section of cranberry bog on which this species is feeding the observer may stand in the midst of thousands of them and see none until something starts them into motion. Then it appears almost as though the entire bog were alive. As the spawnworms hang somewhat tenaciously to their food plants, they are undoubtedly present frequently in numbers without anyone being the wiser.

The half-grown larva is described by Doctor Forbes.[8]

The pupa, shown, ventral view, in figure 6 at *d*, is of robust form, light greenish brown in color, and a little less than half an inch in length (12^{mm}) and about a third of that (4^{mm}) in width.

DISTRIBUTION.

The wide distribution of this insect is shown by the following list of localities, based upon Doctor Packard's list, where the authorities for each locality are given: Maine; Amherst, Cape Cod, Cotuit, Natick, Mass.; West Farms, Center, Albany, and Brewster, N. Y.; Philadelphia, Pa.; Lansing, Mich.; Dayton, Ohio (Pilate); Glencoe, Nebr.; Cadet, Mo.; Centralia and elsewhere in Illinois; Washington and Brookland, D. C.; Georgia; Calhoun, Dawson, and De-mopolis, Ala.; Lake Bearsford, Florida; Bastrop County and elsewhere in Texas.

The above localities indicate a distribution ranging from the transition life zone through the upper to the lower austral. The occurrence of the species in Florida, Alabama, and Texas would indicate that it is to be found throughout the Gulf region. The insects observed by Glover were stated to appear in the Carolinas, Georgia, and Florida in early October.

BIOLOGIC LITERATURE.

The spanworm under consideration was described under the name of *Boarmia pampinaria* by Guenée in 1857.[2] In 1876 Dr. A. S. Packard gave a detailed description of the moth, with a consideration of its distribution and remarks on the larva and pupa, the former being stated to feed on pear.[10] In 1881 Dr. G. H. French[6] had a note on the larva observed feeding on willow and geranium; larvæ transformed to pupæ September 16 and October 2, and the imagoes issued April 17 of the following year. During the year 1883 this species was observed by Dr. J. B. Smith,[7] then a temporary agent of this office, doing injury at Cotuit, Mass. During that year the spanworms were so abundant in the cranberry bogs in that vicinity that their numbers could be compared only to the army worm (*Heliophila unipuncta* Haw.). In the case in question they began in a space about a rod square, devoured that, and spread in a direct line across the bog. The number of moths that would have been produced from these insects should they have been permitted to transform was described as being "frightful." A rather full account by Dr. S. A. Forbes followed in 1884,[8] in which the statement was made that the larva was found in midsummer feeding on leaves of strawberry in southern Illinois. Larvæ obtained August 1 pupated on the 11th, and the moths emerged on the 22d, giving eleven days as the pupal stage at that season. Larvæ collected September 6, about half grown, were believed to represent a second generation. The larva of this species came under the observation of the writer on asparagus first in 1897.[11] In 1899 Doctor Lugger[12] stated that the caterpillars were found on apple and blackberry, and that there were at least two generations annually.

As this is one of the commonest species of its genus, of wide distribution, and authentically determined as living on cotton, there seems little doubt that it was the type of Glover's account of "the larger spanworm," figured and described in his accounts of insects frequenting the cotton plant, published in 1856[1] and again in 1878.[5] A curious blunder was made by M. D. Landon, who figured this species as the "cotton caterpillar (*Noctua xylina*)" in 1865,[3] this illustration being a crude copy taken from Glover's first or 1856 account of this spanworm.

UNPUBLISHED OFFICE NOTES.

June 5, 1879, we received from Mr. William Trelease, then at Dawson, Ala., larvæ found feeding on cotton. June 12 a larva kept under observation changed to pupa, and on June 26 the moth issued, this individual having passed 14 days as pupa. The same year the moth was reared on several occasions from material obtained on red clover in the District of Columbia by Messrs. Pergande and Howard. June 28 the moth issued from the pupa. August 15 the larva was observed feeding; changed to pupa August 25, and issued as moth March 1 of the following year. August 29 the larva was observed feeding: changed to pupa September 4, the moth issuing March 22 of the next year.

February 6, 1880, we received from Lake Bearsford, Fla., from Prof. J. H. Comstock, a larva obtained on orange.

There are also reared specimens of moths in the U. S. National Museum bearing labels showing the rearing of moths and occurrence of larvæ on different plants, as follows: On locust, May 6, 1893, District of Columbia; hickory, November 24, 1894, Cadet, Mo., and August 4 of the same year on pear, locality presumably the District of Columbia. There is also a specimen labeled "on guava," probably from Florida.

August 6, 1904, specimens of this spanworm were received from Calhoun, Ala., where they were found feeding on cotton and were mistaken for the cotton leaf-worm (*Alabama argillacea* Hbn.). The adult issued August 29. Larvæ were about full-grown when received, August 9, and it seems probable that they underwent a short stage of æstivation before transforming to pupæ, as the pupal stage is less than 20 days in midsummer.

During the first two weeks of October for several years larvæ have been observed on asparagus grown in the District of Columbia, the species appearing in moderate numbers. The first moth that has been reared from October-collected larvæ appeared in January, and others appeared in February. As this was in confinement the dates were not natural ones.

LIST OF FOOD PLANTS.

It is, as previously remarked, owing to the omnivorous habit of this species, causing a distribution of attack, that noticeable injury has not been ascribed to it elsewhere than in cranberry bogs. It is common enough in the vegetable and truck garden, but not confined to any particular place on the farm, occurring in orchards, on forest and shade trees, and on other plants. The list of observed food plants includes asparagus, strawberry, blackberry, ornamental geranium, apple, pear, orange, willow, hickory, cranberry, honey locust, cotton, clover, and guava. As a rule the larvæ confine themselves to the foliage of these plants, but Glover states that they sometimes feed upon the petals of the flowers of cotton, although doing little harm to the general crop.

THE INSECT'S LIFE HISTORY.

Our knowledge of the life history of this species is somewhat incomplete. The repeated rearing of moths in early spring and the occurrence of larvæ in the latter part of June in Massachusetts as recorded by Smith, as also in the District of Columbia and elsewhere as late as October, noted by the writer and others, show at least two generations in the Northern States, while the record of the occurrence of the moths in March in Texas (by Belfrage) would indicate that in the Gulf States there may be an additional generation. It would seem practically impossible for larvæ hatching from eggs deposited in early spring to require until late October to attain maturity, hence the natural inference of two generations for a climate like the District of Columbia. The cranberry growers of Massachusetts claim two generations for that State, one appearing as larvæ in June and early July, the other in the latter part of August.

The eggs are unknown, and the periods of egg and larva have not been ascertained, but the pupal condition has been observed to be passed, for the first generation, in from 11 to 14 days, while the over-wintering pupa consumes five or six months in the District of Columbia, a shorter time farther south, and a longer time northward.

The date of the appearance in the North of the first moths has not been learned positively nor the natural time of emergence of the first new generation of moths.

NATURAL ENEMIES.

Doctor Smith [7] has stated that the larvæ of this spanworm are checked by parasites, but that in some localities almost every year they become numerous enough to be destructive. In some years, however, in the cranberry bogs of New Jersey they are not seen at all, showing great scarcity, due probably in part, at least, to natural causes. Only one parasite for this species is known, namely, *Exorista boarmiæ* Coq., a tachina fly reared at this Department from Cotuit and other localities in Massachusetts several years ago.

REMEDIES.

This species is not difficult to control on asparagus or other truck crops. As it feeds in free exposure on the foliage, spraying with Paris green or arsenate of lead will destroy it, and when either of these insecticides is used for the asparagus beetles it will kill all of the spanworms which may be present. The Paris green may be used at the rate of 1 pound to about 100 to 150 gallons of water, and the arsenate of lead at the rate of about 1 pound to 25 to 50 gallons of water. The same remedies will apply equally well to the occurrence of this species in cranberry bogs.

BIBLIOGRAPHY.

1. GLOVER, TOWNEND. Report Commissioner Patents, p. 92, Plate VIII, fig. 4, 1855 (1856).

Probably this species. Appears in Carolinas, Georgia, and Florida early in October and feeds upon the petals of the cotton flower; larva and adult described and figured.

2. GUENÉE, M. A. Species Géneral des Lépidoptères, Vol. IX, Phalénites, pp. 245, 246, 248, 1857.

Original description as *Boarmia pampinaria* from near Baltimore, as *B. frugallaria* from Georgia, and as *B. sublunaria* from North America.

3. LANDON, M. D. Rept. Comm. Agr. f. 1864 (1865), p. 90.

Erroneously figured as the "cotton caterpillar (*Noctua xylina*)."

4. PACKARD, A. S. Report U. S. Geological Survey Terr., Hayden, Vol. X, pp. 432, 442, Plate XI, fig. 20, 1876.

Technical and detailed description of moth; synonymy; distribution and note on larva and pupa, the former feeding on pear.

5. GLOVER, TOWNEND. Cotton and its principal injurious insects<Washington, D. C., Plate VII, figs. 6, 7, 8, 1878.

Figures larva, chrysalis, and moth; found early in October in Georgia feeding on flowers of the cotton plant.

6. FRENCH, G. H. Papilio, Vol. I, p. 82, 1881.

Notes on larva found feeding on willow and geranium.

7. SMITH, J. B. Bul. 4 (o. s.), Div. Ent., U. S. Dept. Agr., pp. 26–28, 1884.

A two-page account in reference to injuries to cranberries; description of larva; referred to as *Cymatophora pampinaria*; remedies.

8. FORBES, S. A. Thirteenth Rept. State Entomologist Illinois, pp. 76–78, 1883 (1884).

A rather full account. Larva found frequently in midsummer in southern Illinois feeding on leaves of strawberry; description of larva, pupa, and imago (quoted from Packard).

9. FORBES, S. A. Trans. Miss. Valley Hort. Soc., Vol. II, p. 235, 1884.

Quotations of first two paragraphs of No. 8.

10. PACKARD, A. S. Fifth Report U. S. Ent. Commission, p. 654, 1890.

Included in a list of insects affecting honey locust (*Gleditschia triacanthos*).

11. CHITTENDEN, F. H. Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 61, 1898.

An unknown geometrid larva feeding on asparagus; subsequently ascertained to be this species.

12. LUGGER, OTTO. Fourth Rept. Entomologist State Exp. Station Minn., pp. 187, 188, fig. 188, 1898 (1899).

Notes on the moth; caterpillar found on the apple and blackberry. Short general account.

13. SMITH, J. B. Farmers' Bulletin 178, U. S. Dept. Agriculture, pp. 19–21, 1903.

Account of injuries to cranberry, life history, and remedial measures.

THE STRIPED GARDEN CATERPILLAR.

(*Mamestra legitima* Grote.)

A strikingly beautiful black and yellow striped caterpillar is frequently found in gardens, and occasionally in such numbers as to attract attention. It is a general feeder, like most of its kind, but is somewhat partial to asparagus, cruciferous plants, peas, and other leguminous vegetables. Its occurrence in the District of Columbia in some numbers, especially on asparagus, has permitted a study of the species, which adds somewhat to what has previously been published. Only a few short notices of this insect have appeared in publications of the Department of Agriculture or elsewhere, to the writer's knowledge. The following somewhat brief account is therefore presented.

This species is a noctuid, related to the cutworms, and is congeneric with the zebra caterpillar (*Mamestra picta* Harr.). The moth was originally described in 1864,[a] the species at that time being known from the middle and eastern States, where it was stated to be common. It is also recorded as occurring in the northern States. Evidently, considering its numbers in the Gulf region, it may be found in most States east of the Mississippi River Valley.

DESCRIPTIVE.

The moth is quite prettily marked, as can be seen by referring to figure 7, *a*. The prevailing tint of the fore-wings is a light lead color, marked with velvety-black and brown spots, the pattern varying somewhat but usually about as figured. The lower wings are fawn colored, with dusky margins, and the veins are moderately prominent. The females, as is usual with this group, have the abdomen as illustrated, while the males have abdomens with bushy tips. The wing expanse is a little more than an inch and a quarter.

The eggs.—No description of the egg is available at the present writing.

The larva is also a pretty form and its markings recall the zebra caterpillar. It will be noticed by the figure (fig. 7, *b*, *c*) that there is considerable difference, however, and the two species are not at all likely to be confused by anyone who carefully examines them. The present species has a larger and wider head and is darker than is usual with the common zebra caterpillar. The appearance of the head from in front is shown at *d*. The stripes with which the body is

[a] *Apamea legitima*, Proc. Ent. Soc. Phila., Vol. III, p. 82.

ornamented are black and yellow, as with the zebra caterpillar, but the lateral stripe is divided into two portions, the upper one lighter than the lower, and the entire lateral surface when marked consists of regular stripes, whereas in the other species these stripes are broken up.

The pupa, when mature, is nearly black in color, and has the appearance illustrated (fig. 7, *e*). It measures about five-eighths of an inch in length, including the tips.

BIOLOGIC NOTES.

This species was briefly mentioned as having been found by the writer in the larval condition on asparagus at Marshall Hall, Md., in October, 1896.[a] At that time it was impossible to ascertain whether or not it bred from eggs deposited on this plant, but later observations conducted in company with Mr. F. C. Pratt during the first and second weeks of October show conclusively that such must be the case, as larvæ were found in the greatest abundance on three large patches of asparagus at Brookland, D. C. They usually occurred singly, but occasionally in pairs.

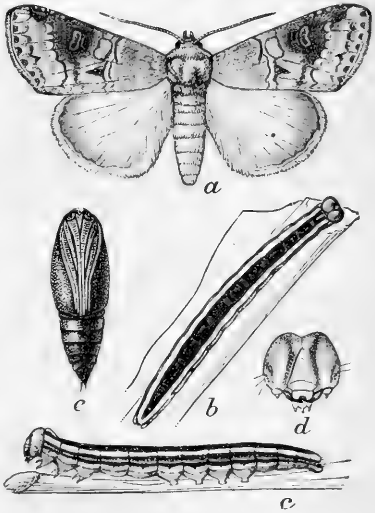


FIG. 7.—The striped garden caterpillar (*Mamestra legitima*): *a*, Adult; *b*, larva from above; *c*, same from side; *d*, head of same from front; *e*, pupa. All natural size except *d*, which is enlarged (from Howard).

During the heat of the day, in the moderately cool and seasonable Indian summer weather usual at Washington at that time of the year, many larvæ would be found stretched out upon dry sprigs of asparagus, and in spite of their bright colors they would easily have escaped the observation of anyone without experience in insect collecting. The larva, in fact, furnishes a good example of protective coloration. An individual would be in plain sight, and then if one's eyes were directed elsewhere for a moment it would sometimes be difficult to find it again, although it might be within a foot of the observer.

Larvæ obtained October 7 and later were kept feeding on asparagus in our rearing cages until the third week of October, when they descended to the earth and soon afterwards assumed the pupal condition. The exact date of the assumption of the chrysalis form was not ascer-

[a] Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 60.

tained, but it was about the 21st of October, which would give a period for the pupa of ten months, as the moths of this lot began issuing August 21.[a]

One individual transformed to pupa October 17 and the imago issued August 24 of the following year.

October 15, 1898, the larva was brought to the writer by Mr. P. H. Dorsett, from his greenhouse at Garrett Park, Md., where the species was feeding on the foliage of violet. The same year, November 3, this larva was found rather abundantly by Doctor Howard in tobacco fields in southern Virginia, near the North Carolina border line, upon the leaves, which in some cases were badly ragged.[b] The first moths issued in July.

During 1900 and 1901 correspondence was had in regard to this caterpillar with Mr. H. Walter McWilliams, Griffin, Ga., who sent specimens, as also larvæ of the so-called cotton cutworm (*Prodenia ornithogalli* Guen.), with which the insect was associated in both years. The caterpillars were noticed there in greatest numbers during November, and both species were reported as destroying a number of garden crops, among which were cabbage, collards, turnip, ruta-baga, rape, peas and related plants, as also some other vegetables. Mature larvæ were seen as late as the last week of November.

Among other office records are two which also have a bearing on the biology of this species. One of these was made by Mr. Theo. Pergande, who found the larvæ in the District of Columbia feeding on blackberry and on flowers of a goldenrod (*Solidago* sp.). The other is a short note by Mr. F. M. Webster upon the rearing of the moth in spring from the seed pods of milkweed (*Asclepias incarnata*), near Lafayette, Ind. "The larva appeared to subsist upon the seeds, the pods being attached unopened to the wrecked plant."[c]

October 21 the larva was found at Washington, D. C. We have no further records in regard to the habits of this species other than the capture of moths in the District of Columbia July 25, August 22 and 25, and September 2, and there are specimens also in the U. S. National Museum from Lewis County, N. Y., July 4, collected by O. Meske, and others from New Jersey without definite locality. The species is also said to occur at Portland, Oregon. It is interesting to note that among these specimens are inflated larvæ and mounted heads labeled "pretty cutworm," which might be termed a manu-

[a] The rearing jar was kept under somewhat unnatural conditions, at times too warm and dry, but the effect of one condition might have been counteracted by another, and the date of issuance of the adults was not far from that which would be assumed in nature—more likely earlier than otherwise.

[b] Yearbook U. S. Dept. Agric. for 1898, p. 142.

[c] Insect Life, Vol. II, p. 382, 1890.

script name, as I do not find this insect mentioned under this cognomen in print. With present knowledge of the species it can not properly be classified as a cutworm.

Among the files of the Department of Agriculture there are a few notes which are of interest as showing the cycle of periods from egg to about the last stage of the larva. These notes were made in 1882 by Mr. Albert Koebele, and the mounts which were made with them are not sufficiently fresh for description. From these notes the following is taken:

Moths collected at sirup, near the District of Columbia, September 16, were placed in a rearing jar with grass, where two batches of eggs were laid between 11 and 12 o'clock at night, one of these being deposited around the stem of grass.

September 18 the eggs hatched, showing the egg period to be only 2 days. On the 21st the larvæ had completed the first molt, making the first larval instar 3 days. September 23 the second molt was observed, which gives 2 days as the second larval instar. September 27 larvæ changed their third skin, leaving 5 days as the period of the third instar.

October 1 the fourth molt occurred, making 4 days for the fourth instar. By October 9 all the larvæ had changed the fifth skin, when they developed cannibalistic tendencies and were removed to a larger jar. The period of this instar was 8 days. The remaining larvæ refused to eat and finally died, so that the complete life cycle could not be ascertained.

NATURAL ENEMIES.

Soon after bringing larvæ in from the field some were noticed to be dying from fungous attack. In the asparagus fields *Estigmene (Leucarctia) acræa* Dru. and *Dissosteira carolina* L., the salt-marsh caterpillar and Carolina locust, respectively, were also dying in considerable numbers, and it was conjectured that the disease might have originated with these and spread to the Mamestras. After the diseased caterpillars had been frequently removed, however, the fungous attack abated. Specimens of infected larvæ were referred to the Bureau of Plant Industry, and the fungus was identified by Mrs. Flora W. Patterson, assistant pathologist, as an undescribed species of Verticillium. At another time larvæ which showed signs of disease after capture were examined by Mrs. Patterson, who recognized the presence of the fungus *Sporotrichum minimum* Speg. A larva, when placed with diseased insects, including some of its own species, did not contract the fungous disease, from which it seems probable that the disease is not readily communicable, and hence of no use as a possible means of destroying this species.

SUMMARY OF HABITS.

From present knowledge of the caterpillar two generations annually are indicated, although only one has been observed. Moths have been reared by the writer in July and August and they have been captured out of doors during the same months and in September. From available data it would appear that an average life history would be about as follows: Egg period, 3 to 5 days; first larval instar, 3 days; second larval instar, 2 days; third, 5 days; fourth, 4 days; fifth, 8 days, and pupal stage, 7 to 10 months. Hibernation occurs in the pupal stage.

The observed food plants include asparagus, cabbage, collards, turnip, ruta-baga, rape, peas and related plants, greenhouse violet, tobacco, grass, and blackberry. Of wild plants, golden-rod and milkweed have been observed, the larva attacking the flowers of the former and the seed pods of the latter.

METHODS OF CONTROL.

Although the early habits of this species as it occurs in the field have not been observed, there is no doubt that, like the zebra caterpillar, the young when first hatched are gregarious for some time, and hence may be easily discovered and destroyed by mechanical means or by arsenicals. All of the caterpillars of this class readily succumb to arsenical poisons, and for this species in its occurrence on asparagus and some other plants arsenate of lead is to be preferred. It may be used at the rate of about 1 pound combined with 15 to 25 gallons of water or Bordeaux mixture. If an adhesive resin soap, such as resin fish-oil soap, is added, it makes this mixture all the more permanent, and a single application is then all that is necessary. Paris green may be used in the same manner at the rate of 1 pound to 100 or 150 gallons of water. It is evident that this species, like the zebra caterpillar, does no particular harm as a rule in its first generation, but is much more abundant in the second or late fall generation, when certain plants are injured by it. Owing to the difficulty of locating the larger larvæ, it is evident that hand-picking would not be applicable for them in their later stages.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part IV.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE LEAFHOPPERS OF THE SUGAR BEET

AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

BY

E. D. BALL, PH. D.,

Special Field Agent.

ISSUED JANUARY 27, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

CONTENTS.

ILLUSTRATIONS.

PLATES.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

By E. D. Ball, Ph. D.,
Special Field Agent.

INTRODUCTION.

Ever since the introduction of the sugar beet into the intermountain region more or less loss has resulted each season from a condition called "curly-leaf," or "blight." (See Pl. I, fig. 1, *j*; Pls. II, III; Pl. IV, fig. 1.) Around Grand Junction, Colo., the beet growers have suffered frequent losses from this source. Supt. George Austin, of the Utah Sugar Company, reported a serious loss around Lehi, Utah, in 1897. In 1903 the beet crop in Sevier County, Utah, was somewhat injured, the next year the damage was worse and more widespread, while in 1905 it extended throughout the State of Utah and the adjoining portions of Colorado and Idaho.

Until 1905 the condition had been looked upon as a result of some fungous or bacterial disease, or due to a soil or climatic condition. During that season it was noticed for the first time that a leafhopper (*Eutettix tenella* Baker) was present in large numbers in the fields where this damage was the worst, and the writer, in connection with his duties as entomologist of the Utah Agricultural Experiment Station, commenced an investigation of the insect and its relation to the damage. It was then too late to work out its life history, so most attention was paid to a study of its relation to the "curly-leaf" condition and to experiments with remedies. This investigation was continued in 1906 and 1907, in cooperation with the Bureau of Entomology, and the life history was worked out. Owing to the small number of insects appearing these two seasons, little more was done with remedies, but many new facts were learned in regard to methods of attack and the causes of the injury.

The writer's attention was first called to the "curly-leaf" in August, 1900, by Prof. F. H. Shaw, then chemist of the Grand Junction (Colo.) Sugar Factory. A careful examination was made at this time and again in succeeding years, but no explanation was found for this condition. These examinations were, however, always made late in the season after the curly-leaf character had become general and after the greater number of insects had disappeared. Examination of the beets always revealed a few specimens of *Eutettix tenella* along with other leafhoppers and miscellaneous insects, but never in sufficient number to cause suspicion.

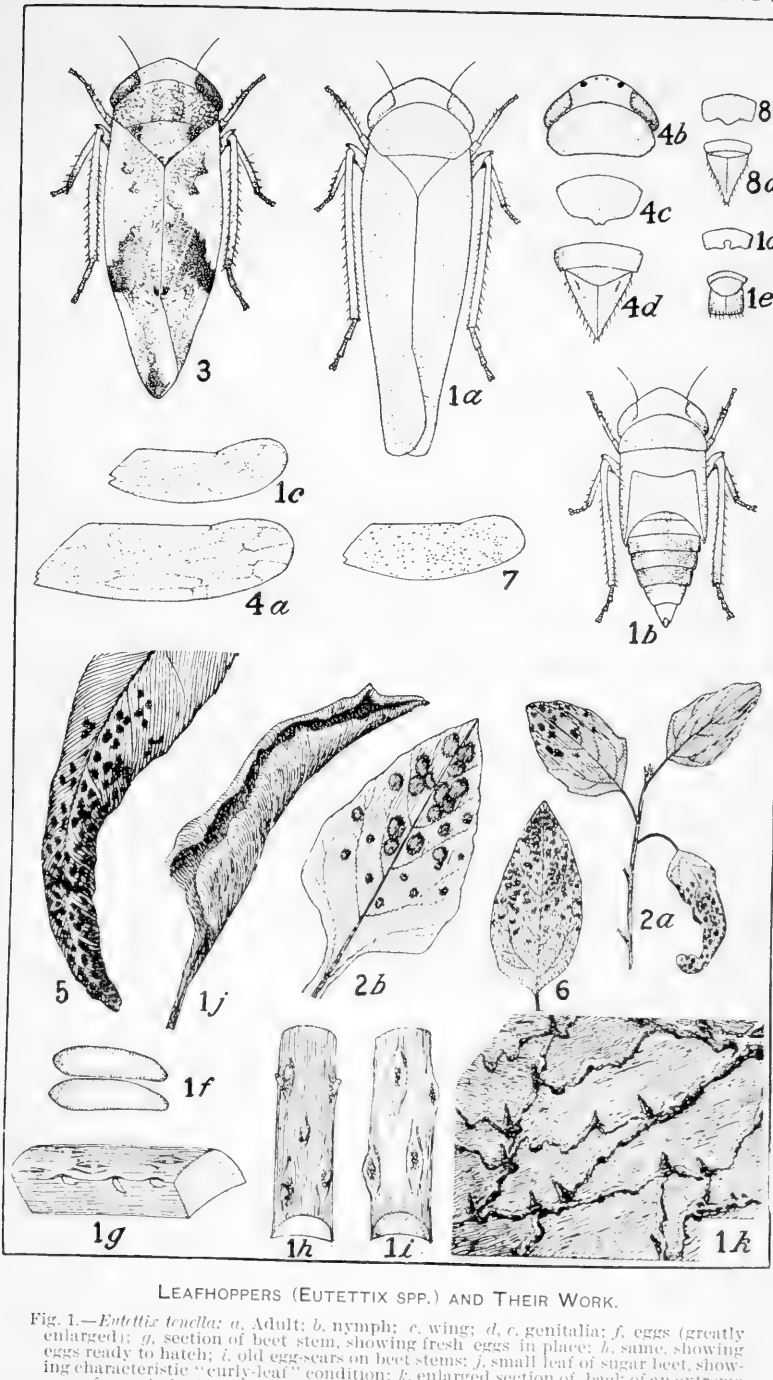
Late in June, 1905, reports began to come in to the Utah experiment station of the appearance of an insect in the beet fields of the southern and central portions of the State, and on July 8 the writer, in company with Mr. George Austin, visited the fields around Lehi and there found the beet leafhoppers, associated with smaller numbers of false chinch bugs (Nysius) and leafhoppers of the genus Agallia, causing serious damage to the young plants, especially in the late-planted fields.

From the size of the beets and the number of the beet leafhoppers present when first examined in 1905, the prediction was made that the insects would not be able seriously to retard the further growth of the beets. This prediction was based on the ordinary amount of damage done by insects of sucking habits. That the number of insects found would be able to injure or even seriously retard a very young beet was recognized, but that the same number could have any appreciable effect on large beets was contrary to all expectations based on a knowledge of similar attacks by Nysius, Agallia, and other sucking insects.

The trouble soon afterwards appeared in the Cache Valley, Utah, and was under observation there throughout the remainder of the season, while several trips were made to various parts of the State. Wherever it appeared it gradually grew worse, and although the year 1905 started with everything favorable in the early season, the Utah beet crop fell below the average about 75,000 tons. This, however, did not anywhere represent the entire loss, as both sugar content and purity of the beets harvested fell far below the average, entailing further loss to the sugar companies and bringing the total to more than half a million dollars.

In Sanpete and Sevier counties, in the southern part of Utah, a large part of the acreage was abandoned early in the season, while the rest barely paid the expense of harvesting. In Utah County the crop varied from a total loss on a few late fields to a full crop, with an average of more than a half crop harvested. In the Cache Valley, in the northern part of the State, the loss was about one-third in tonnage, and in Weber and Boxelder counties less than that.

In 1906 a very small number of leafhoppers appeared, and, as the season was cool, even where they were most abundant little damage was done. A careful study was made of the life history and distribution of the species, and a number of tests were made of its injury to the beets.



LEAFHOPPERS (EUTETTIX SPP.) AND THEIR WORK.

Fig. 1.—*Eutettix tenella:* *a*, Adult; *b*, nymph; *c*, wing; *d*, *e*, genitalia; *f*, eggs (greatly enlarged); *g*, section of beet stem, showing fresh eggs in place; *h*, same, showing eggs ready to hatch; *i*, old egg-scars on beet stems; *j*, small leaf of sugar beet, showing characteristic "curly-leaf" condition; *k*, enlarged section of back of an extreme case of "curly-leaf," showing "warty" condition of veins. Fig. 2.—*Eutettix strobi:* *a*, Work of nymphs on lambsquarters; *b*, work of nymphs on sugar beet. Fig. 3.—*Eutettix scitula:* Adult. Fig. 4.—*Eutettix clarivida:* *a*, Wing; *b*, head and pronotum; *c*, *d*, genitalia. Fig. 5.—*Eutettix nigridorsum:* Work of nymphs on leaf of Helianthus. Fig. 6.—*Eutettix straminea:* Work of nymphs on leaf of another Helianthus. Fig. 7.—*Eutettix insana:* Wing. Fig. 8.—*Eutettix stricta:* *a*, *b*, Genitalia. (Author's illustrations.)

THE BEET LEAFHOPPER.

(*Eutettix tenella* Baker.)

DESCRIPTIVE.

The adult (Pl. I, fig. 1, *a*) is a small, pale yellowish-green species, little larger than an Empoasca or Typhlocyba, with which it might easily be confused in the field were it not for the stouter build and greater activity. When fresh or when flying this leafhopper appears almost white, and for this reason it has often been called the "white fly." (Wing, Pl. I, fig. 1, *c*; genitalia, Pl. I, fig. 1, *d*, *e*.)

The eggs (Pl. I, fig. 1, *f*) are white, elongate, slightly curved and tapering at one end, and are thrust into the leaf stem in a slightly downward direction. At first they are scarcely visible (Pl. I, fig. 1, *g*), but as the stem grows they are pushed out with the opening up of the injured spot until at hatching time they are often half free (Pl. I, fig. 1, *h*). After the eggs hatch, the egg scars continue to enlarge and remain throughout the season as irregular, elongate, crater-like swellings (Pl. I, fig. 1, *i*). The eggs are deposited on all parts of the leaf stem, usually one in a place. In the cages they were often placed close together, very likely in this case by different insects, however, and a number were inserted into the midrib and secondary veinlets of the leaf and a few into the leaf margin near the base.

The nymphs (Pl. I, fig. 1, *b*) are very active, pale creamy white or variously colored forms. The commonest form is pale creamy in color with a brown saddle on the middle of the abdomen and various mottlings on the prothorax and wing-pads. Some have the same pattern with a reddish ground color, more are creamy yellow, and occasionally one is seen with a broad and somewhat irregular dark stripe down the back. When small the nymphs will be found most commonly down in the unfolding leaves at the center of the beet, but as they grow older they spread out over the plant.

FOOD PLANTS.

The original food plant of this species is still in doubt. In the spring it was found on greasewood (Sarcobatus), sea-blite (Dondia), several species of Atriplex, Russian thistle, and rarely on other plants of these two families occurring on the waste land. As these places dried up, most of the leafhoppers went to the sugar beets in the areas under observation. In one case, however, the species was found in some numbers on greasewood during egg-laying time, which would suggest this plant as its original host. Its known distribution is all within the area in which this plant is abundant.

DISTRIBUTION.

This leafhopper is apparently a native of the southwestern part of the United States. It has been collected from about the region of Denver, Colo., south along the edge of the mountains, through New Mexico, and west through Arizona, Utah, and southern Idaho to the coast in California and Oregon. Though confined to the mountain region, its distribution is restricted to the lower levels, and it is never taken on the mountains themselves. From this region it has not spread very far up to the present time. It was taken at Fort Collins and Lamar, Colo., in 1901—in one case 100 miles north of its known habitat, on wild plants, and in the other an equal distance east, but was rare in both situations. In Utah it has spread to the northern line of the State and into Idaho as far as that particular beet area has been extended, while it has not as yet been taken from the wild plants north of Ogden, Utah.

LIFE-HISTORY STUDIES.

Search was made for this species as soon as the growing season commenced in the spring of 1906, but no specimens were discovered in the Cache Valley, Utah, up to the time the beets came up. A trip to Sevier County, Utah, at the time the very earliest beets were just showing (April 22) failed to disclose a single individual, either in the beet fields or in waste places or hedgerows adjacent to the beet-growing districts. The first specimens discovered this season were found at Thompsons, Utah, May 3, feeding on Russian thistle, and a few days later the insect was found on the same plant and on an annual saltbush (Atriplex) at Grand Junction, Colo.

Beet fields were examined at Grand Junction, Colo., May 8, and in Utah at Lehi, May 9; Smithfield, May 12; Garland, May 13; Lehi, May 17; Corinne and Penrose, May 22; and Provo and Lehi, June 1, without finding a single leafhopper on any of them. The beets were not up at Lehi on May 9, nor at Smithfield, but the fields were examined carefully, especially where weeds were beginning to appear. Fields at Logan, Utah, were under observation during all this time and up to July 1, but no leafhoppers were found.

RECORD AT LEHI, UTAH.

On June 21 a field was examined at Lehi in which there was an average of one or two leafhoppers to a beet. They were all adults and two-thirds of them females. The beets in this field were from 6 to 10 inches across, and no sign of injury was observed. On examining the other fields in the valley a very much smaller number of leafhoppers was found. Some fields had one individual to 10 beets, while some had none at all. The average would not have been more than one leafhopper to 25 beets. They were most numerous on the higher, drier fields, and on the early beets. Two patches of very late beets close to the first one visited had no leafhoppers at this time.

Eight females from this field were dissected, and fully developed eggs were found in each one, 9 in one, 7 in another, and from 2 to 4 in each one of the others. Only large eggs could be seen with the lens used, and probably some of these were crushed while being removed. The fact that all females had fully developed eggs and that there were more females than males indicated that these adults had been out a long time and were not new ones of a brood that had just flown in from surrounding wild land.

On June 29 a few were found in the late beets, but no nymphs were found anywhere.

July 10 the adults were present in about the same numbers as before, the females still containing eggs, and a few very small nymphs were found.

July 23 the adults were slightly less numerous, and the nymphs from small to one-third grown and quite abundant. A few of them were nearly grown, but no fresh males could be found. More nymphs were found on the early beets, more "curly leaf" on the late ones.

August 3 the nymphs were mostly about two-thirds grown, some were small, and some full-grown. Large numbers of adults of the new brood were out, about half of the leafhoppers being adult at this time.

August 14 the adults were abundant. The leafhoppers were nearly all adults or large nymphs, but a few small nymphs were still to be found.

On August 29 the insects were mostly adult, males being still in the majority, but there was still quite a number of full-grown nymphs. Many females were dissected and a few found that had from 4 to 7 large eggs, but the rest had no sign of any. These few were probably the last remnant of the over-wintered brood of females.

September 12 the adults were still common and more males than females were taken by sweeping. Large nymphs were still present in small numbers. Ten females were dissected, but no eggs found, and the abdomens were all small. Evidently there was to be no egg laying for some time, probably not that season.

NOTE.—The season opened unusually late at Lehi in 1906, and these dates would be from one to two weeks late for an ordinary season.

RECORD AT MONROE, UTAH.

In Monroe, Sevier County, the season opened early, and the beets were nearly all planted in April. An examination April 22, as mentioned above, failed to discover a single leafhopper.

On June 26, on a second visit, nearly all the beets were in fine shape, with leaves touching in the rows, and only lacking a few inches of touching across rows. The leafhoppers were present in every patch, both adults and very small nymphs, and occasionally a larger nymph was seen. Mr. Fred Gould, field superintendent, said that he had observed the adults for some time. There were more leafhoppers on the older patches than on the late planted ones, indicating that they had migrated in before the younger beets were far enough advanced to attract them.

On July 25 the leafhoppers had increased in numbers, averaging from 10 to 20 to a beet on the earlier patches. Adult males were common, showing that the nymphs had commenced to change to adults again. All stages of nymphs were still common, however.

On September 14 the numbers of leafhoppers were beginning to decrease. Several countings gave an average of 7 males to 5 females and 5 large nymphs. The dissection of a number of females showed no eggs developed as yet, and there seemed little doubt that they would hibernate.

OTHER RECORDS IN UTAH.

A field belonging to a Mr. Irons at Moroni, Sanpete County, was visited June 27, and an average of one leafhopper to every two beets was found. Mr. Irons, who is a very careful observer, said that they had been there for some time. A careful search was made for the nymphs, but none was found. This was by far the worst infested field in the county, the average being less than one insect to ten beets.

July 26 adults and nymphs were about equally common, and few of either.

In the Cache Valley and the rest of the northern end of the State the leafhoppers did not appear in sufficient numbers to enable one to make any life-history notes. On this account all cage experiments were transferred to Lehi.

CAGE EXPERIMENTS, LEHI, UTAH.

The field observations on life history were all checked by cage experiments (Pl. IV, figs. 2, 3). Cages 1 to 3 were failures, through the adults escaping from the material used. Later a very fine silk scrim was used and proved satisfactory for the life-history work, but was too closely meshed to obtain normal temperature and moisture conditions inside. All cages were run in pairs on similar beets, one with insects and one without, as a check on the injury to the beet.

Cages 4 and 5 (glass globes upon beets about 8 inches in diameter).—On July 10, 16 adult leafhoppers, 12 of which were females, were introduced into cage 4. Previous dissections had shown that all females were bearing eggs, and the presence of a very few small nymphs in the field proved that the earliest ones began depositing eggs some time before. It was therefore expected that some of the females introduced would begin depositing at once.

On July 23 these cages were examined, and in the one containing the leafhoppers the stems were found to be fairly covered with egg scars. Two of the stems were removed and preserved, and found to contain 161 eggs—not more than one-sixth of the total number present. A number of females were seen in the cage, but no nymphs.

July 27 the stems showed still more egg scars, and there was quite a number of small nymphs that had apparently been out several days. The insects had been in the cage only seventeen days, so these eggs must have hatched within thirteen to fifteen days from the time of laying, under the conditions found in the cage. Another stem was removed and preserved, and the rest left as before.

On August 3 another stem was removed. The eggs had almost all hatched by this time. Some had dried up and a few were found just ready to hatch. A few were sticking out of the stalk and looked quite fresh, but were probably infertile. Some of the leaves had wilted and died, and the remainder were literally alive with small to half-grown nymphs, together with a few adults, no doubt the remaining parents.

These half-grown nymphs were no doubt those hatched between July 23 and 27, and would thus be between eight and eleven days old, roughly indicating a nymphal period of between sixteen and twenty-two days under these conditions.

On August 14 this cage was visited again, and the beet found dead and dry. From appearances it had been dead several days. The few leafhoppers that survived were adults and large nymphs. They were so few in number that it was impossible to tell whether they were the surviving parents or a new generation, so they were released.

Cages 6 and 7 (silk scrim 2 feet square).—On July 23, 18 nymphs varying between one-third and two-thirds grown were introduced into cage 6. These were intended to represent the larger ones found in the field at that date.

On July 27 no adults could be seen.

On August 3 most of the nymphs had changed to adults. This period of eleven days was, then, more than one-third and slightly less than two-thirds of the nymphal period. This gives about the same result as the test in cage 4.

Cages 8 and 9 (silk scrim with glass top).—On August 3, 40 leafhoppers were introduced into cage 8; of these 23 were females.

apparently all fresh, 10 were males, and 7 were large nymphs, the aim being to get as many of the earliest ones of the maturing brood as possible without introducing any belated ones of the parent brood. By this method it was hoped to get the succeeding brood, if there was to be one, as soon in the cages as it appeared in the field, and thus establish a minimum time between broods.

On August 14 this cage was examined, and all leafhoppers seen were adults. There were no signs of egg scars or of damage.

On August 30 but few leafhoppers could be seen, and no egg scars or damage.

On September 12 the leafhoppers were almost all gone, and no eggs had been laid, either in the cage or field, and dissection showed that the females had no visible eggs in the abdomen up to date. It was thought at this time that the adults would lay eggs in the fall and then die. Accordingly a new lot was started, as shown below.

Cages 10 and 11 (large lantern globes).—On August 30, 30 leafhoppers were introduced into No. 10, of which 12 were females. In No. 11 one female and several males were introduced. On September 12 no egg scars could be found in either cage.

Cages 13 and 14 (silk scrim with a glass top).—On September 12, 20 leafhoppers, nearly all of which were females, were placed in cage 13.

On October 20 the field of beets was harvested. The cages were removed and the beets labeled and sent on for examination. Each leaf and stem, and even the parts of the beet itself protruding from the ground, were examined carefully, but no sign of any egg scars could be found on these beets or on those from the previous cages. Many of the leafhoppers were alive at the time the cages were removed, and there seems to be no doubt that they must hibernate as adults.

SUMMARY OF LIFE HISTORY.

By the time the beets were thinned the leafhoppers began to appear in the fields and by the middle of June were well distributed. They gradually increased in numbers for some time after this. Egg laying began at Lehi, Utah, late in June and continued until late in August, each female depositing about 80 eggs, the period of deposition extending through several weeks, the greater number of the eggs, however, being deposited in the ten days preceding the middle of July. The nymphs appeared in small numbers by July 10, and were still to be found in small numbers in September. A great majority of them emerged from the eggs the last ten days in July and changed to adults some twenty days later. The first adults appeared from these nymphs the last of July and continued to increase in number through August. The egg stage in the cage experiments was between thirteen and fifteen days; the larval stage between sixteen and twenty-two days.

ECONOMIC RELATIONS.

The first fact observed in 1905 was that different fields were affected very differently, and much time was spent in studying conditions in an attempt to discover just what combination of factors was necessary to produce the "curly-leaf," so fatal to the beets. Even in the worst fields examined there would be here and there a beet that was apparently untouched and growing as usual, while in the best fields only here and there could an affected one be found.

As a result of the season's observations there seemed to be little question that the "curly-leaf" condition was the result of the attack of the leafhoppers combined with the effect of a very hot, early season.

In many places it was noticed that along the edges of the fields where the beets had any shade—such as would be furnished by a hedgerow, or even by a vigorous stand of sweet clover on a ditch bank—there would be a marked difference for the first few rows. In Sevier County, where many of even the early-planted fields were abandoned and where the rest averaged from 2 to 4 tons per acre, one field was seen that did not show much damage and yielded 12 tons per acre. This field had a block of tall poplar trees on the south and a row of equally tall ones on the west side. In other places it was observed that the fields that were the weediest had better beets than those that had been well cultivated. Under ordinary conditions the results in all these cases would have been just the reverse, and the only explanation that seemed plausible was that the shade of the trees and of the weeds kept the ground from becoming quite so hot and thus allowed the beets to overcome the effects of the leafhoppers. In ordinary practice the beets are not irrigated until they have made considerable growth; thus the taproot is forced to descend for water, and a long, symmetrical beet results, while if watered too soon the beets are short and sprangly. In one place, in 1905, it was found that the water had escaped from a ditch and irrigated one corner of a field much earlier than it had been applied to the rest, and this corner was the only place that was not seriously affected with the "curly-leaf." In another place the water supply failed just as they started to irrigate the field, and the remainder was not irrigated until a week later. The difference in the amount of "curly-leaf" on these beets showed plainly to the end of the season just how far the early water reached. At first these differences were attributed to the effect of the early water on the beet itself, but on further investigation a number of fields was found where subirrigation was depended upon entirely and where, ordinarily, fine beets were raised. In these fields the taproots of the beets were found to extend into a stratum of saturated soil and yet the beets were badly affected and continued to grow worse throughout the season. The only explanation found for that condition was that, while the beet had plenty of water, still the top soil was dry and dusty, and the ground was as hot as in an ordinary field, while in the fields that were irrigated early the evaporation from the moist surface kept the temperature down until the beets were large enough to shade the ground. This would also explain the fact that everywhere in the State, except in Sevier County, the late beets were affected much worse than the early ones. In other portions of the State the early beets were large enough to shade the ground in the rows by the time the hot weather and leafhoppers appeared. In Sevier County, on the other hand, the hot, dry weather came on earlier and the leafhoppers were so much more numerous that even the earliest beets could not withstand their attack when exposed to the full force of the sun.

The unusual numbers of the beet leafhopper were apparently largely the result of a winter and spring favorable for the preservation of insect life, as almost all injurious insects were present in increased numbers during that season (1905). The leafhoppers had, however, evidently been increasing for several years and had even before this reached destructive numbers in Sevier County, as the beet growers there had been suffering increasingly from what they called "blight" for two years previous to this, and this increase in the number of insects, followed by a winter favorable to their survival, resulted in the outbreak of 1905.

The leafhoppers were present in every field examined in Utah that season, and occurred in the greatest abundance in the areas in which the "curly-leaf" was worst. The average number of adults of the over-wintered brood to a beet varied from 3 or 4 up to 10 or 15, and probably even more than that in Sevier County, judging from the number found there later. No serious damage was done where there were only the smaller numbers, and even where the damage was worst it seemed to depend more upon how early they appeared and the temperature and moisture of the locality at that time than on the actual number above an average of possibly 5 or 6 to a beet. In 1906 they appeared in very small numbers. The field at Lehi, Utah, where the experiments were conducted, was by far the worst found, and here they averaged only about 1 or 2 to a beet, while the average of the valley would not have been more than 1 to every ten or fifteen beets, and the average of the State was even less.

A field in Boxelder County, Utah, was examined in August, 1905, in which the leafhoppers had recently appeared in large numbers, averaging 100 or even 200 in some places to the beet. The beets were large enough then to shade the ground, and the field was well irrigated from that time on. Almost no curling of the leaves could be found in this field, and in the fall the yield was nearly up to the average. This was the only field examined in which the leafhoppers did not appear until after the adults had hatched out. On the other hand, many fields were examined in which the leafhoppers had been present early in the season but had almost disappeared after the nymphs had matured, and yet in these fields the curling continued to develop throughout the season and the beets grew worse instead of recovering.

Spraying with kerosene emulsion was tried on a field in the Cache Valley, Utah, in 1905. This field contained numerous adults and nymphs in all stages. Four nozzles were used, each one set about 18 inches above the row and pointing obliquely down and forward, and just in front of them a bar drew the beet tops over and caused the leafhoppers to jump just as the spray struck them. An emulsion diluted with 15 parts of water had little effect on the adults, and only killed a few of the smaller nymphs. Most of the nymphs would kick about on the ground and some would become quite still, but a little later most of them would recover and hop away. An emulsion diluted with 8 parts of water produced the same effect on the adults that the weaker dilution did upon the nymphs, and killed the majority of the nymphs that it struck. Many of the latter would, however, escape the spray on account of the broad leaves of the beet, and the results were not considered entirely satisfactory.

In the cage experiments it was expected that the number of leafhoppers necessary to cause "curly-leaf" on different-sized beets would be ascertained, but owing to the fineness of the gauze necessary to hold them the temperature and moisture could not be controlled and no "curly-leaf" was produced.[a] The damp conditions of the cages also made it difficult to keep the insects for any length of time.

In one experiment 16 leafhoppers, 12 of which were females ready to deposit eggs, were placed on a beet with a top 8 inches in diameter

[a] This manuscript was originally prepared and submitted at the close of the season of 1906. Some revision was made to include the important facts of the work of 1907, but the main discussions, including the above paragraph, were written in 1906. Since that writing "curly-leaf" has appeared in cages arranged by Prof. E. G. Titus in joint investigations with the writer. Mr. H. B. Shaw, assistant to Dr. C. O. Townsend, in charge of Sugar Beet Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, has also succeeded in producing "curly-leaf" under experimental conditions. He writes me under date of October 23, 1908, that curly top or "curly-leaf" appeared in the cages on the experimental plat at Garland, Utah, in which he introduced the beet leafhoppers, and that later he sent a number of leafhoppers to the office of Sugar Beet Investigations, Bureau of Plant Industry, where 6 of them were placed in a cage with 11 young beets, 9 of which showed distinct symptoms of "curly-leaf" within five weeks after the insects were introduced.

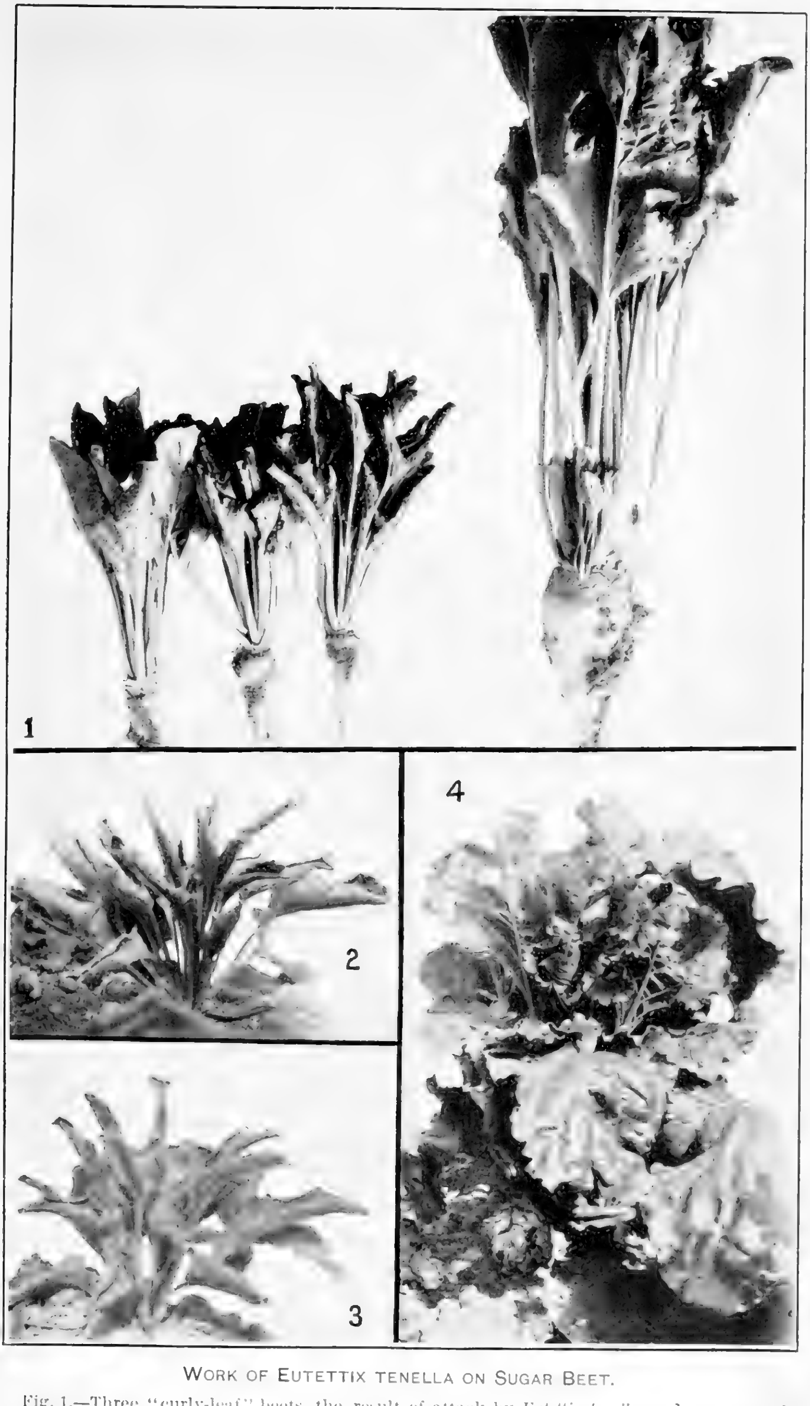
and consisting of a dozen or more leaves. Over another beet of the same size a check cage was placed. Seventeen days later the eggs had just begun to hatch, and already the beet in the cage without any hoppers was nearly twice the size of the first one. The beet on which were the leafhoppers continued to grow for a week or more, then practically stood still, and on the seventeenth day it was apparently smaller than when examined five days before. Seven days later a large number of nymphs had hatched out, the outer leaves were dead, and the rest looking sickly; ten days later than this the cage was examined again and the beet was dead and dry, while the beet in the check cage had again doubled in size. Twelve leafhoppers and their eggs stopped the growth of a beet in less than two weeks, and they, together with their progeny, killed it in less than two weeks more. The same number of adult specimens of Agallia, Nysius, or Empoasca would scarcely have made an impression on a beet of that size.

CHARACTERISTICS OF "CURLY-LEAF."

The first symptom of "curly-leaf" or "blight" of the beet is a thickening of all the smaller veinlets of the leaf, giving it a roughened appearance on the underside. This is followed by a curling of the edge (Pl. III, fig. 1) and a final rolling up of the leaf (Pl. I, fig. 1, *j;* Pl. II, figs. 2, 3; Pl. III, fig. 2), the upper surface always being rolled in. As this progresses the small veinlets grow still larger and more irregular, knotlike swellings appear at frequent intervals (Pl. III, fig. 2), and in extreme cases little nipplelike swellings appear, extending to a height of nearly one-fourth of an inch (Pl. I, fig. 1, *k*). This will be noticed first upon a medium-sized leaf, gradually spreading to the younger ones, while at the same time the beet almost stops growing and a large number of fibrous roots are sent out (Pl. II, fig. 1). These roots are not confined to two irregular lines as in a healthy beet. The beet often continues in this way throughout the season, in bad cases it shrivels and dies, while in a few instances there is a partial recovery and a new set of leaves, though the sugar content remains very low.

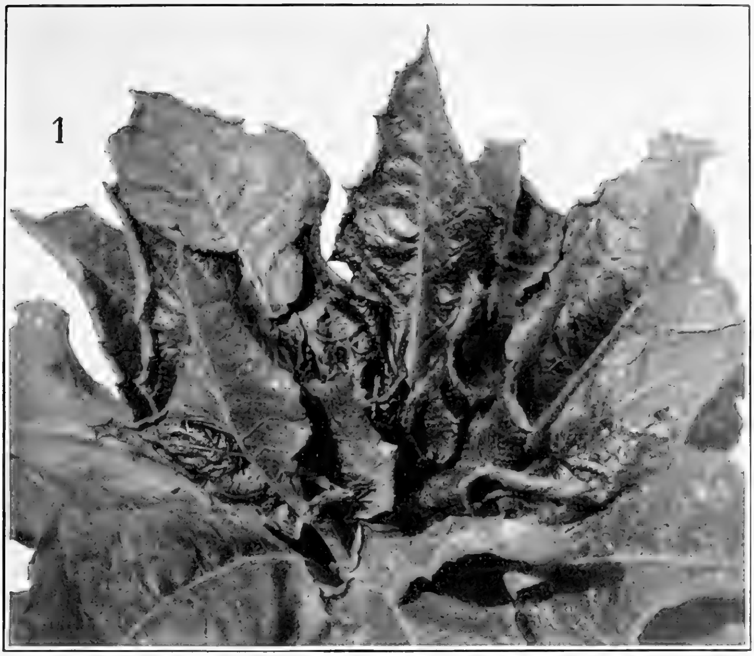
Many of the species of this genus of leafhoppers produce a discoloration or distortion of the leaves of their food plant. This appears to be of the same nature as the work of the gall-forming species, and is a process little understood. The wrinkling and folding of the leaves by some of the species is very similar in appearance to the work of some gall-forming aphides. Some species also produce a change in color similar to that produced in many galls.

In the case of *Eutettix strobi* (Pl. I, fig. 2 *a*, *b*) and *E. scitula* on the Chenopodium or on the sugar beet and of *E. nigridorsum* and *E. straminea* (Pl. I, fig. 6) on the Helianthus the discoloration appears as



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—Three "curly-leaf" beets, the result of attack by *Eutettix tenella*, and one normal beet from the same field, showing difference in size. Figs. 2, 3. "Curly-leaf" beets as seen in the field. Fig. 4.—Normal beets from same field. (Original.)



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A large beet becoming "curly." Fig. 2.—Back of a leaf affected by "curly-leaf," showing "warty" condition and curled edges. (Original.)

soon as the little nymphs begin to feed, and this is soon followed by the distortion of the leaf in a certain definite way in each case. That this is not caused by the mechanical injury of the puncture or due alone to the loss of sap seems to be abundantly proved by the fact that the Chenopodium is often attacked by other sucking insects in much larger numbers without producing either the red pigment or the gall-like distortion. The fact that a certain characteristic color and appearance are always produced by a given species, no matter whether on a Chenopodium or on a sugar beet, and that the color and form vary for the different species of the same genus even when working on the same plant, would indicate that there is some definite agency back of it all. It has also been noticed that in all this group the greatest amount of damage is done in hot, dry situations.

Whether or not the "curly-leaf" condition is entirely the result of the change in the beet caused by the attack of the beet leafhopper is still an open question, but that there is some relationship between the leafhopper attack and the "curly-leaf" does not seem to admit of a doubt in the light of the facts brought out in the investigations. The amount of damage in a given valley was directly proportional to the number of leafhoppers present, the injury appeared only after the appearance of the leafhoppers, and the "curly-leaf" condition is known to occur only on beets growing within the range of this insect.

Attention was not called to the damage early enough in 1905 to ascertain whether or not the "curly-leaf" appeared before the first appearance of the nymphs. At Lehi, Utah, the "curly-leaf" appeared very soon after the first nymphs. In the Cache Valley, Utah, the nymphs were common by the time the first curling was noticed. In 1906 very careful watch was kept in all parts of the State for the very first sign of leaf-curl, and in no case did it appear (except on the mother beets) until after the nymphs began to hatch out. In fact, in almost every case examined the cast skins of nymphs could be found on the back of curled leaves, while on healthy beets these were very seldom found. In all observations of both years more leafhoppers were found on the curled beets than on others. At first this was thought to show a gregarious habit in the adult, but it may be due to the fact that a given female lays most of her eggs on a single plant and the nymphs tend to remain there. In *Eutettix strobi* and the other leaf-curling forms, where the nymphs are brightly colored and depend on their discolored spots for protection, it is not unusual for a given nymph to pass its whole life on a single leaf, or on two or three adjoining ones; in most cases but a single nymph will be found on a plant, and sometimes the adult and the nymphal skin of each stage may be found under a single leaf. It is very likely that the same habit persists in *Eutettix tenella* and that this fact, in part at least, accounts for one beet being badly affected while the adjacent ones are unharmed. In the case of *Eutettix strobi* and its allies, where most of the leaves of a small plant are affected by the distortion, the plant usually shrivels up and dies, but where only one or two leaves on a large plant are distorted the plant does not appear to be affected at all, and in no case does the color appear in any of the new leaves. In several cases small beets have been seen in which every leaf has been deformed by the work of *strobi*, and they had apparently stopped growing.

In the case of the "curly-leaf," however, the abnormal condition apparently spreads from leaf to leaf until finally the whole plant is affected, even though the leafhoppers may have disappeared before the process is complete. This was abundantly demonstrated by the mother beets set out in the spring of 1906. These beets were selected from the best-looking beets of 1905, and would naturally have been ones that showed little or no effect of the "curly-leaf" the season before. In every case observed the first leaves sent up by these beets were as curly as the average of the year before, and most of them formed stunted lettucelike heads, and later withered and died. Some, however, survived through the season, and a few sent up stunted blossom stalks, but as a seed crop they were an entire failure. This curling took place before any leafhoppers were found in the beets, and in rows adjoining young beets that were not at all affected and did not become affected during the season. This would indicate that the agency, whatever it may be, that causes "curly-leaf" remained in the beet itself over winter and was transmitted to the first leaves in the spring.

In early September, 1907, the sugar-beet region around Spreckels, Cal., was visited by the writer and a number of cases of what was commonly called "blight" or "curly-leaf" were examined. These, however, proved to be quite different in character from the "curly-leaf" condition caused by *Eutettix tenella*. The leaves of the beet were found to be covered with pale spots, the edges were turned down instead of up, and the whole appearance was quite different. A careful search was made over many acres for specimens of *tenella*, but none was found; instead a species of Empoasca was always found associated with this appearance of the beets. The matter will be discussed further in connection with that species (p. 51).

OTHER RECORDS.

Prof. E. G. Titus reports that on a trip through the sugar-beet regions of the West in September, 1904, he found *Eutettix tenella* at La Grande and Echo, Oreg. At La Grande little damage was done, while at Echo one field of 10 acres was so seriously injured by what

WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A field of beets destroyed by "curly-leaf." Figs. 2, 3.—Cages used in the life-history experiments. (Original.)

was then called "blight" that it was not harvested. Many of the beets had died and the rest were small and stunted, while the leafhoppers could be swept up in numbers.

In California "curly-leaf" conditions were seen by Professor Titus at Oxnard and Spreckels and reported to be quite serious on the higher lands back of Salinas. Whether this was the true "curly-leaf" or the type found there this year was not determined.

In August, 1907, another trip was made by him through the same territory and a few specimens of *Eutettix tenella* taken at Payette, Idaho. Little damage was being done that season, but field men reported considerable loss in 1905 in both Payette and Blackfoot, Idaho. A few *E. tenella* were taken at Union, Oreg., and Echo, Oreg., in August, 1907, only slight damage showing in either place. Large nymphs were taken with the adults.

In California a number of places were visited by Professor Titus in August, 1907, but no specimens of Eutettix taken. In September another trip through the California districts was made, and a few specimens of *E. tenella* were taken at Chino on the 13th. No very definite cases of "curly-leaf" were noticed.

ECONOMIC SUMMARY AND PROPOSED REMEDIES.

The "curly-leaf" condition or "blight" of the sugar beet, as it occurs in Utah and the surrounding region, appears soon after an attack of the beet leafhopper (*Eutettix tenella* Baker). Its severity is conditional upon the number of insects present, upon the time of their appearance, upon the size of the beets, and upon the temperature of the surface soil, together with the temperature and moisture of the surrounding air.

More should be known about the places of hibernation and early spring history of this insect. It could not be found in the rubbish around the fields in early spring, and only a few specimens were found in waste places up to the time they appeared on the beets. When once the place where the greater number of them pass the winter is discovered, it may be possible to destroy them there or on their spring food plants before they migrate to the beets. After they have appeared on the beets it will be necessary to be very prompt in the matter of remedies if the injury is to be prevented. A thorough spraying with kerosene emulsion at a strength of 1 part of the stock solution [a] to 5 parts of water would destroy most of the insects that it hit, and by using a drag in front of the nozzles to turn the leaves over and cause the insects to jump, most of them could be reached. Where the insects

[a] For directions regarding the preparation and use of kerosene emulsion see Farmers' Bulletin 127, U. S. Dept. of Agriculture, pp. 20–21, and Circular 80, Bureau of Entomology.

were coming in in numbers this spray would need to be followed by a second one 10 days later.

Several mechanical devices have been used to catch different leafhoppers, and no doubt several of these could be used against this insect with advantage. The tar pan, or "hopper-dozer," drawn over the beets two or three times in the first few weeks would capture a large number of them. The females, before the eggs are laid, are quite heavy and do not jump or fly as readily as the males and would be easily caught. A modified form of this machine, consisting of a couple of tarred wings to be drawn along on each side of a row of beets, while a drag agitated the tops and caused the insects to fly, would probably capture more than the simpler tar-pan.

If the insects appeared while the beets were quite small, they could be largely destroyed by rolling when the weather was cold or damp and the insects sluggish.

A number of preventive measures may be used to assist the beets in withstanding the attack of the leafhoppers. In some sections early planting will produce beets large enough to shade the ground by the time the beet leafhoppers appear, and thus reduce the temperature below the danger line. In a few places, like the Grand Junction district in Colorado and Sevier County in Utah, early planting alone would not avail, as the insects appear soon after the earliest beets come through the ground. For such sections early and frequent irrigations would assist in keeping the ground cool until the beets grew large enough to shade it and thus take care of themselves.

All preventive measures will depend for success upon some method of controlling the temperature in the field so that the ground may not be hot and dry at the time the leafhoppers appear.

BIBLIOGRAPHICAL REFERENCES.

1895. GILLETTE, C. P., and C. F. BAKER.—A preliminary list of the Hemiptera of Colorado. <Bul. 31, Colo. Agric. Exp. Sta., p. 100.
On sugar beets in Colorado. Mention as *Thamnotettix tenellus* Uhl. MSS.

1896. BAKER, C. F.—New Hemiptera. <Psyche, Vol. VII, Suppl., p. 24.
Species described from New Mexico as *Thamnotettix tenellus* n. sp.

1900. FORBES, S. A., and C. A. HART.—The economic entomology of the sugar beet. <Bul. 60, Ill. Agric. Exp. Sta., pp. 423, 523.
On sugar beets in Colorado. Mention as *Eutettix tenella* Bak.

1903. CHITTENDEN, F. H.—Yearbook U. S. Dept. Agric. f. 1902, p. 730, 1903.
Mention. "Reported as injurious to sugar beet in Arizona."

1906. HOWARD, L. O.—Yearbook U. S. Dept. Agric. f. 1905, p. 630, 1906.
Injury in Utah. Mention as *Eutettix stricta* Ball.

1907. BALL, E. D.—Report of the entomologist. <16th Rept. Utah Agric. Exp. Sta., p. 16.
Character of injury and damages in 1905. Mention as *Eutettix tenella* Bak.

1907. BALL, E. D.—The genus Eutettix. <Proc. Davenport Acad. Sci., Vol. VII, pp. 27–94, Pls. I–IV.
A systematic and economic review of the group, with original illustrations.

OTHER LEAFHOPPERS.

Seven species of leafhoppers of the genus Eutettix besides *tenella* are known to have definite food plants related to the sugar beet, and several more, the food plant of which is not known, will probably be found to have similar habits. All of these species will no doubt be found on the sugar beet as fast as its cultivation is extended into the regions where these insects occur. The following species of Eutettix are already known to occur on the beet, and are arranged in about the order of their present importance.

Eutettix strobi Fitch.—The nymphs of *Eutettix strobi* are thickly spotted with red, giving them a strongly reddish appearance. They are found on *Chenopodium album* (Pl. I, fig. 2, *a*) and are confined strictly to the underside of the leaf. The attack produces a red discoloration and a curling of the leaf, which serves as a double protection for the insect. There are two broods in a season, the nymphs appearing in late May and early June and maturing from the middle of June into July. The adults of this brood are common from the middle of June through July. Nymphs appear again late in July, from which adults appear late in August, and more commonly in September. This species was carefully studied through the first brood in 1906. Then the area under observation was pastured and the record lost. The Colorado records agree with last year's work for the first brood, and furnish data for the second one. Prof. Herbert Osborn [a] first called attention to the red coloring of the leaves. It has been noticed many times since. This is, no doubt, the *Allygus* sp. of Bruner.[b] Forbes and Hart have mistaken the nymph for that of *Phlepsius irroratus* Say.[c] The larva of *P. irroratus*, however, is brownish and fuscous and lives on the ground. *Eutettix strobi* has been found on beets (Pl. I, fig. 2, *b*) in a number of places in Colorado and Utah, nearly all of them, however, around the margins of fields. In one place the insects had appeared on the beets when they were quite small, and had been numerous enough to deform every leaf on a number of beets and entirely stop their growth.

Eutettix scitula Ball (Pl. I, fig. 3).—*Eutettix scitula* is a white species with a brown saddle and brown pronotum. The nymphs are of a powdery pink color and live on the underside of the Chenopodium leaf in the same way that those of *Eutettix strobi* do, except that the discolorations are lighter. This species is apparently two-brooded. The first brood has been carefully worked out, but only adults have been observed in the fall. The broods appear about the same time as those of *E. strobi*. This is a western species occur-

[a] Science Vol. X, p. 166, 1887.
[b] Bul. 23, o. s., Div. Ent., U. S. Dept. Agric., p. 17, 1891.
[c] Bul. 60, Ill. Agric. Exp. Sta., p. 424, 1900.

ring in Colorado and Utah and has been found on sugar beets only at Grand Junction, Colo. The adults of the species are almost invariably found on poplar trees, and it seems probable that the eggs are deposited on twigs of the trees and that the nymphs drop to the ground to find a home on the Chenopodium. The adults of *Eutettix strobi* and *E. seminuda* are often found on trees and may have the same habit. In the case of *E. strobi* and *E. scitula*, nearly all instances of bad infestation have been near trees. In the case of *E. scitula* these have been poplars, but two of the worst instances of injury from *E. strobi* were alongside apple trees.

Eutettix seminuda Say.—*Eutettix seminuda* is a white insect with a brown saddle. It occurs from Kansas east to the Atlantic coast. The nymphs are pale, with a brown saddle on the abdomen and some brown on the thorax. Nothing is known as to their native food plant, but from the close relationship to the preceding species it is likely that it will prove to be a Chenopodium. There are two broods in a season, the first one appearing slightly earlier than in the case of *E. strobi*. *Eutettix seminuda* has been reported on beets in Illinois. It does not occur in the West, where the writer has worked on beets.

Eutettix clarivida Van Duzee (Pl. I, fig. 4, *a*, *b*, *c*, *d*).—*Eutettix clarivida* is a green species with four black points on the margin of the vertex. It occurs very commonly on the shad scale (*Atriplex confertifolia*) and on one or two other species of the same genus in the arid regions. It has been found on beets at Grand Junction, Colo. The nymphs are green, with two black spots on the vertex. The life history is not known.

Eutettix insana Ball (Pl. I, fig. 7), *E. albida* Ball, and *E. pauperculata* Ball occur on different species of Atriplex in the arid regions, and may be expected to occur on the beets.

Eutettix stricta Ball (Pl. I, fig. 8, *a*, *b*) is an Arizona species and the nearest relative of *E. tenella* that we know. There is probably more danger from this than from any other species of the group, if the sugar beet should be introduced within its range.

All the species of Agallia in a given section will be found attacking the sugar beet more or less. Several of the species seem to be almost omnivorous in food habits, but where they do show a preference it is for the relatives of the beet. For two of the species (*cinerea* and *bigeloviæ*) a definite food plant is known, and in both cases they are close relatives of the beet. The species of Agallia are divided into two groups, based on structural and life-history characters. In one group, which includes *sanguinolenta*, *uhleri*, *cinerea*, and *bigeloviæ*, they seem to prefer warm and rather dry situations, the adults hibernating and spreading over the beet fields in the spring in time to lay their eggs and produce their single brood of young there.

Agallia sanguinolenta Prov. is the most abundant species of the genus in the western country and is found in all fields. Together with *A. uhleri* this species has been observed to do considerable damage in the Arkansas Valley, in Colorado, and around Lehi, in Utah. The nymphs appear early in June and mature in the last half of July and the first half of August, a few running on through the month.

Agallia cinerea Osborn and Ball is found almost exclusively on the "shad scale" of desert regions, and from this adults often fly to near-by fields of beets. It was common at Grand Junction and Loma, Colo., and at Monroe, Utah. Under the hot desert conditions the nymphs appear in June and mature the last half of July, while on the beets they do not mature until some time later.

Agallia bigeloviæ Baker occurs in abundance on a tall species of sea-blite (Dondia) growing on alkaline soil, and has been found in the beet fields at Grand Junction and Palisades, Colo.

Agallia quadripunctata Prov. and *A. novella* Say belong to the other group of the genus and pass the winter as partially grown nymphs, which change to adults in late May and June. The nymphs appear again in August and develop slowly until fall, when they hibernate. These two species and *A. sanguinolenta* are discussed by Osborn and Ball (Iowa Experiment Station Report for 1897, p. 112), the nymphs and adults being figured and the life histories given. The dates given there are, however, too early for western conditions. This group thrives best in damp situations where rank vegetation abounds, and will not do any serious damage to beets unless planted alongside places of this character, from which the nymphs can migrate in early spring. By the time the adults are mature and ready to fly, the beets are well started and beyond their injury.

Empoasca sp.—A large number of adults of a small green *Empoasca* were found on sugar beets at Spreckels, Cal., in early September by Prof. E. G. Titus and the writer. The beet crop was not seriously injured, but a number of beets were found in which there was a slight curling of the leaves resembling " curly-leaf," except that in this case the edges of the leaf turned down rather than up, and the surface of the leaf, instead of being roughened, was covered with small pale spots. This pale spotting of the leaves is quite characteristic of the injury of the Empoascas and their relatives and is commonly seen on apple and rose leaves. The insects were all adults at this time, so that it was impossible to be certain that they had bred on the beets, but from the appearance of the leaves it is probable that they had. The nymphs of nearly all of this group are slender, pale-greenish forms and are found mostly on the underside of the leaf, while the white spots caused by their punctures show more plainly on the upper surface.

Professor Titus reports finding an Empoasca common on beets at Chino, Cal., in August, 1907, and states that the beet leaves showed the characteristic spotted appearance, but that no curling was noticed. In his trip in 1904 Empoascas were noticed in several places in California, and quite serious damage from "blight" or "curly-leaf" was found in a few places, but the particular nature of the injury was not observed.

The Empoascas nearly all pass the winter as adults, hibernating in rubbish and sheltered places near their food plants. In the spring they feed on anything that offers until their food plants start, and then they gather on them, laying eggs in early summer. The young nymphs feed on the underside of the leaf and are quite active and keep out of sight.

Spraying with kerosene emulsion, 1 part of the stock solution to 8 parts of water, proved to be a satisfactory remedy for an Empoasca on potatoes in Iowa some years ago, and no doubt could be used on the beets with success. Burning off rubbish around the field in the late fall would probably reduce their numbers.

CONCLUSIONS IN REGARD TO "CURLY-LEAF."

As a result of the above investigations, it appears that there are at least two distinct kinds of "curly-leaf" that have been confused under one name. One, in which the leaves become rough and warty and curl up and in which the beet is stunted and does not recover; the other, in which the leaves remain smooth but show numerous pale spots and in which the edges turn down, and in which, as far as known, the injury is confined to the leaves attacked. The first-mentioned kind of "curly-leaf" occurs from Grand Junction, Colo., west to the Pacific coast and is the one that has been seriously injurious in the intermountain region. This condition is brought about by the attack of the beet leafhopper (*Eutettix tenella*), and will, no doubt, be confined, for some time at least, to the southwestern part of the United States, the native home of this insect. The second kind of "curly-leaf" has been found in California quite commonly, and doubtless will be found to occur sparingly at least in the eastern part of the United States, or wherever an Empoasca attacks the sugar beet.

Besides these two types of this injury it is quite possible that in rare cases other types with still other causes have been seen and not recognized at the time as distinct. Investigations in the California field have been so meager that it is impossible to say as yet which type has caused the greatest injury. In the intermountain region, where most of the work has been done, practically all the injury is known to have been caused by the first type.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part V.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE SEMITROPICAL ARMY WORM.

BY

F. H. CHITTENDEN AND H. M. RUSSELL.

Issued January 28, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

CONTENTS.

ILLUSTRATIONS.

66—v

ERRATA.

Page 65, line 15 from bottom, for *fresh air-slaked* read *freshly slaked*.
Page 68, line 8, for *6* read *50*.

U. S. D. A., B. E. Bul. 66, Part V. Issued January 28, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE SEMITROPICAL ARMY WORM.

(*Prodenia eridania* Cram.)

By F. H. Chittenden and H. M. Russell.

INTRODUCTION.

During the summer of 1907 a smooth or hairless caterpillar (*Prodenia eridania* Cram.) related to the cotton cutworm came under the observation of the junior author at Orlando, Fla. It was observed attacking the foliage and, in many cases, the stems and fruits of all forms of garden truck grown in that vicinity, the list including tomato, potato, sweet-potato, eggplant, pepper, okra, collards, and cowpeas. The infestation was of considerable severity, and great injury was done in fields and gardens in that and in some other regions of Florida, notably at St. Augustine and on the west coast of the Manatee River. What is believed to be the same species was reported injurious in Porto Rico by Mr. W. V. Tower. Aside from a brief notice which has been made of the present invasion there does not appear to be any other record of the injurious habits of this species; hence the following account has been prepared for publication by the senior author. The chapters on recent injuries, natural enemies, and experiments with remedies have been compiled from the junior author's notes. The technical descriptions of the egg and larva have been prepared by Dr. H. G. Dyar, while other assistance in the preparation of this article is duly acknowledged in its proper place.

In ordinary seasons the species under consideration confines itself largely to weeds, among which are the poke-weed, spiny amaranth or careless weed of the South, and a wild Solanum. It has habits different from those of the northern cutworms and can scarcely be classified with the climbing cutworms, although it has the climbing habit. It has a decided tendency to travel in armies like the army worms and is practically confined to semitropical regions. It is remarkable as being injurious throughout the warm season and breeding continuously, there being evidently at least four generations a year in nature.

DESCRIPTIVE.

The adult is a noctuid moth, and while the larva is quite readily referable to the genus Prodenia, the moth has little of the appearance of our other two North American species.[a]

The moth.—The adult or moth has a wing expanse of nearly $1\frac{1}{2}$ inches ($33–38^{mm}$); the fore-wings are dull gray, sprinkled and dotted with brownish and black scales forming a pattern as shown in figure 8, *d*. There is considerable variability in these markings, some individuals having a strongly marked reniform spot, a very prominent blackish posterior marginal line, and a similar black line

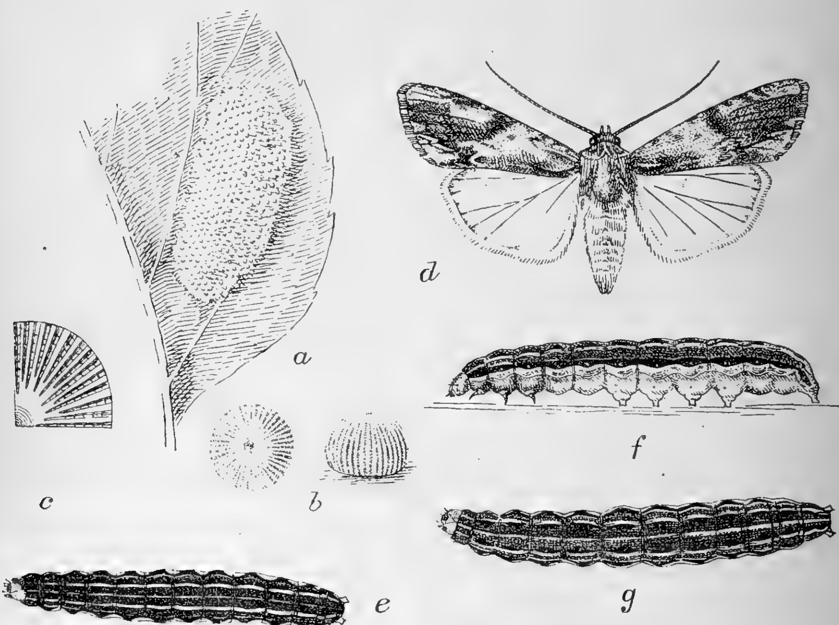


FIG. 8.—The semitropical army worm (*Prodenia eridania*): *a*, Egg-mass on leaf; *b*, egg, much enlarged, showing lateral view at right and top at left; *c*, section of egg; *d*, moth; *e*, dark form of larva nearly grown; *f*, *g*, larva, full-grown. *a*, *d–g*, Enlarged; *b*, highly magnified; *c*, more magnified. (Original.)

on the latero-posterior margin. Individuals also occur in which there is a straight, broad, jet-black dash or band beginning at the middle of the fore-wing and extending to the lateral margin. This is the *nigrofascia* of Hulst. The hind-wings are pearly white above, this pearly luster being still stronger below. The body is brownish gray and the antennæ are yellowish brown.

The darkest forms of this species are marked very much as in the genus Acronycta.

The eggs.—The eggs are deposited in irregular masses, as shown in figure 8, *a*, closely placed together, sometimes in two layers and

[a] *Prodenia ornithogalli* Guen. ("cotton cutworm") and P. *commelinæ* S. & A.

covered with whitish down, from the body of the female. They are distinctly green when first deposited and have the appearance illustrated at *b* and *c*.

The larva.—The caterpillar resembles that of the other two species of Prodenia sufficiently to be naturally referred to that genus, and it is subject to similar variation in color. The ground color is dark grayish in pale individuals and nearly black in the dark forms. These latter, especially when approaching maturity in the penultimate stage, are sometimes so dark as to resemble Mamestra. The body is ornamented with a narrow, slightly interrupted, median yellow longitudinal dorsal stripe, a similar slightly wider dorso-median stripe, and a wide and brighter yellow substigmatal stripe, which becomes obscured in the thoracic segments of the penultimate stage. In the very dark forms the triangular velvety dorsal spots characteristic of the genus can scarcely be seen, and in the paler forms they are seldom as distinct as in the other two species. When full-grown the larva measures about an inch and a fourth to an inch and a half in length (25–37^{mm}), and the width varies from one-fourth of an inch to a little larger. The head measures nearly 2.5^{mm}.

The mature larva is illustrated at *f* and *g* of figure 8 and a dark form nearly grown at *e*.

The pupa.—The pupa resembles closely that of *Prodenia commelinæ*. The head and abdomen are well rounded. The color is mahogany-brown, with the head, spiracles, and anterior edges of the abdominal segments darker. The surface is smooth and shining, with the anterior edges of the abdominal segments finely punctured. The anal segment terminates in a two-spined cremaster-like process. Length, 16–18^{mm}; width, 5–6^{mm}; length of head to end of the wing-cases, 10^{mm}.

The following technical description of the egg and larval stages was kindly contributed by Dr. H. G. Dyar.

TECHNICAL DESCRIPTION OF THE EGG AND LARVAL STAGES.

The egg.—Hemispherical, smooth, pale green, shining; ribs very fine, obscure, numerous, ill-defined, radiating from the micropyle; cross-striæ imperceptible. Diameter, 0.6^{mm}. Laid in a patch, covered by a thin layer of whitish wool.

Stage I.—Head rounded, bilobed, mouth pointed, shining greenish-black; eyes black, mouth brown; width about 0.3^{mm}. Body robust, uniform, joint 12 slightly enlarged, feet of joints 7 and 8 a little smaller than the others and not used in walking; translucent greenish, cervical shield, leg plates, thoracic feet, anal plate, and the large round tubercles shining black; tubercles i and ii of joint 12 in a square; setæ rather coarse, moderate, black, simple.

Stage II.—Head rounded, slightly bilobed, the vertex level with joint 2, shining luteous, blackish shaded over the vertices of the lobes; ocelli black, mouth brown, width, 0.4^{mm}. Body somewhat thickened at joints 5 and 12, feet normal, equal; greenish luteous, cervical shield and anal plate blackish infuscated;

tubercles rather large, low-conical, black; leg shields slightly smoky; tubercle vi present; a large red blotch around tubercles i and iv on joints 5 and 12; setæ short, black, stiff; traces of a white dorsal line showing especially by the cut between the red blotches at tubercle i of joint 5; no other lines.

Stage III.—Head rounded, the vertex just within joint 3, pale reddish over the lobes and sides, luteous on the face, shining, very small in proportion to the body; width, 0.6^{mm}. Body robust, slightly thickened at joint 5, more so at joint 12; feet normal; pale green; a straight dorsal and a subdorsal white line and traces of a broken lateral one; subventral region slightly pale, without defined line; tubercles small, black; a large, vinous, somewhat elevated blotch on tubercles i and iv on joint 5 and on tubercle i on joint 12, more diffusely about the spiracle on joints 11–12; anal feet reddish; cervical shield small, infuscated, cut by three white lines; anal plate blackish; thoracic feet blackish, abdominal ones greenish.

Stage IV.—Head rounded, rather quadrate, not notched, the clypeus high, vertex even with joint 2; pale red, paler on the clypeus, ocelli and antennæ dark; width 1.0^{mm}. Body robust, thickened at joints 5 and 12, feet equal; blackish olivaceous, dorsal and subdorsal lines straight, yellowish white, edged with vinous dottings; traces of a lateral line; subventral region paler below the spiracles, especially after joint 5; large blackish-red blotches at tubercles i and iv on joint 5 and on joint 12 and tubercle i and stigmatally on joints 11–12; white dotting in the ground color most conspicuous stigmatally; thoracic feet black, abdominal ones pale, anal pair reddish.

Stage V.—Head quadrate, rounded, slightly bilobed, shining light red-brown, the clypeus high; ocelli and setæ black; width, 1.6^{mm}. Body thickened at joints 5 and 12, feet equal, normal, the abdominal ones pale, slightly infuscated, the thoracic ones black-ringed; dark gray to black, strigose-dotted with white; dorsal line narrow, subdorsal broader, straight, even, yellowish white, centered with reddish mottlings, cutting the sooty-black cervical shield, but not the anal plate; a quadrate black patch between the lines on joint 5, a small angular one next the subdorsal line on all the other segments, large on joint 12 and shaded across; a narrow white-dotted lateral line, scarcely different from the dots of the ground color; subventral band straight, yellow-white, broad, broken at joint 5, reddish-filled around the spiracles, black spots at tubercles iii with a distinct white dot below; subventral region of thorax blackish, of abdomen paler, white-dotted.

Stage VI.—Head rounded, quadrate, about as high as wide, slightly bilobed, the vertex level with joint 2; clypeus high and large; red-brown, darker reticulate, mouth parts concolorous, ocelli black; width 2.1 to 2.4^{mm}. Body robust, cylindrical, tapering from joint 5 to joint 2, the head small; joint 5 slightly, joint 12 distinctly, enlarged and abruptly tapered to joint 13; black, strigose-dotted with white; cervical shield deep black, white-dotted, cut by three white lines; anal plate similar, small, cut by the dorsal line only; dorsal line narrow, black-dotted and broken, yellowish white, reddish on the centers of the segments; subdorsal line broader, straight, yellow-white, reddish centered on the segments, with a median row of gray dots, but not incised on the margins; a row of segmental black triangles above it, free of white dots, largest on joint 5, the one on joint 12 now scarcely larger than that on joint 11; upper half of the lateral area grayer, with many white dots, lower half blacker, with few dots on joints 5 to 13, separated by a row of brighter dots representing the lateral line; on joints 2 to 5 this distinction is weakly developed; spiracles in a blacker shade with a white dot above tubercle iv; substigmatal band broad, even, undulate, weak and broadly gray, centered on joints 2 to 5, fading out at joint 5, sharply reappearing at joint 5 posteriorly, then pale yellow, centered with blackish mottlings at the centers of the segments and red above these; subventral region black-shaded, strongly so on joints 2 to 5, weakly on the abdomen, white-dotted, paling to the venter; thoracic feet dark brown, the abdominal ones pale brown, shining; a single cylindrical, round-tipped neck gland reaching to the end of the labial palpi; crochets of abdominal feet in a single row, dark; tubercle iv slightly above middle of spiracle on joint 7. [Harrison G. Dyar.]

ORIGIN AND DISTRIBUTION.

This is a Lower Austral form and probably of tropical origin. In the National Museum are specimens from Cocoanut Grove, Crescent City, and Orlando, Fla. The species is also recorded from Tallahassee, and reported from St. Augustine and the region about the Manatee River in Florida. From Texas we have specimens from Bosque County (Belfrage) and Dallas, and there are specimens collected at Pernambuco, Benito Province, Brazil, by Mr. Albert Koebele. Dr. J. B. Smith records the insect from Georgia and Central and South America, and Grote records it from California. This indicates a range extending from Brazil to Mexico, Central America, and the Antilles, and from Florida westward through the Gulf region and Texas to California.

LITERATURE AND HISTORY.

Considering the fact that this species is really common in the South and that it feeds gregariously and voraciously, it is somewhat remarkable that it has not hitherto attracted attention by its depredations. The moth was described by Pierre Cramer in 1782.[1] [a] Its natural food plants were known to Smith and Abbot, who wrote of it in their classic work published in 1797.[2] The illustration accompanying that work, though over-colored as usual, depicts a perfectly recognizable moth of this species but a too-brilliant and light-colored larva. Light and dark forms of the moth are figured. The species is mentioned as *Phalæna phytolaccæ* and is compared with the related *Prodenia commelinæ* and *Laphygma frugiperda*, which form the subject of the two plates and pages immediately preceding the account of *phytolaccæ*.

As Smith and Abbot's work is not accessible to many, the following copy of their account of this insect is republished:

PHALÆNA PHYTOLACCÆ. Poke-weed moth.

Phytolacca decandra. Linn. Virginian poke-weed.

Ph. *Noctua* spirilinguis cristata, alis deflexis: primoribus fusco striatis puncto obscuro margine postico nigro maculato; anteriori punctato.

---

[a] Numbers in superior type refer to corresponding numerals in the appended bibliographical list (p. 70).

Feeds on the Poke, Careless, &c. It went into the ground July the 5th, and came out the 16th. I once met this caterpillar in such abundance, that among a great quantity of Poke plants there was scarcely a single leaf untouched; most of these caterpillars, however, were fly-blown by a kind of *Ichneumon*. The moth is rare.

This is allied to our *Ph. frugiperda* and *Commelinæ*. Between the under wings of all these there is the greatest affinity. Their *pupæ* too are of a similar bright red color, and their smooth-striped caterpillars have much resemblance to each other.

RECENT INJURIES AND BIOLOGIC NOTES.

On May 14, 1907, this species was observed on the leaves of tomato in the truck garden of Mr. C. M. Berry, at Orlando, Fla., where it was eating holes in the leaves. Numbers of plants, here and there. were infested and in most cases the entire plant was injured. The same larva was observed on pokeweed (*Phytolacca decandra*), and afterwards on spiny amaranth (*Amaranthus spinosus*). By May 20 the larvæ were scattering and had grown rapidly, some being an inch long. While young, these larvæ feed on the underside of the leaf, but with larger growth some were noticed feeding on the upper surface as well.

May 24 an egg-mass was found on a leaf of the spiny amaranth, laid in two sections on the under surface, one on each side of the midrib. One mass had hatched at this time and the larvæ were beginning to eat pinlike holes through the leaf.

On July 3 a field of Irish potatoes was found to be very badly infested by these larvæ. They were now nearly full-grown and had stripped the potato vines, many being observed crawling away from the field in all directions. On one side they infested a garden at least 600 feet away, and were feeding upon eggplant, pepper, okra, and castor-oil plants.

Some interesting notes were made on the abundance of this species in this potato field. On a single young plant of Amaranthus, 41 larvæ were counted, and as many as 314 on a plant measuring 6 feet in height. A careful estimate of the larvæ on 10 plants of careless weed, not over 6 feet in height, gave a total of 1,300 individuals. (See fig. 9.)

To illustrate the voracity of these larvæ, where any potatoes were exposed, they were soon covered by the larvæ and the entire contents eaten out so that they were rendered worthless in about ten minutes. About this same date, July 3, the larvæ were reported making quick work of amaranth; whenever a branch became broken from any cause, larvæ entered at the break and excavated tunnels several inches in length. Pokeweed was entirely stripped of leaves, the stalks and the shoots being eaten off at the outer end. Potatoes dug at this time were frequently found full of holes, the work of these larvæ. The following day, July 4, the amaranth was almost completely denuded, illustrating the rapid work of this species when in large numbers (see figs. 10, 11). By July 8 the larvæ had almost completed their work in the field, after having eaten everything clean. Many were full grown and had commenced to enter the ground. July 9 the potato field was stripped, the vines were dead and dry, and the larvæ had almost disappeared. The ground was full of pupæ, none of them at a greater depth than 4 inches, and in

FIG. 9.—The semitropical army worm (*Prodenia eridania*); Work of larvæ on "careless weed" in potato field; 311 larvæ were on this plant when photographed. (Original.)

many cases only 2 inches. Upon digging into the hills, it was found that they did not average more than four good-sized potatoes to the hill, and in many cases these had been rendered useless by the inroads of the larvæ. (This crop averaged small because of late planting.)

Many larvæ were found feeding on sweet potatoes at Mr. John M. Cheney's place at this time, most of them still in young stages. A few fully matured larvæ also were found, showing the overlapping of the two generations; in fact, observations conducted both in the field and at the insectary at Washington, D. C., show that this species is undoubtedly a continuous breeder, as in the case of the variegated cutworm (*Peridroma margaritosa* Haw.), the larvæ being present in the field throughout the long summer season of the South.

July 30, by request of the county commissioner, Mr. H. H. Dickson, the junior author went to the County Home and found a sweet-potato patch badly infested, thousands of larvæ present, and the leaves turning brown and drying out. Superintendent Harris stated that an earlier brood did great damage to cowpeas, but this could not be verified by specimens. In the sweet-potato field the larvæ started on the south side and, after stripping the first four or five rows, moved over to the next rows and eventually infested the entire

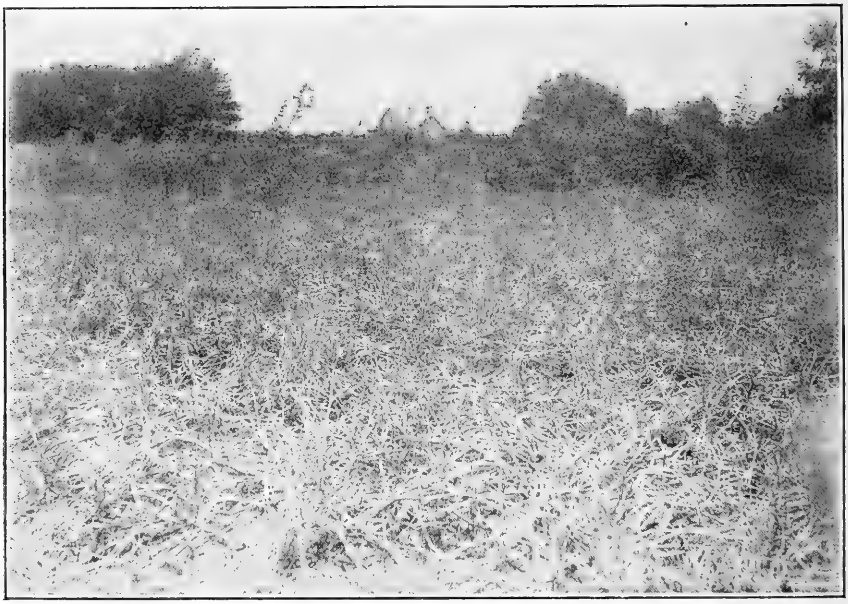


FIG. 10.—The semitropical army worm (*Prodenia eridania*): Field of late Irish potatoes showing vines entirely stripped by larvæ; Orlando, Fla., July 6, 1907. (Original.)

field. A Mr. Porter, near the County Home, reported 5 acres stripped in three days after the larvæ were noticed at work, these having started at one side of the field and swept it clean. The larvæ of a third generation were observed at Mr. Cheney's place at this time; most of them, however, had already gone into the earth to transform.

August 3, adults that had pupated about July 25 began to emerge. Thus the pupal period occupied about nine days. At this time a number of young larvæ were noted feeding upon amaranth, wild Solanum, and castor-oil plants. When disturbed they dropped and hung by threads.

By the first of September Mr. Cheney's patch of sweet potatoes was entirely free from this insect, evidently owing largely to parasites and to the spraying with arsenate of lead.

August 30, 1907, Mr. Wm. Donnell, St. Augustine, Fla., reported that a cutworm, which he identified as this species, had been very destructive in that region, being especially abundant on beets, and

FIG. 11.—The semitropical army worm (*Prodenia eridania*): Larvæ eating bark of "careless weed;" also nymph of *Podisus maculiventris*, predaceous on the larvæ. (Original.)

later affecting cabbage, carrots (by eating the tops), and some other plants, its operations being most noticeable at night.

Mr. E. L. Worsham, while employed by this Bureau, noticed this species on the west coast, near the Manatee River, in Florida, and reported it working quite extensively in that region in August.

On November 23, 1907, an egg-mass was found on pokeweed at Dade City, Fla., and December 2 another was observed, from which the larvæ hatched December 4. These molted between December 10 and 13, while being transported to Orlando, but soon died, as frost killed off the food plants.

July 25, 1908, Mr. H. H. Dickson asked for a remedy to apply against the larvæ on sweet potatoes at the Orlando Truck Farm.

Egg-masses received May 24, 1907, hatched at that time and the larvæ entered the earth in the rearing cage June 19. In dry sand the pupæ were found at a considerable depth, but in moist sand they were found barely under the surface.

July 8 larvæ in the rearing-cage were almost full grown. Larvæ hatching from egg-masses, and others a few days old, were also found in abundance on sweet-potato plants. As soon as hatched they separate, feeding on the leaf on which the egg-mass was laid, perforating the underside full of minute holes, and leaving only the upper epidermis, which turns brown. On growing larger they separate, as in the case of most caterpillars, except those of peculiarly gregarious habit, and soon become widely scattered. Even when abundant it is common to see eight or a dozen on the underside of a single leaf, and frequently as many as an hundred. Occasionally a nearly full-grown larva feeds on the upper side of a leaf. In many cases large larvæ were found hiding during the day at the bottom of furrows.

June 15, 1908, the larvæ of this insect were found to be very abundant at Orlando, Fla., in one part of the town feeding on pokeweed, and in another on amaranth.

EARLY RECORDS.

Among the records of the Bureau of Entomology is one of May 22, 1887, when larvæ and pupæ were received from Mr. E. A. Schwarz with report that the species was very injurious to the eggplant at Cocoanut Grove, Fla.

In September, 1905, Mr. F. C. Pratt sent to the Bureau a large colony of the larvæ found feeding on pokeweed at Dallas, Tex., the moths from which began to issue September 26.

LIFE-CYCLE PERIODS AND GENERATIONS.

Larvæ mailed from Orlando, Fla., July 3, arrived at Washington, D. C., July 5 and began to enter the earth for pupation the following day. On the 16th two had transformed to pupæ, on the day following three more, and the remainder transformed within a week. This experiment shows a pupal period of about 9 days, allowing 1 day for the larvæ in the earth before pupating. The weather was quite hot. In a cooler temperature in August the pupal period required 11 to 13 days.

The moths hatched from different lots were separated and the egg-period observed. In one case this lasted from August 8 to 12, or

4 days, and in another case from July 18 to 22, or 4 days. In the first instance the temperature averaged between 76° and 80° F. and in the second from 80° to 88° F. Evidently this is the maximum period.

As regards the duration of the entire life cycle, it was noticed that eggs deposited July 3 produced caterpillars on the 9th, or in 6 days. These penetrated the earth, being full-grown, on the 26th, making the entire life period of the larvæ 17 days. They began to issue as moths August 5. This gives a total period for the life cycle of 31 days for extremely hot weather. In an ordinary outdoor summer temperature the period would be about 35 days, or 5 weeks.

Our rearing records are not quite as accurate as could be desired, owing to unfortunate conditions at the insectary and to three changes in the office force during the time when the insect was under observation. There were, however, positively four generations here, and about the same number was observed at Orlando. There is also the possibility of an earlier fifth generation in nature. The exact periods for the appearance of these should be recorded in the field.

NATURAL ENEMIES.

The unusual abundance of this species at Orlando, Fla., during the season of 1907 afforded a most excellent opportunity for the study of its insect natural enemies. These came under observation as early as May and were still abroad as late as August, appearing to increase somewhat as the season advanced.

PARASITES.

The parasitic species observed were seven in number; the predaceous enemies, six.

Ophion tityri Pack. (?)—Issued July 17–August 1.

Limnerium sp.—Issued May 25–30.

Meteorus sp.—Issued July 11–August 2.

Chelonus sp.—Issued July 6, 1908.

Spilochalcis spp.—The Meteorus was attacked by two species of secondary parasites of the family Chalcididæ. These issued August 2 from the peculiar brown cocoons of the Meteorus.

Winthemia quadripustulata Fab., a moderate-sized tachina fly, is also a parasite on the larva of this species. Adults issued August 8 but did not appear abundant. Of a lot of larvæ taken at random from different portions of a field, upward of 50 per cent bore tachina-fly eggs. Evidently a large percentage fail to hatch.[a]

[a] A small fly was also observed feeding on the pupæ. It is *Aphiochæta nigriceps* Loew, one of the Phoridæ, which comprises species of scavenging habits and not parasitic.

PREDACEOUS ENEMIES.

Calosoma sayi Dej.—The larvæ of the carabid beetle *Calosoma sayi* were observed in considerable numbers and were reared to adults. They were first noticed July 6, when they were quite abundant in the furrows between rows of sweet potato. They were found concealed by the vines, feeding on the larvæ of the Prodenia, and after sucking out the juices of one larva they immediately attacked another. The adults issued in our rearing cages August 11.

Polistes annularis L.—The large brown wasp *Polistes annularis* was observed July 2, flying quite commonly in sweet-potato fields. One was watched which alighted on a leaf and began searching for prey, after the custom of such wasps. The search was continued from plant to plant and from leaf to leaf until a Prodenia larva was located, when it was at once seized behind the head and chewed into a shapeless mass. Other wasps of this species were also seen on fence posts dragging Prodenia larvæ about with them.

It is interesting to note that Mr. F. F. Crevecoeur, Onaga, Kans., reports having seen this wasp being carried away by the asilid robber-fly, *Deromyia ternata* Loew.

Stiretrus anchorago Fab., var. *diana* Fab.—The blue-and-red and the uniformly blue forms of the soldier-bug *Stiretrus anchorago*, which are common in Florida, were observed in numbers attacking the Prodenia larvæ in July.

Podisus maculiventris Say.—During July the spined soldier-bug was seen preying upon the Prodenia larvæ. (See fig. 11.) In one instance 18 nymphs were counted on a single amaranth plant infested by the cutworm. The length of the life cycle of this species from hatching (not from egg-laying) was determined to be 16 days in hot July weather.

Apateticus (*Eupodisus*) *mucronatus* Uhl.—July 17, and again in December, 1907, this pentatomid bug was observed preying on the larva of this species of Prodenia at Orlando, Fla. It is considered a rare species and this is probably the first observation which has been made on its habits.

Owing to the obscurity of the host insect in the past, no records can be found of any of these parasites or of other natural enemies which affect it, but in Smith and Abbot's work mention is made of a species of "Ichneumon" which attacks the larva (see p. 58).

Pontia rapæ L.—July 22, 1907, the young larvæ of the imported cabbage worm, which had hatched out on cabbage used as food for *Prodenia eridania* Cram. in our rearing cages at Washington, were observed feeding on the eggs of the latter.[a] The cabbage worms were between one-quarter and three-eighths of an inch in length at this time.

A FUNGOUS DISEASE.

Empusa sp.—September 8, 1907, a few Prodenia caterpillars, which were found dying of a fungous disease in our rearing cages, were referred to the Bureau of Plant Industry for identification of the fungus. Mrs. F. W. Patterson stated that it was a species of Empusa.

METHODS OF CONTROL.

The arsenical poisons are effective against this army worm under ordinary conditions. Experiments performed at Orlando, Fla., however, brought out the fact that Paris green, on account of the frequent rains which occur at the height of the principal outbreaks in the infested regions of Florida, such as Orlando, is almost ineffective and it is therefore necessary to use arsenate of lead. Owing to the greater adhesiveness of the latter it remains on the plants when the former is washed off.

Paris green, arsenate of lead, and a special preparation which may be called adhesive copper arsenite, were tested, the last by request of its inventor. It was used in experiments Nos. 8, 10, and 11. A barrel sprayer, fitted with Vermorel nozzle, was used for a number of these experiments, but for most of them a knapsack sprayer of fine quality was employed. Sweet potatoes were sprayed in every case except in experiment No. 5, where collards were also sprayed, and the work was usually begun between 8 and 10 a. m. in bright sunlight. Spraying experiments commenced July 12 and were continued until August 7.

Experiment No. 1.—July 12, infested plants were sprayed with a solution of Paris green, 5 ounces, and fresh air-slaked lime, 5 ounces, in 50 gallons of water. The spraying was done in the morning and rain fell before noon. The next day when the field was examined the larvæ were found uninjured and practically no poison remained on the leaves. The experiment was therefore a failure.

Experiment No. 2.—July 12, Paris green, 8 ounces, and freshly slaked lime, 1 pound to 50 gallons of water, were sprayed the same day and with the same results.

Experiment No. 3.—July 17, Paris green was sprayed as in No. 2. Again rain fell hard and steadily before noon, with the same results as in experiments 1 and 2.

---

[a] This would seem to furnish at least one reason why this important insect has been able to supplant its American cousins such as *Pontia napi* L., *P. protodice* Bdv. & Lec., and *P. monuste* L., all of which feed on crucifers and are called cabbage butterflies or "worms."

Experiment No. 4.—Arsenate of lead, 2 pounds to 50 gallons of water, was used. Rain fell as before, resulting in partial failure of the experiment, the poison being washed off before it had time to dry thoroughly.

Experiment No. 5.—July 20, arsenate of lead was used as in experiment No. 4. Collards were also sprayed. Rain did not ensue for at least six hours, giving the spray time to dry on well in the warm sun. The following day it rained hard for several hours, but the next day the spray was found to be as thick on the sweet potatoes as when first put on, in spite of two partially rainy days. The poison was nearly as thick on the collards. An examination of the infested plants two days after spraying showed that only 25 per cent of the caterpillars were killed, but July 23, a day later, few large larvæ remained on the plants, showing that as soon as they have eaten sufficient poison they are killed.

July 29, when the rows sprayed with arsenate of lead were again examined, they were found in much better condition than the check or unsprayed rows, few larvæ being seen feeding, while dead ones were plentiful.

Experiments Nos. 6 and 7.—July 20, a sweet-potato patch was sprayed with Paris green, 8 ounces to 50 gallons of water. As in the case of experiment 5, no rain fell for about six hours; therefore the poison dried on well, as previously. The following day it rained hard for several hours, with the result that by July 22 the poison was all washed off and only a few dead larvæ were found. All of the Paris green experiments were failures, since the rain washed the poison off either before it could dry or after it was well dried on the plant.

Experiment No. 8.—July 23, the adhesive copper arsenite (combined with dextrine and glucose) was used at the rate of 1 pound to 100 gallons of water and applied as in previous experiments. The following day no results were observed, but the foliage was not burned. At the end of a week no good was accomplished and the experiment was pronounced a failure.

Experiment No. 9.—July 25, plants were again sprayed with arsenate of lead, 2 pounds to 50 gallons of water, the conditions being as in experiment No. 5. Rain at 12.45 p. m. washed off the poison, consequently the spraying was a failure.

Experiment No. 10.—July 25, plants were sprayed with the copper arsenite mixture; 10 ounces to 50 gallons of water were applied as in experiment No. 8, an equal quantity of lime having been added. The spray did not show well on the foliage and was invisible when dry. It does not remain in suspension as well as Paris green and much residue remains in the tank. July 28, a few dead larvæ were found on the vines and only a few live ones, but the same conditions were observed on the check rows. The experiment was an absolute failure.

Experiment No. 11.—July 29, plants were sprayed with copper arsenite mixture at the rate of 15 ounces to 50 gallons of water. In this case 1½ ounces of copper arsenite and 1 quart of thick lime were used with 5 gallons of water. Two days later the spray showed better than in experiment No. 10 because of an abundance of lime and was very finely and evenly applied to the leaves. Four larvæ were dead on a few plants examined against 32 living Prodenia and 3 living sweet-potato sphinx-moth larvæ (*Phlegethontius convolvuli* L.).

August 6, this spray still remained on the foliage, seeming to adhere well, but the experiment was a failure in killing larvæ.

Experiment No. 12.—July 29, plants were sprayed with arsenate of lead, 3 pounds to 50 gallons of water, applied as in previous experiments with lead arsenate. There was no rain for 24 hours. On a few plants examined three days later 41 dead larvæ were found and 49 living, an observed death rate of less than 50 per cent. It should be pointed out at this time, however, that it is difficult to find dead larvæ, as they sometimes dry up or crawl away.

August 2, the vines were almost free from larvæ. The experiment was pronounced very successful.

Experiment No. 13.—July 30, arsenate of lead, 2 pounds to 50 gallons of water, was used without ensuing rain. In some rows examined August 1 about 20 per cent of the larvæ were dead; in others 48 per cent, 54 per cent, and 61 per cent were killed in two days. August 5, these rows appeared entirely free from larvæ unless closely inspected, when only 5 or 6 could be found to a row. These might have crawled from unsprayed weeds or other plants.

Experiment No. 14.—July 30, arsenate of lead, 3 pounds to 50 gallons of water, was used. Three days later 84 per cent of the larvæ under observation were destroyed, the rows being quite clean. In both of these experiments, 13 and 14, many dead larvæ were found in rows *not* sprayed, as many as five rows away from the sprayed ones.

Experiment No. 15.—August 7, arsenate of lead, 2 pounds to 50 gallons of water, was sprayed by a laborer, under supervision. It rained at 1 p. m., but the spray remained on the leaves in large amounts and, for having been applied by an inexperienced hand, was well distributed. In this experiment, for some reason, the first four rows sprayed at one filling of the tank produced quite a number of burned leaves. This was attributed to a possible mistake in weighing out the chemicals. It did not, however, permanently injure the plants.

Caterpillars in the last 4 experiments, supposedly of the third generation, were very small, not over one-fourth or one-third of an inch in length. As a consequence they were quickly killed, large numbers of them being found dead soon after spraying. Forty-three dead larvæ were found in a furrow beside one plant which contained 29 dead larvæ. In another place 112 dead larvæ were counted in 3 feet of furrow.

RÉSUMÉ OF EXPERIMENTS, AND CONCLUSIONS.

Experiments 1, 2, 3, 6, and 7, in which Paris green was used at the rate of 5 to 8 ounces in 6 gallons of water, were failures because in each case the rain which followed the application washed off the poison.

Experiments 4 and 9, in which arsenate of lead was used at the rate of 2 pounds to 50 gallons of water, were also failures for the same reason.

Experiments 8, 10, and 11, in which copper arsenite was used at a rate of from 10 ounces to 1 pound in 50 gallons of water, failed, not because of burning the foliage, as was feared, but because the insects were not killed.

Experiments 5, 12, 13, 14, and 15, in which arsenate of lead was the insecticide employed at the rate of 2 to 3 pounds in 50 gallons of water, were successful in each case.

The results of this series of fifteen experiments show conclusively the superiority of a spray of arsenate of lead to one of Paris green when applied under suitable conditions. It is in every way more effective and more satisfactory than the latter, as Paris green is so likely to be washed away by the frequent rains of the wet season of Florida. These remarks apply practically to all cutworms, caterpillars, and other larvæ which devour truck and related crops in central Florida or similar regions.

ADHESIVE COPPER ARSENITE MIXTURE.

The preparation of copper arsenite used in the experiments that have just been reported was stated by its inventor to be free from soluble arsenious acid and to possess the adhesive properties found in no other adhesive insecticide. It was stated to be composed of 36 per cent dextrin and 4 per cent gum and was prepared to be used in conjunction with lime in the proportion of 1 part by weight to from 4 to 6 parts of lime—either dry or in solution, according to the foliage to be tested. The inventor also expressed his confidence that this insecticide would prove a most economical one for general garden and other use, as the loss by wind and rain would be reduced at least 50 per cent and the first cost of the article would be about half that of Paris green or arsenate of lead.

Samples of this mixture were submitted to Mr. J. K. Haywood, Chief of the Miscellaneous Laboratory, Bureau of Chemistry, who furnished the following analysis, August 7, 1907:

Analysis of 4551 Misc.

	Per cent.
Moisture	4.85
Total arsenious oxid	40.42
Total copper oxid	24.87
Gum and dextrin (approximate)	20.00
Acetic acid and other undetermined	9.86
Total	100.00
Soluble arsenious oxid	11.36
(10 day water ext. method.)	

From the above analysis the sample evidently consists of about 20 per cent gum and dextrin and 80 per cent Paris green. The amount of soluble arsenic is very high and would undoubtedly give rise to serious trouble.

SUMMARY.

The semitropical army worm is a smooth or hairless noctuid caterpillar, *Prodenia eridania* Cram. It feeds normally on weeds, such as the pokeweed and spiny amaranth or "careless weed" of the South, and is confined to semitropical America as a pest. When it becomes unduly abundant it attacks the foliage and, in some cases, the stems and fruits of all forms of garden truck growing in its habitat, the list of known food plants including tomato, potato, sweet potato, eggplant, pepper, okra, collards, and cowpeas. In its habits it is similar to the cutworms, having also the climbing habit, and when extremely abundant it migrates in armies like the common army worm, whence the name.

Experiments show that the egg period may be passed in a minimum of 4 days, the larval period in 17 days, and that the entire life cycle, in an outdoor summer temperature, would be about 35 days or 5 weeks; also, that there are four generations and possibly five produced in a year, the insect breeding practically continuously during the warm season. In ordinary years the species is largely controlled by natural enemies, of which seven are parasitic and six predaceous.

A series of fifteen experiments was conducted against this species in Florida during 1907, which shows conclusively that a spray of arsenate of lead is the best remedy, being much superior to Paris green when applied under local conditions. It is in every way more effective, chiefly because less likely to be washed away by the frequent rains of the wet season in that region. It is best applied at the rate of 2 or 3 pounds in 50 gallons of water, and applications must be renewed when the insects again become numerous, as the latter are apt to spread from unsprayed plants.

BIBLIOGRAPHICAL LIST.

1. Cramer, Pierre.—Papillons exotique, Vols. III & IV, p. 133, pl. 358, fig. E. & F. (2), 1782.

Description and figures of both varieties of moths.

2. Smith, J. E. and Abbot, M. J.—Lepidopterous insects of Georgia, Vol. II, p. 193, pl. 97, 1797.

Described as *Phalæna phytolaccæ* with brief account of habits. Figures of moth and larva.

3. Grote, A. R.—Bul. Buff. Soc. Nat. Sci., Vol. II, p. 28, 1873.

Listed as *Xylomiges phytolaccæ* (S. & A.) and recorded from California and Atlantic District.

4. Morrison, H. K.—Proc. Acad. Nat. Sci. Phila., p. 62, 1875.

Technical description as *Actinotia derupta* n. sp., from Texas, September 21. Briefly compared with *phytolaccæ* S. & A.

5. Grote, A. R.—Can. Ent., Vol. XI, pp. 205, 206, 1879.

Received from Texas and referred to *Prodenia phytolaccæ;* characters, etc. No excuse for Morrison's *Actinotia derupta.*

6. Hulst, G. D.—Bul. Brooklyn Ent. Soc., Vol. III, p. 77; Vol. IV, p. 7, pl. 1, fig. 9, 1881.

Described as *Leucania nigrofascia* from one specimen taken by Koebele at Tallahassee, Fla.

7. Smith, J. B.—Catalogue Noctuidæ Boreal America, p. 169, 1893.

Bibliography; synonymy and distribution.

8. [Chittenden, F. H.]—Yearbook U. S. Dept. Agr., 1907 (1908), p. 545.

Brief unsigned notice of injury to truck crops in Florida.

In Smith's catalogue of Noctuidæ,[7] fifteen references are given to this species, but as only a few of these are of interest in connection with the present account, the reader is referred to that list. The more important references are listed above.

66—v

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part VI.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE HOP FLEA-BEETLE.

BY

Frank

F. H. CHITTENDEN, Sc. D.,

In Charge of Truck Crop and Special Insect Investigations.

Issued May 8, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

CONTENTS.

ILLUSTRATIONS.

PLATES.

U. S. D. A., B. E. Bul. 66, Part VI. ISSUED MAY 8, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE HOP FLEA-BEETLE.

(*Psylliodes punctulata* Melsh.)

By F. H. CHITTENDEN, Sc. D.,
In Charge of Truck Crop and Special Insect Investigations.

INTRODUCTORY.

A minute, metallic blackish flea-beetle, *Psylliodes punctulata* Melsh., known by different local names, has been reported in recent years as doing very extensive injury to the hop plant and considerable injury to sugar beet. Since 1904 it has been reported in numbers on sugar beets grown in several localities in Idaho, Utah, and Colorado. In the Northwest, and particularly in British Columbia, it does serious damage in hopyards, and has been especially destructive since 1903. During the past three years, indeed, this species has become unusually abundant, with the result that in the Chilliwack and Agassiz Valley hop-growing regions of British Columbia it has accomplished damage which has been estimated by Mr. H. J. Quayle as about 80 per cent of the crop. Mr. Theo. Eder informs the writer that this means a cash loss of not less than $125,000 in that district. The species during that period has been the subject of considerable correspondence between this Department and persons practically interested in the growing of hops in the affected region.

The insect has received the name of rhubarb flea-beetle, from its common occurrence, especially in the East, on rhubarb. In the West it is called the hop flea-beetle, or "hop flea," or simply "flea," and in literature it has received mention as the punctulated and the small-punctured flea-beetle.

While the species is not known to be of the highest importance as a sugar-beet pest, the probabilities are that it may become so, and at the present time it is probably the most important hop pest in the entire world. The incorporation of some new matter, gained from conversation with Mr. Theo. Eder and by correspondence with Mr. H. J.

Quayle, has added much to the value of the present paper. Although the species is much more serious as a pest in British Columbia than in the United States, it is likely to become important throughout the Pacific coast region where hops are grown. Mr. Eder represents the E. Clemens Horst Company, which owns extensive hop-yards in British Columbia, and has already expended considerable sums in investigation and experiments. The hop flea-beetle is now abundant practically on the border line between British Columbia and the State of Washington, and threatens our own industries. It is, therefore, advisable that everything possible concerning it should be made public before its appearance in the spring, although there are several points in its life history still to be worked up.

DESCRIPTIVE.

The hop flea-beetle (fig. 12) is a member of the tribe Halticini, family Chrysomelidæ, and resembles other flea-beetles in its strongly

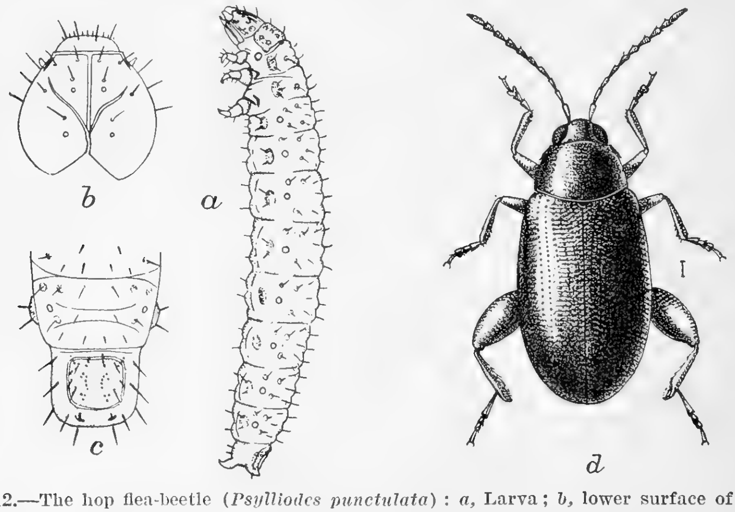


FIG. 12.—The hop flea-beetle (*Psylliodes punctulata*) : *a*, Larva ; *b*, lower surface of head of same ; *c*, upper surface of anal segments of same ; *d*, beetle. *a*, *d*, Much enlarged ; *b*, *c*, more enlarged. (*a–c*, After Carpenter ; *d*, original.)

developed hind thighs. It is of oval form, with a greenish tinge, brassy blackish, and punctulate or finely punctured, whence its specific name. The femora, tarsi, and basal joints of the antennæ are pale yellowish. The punctulations of the thorax are particularly fine and appear as if made with the point of a very fine needle. The punctures of the elytral striæ are closely placed, almost crenate. The beetle is only about one-tenth of an inch (2^{mm}) in length and less than 1^{mm} in width. The male is particularly distinctive, having the first joint of the anterior tarsi broadly dilated and the last ventral segment sinuate each side, while the middle of the disk near the apex has a semioval depression.[a]

The species was first described in 1847.[1] [b]

DISTRIBUTION.

The hop flea-beetle is a native American species, quite distinct from any species found on hops in England or on the Continent.

The collection of the U. S. National Museum and the published records and specimens before the writer show the species to be generally distributed in the northern United States and southern Canada, from the Atlantic to the Pacific. It does not appear to occur south of Nebraska. The list of known localities follows: Cambridge, Mass.; Dundee, Ithaca, Long Island, Staten Island, and New York, N. Y.; New Jersey, generally distributed (Smith); Pittsburg, Pa.; Marshall Hall and Cabin John, Md.; Marquette, Detroit, Grand Ledge, and Byron, Mich.; University, N. Dak.; Lincoln and Omaha, Nebr.; Fairfield, Wyo.; Denver, Longmont, Grand Junction, Delta, Montrose, Paonia, and Ft. Collins, Colo.; Logan, Garland, Lehi, Salt Lake, and Park City, Utah; Elko, Nev.; Blackfoot, Idaho; San Francisco, Martinez, Monterey, Huntington Beach, Pasadena, and Chico, Cal.; Tenino, Wash.; Astoria and Marion, Oreg.; Agassiz, Sardis, and Vancouver, British Columbia; Northwest Territory; Manitoba; and "Assiniboia" (now Saskatchewan).

RECENT INJURIES.

September 16, 1903, the late Dr. James Fletcher first reported this species injuring hops in British Columbia.

During 1906 Mr. Theo. Eder wrote from San Francisco, Cal., under date of April 9, that hop growers were troubled considerably in some sections by "hop fleas," or flea-beetles. May 29, specimens were received from Perkins, near Sacramento, Cal., which proved to be the species under consideration. August 13, Mr. Hugh F. Fox, New York, N. Y., sent specimens and transmitted a report from Mr. Geo. Heggie, manager of a large hopyard, the Stepney ranch, owned by Sir Arthur Stepney, at Enderby, B. C., where this pest was very injurious. Mr. Heggie wrote as follows:

> We have been sorely troubled this year in our hopyard with the "hop flea-beetle," which attacks the young vine and leaf as soon as they appear above the ground, and eats out large holes in the leaf, resulting in the plant being

---

[a] In the very closely related *Ps. convexior* Lec. the last ventral segment of the male is convex and not impressed. The latter species is, moreover, larger, broader, and more convex, and the elytral striæ are not impressed.

[b] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 91.

impoverished in vitality and the growth thereby seriously retarded. We were troubled with them last year [1905], but not to the same extent, and had them till after hop picking. In the middle of July they were so numerous that the ground was fairly alive with them. They go into the ground in the evening and come out again in the morning, and there has been no spray found to have any effect without killing the plant.

Substantially the same form of injury was reported during the same year at Agassiz, B. C., by Mr. John Wilson in a letter to Doctor Fletcher. Writing September 7, 1906, Doctor Fletcher stated that this species had been enormously destructive in British Columbia, one correspondent reporting the loss of many thousands of dollars. He estimated his crop as possibly 70 bales, whereas he should have had 250.

Writing of this species, January 30, 1907, Dr. E. D. Ball, while working in cooperation with the writer, stated that it was by far the most injurious species on sugar beet in Utah. It was found everywhere and was apparently the most common species in early spring. It was observed hibernating around the edges of fields, in patches of dead mustard, along ditch banks, and in similar places. Where ditches were covered with patches of roses these seemed to furnish a favorite retreat. These clumps grew to a height of 2 or 3 feet and were very dense, and from them one could see the injury to the beets radiating in every direction, the affected area growing wider and wider as time went on. In early spring this species fed on almost anything that came to hand, but its injury to beets was practically all done at the time the plants were first appearing through the ground or within a few days thereafter. Cases were observed where the rows of young plants could be seen the entire length of the field one day, and two days later scarcely a beet plant could be found, the beetles having eaten the tender stem, causing the tops to fall off and the beets to die. Frequently they attacked beets just as the latter were pushing through the ground. Hundreds of acres had been destroyed in this way, injury varying greatly in different years and in different localities.

Great damage was done near Logan, Utah, where the hedge mustard was overrunning the fields. At Lewiston, Utah, at the northern end of the same valley, injury was also severe, although there was little of the common black mustard.

The destruction of a crop by this species does not necessarily entail a complete loss, as the growers replant. The late plants, however, are not, as a rule, as good as the earlier ones, and the weeds get such a start that the land is hard to cultivate. After the beets had reached a leaf diameter of 3 or 4 inches no material injury was noticed, although the beetles continued to appear in the fields throughout the season. Beetles were observed July 20, 1906, at Cache Junction, Utah, enormously abundant on a form of hedge mustard along the railroad tracks, feeding on the half-grown seeds. Single plants were seen on which a double handful of beetles could be taken at one stroke of the net.

In a letter dated July 20, 1908, the E. Clemens Horst Company, Perkins, Cal., wrote of extensive injury by this species, and as this letter contains much of interest it is transcribed herewith. The writer is greatly indebted to the same company for the excellent photographs from which the ten half-tones illustrating this article are taken.

We are extensive growers of hops on the Pacific Slope, California and Oregon, and also have about 600 acres of hops in two ranches in British Columbia. For the past three years we have been very much molested in British Columbia by a variety of flea-beetle that seems to take an especial liking to hop foliage and eats the young, tender shoots as they come out of the ground, and also the developed and partly developed leaves of the vines after the same are above ground. There are two other growers in the same section that were bothered one or two years previous to ourselves, and as they had some foreign varieties of hops we at first supposed the insects had been imported from England in the roots. Since, however, we have found that the same insect has been in the neighborhood in very small numbers for quite a long term of years. Our crops in British Columbia suffered quite a bit last season, but this year are very nearly a total failure. From the one place, Chilliwack, B. C., containing 278 acres, we do not expect to reap a harvest of more than 600 bales, whereas we should have from 2,500 to 3,000 bales. From the other place, Agassiz, B. C., we do not expect over 250 bales of hops, whereas we should have 2,250 to 2,700 bales. This will give you some idea of the inroads made by the insect and the resultant loss to persons engaged in hop growing when their yards are attacked by these pests. Of course we readily understand that it would be somewhat out of the ordinary for your Department to attack this problem inasmuch as it is out of the United States, but inasmuch as the pests are now so numerous within about 20 miles of the United States boundary and only a short distance from the Washington State hopyards we believe it is well worth your consideration. Just imagine for a moment the loss that would fall to the numerous growers of hops in the States of Washington, Oregon, or California, if this pest should not be held in check, and would migrate to these sections. We have definite knowledge of their already having spread as far as Sumas Junction, which is on the boundary line between the United States and Canada, where they are attacking cabbage, potato, beets, and other root crops, though the damage done here is not nearly as bad as in the hop fields. * * *

A badly damaged hopyard is shown in figure 13.

During 1908 injury from the hop flea-beetle was reported by Mr. W. W. Stockberger, of the Bureau of Plant Industry of this Department. He mentioned the cases already cited and one reported by Mr. Robert Maitland, of Agassiz, B. C., the latter stating that the ravages of this insect would almost destroy the prospect for a crop during the season. Mr. John Wilson, Agassiz, B. C., who complained of this species in earlier years, reported, under date of July 11, as follows:

The flea-beetles have been so numerous that they have stripped every portion of the yard this season. I have noticed these last three days that they are all disappearing, but they all disappeared last season about this time and a second brood came about the middle of July.

This "second brood" was probably merely the first-developed generation of the year.

This species has also come under the observation of various other collectors and observers. During 1906 Mr. Frederick Maskew, while working under the writer's direction in southern California, took it generally in many beet fields. Mr. E. G. Titus, while coöperating

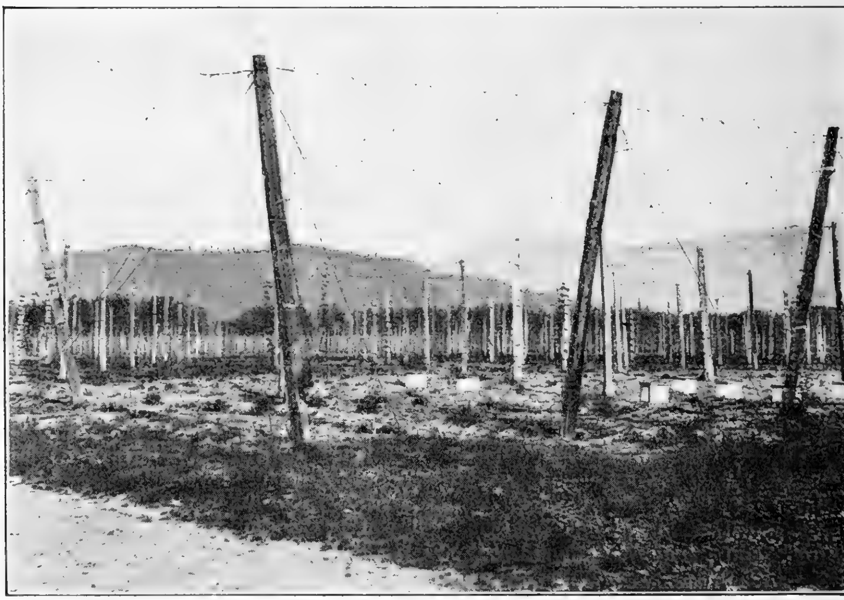


FIG. 13.—View of hopyard, showing how completely the hop flea-beetle keeps down the vines. Note occasional vine that grows up. Agassiz, B. C., June 24, 1908. (Original.)

with this Bureau in the investigation of sugar-beet pests, found it abundantly, and many of the locality records given under the heading "distribution," in California, Utah, Idaho, and other States are from specimens collected by him on sugar beet in 1905, 1907, and 1908.

Writing of this species in July, 1908, Mr. I. J. Condit stated that the beetles were then very common in the vicinity of Chino, Cal., on *Chenopodium album* and *C. rurale*.

METHODS OF ATTACK, FOOD HABITS, AND GENERATIONS.

This flea-beetle affects both surfaces of a leaf, gnawing through the skin and devouring the pulp, usually leaving the skin on the opposite side entire; this later becomes discolored, forming yellowish-brown freckles as the leaf grows and expands, the skin at this point in time becoming torn and frequently showing holes. When the beetle occurs in moderate numbers the leaves (fig. 14) become riddled, as by fine shot, the punctures being most obvious after the plants have made some growth. In its attack on hops it frequently causes the leaves to look like a mass of network or more or less completely strips the vines of leaves, as shown in figures 15 and 16. As is the case with flea-beetles in general, this species does most harm to young plants. When the beetles occur in considerable numbers they are capable of doing great damage in a comparatively short time, completely devouring the young and tender leaves as fast as they come up.

FIG. 14.—Hop leaves, showing work of flea-beetle. (Original.)

Injury is most noticeable on hops, sugar beet, rhubarb, and some other vegetables.

The beetle is a general feeder, the list of its food plants including, among vegetables, rhubarb, beet, cucumber, turnip, radish, cabbage, mustard, and potato. It feeds also on hops, red and white clover, nettle, dock (Rumex), lamb's-quarters (Chenopodium), pigweed and tumbleweed (*Amaranthus retroflexus* and *A. graecians*), hedge mustard, and common wild-growing black mustard. The probabilities are that, as all of these plants are affected by the adult beetles, a considerable proportion of them serves as food for the larvæ. On this head Mr. Quayle has written that the eggs, larvæ, and pupæ were taken at a depth of from three to six inches from the surface of the ground in hop fields and that the larvæ apparently feed on the roots of hop as well as those of other plants growing in the yards. Since it is well known that the beetles occur in other regions where hops do not grow there must be other larval food plants. It would be interesting, and is important, to ascertain exactly what plant, or plants, is the favorite with the larvæ.

Fletcher,[11] in writing of this species, says that in Canada there are two generations a year, the first appearing in June and the second in August. The generation appearing in August is with little doubt the newly developed first generation, and, reasoning from analogy, i. e., from what we know of related flea-beetles, it is this generation of the beetle that hibernates; thus the so-called "first generation" is simply that same generation reappearing the following spring and early summer

FIG. 15.—Work of flea-beetle after vines are grown. (Original.)

As to hibernation, Piper [6] and Doane [8] have recorded that the beetle passes the winter under stones or rubbish, in which respect it resembles practically all other species of American flea-beetles, and that with the first warm days of spring the beetles emerge from their winter quarters and immediately commence feeding voraciously upon their various food plants.

The following account of the life history and habits of the species in the worst affected locality in British Columbia has been kindly furnished by Mr. H. J. Quayle, who has also given an account of remedial experiments which supplement those previously furnished by conversation with Mr. Eder; indeed, without the information supplied by these two gentlemen this article would be quite incomplete. Before transcribing Mr. Quayle's account it may be well to draw from it, according to the statement of Mr. H. Hulbert, Sardis, B. C., that this species made its first appearance as a hop pest in British Columbia in 1894 and that it has been of great importance for five years, or since about 1903. In regard to Mr. Hulbert's statement that the beetles disappear about June 1 and reappear the last of July, it is obvious that during that period the larvæ are maturing, the pupæ are formed, and the beetles of the first, or new, generation appear.

The following account of the life history and habits of this species as it occurs in British Columbia is taken from Mr. Quayle's manuscripts:

LIFE HISTORY AND HABITS.

The adult.—The beetle appears very early in the spring and, according to reports, patiently awaits the coming of its food plant. This early attack of the beetle as the plants are bursting through the ground and before the leaves are fully expanded is one of the things that makes control work difficult. Before the hops appear the beetles are known to attack the nettle, and often completely riddle the leaves. They also attack other plants, and have been seen, and evidence of their work noticed, on potato, mangel, beet, turnip, dock, lamb's-quarters, pigweed, and red as well as white clover. None of these plants is attacked, however, in preference to hops and it is rarely that they are found at this season on anything but hop vines. In one or two cases they were observed in some numbers on potato, at a considerable distance from hop vines. On a small field of hops that was deserted last year on account of this flea-beetle and planted to clover, the leaves of the latter were considerably eaten.

The first appearance of the beetles in this section, according to Mr. Hulbert, was fourteen years ago, and they have been attacking his hops for the past five years. The beetles jump very readily when disturbed, but fall to the ground, usually not far from the base of the vine. Experiments to determine the power of jumping, which is an important factor in control work, indicate that they may not jump more than a foot in the vertical and about a foot and a half in the horizontal.

FIG. 16.—Trained hop shoots stripped by flea-beetle. (Original.)

Feeding occurs almost entirely on the upper surface of the leaves, where they eat out small, nearly round holes about one-eighth of an inch in diameter. This is continued until the leaf is reduced to a network and finally nothing but the main ribs remain. Many of the vines grew to a height of three or four feet, then the foliage was completely stripped off, leaving the dead stalks, which may still be seen in the fields. Many of the vines are thus killed to the ground. Strings were put in place in 1908 in anticipation of the usual crop, but were taken down and saved for another year, as the vines that started afterward were too late to make a crop. Cultivation was stopped and a thousand sheep were imported from California by the Horst Company to feed in their yards.

The beetles, with their more or less cone-shaped bodies, readily make their way through anything into which they can get their heads, and our experimental cages [fig. 17], which were covered with cheese cloth, had to be re-covered with calico. They also make their way through the soil with little difficulty. Experiments to determine this point consisted in burying them at different depths, enclosed in tin cylinders. In two days the beetles appeared through 2, 4, and 6 inches of loose soil, but did not appear from these same depths where the soil was made compact by tamping.

The egg.—A few eggs have been taken on the hop roots about 4 inches below the surface. Obviously, these are most difficult to find and can not be detected at all without a magnifier. To more easily obtain the eggs and younger stages, tin cylinders, 8 inches in diameter and 2 feet high, have been sunk to a depth of 8 inches in the ground, some enclosing hop vines and others in the open field. Large numbers of beetles have been liberated in each of these, and they will be taken up with the soil intact in the tins in two, three, and four weeks, and the soil carefully examined for eggs and larvæ. Beetles taken in mating, and enclosed in vials with earth at the bottom, have laid eggs in from eight to ten days.

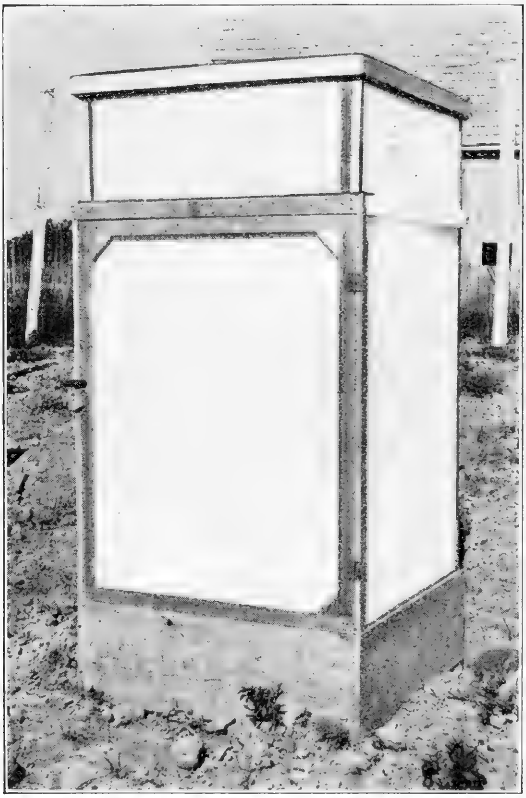


FIG. 17.—Breeding and control cage in place over a hill. (Original.)

The larva.—Larvæ of what the writer believes to be this flea-beetle have been taken from 2 to 4 inches below the surface, both around hop roots and in the spaces between the vines away from any hop roots. While most of the larvæ have been taken about hop vines, I think that they are not restricted, in feeding, to the roots of the hop exclusively, since some have been taken in spaces between the hop vines and also because of the wide distribution of the beetle, both in the United States and in the valleys of the Chilliwack and Agassiz, away from any hopyards. Search about the roots of the nettle and other plants growing along the borders and roadsides failed to reveal any larvæ.

The pupa.—We have also taken pupæ of what was considered this flea-beetle. Transformation to the adult was, of course, necessary to establish this positively and some of the pupæ taken to the laboratory duly transformed. These were taken about the hop roots 3 or 4 inches below the surface.

Both larvæ and pupæ, when sought at the same time, were extremely scarce, and sometimes an hour's search would result in finding nothing. Earlier in the year would undoubtedly be a more opportune time for getting the younger stages, but our rearing-cage experiments, starting with the beetles in mating, should give us ample material for the study of the younger stages. The scarcity of the larvæ at the time when sought is attributed by the writer to the fact that it was too late for the large numbers of spring and too early for those expected to appear about six weeks later, according to reports of previous years. Those few which were obtained are probably late individuals of the last brood.

Two other kinds of larvæ are taken commonly in the ground, these being wireworms and carabid larvæ. Many of these are very small, just about the size of our flea-beetle larvæ, and the wireworms, when first hatched, are of the same white color, but both of these forms of larvæ can be readily distinguished from the flea-beetle larvæ. The few pupæ obtained are undoubtedly those of what we consider the flea-beetle.

Development.—From all accounts this flea-beetle keeps emerging continuously throughout the season, though there are periods when the beetles occur much more abundantly than at others. Last year Mr. Hulbert stopped using the tarred boards June 1, when practically all of the beetles had disappeared. They did not reappear until the last week in July, when the jarring method was resumed. This year (1908) he continued the use of the tarred boards up to the second week of July, this difference over 1907 being attributed to the cold wet season. According to this, the next lot of beetles may not appear before the last of August of the present year. Beetles have been seen breeding continuously during the past two weeks, though not abundantly, one pair being seen out of seventy-five or one hundred beetles. Beetles are usually present in considerable numbers in the fall, when the hops are mature, and do much direct injury to the product.

NOTES ON OTHER SPECIES.

A few remarks in regard to the larval habits of our other American and some European species of Psylliodes may be interesting. The writer has several times observed the beetles of the equally well-known *Psylliodes convexior* Lec. in numbers on shepherd's purse (*Bursa bursa-pastoris*) in June near the District of Columbia, and it is probable that this is the larval food plant. Until the publication of Mr. Quayle's article [12] there was no record of any of our four species having been reared; hence, the natural conclusion that they were root-feeders. In Europe no less than forty-nine species of Psylliodes are recognized in a recently published catalogue,[a] and the habits of those which have been studied indicate a preference for cruciferous plants, although several are attached to widely different groups of plants. Thus among European species are the hop flea-beetle (*Ps. attenuata* Koch), the potato flea-beetle (*Ps. affinis* Payk.), and a species which is mentioned and figured by Taschenberg[b] as the "raps-erdfloh" (*Ps. chrysocephala* L.). The last is very abundant and has been known for years to attack edible cruciferous crops. It has been recently treated (1906) by Mr. Geo.

---

[a] Reitter, Catalogus Coleopterorum Europæ, pp. 572–574, 1906.

[b] Praktische Insekten-Kunde, Pt. II, p. 303, fig. 79. Bremen, 1879.

H. Carpenter as a cabbage pest in an article in which the larva is described and illustrated in detail. As to its biology Mr. Carpenter[a] reaches the conclusion that the female beetle lays her eggs on the underground part of the stem and that the young larva burrows through into the interior and feeds in the central tissue of the stem and taproot until mature. The papal stage lasts about three weeks and is passed in an earthen cell just beneath the surface. The natural larval food plant is evidently a wild crucifer.

LOCAL CONDITIONS AND NATURAL INFLUENCES.

Inquiry was made of Mr. Eder during his visit to Washington, D. C., in December, 1908, as to the local conditions in the infested area. From what was learned through him it would appear that the insect's occurrence in such great numbers in the hopyards of British Columbia was due to the equable temperature and to the humidity, which keeps the soil practically always sufficiently moist for the operations of the larvæ feeding beneath the surface.

There can be no doubt, from the writer's observations of our eastern flea-beetles, that these are largely held in check, especially in regions like the District of Columbia, by the extremely dry heat of midsummer. At the time that the flea-beetles are developing as larvæ or undergoing their transformation the ground is nearly baked by the heat during the day and softened only by dews at night. The conditions are very different in British Columbia, and there are, moreover, no other natural causes known which might assist in depleting the numbers of the little pest.

Among natural agencies only a single species of insect has as yet been discovered preying upon this flea-beetle, a hymenopterous parasite which was known to Fitch[2] and which he mentions as a "Chalcidian." It is evidently a species of Perilitus, probably the same species, *schwarzii* Ashm. (?), as has been encountered by the writer on other species of flea-beetles of the genera Epitrix and Phyllotreta. It develops within the body of the adult or beetle. It is not known if this species occurs also in the Pacific region. If not, it might be possible to introduce it.

Fitch's observations and conclusions are interesting, since we have no reason to doubt his theory. Briefly he observed on June 4, 1863, two flea-beetles pairing on a leaf of rhubarb. Presently a parasite alighted near them. It darted upon the back of the female, appearing to be inserting its sting in the tip of her body, whereupon she gave a leap and they both disappeared among the foliage. Fitch conjectured that the "chalcidian" was an egg-parasite of the flea-

[a] Journal of Economic Biology, Vol. I, pp. 152–156, Pl. XI. London, England, November, 1906.

beetle and that the eggs of the latter were so minute that the larval parasite required several of them to nourish and bring it to maturity, as observed of an egg-parasite of the Hessian fly. The parent, watching her opportunity, deposits an egg internally in the ovaries of the flea-beetle, or in the passage-way therefrom, and the parasite larva, taking up its residence there, consumes the eggs of the flea-beetle, one after another, as they develop, whereby none of them will be extruded until after the parasite has attained its growth. In conclusion he writes, "Most singular and truly wonderful as such a provision of nature would be, it is the most probable conclusion I am able to arrive at from past observations."

METHODS OF CONTROL.

Correspondents who have inquired for a direct remedy for use against this species have been advised to experiment with all of the usual flea-beetle remedies. These are, in brief, arsenate of lead. arsenate of lead with resin-fishoil soap, Paris green with and without Bordeaux mixture, Scheele's green, arsenite of lime with soda, dry Paris green with air-slaked lime, Bordeaux mixture alone, and kerosene emulsion. According to Messrs. Eder, Quayle, and others, most of these remedies have been tested more or less completely without being found to be thoroughly effective, owing to the great numbers of the flea-beetles and the rapidity with which the tops of the hop vines grow. All remedies that have been employed have been directed against the beetles only. Unless the hop plants are sprayed nearly every day it is practically impossible to keep them covered with any poison so as to entirely protect them from the ravages of the "fleas." Among other substances tested were tarred boards and sheets, as for leafhoppers. On account of the employment of cheap labor, chiefly Hindu, mechanical and hand methods were found of some value. Snuff was found effective on a small scale and finely powdered tobacco, such as is now on the market as an insecticide, is to be tested.

According to Messrs. Quayle, Eder, and others, the difficulties encountered in the economic treatment of this species are due to two causes: (1) The continual emergence or appearance of the beetles, rendering any method that has yet been employed, such as an arsenical or contact spray, or any mechanical means of capture, such as jarring, of only temporary value, and (2) the extremely rapid growth of the young hop vines, making frequently repeated applications of a spray or other direct remedy a necessity.

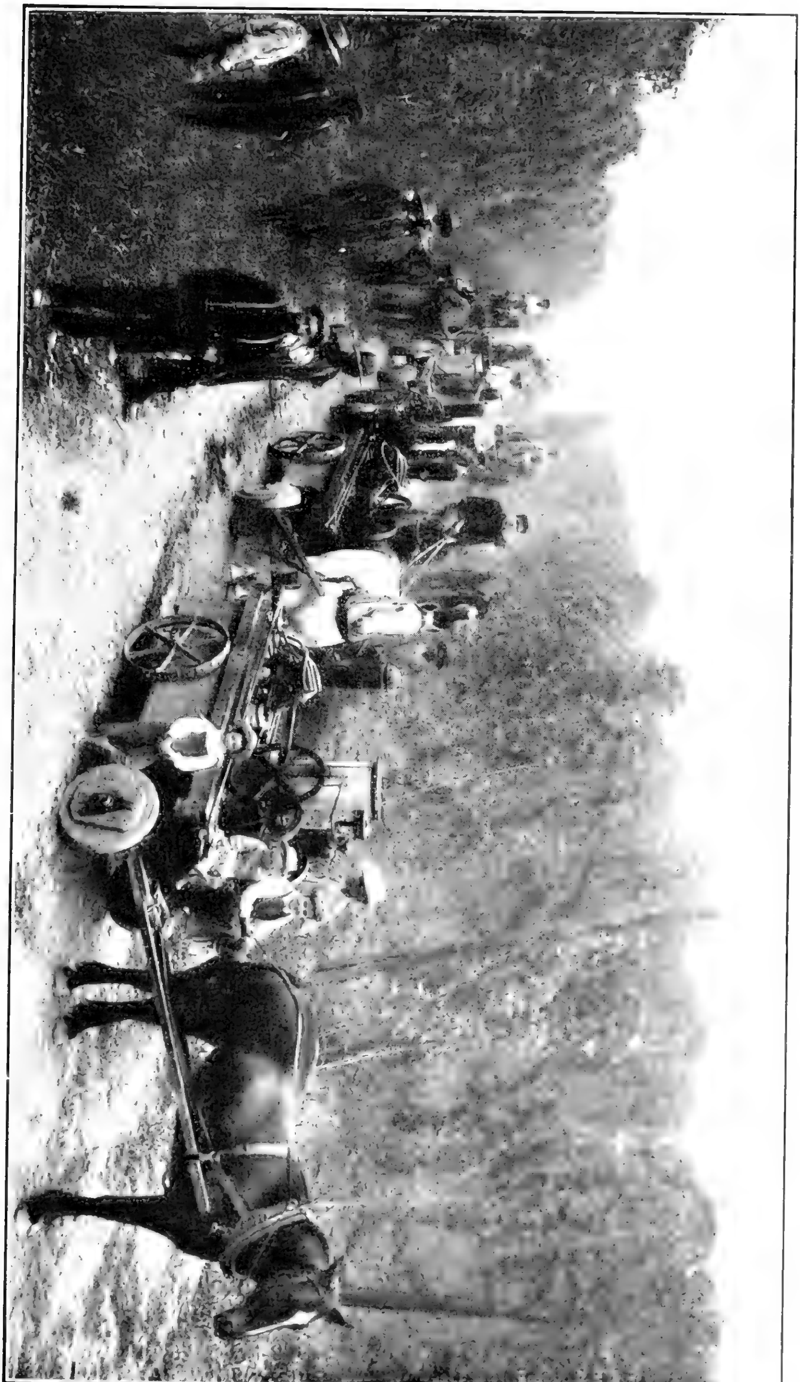
ARSENICALS.

Arsenate of lead.—Arsenate of lead, applied at the rate of about 1 pound in from 20 to 50 gallons of water, is advised for use against the hop flea-beetle. Being more adhesive, this mixture, when sprayed upon the plants, sticks more firmly to the leafage than Paris green, and is also very much less likely to produce scorching or burning; indeed, it has been used at 1 pound to 10 gallons of water on some of the hardier plants, such as potato, without injurious effects. This is, however, not advisable, owing to the extra cost, provided that a weaker solution will accomplish the object. Moreover, scorching is apt to follow its use at this rate on some plants, especially when these are exposed to the direct rays of the sun. The adhesiveness is still further enhanced by the addition of about the same amount by weight of resin-fishoil soap as of the arsenical employed. Mr. Wilson reported that arsenate of lead, applied at the rate of 4 pounds to 40 pounds of Bordeaux mixture, was inadequate, yet Mr. Quayle reports that used at the rate of 5 pounds to 50 gallons it will kill a large number of the beetles, although many take to the new growth that is constantly appearing, or apparently carefully avoid those places on the foliage that have a good coating of poison. The failure of these two arsenicals must be attributed, in large part, to unsuitable spraying apparatus; either of these applications should kill insects on hops, as they have both been found effective, according to Fletcher, against this same beetle on rhubarb in the Northwest Territory and Manitoba.

Dry Paris green.—Mr. Thos. Cunningham reported that very little impression was made by an arsenical spray in the region just mentioned, but stated that Paris green dusted on the plants seemed to produce better results. It was applied by means of a Leggett powder gun. Even then some trouble was experienced; in fact, as the arsenical dust or so-called "dust spray" struck the vines the "fleas" hopped to the ground. "In all my experience with insecticides," he says, "I have never seen anything which will approach the fleas in resistant power."

Paris green spray.—Paris green, being the most readily obtainable insecticide, was advised by this Bureau when information as to remedies was requested. When properly prepared and applied, according to the directions furnished in Farmers' Bulletin No. 127, this insecticide should have no deleterious effect on the hop or other plants affected. It was advised that other food plants growing in the vicinity, such as rhubarb, turnips, and weeds, should be sprayed with the solution.

Regarding its efficiency in hop fields Mr. John Wilson, in a report to the late Doctor Fletcher, stated that when applied at the rate of from 4 to 8 ounces, in combination with Bordeaux mixture, made according to the 4-4-40 formula, or in 40 gallons of water, it was not successful.



SPRAYING APPARATUS USED IN HOPYARDS IN BRITISH COLUMBIA. (ORIGINAL.)

For use against this species in its occurrence on field and garden crops in Washington State, Messrs. Piper and Doane have advised Paris green. The former states that he obtained excellent results by using Paris green liberally but that it is necessary in the treatment of young plants to apply the remedy as soon as attack by the beetles is noticed. Both the wet and the dry methods are advised, as well as the addition of Bordeaux mixture.

Other arsenicals.—Other arsenicals advised in such cases are arsenite of lime with soda,[a] which has the merit of being as effective as Paris green and lime and far cheaper, and Scheele's green, which is similar to Paris green and is employed in the same manner.[b]

SUMMARY ON THE USE OF ARSENICALS.

To sum up the directions for the use of arsenicals, it should be stated that arsenate of lead should take first place because it can be purchased already combined in paste form, and especially because it contains a smaller percentage of free arsenic (60 to 70 per cent), and is therefore less likely to produce scorching or burning; and, moreover, being adhesive, it remains on the plant longer.

Paris green, when combined with lime and water, or with Bordeaux mixture, is almost equally as good as arsenate of lead, and is more readily obtainable in most markets, the ingredients being purchasable practically anywhere. It is quicker in action, but not so adhesive.

The number of sprayings will naturally depend upon the locality and seasonal conditions; possibly it may be necessary to spray every few days when the plants are quite young and the beetles are most abundant. Later there should be longer intervals between sprayings.

Dry mixtures are as a rule not in the same class with the sprays, as they can not be applied so economically, do not so thoroughly cover or adhere so closely to the leafage, and are more apt to cause burning to delicate foliage. Dry Paris green mixed with air-slaked lime in the proportion of about 1 part of Paris green to 10 or 20 of lime is sometimes used, but is less effective, and frequently much of the material is wasted in applying it.

The spraying apparatus used in the hopyards of British Columbia is shown in Plate V and figure 18, the second illustration showing a crew spraying hops through the rows.

CONTACT SPRAYS.

Among the contact sprays tried during 1908 were whale-oil soap, 1 pound of soap to 10 gallons of water; kerosene emulsion, ¼ pound

[a] Prepared in accordance with instructions in Farmers' Bulletin No. 283, p. 37.

[b] Discussed in the publication quoted, as also in Farmers' Bulletin No. 127.

soap and 1 gallon of kerosene to 25 gallons of water; resin, 1 pound to 16 gallons of water; and black leaf tobacco extract, 1 gallon to 65 gallons of water. Of these Mr. Quayle says that the last seemed most effective, with kerosene emulsion next, and that none of these sprays in the given proportion injured the foliage at all.

It is entirely possible to kill most of the beetles well hit by the spray, but many escape between clods in the soil or are protected by the vine or are concealed in the growing tip. The percentage killed, however, will be satisfactory, but this [treatment] must be repeated so often that the operation becomes laborious and costly.

While kerosene emulsion and whale-oil soap are practically never advised as standard remedies for mandibulate or chewing insects,

FIG. 18.—A crew spraying hops in British Columbia. (Original.)

such as this flea-beetle, both are employed in the infested territory against the hop aphis, or "louse," and therefore the hop grower is familiar with their preparation and use. It has been ascertained that when these are used against the hop aphis the flea-beetles coming into contact with the emulsion are killed. The probabilities are that kerosene emulsion properly prepared and applied in the affected regions will be considerably less expensive than a tobacco extract, and it is possible to make a tobacco extract which would be comparatively cheap. In recent experiments made under the writer's direction at Norfolk, Va., whale-oil soap, used at the rate of about 1 pound to 10 gallons of water, employed against aphides, has proved quite as effective and as economical as kerosene emulsion, considering the fact that unskilled laborers are likely to make imperfect emulsions and waste the material in applying it. With competent help, and other things being equal, kerosene-soap emulsion should be the more economical spray. It would be well to continue the use of kerosene emulsion at varying rates, including the rate that has been already used and up to 1 pound of soap and 1 gallon of kerosene emulsion to 30 gallons of water. It is possible that if the emulsion were diluted with 10 gallons of water still better results might be obtained, but if labor is cheap the weaker solution, other things being equal, should prove to be the more economical preparation.

BORDEAUX MIXTURE.

Bordeaux mixture, as has been known for years and frequently demonstrated, is a powerful deterrent against flea-beetles and other leaf-beetles, and its use should be continued. Since, as appears to be demonstrated by the observations of Mr. Quayle, this flea-beetle is quite discriminating in taste, it would be well to apply Bordeaux mixture over a considerable surface and use Paris green or arsenate of lead for the remainder of a field, i. e., to spray the majority of the plants in such manner that those which reject the Bordeaux mixture on treated plants would resort to those sprayed with Paris green or arsenate of lead. It should be determined which of these two insecticides has the greater deterrent effect against flea-beetles.

MECHANICAL AND CULTURAL METHODS.

Trap crops.—The great fondness displayed by this species for rhubarb suggests the use of the latter between rows, e. g., in the vicinity of woods, as an attraction or lure for the beetles, it being believed that the beetles will concentrate on these plants and thus give the crops an opportunity to grow to a sufficient height and strength to be able to resist the ravages of the pest. Since certain cruciferous crops are also attacked, such as turnips, it is further suggested that these and other varieties like swedes and rutabagas, rape, and mustard be employed. In the mild climate of the infested region all of these can be grown during the winter, and it seems probable that kale will be found equally effective. Beets, especially mangels, are grown in the affected region and tests should be made with these as trap crops, as also with sugar beet in regions where this crop can be grown profitably.

Rolling the fields.—One of the remedies attempted against this flea-beetle in its occurrence in beet fields, as reported by Doctor Ball, consists in the use of rollers. He reports that "running a corrugated roller over the field as soon as the damage is first discovered seems to have a very good effect. Just why, is not so clear, possibly because it loosens the ground, breaking up any crust that may have formed, and allows all the beets to get through at one time and in this way some of them get ahead of the beetles. The farmers think it kills the beetles. Cleaning up hedge-banks and rubbish around the fields has been recommended and appears to have had a good effect. It is a lamentable fact that a field that is slightly weedy when the beets appear will not be injured as badly as one that is free from weeds, which probably accounts for the fact that replanted beets are rarely destroyed."

The use of fertilizers.—Where fertilizers are used the plants are undoubtedly aided in recovering from attack by this flea-beatle, but fertilizers are not remedies. Possibly where mineral fertilizers are applied heavily they might have some effect on the larvæ, but it is doubtful if a sufficient amount of an irritant salt would remain in the earth to destroy any large percentage of larvæ at the time when those which have just developed from the egg or have just molted are feeding on the roots. It is worth mentioning, however, that Mr. Theo. Eder noticed that when a fertilizer consisting of 3 per cent nitrogen from nitrate of soda, 12 per cent potassium oxid (K_2O) from muriate (chlorid) of potash, and 9 per cent phosphorus pentoxid (P_2O_5) from superphosphates was applied there were practically no flea-beetles. This fertilizer, however, was considered too expensive, owing to the cheapness of hops in the affected region of British Columbia.

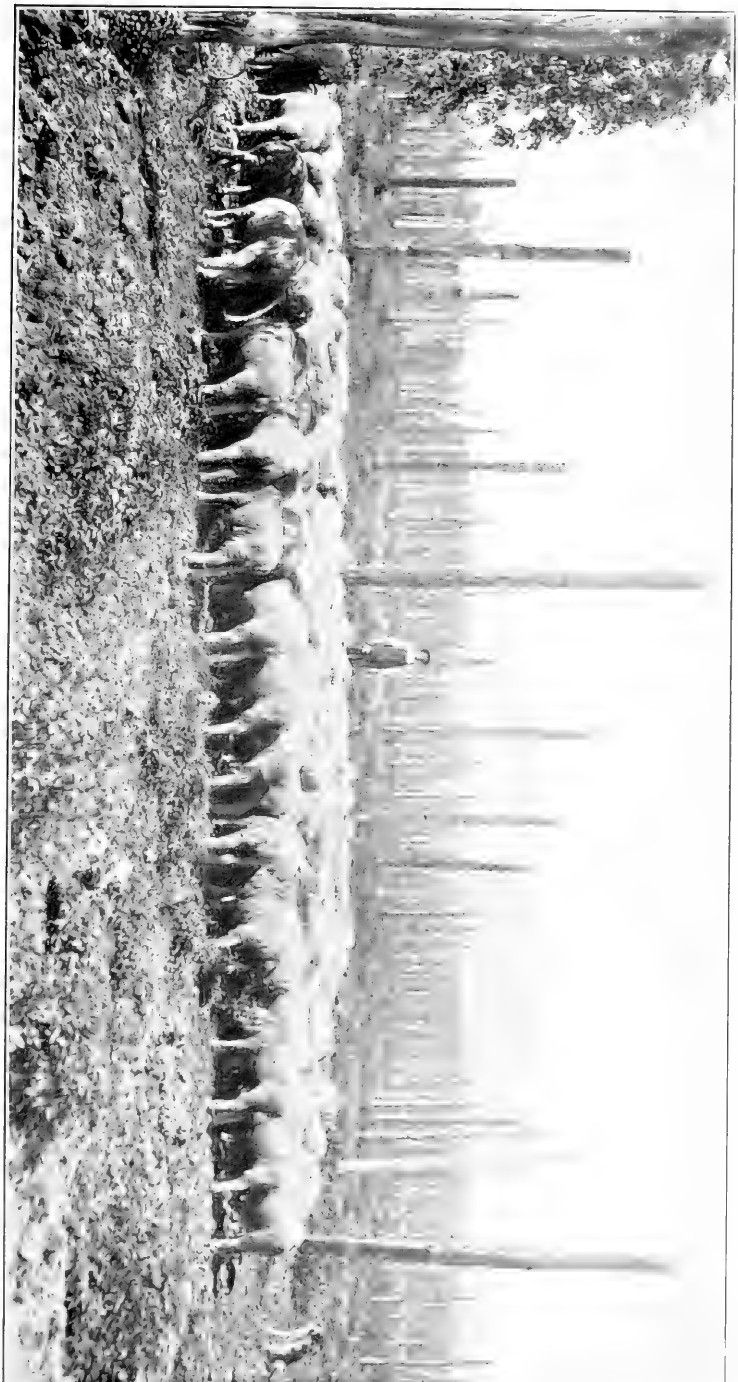
Irrigation.—Irrigation has been suggested and, on the authority of Prof. E. G. Titus, the flea-beetle, when it is working on sugar beets, can be driven away during irrigation by disturbing the beets, thus causing the beetles to jump into the water and be swept away.[a]

Tarred catchers.—Tarred sheets, boards, or similar contrivances on the plan of "hopperettes," in use against leafhoppers, have been employed in the infested region for capturing the flea-beetles. Mr. Hulbert reports having destroyed large numbers by catching them on tarred sheets as they fell from the vines after being disturbed. Mr. Quayle also reports success with a "catcher" which he describes substantially as follows:

> The receptacle used consists of a stout canvas about 3 feet by 4, to which is nailed, on the under side, three strips of boards with one at right angles, to keep the canvas taut. A handle is fastened to two of these strips to project upward and backward, by means of which the apparatus is operated. This is lifted from vine to vine and the beetles jarred off with wisps of hay. Usually two men work together on the same row, the two canvases placed together on each side of the vine.

---

[a] Bul. 67, Bur. Ent., U. S. Dept. Agr., p. 112, 1907.



HOP FIELDS FROM WHICH TRAINING TWINE WAS REMOVED IN JUNE OR JULY, PHOTOGRAPHED IN AUGUST.

Beetles abated somewhat the last of July and hops began to put out new shoots. Weed growth kept down by sheep pasturage. Hop leaf growth pastured very close in fall. (Original.)

This method captures a satisfactory percentage of the beetles and should be comparatively inexpensive. But unfortunately the repeated operations which are necessary bring the cost to a high figure. It cost Mr. Hulbert last year approximately $1.25 per acre for each operation. He went over his vines six times, and some parts of the yard eight or ten times. He expected to go over it at least twice more, so that the total cost would be from $10 to $15 per acre.

In figure 19 a portion of a hop field is shown which illustrates the tarred "boards" in place for use. The flea-beetles are dusted off of the vines upon these tarred receptacles with wisps of hay, as

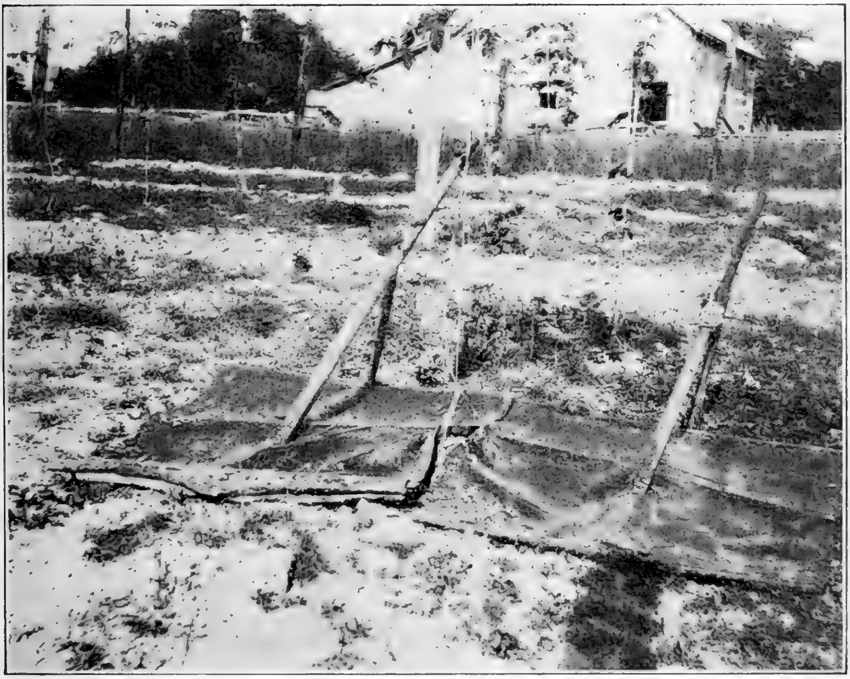


FIG. 19.—Portion of hop field with tarred boards in place. Flea-beetles are dusted with wisps of hay from the vines onto tarred boards. (Original.)

described above. All of the vines were tanglefooted, but the flea-beetles went up the poles and crossed over on the wires overhead until the tanglefoot was applied. Plate VII illustrates the method of capturing the hop flea-beetle on tarred horse sledges, also by shaking the vines. Millions were captured in this way.

CLEAN CULTIVATION.

Frequent stirring of the soil and other cultural operations seem, as yet, to be of no appreciable help, according to Mr. Quayle, and the kind of soil also seems to have little or nothing to do with the abundance of the beetles, which are found in light, sandy, and heavy soils. Mr. Quayle further says:

> The control measures which have been tried have been necessarily directed entirely against the adult or beetle, and considering the rapid growth of the vines and the continuous appearance of the beetles no effective and practical remedy has yet appeared. With further work on the younger stages it may be possible to find here a vulnerable point of attack.

One of the most promising remedies for this as well as other insect pests is the employment of clean methods of culture. Since it has been found that the flea-beetles ensconce themselves in any available shelter, such as the cracks in the hop poles, even although these may have no bark remaining, it has been thought desirable to dip the poles in a preparation which will not only close the cracks but which will also repel the pests. Fuel oil, a grade of crude petroleum, is being tried, according to Mr. Eder, since it can be purchased as low as 2 cents a gallon. Tar might serve the same purpose and should act as strongly as a repellent and close the cracks more closely and would not be so disagreeable to handle. The poles are dipped into the boiling fuel oil, but the tar would also have to be heated very hot before dipping.

It is customary to plow thoroughly and to cultivate where possible so as to keep down the weeds, and this method of tillage must, of course, be continued, as the insects find food in weeds of the kind which have been mentioned in the opening paragraph, viz, dock, lamb's-quarters, pigweed, and the like, and also cruciferous weeds. If, by preventing the insects from hibernating in the hop fields in débris, the fields can be practically freed from them, the next step is to prevent their hibernating in near-by timber, as there can be little doubt that in such places are their favorite winter quarters. It is practicable in many cases to cut down small sections of timber in order to accomplish this purpose.

In answer to the question as to the remnants after the hops are picked, Mr. Eder informed the writer that the expedient of cutting the tops and destroying them by burning led to the discovery that the beetles enter into the hollow stalks, remaining in hibernation there in great numbers. With the discovery of this habit he will permit remnants to remain as long as there is any prospect of the insects' trying to obtain winter shelter in them, and then will have all débris burned at about the time of the first frost. One method of destroying field remnants and weeds, by sheep pasturage, is illustrated by Plate VI.

The writer has suggested the addition of burlap wrapped about the poles which have been treated with tar or which do not have an odor strong enough to repel the insect. This will attract the insects for hibernation, and can be removed after the first frost, or there-

METHOD OF CAPTURING HOP FLEA-BEETLES ON TARRED HORSE SLEDGES BY SHAKING THE VINES; MILLIONS CAPTURED IN THIS WAY. (ORIGINAL.)

abouts, and thrown into hot water, and after drying will be available for use in other seasons.

If, with another year's experience, we could ascertain how best to control the insect, either by killing the beetles with arsenate of lead or other arsenical, kerosene emulsion, or whale-oil soap, or by destroying the larvæ in the ground, the problem would be partially solved. One, two, or perhaps even three of these remedies might be used in combination and excellent results obtained. In any case, if we can partially control the insects by any one of them we should not forget that cultural remedies, and especially clean culture, are the most valuable remedies that can possibly be employed against insect pests. Indeed, with many species, if cultural practices were properly followed out, with the cooperation of our neighbors, insecticides would in the course of time, after the balance of nature had been restored, seldom be needed save in case of severe outbreaks, which are likely to occur more or less spasmodically with most of our noxious insects.

LITERATURE.

A complete bibliography of this species is appended and only a brief review of published accounts need be given. The original description of the species appeared in 1847,[1] and it was not until twenty years later that we had any record of the insect's habits. In 1867 Fitch[2] wrote a two-page account regarding injury to cucumber, rhubarb, and radish, furnishing notes on a parasitic natural enemy. In 1884 our first account of injury to hops, a brief one, was written by Dr. J. B. Smith.[4] These accounts were followed by one from Piper[6] on injuries to certain truck crops in Washington State in 1895 and by Doane[8] of similar injuries in 1900. The writer[7] noted the abundance of the species on rhubarb near Washington, D. C., in 1897. Forbes and Hart[9] have given a brief account of the insect from the standpoint of its injuries to sugar beet in Illinois, and Fletcher[10, 11] published two accounts of the species in 1904 and 1907, respectively. In 1908 was published H. J. Quayle's article,[12] in which first mention is made of the larval habits of the insect.

BIBLIOGRAPHY.

1. Melsheimer, F. E.—Proc. Acad. Nat. Sci. Phila., Vol. III, p. 166, 1847.
   Original description from Pennsylvania as *Haltica punctulata* n. sp.
2. Fitch, Asa.—11th Rept. Ins. New York, pp. 38–40, 1867.
   A 2-page account with mention of food plants and a parasite; observed feeding on cucumber, rhubarb, and radish.
3. Fitch, Asa.—Ill'd Ann. Reg. Rural Affairs, 1867–8–9, Vol. V, p. 204, 1873.
   A brief note, with mention of attack on cucumber and melon.
4. Smith, J. B.—Bul. 4, o. s., Div. Ent., U. S. Dept. Agr., p. 50, 1884.
   Mere mention of occurrence in hopyards, where the beetles eat small holes in the leaves, doing no great damage.
5. Horn, G. H.—Trans. Amer. Ent. Soc., Vol. XVI, pp. 310, 311, 319, 1889.
   Revised technical description, distribution, and systematic bibliography.

6. PIPER, C. V.—Bul. 17, Wash. State Agr. Exp. Sta., pp. 55, 56, 1895.
Short general account, with list of food plants. Species stated to be "by far the most destructive flea-beetle in the State" [of Washington].

7. CHITTENDEN, F. H.—Bul. 9, n. s., Div. Ent., U. S. Dept. Agr., p. 22, 1897.
Short note on abundant occurrence on rhubarb near Washington, D. C.

8. DOANE, R. W.—Bul. 42, Wash. Agr. Exp. Sta., pp. 11, 12, figs. 2, 3, 1900.
A 2-page general account with two original illustrations.

9. FORBES and HART.—Bul. 60, Univ. Ill. Agr. Exp. Sta., p. 472, 1900; 21st Rept. State Ent. Ills., p. 124.
A brief account; on sugar beet in Illinois.

10. FLETCHER, JAS.—Rept. Entom. and Bot. Canada for 1903 (1904), p. 177.
Mere mention as affecting hops at Sardis, B. C., in noticeable numbers.

11. FLETCHER, JAS.—Rept. Entom. and Bot. Canada for 1906 (1907), p. 215.
Account of injuries in the Fraser River Valley, B. C., in 1906, with quotations from John Wilson, Agassiz; Thos. Cunningham, Vancouver; and H. Hulbert, Sardis, B. C., which include experiences with remedies.

12. QUAYLE, H. J.—Journ. Econ. Ent., Vol. I, p. 325, October, 1908.
A short article, with notes of injury in British Columbia; account of habits, all stages, including the egg, being taken 3 to 6 inches from the surface of the ground, larvæ feeding at the roots of hop and other plants growing in the yards; list of food plants, and difficulties of applying remedies.

SUMMARY.

The hop flea-beetle, a minute, black insect, feeds on various succulent plants. It does serious damage to hops in British Columbia and less injury to sugar beet and vegetable crops in the Pacific coast region.

Its life history is only partially known, but all stages have been found about the roots of hops and the larva probably feeds on most of the same plants as the adult. It is feared that this species may become an important hop-pest in Washington and Oregon, and it doubtless does more injury to beets than is generally accredited to it. Injury is most severe to young plants, but on sugar beet the operations of the beetles throughout the season undoubtedly have a deleterious effect and necessarily decrease the yield.

The abundance of the beetles when they appear early in the season on young plants, their constant reappearance, and the constant new growth of the plants from day to day make it difficult to apply direct remedies with more than temporary benefit. Where the hops are sprayed with kerosene emulsion or whale-oil soap for the hop aphis the numbers of the beetles are lessened. Among measures which give promise of value are the institution of clean methods of cultivation, including deep fall plowing, treating hop poles in such manner as to prevent the beetles from hibernating in them, and clearing all remnants from fields so as to leave them as bare as possible to prevent the beetles from sheltering there in winter. Arsenate of lead, Paris green, kerosene emulsion, whale-oil soap, and Bordeaux mixture should receive further tests, as should the employment of trap crops in the manner advised in this article.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part VII.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

BY

F. H. CHITTENDEN, Sc. D.,

In Charge of Truck Crop and Stored Product Insect Investigations.

ISSUED JULY 19, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

CONTENTS.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

SUCCESSFUL USE OF ARSENATE OF LEAD AGAINST THE ASPARAGUS BEETLE.

During the first week of June, 1908, Mr. W. A. Orton reported the common asparagus beetle (*Crioceris asparagi* L.) very injurious at Takoma Park, D. C., and made some experiments with arsenate of lead with complete success. Directions for application, as given in Circular 102 of this Bureau, were followed. The first application was made with 1 pound of arsenate of lead to 20 gallons of water and the second a week later, as the plants had grown rapidly in the meantime and a great many new larvæ had hatched. The second application was made at the rate of 1 pound to 15 gallons of water. The first application destroyed most of the insects, but after a few days a considerable number had developed. These appeared to have been all killed the day after the second spraying. Neither spraying seemed to injure the plants in the least, but the liquid adhered in fine drops to the foliage and was visible there for some time. An unsprayed plat on a neighbor's place was considerably injured by these insects, and up to July 1 no more had appeared on Mr. Orton's crop. He pronounced the treatment very effective. The work was done with a compressed-air machine or autospray.

Mr. Edward A. Eames, Buffalo, N. Y., writing of the value of arsenate of lead as a means of combating the common asparagus

Note.—The accompanying Part VII includes short notes on some of the insects which have been treated in earlier parts of this bulletin and notes on two insects not hitherto recorded as injurious in the United States. To the former class belong notes on the asparagus beetles and the asparagus miner, species considered more in detail in Part I, pages 1–10, and notes on water-cress insects in addition to what has been published in Part II, pages 11–20. To the second class belong notes on the injurious occurrence of the pea moth in the United States and a short account of a new western root-maggot.—F. H. C.

beetle, stated that the larvæ of this species threatened to devour his this year's spring-set asparagus to the ground. But after one thorough spraying with arsenate of lead it was difficult to find any but dead larvæ on the plants. Successive sprayings were of course necessary, because the beetles continued to come from neighboring gardens to deposit eggs on the plants and because the developing plants continually presented fresh unsprayed foliage for larval food.

Mr. Eames stated positively that arsenate of lead adhered well, even through several rains, just as its various promoters claimed—a fact which justifies its use in any case even at more initial cost than other poisons which might be used. He also expressed the view that asparagus growers generally should be impressed with the fact that, because of the tendency to spray only once, additional information should be given of the value of extra applications. In conclusion, he stated that he believed arsenate of lead was a specific for this class of insects.

Our correspondent is undoubtedly right. It seems to be as nearly a specific for asparagus beetles as anything that can be obtained, provided it is applied according to directions and that applications are repeated as often as necessary. The trouble is that many truck growers, after spraying a single time, consider that the matter should then be dropped, and if the desired result is not produced, i. e., if the trouble is not wholly stopped, the spraying is condemned or at any rate the insecticide is discontinued, while all that is necessary for the entire season is a second or third application.

A NOTE ON THE ASPARAGUS MINER.

The asparagus miner (*Agromyza simplex* Loew) was reported by Mr. I. J. Condit in the vicinity of Antioch, Cal., August 19, 1908, where the common asparagus beetle was also abundant. The miner was said to be equally numerous and stalks showing infestation were received. The miner-infested stalks could generally be detected by their roughened appearance near the ground.

This species was also taken by Mr. Condit at Oakley and it seems probable, since the common asparagus beetle is found in both localities, that it is becoming generally distributed in California. In one place at Oakley Mr. Condit observed the miner quite common on some stalks, but it did not appear to be equally common over the entire ranch.

During October, 1908, the writer observed this species well established on asparagus in the vicinity of Portsmouth, Va. In October, also, Mr. J. B. Norton reported very severe injury to asparagus in the vicinity of Concord, Mass. The roots of the plants were not only girdled, but the miners worked up the stalks some inches above the ground.

INJURIOUS OCCURRENCE OF THE PEA MOTH IN THE UNITED STATES.

Prominent among the injurious occurrences of the year 1908 was the discovery of the pea moth (*Enarmonia nigricana* Steph.) for the first time in the State of Michigan. August 10 we received from Mr. J. E. W. Tracy, Bureau of Plant Industry, specimens of the larva of this species and its work in growing peas and pods from Charlevoix, Mich.

Mr. Tracy wrote that he obtained the specimens on that day and some days earlier and that Mr. E. W. Coulter and others in that vicinity knew nothing of the identity of this insect, which was causing them considerable concern. The caterpillar first showed itself in very small numbers four or five years before, but it had increased rapidly until the year of writing, when 15 per cent of the peas were ruined. The insect appears to start operations by eating the embryo stem and then moves along the pod until it makes its exit and disappears. Early varieties of peas were the worst sufferers in the affected district. At the time of writing our correspondent found a less number of living larvæ than previously.

This appears to be the first record of the appearance of this insect in the United States, although it has been known as a pest in Canada for several years and has undoubtedly been present in our Northern States, where peas are grown, without having been recognized as anything new or unusual.

A two-page account of this species has been published by the writer in Bulletin No. 33, pages 96–98, which includes a brief illustrated description of the moth and larva and a consideration of the distribution, nomenclature, history, habits, and remedies.

This insect first came to notice near Toronto, Ontario, in 1893, and notices of its ravages in Canada were given in several subsequent years by the late Dr. James Fletcher in his report as entomologist and botanist of the Dominion of Canada. It is an importation from the Old World and is well established in New Brunswick and Nova Scotia as well as in Ontario, and is also recorded from Manitoba.

The name of this species was omitted from the Dyar catalogue of Lepidoptera, but is included in Smith's Check List of Lepidoptera under No. 5702. In most publications the species is mentioned as *Semasia nigricana*.

A NEW WESTERN ROOT MAGGOT.

August 16, 1907, Mr. E. M. Ehrhorn sent from San Francisco, Cal., some radishes, the roots of which were affected by a maggot. The adults were reared September 3 to 20 and were referred to Mr. D. W. Coquillett for identification. They were first mistaken for *Pegomya cepetorum*, because of the very close relation of the two species, but when more material of both sexes was obtained they were seen to be different. Mr. Coquillett states that some individuals have the bristles practically as in *cepetorum*, but in the males the median black stripe of the abdomen is continuous. This material corresponds so well with Stein's description[a] of *Chortophila planipalpis* as to leave no reasonable doubt of the species. The type locality is Idaho. The insect will therefore be known as *Pegomya planipalpis* Stein, and may be called the western radish maggot. Another lot of the maggot was received from the same source October 1, larvæ and pupæ both being present. From this lot adults issued November 1 to 21.

November 21, 1908, we received from Mr. Charles Heise, Aberdeen, Wash., a section of turnip mined by larvæ which are probably of this species, as also a number of puparia. Our correspondent stated that his observations showed that the maggot works on onions as well as on turnips. As we do not know to the contrary, and do not know positively of the occurrence of any onion maggot in that State, this surmise may be correct. It remains to be verified or disproven. The seed-corn maggot (*Pegomya fusciceps* Zett.) occurs in that region and is more apt to be the onion-feeding species.

Two natural enemies of this radish maggot have come under observation and have been identified by Mr. J. C. Crawford, as follows:

Aphæreta sp.—September 3, 1908, many braconids of a species of the genus *Aphæreta* emerged from material in which this root-maggot was breeding in infested radish from San Francisco, Cal. It is a small species, shining black in color, with dusky wings and yellow legs. In some specimens there are 21 joints to the antennæ on one side and 22 on the other. It is very similar to the type of *muscæ*, but is larger.

Polypeza sp.—This species was reared from its host October 10, 1907, and appears to be undescribed.

NOTES ON WATER-CRESS INSECTS.

The water-cress leaf-beetle.—May 2, 1907, Mr. J. W. Bryan brought to this office from Halltown, W. Va., specimens of the water-cress leaf-beetle (*Phædon æruginosa* Suffr.), present in the beetle and larval forms, the larvæ at that time about half grown. The beetles were beginning to die and a fungus attack was noticed when received. Numerous individuals of the beetle and one larva were parasitized by the fungus. The fungus was tentatively determined by Mr. Haven Metcalf, Bureau of Plant Industry, as *Entomophthora sphærosperma*. If this identification is correct, there can be no doubt that the fungus attacked the insect before death, and may therefore be a factor of value in its natural destruction.

---

[a] Berl. Ent. Zeitschr., Vol. XLII, pp. 234–235, 1897.

Since the publication of the writer's preliminary articles on the water-cress leaf-beetle and sowbug in the present bulletin (pp. 11–20) it has been noticed that earlier accounts of the related European *Phædon betulæ* L., known as the mustard beetle and "blackjack," were made by Miss E. A. Ormerod, who furnished several references with illustrations in her manual.[a] From this account it appears that injury was first noticed, at least in England, in 1854, to white mustard crops near Ely. Another account of this insect is given in the same author's report for 1886.[b]

The water-cress sowbug.—April 16, 1907, Mr. C. A. Killinger, Shippensburg, Pa., sent specimens of the water-cress sowbug (*Mancasellus brachyurus* Harg.) in different stages, stating that it was destroying his water cress, working on the leaves under water, cutting them close to the stem. If the cress is light or does not grow fast, as happens in winter, they also work on the stems and roots, cutting the plants loose and causing them to float downstream. Our correspondent thought that this species was brought to that section from Virginia.

Experiments conducted with lime in a small spring the previous summer succeeded in killing most of the sowbugs, but plenty of them remained at the time of writing. The lime, however, burned the cress, causing it to turn yellow.

December 23, 1908, Mr. F. W. Houston, a grower and shipper of water cress at Lexington, Va., wrote of this species, inquiring for literature and a remedy. He stated that he had a spring under cultivation that was infested with the water-cress sowbug, and later—March 11, 1909—he sent specimens. In this connection he wrote as follows:

> I have a spring under cultivation which has been infested by them for several years. I fought them for a time by putting the water into ditches and exposing the rest of the cress bed to the sun. In these ditches I would make frequent applications of lime; this, of course, was done during the early summer, after the shipping season closes. It seems to kill all of the sowbugs, but when I put the water into the beds and reset the cress, hauling it from an uninfested spring, it was not long until the "bugs" were again noticed, and in a short time they were as thick as ever.

Mr. Houston was advised that in the case of the old beds the water should be drawn or turned off and that the cress should be completely destroyed and the spring reset with uninfested cress.

---

[a] Manual of Injurious Insects and Methods of Prevention. London, 1890, pp. 151–156.

[b] Report on Injurious Insects for 1886, pp. 59–60.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

CONTENTS AND INDEX.

ISSUED MARCH 17, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

I. THE ASPARAGUS MINER.

NOTES ON THE ASPARAGUS BEETLES.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

II. THE WATER-CRESS SOWBUG.

THE WATER-CRESS LEAF-BEETLE.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

III. THE CRANBERRY SPANWORM.

THE STRIPED GARDEN CATERPILLAR.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

IV. THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

By E. D. BALL, Ph. D., *Special Field Agent.*

V. THE SEMITROPICAL ARMY WORM.

By F. H. CHITTENDEN and H. M. RUSSELL.

VI. THE HOP FLEA-BEETLE.

By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Special Insect Investigations.*

VII. MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Stored Product Insect Investigations.*

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1910.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*
R. S. Clifton, *Executive Assistant.*
Chas. J. Gilliss, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

Truck-Crop and Stored Product Insect Investigations.

F. H. Chittenden, *in charge.*

H. M. Russell, C. H. Popenoe, D. K. McMillan, H. O. Marsh, E. G. Smyth, Thos. H. Jones, *agents and experts.*
E. D. Ball,[a] *special field agent.*
E. G. Titus,[a] I. J. Condit, H. S. Heller,[b] W. B. Parker, *collaborators.*

---

[a] Resigned June 30, 1909. [b] Resigned January 31, 1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., January 25, 1910.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 66, seven papers dealing with certain insects injurious to truck crops. These papers, which were issued separately during the years 1907 and 1909, are as follows: The Asparagus Miner and Notes on the Asparagus Beetles, by F. H. Chittenden; The Water-Cress Sowbug and the Water-Cress Leaf-Beetle, by F. H. Chittenden; The Cranberry Spanworm and the Striped Garden Caterpillar, by F. H. Chittenden; The Leafhoppers of the Sugar Beet and Their Relation to the "Curly-Leaf" Condition, by E. D. Ball; The Semi-tropical Army Worm, by F. H. Chittenden and H. M. Russell; The Hop Flea-Beetle, by F. H. Chittenden; Miscellaneous Notes on Truck-Crop Insects, by F. H. Chittenden.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The present publication comprises a series of articles which have been issued in seven parts and are now brought together as a single bulletin. It relates to a line of investigations begun in 1896, the earlier results of which were published in previous bulletins of the present series, in Yearbooks of the Department, and in circulars of the Bureau. The title, "Some Insects Injurious to Truck Crops," is used in a wide sense and includes insects injurious to sugar beet, since the same classes of insects which affect this important crop also attack table beets and spinach.

The initial article is the first treatment that has been given to the asparagus miner in a Government publication. The second article, entitled "Notes on the asparagus beetles," is a sequel to a general article on the asparagus beetles which appeared in the Yearbook for 1896. It places on record all important new localities to date, and furnishes similarly the latest information in regard to remedies. The importance which has been assumed by the water-cress sowbug since 1902 has necessitated the preparation of a publication covering this species, with suggestions for its control. The subject of water-cress insects has never been considered in a Department publication hitherto, and similar treatment of the water-cress leaf-beetle to that furnished on the sowbug follows. The cranberry spanworm is given monographic treatment not hitherto furnished for it. It is an omnivorous feeder, and has attracted attention on various crops, and especially on asparagus and strawberry. A similar article on the striped garden caterpillar, also an omnivorous form, completes Part III of the bulletin.

The article representing Part IV is a detailed consideration of the sugar-beet leafhopper and of other affiliated species in their relation to the "curly-leaf" condition of the sugar beet. It was prepared by Dr. E. D. Ball, while special field agent of this Bureau in Utah; he has been engaged on this work for a number of years. The semi-tropical army worm is the subject of Part V. It was the most troublesome insect on truck crops in Florida during 1907, and was given detailed study from every possible standpoint by the authors. In the experiments with remedies, which were conducted by the junior author, Mr. H. M. Russell, a series of 15 trials was performed, proving that a spray of arsenate of lead is far superior to Paris green under local conditions. The final article of the series, entitled "The hop flea-beetle," has been a subject of study for a number of years. Its treatment is monographic to date, and, while some of the data furnished are preliminary in character, it will constitute a basis for future work on the same species. This insect is given the name of flea-beetle because of the local name, "hop flea," used in the hop-growing region of the Pacific coast, but it is also a pest in sugar-beet fields and injurious to rhubarb, radishes, and other truck crops. In the preparation of the article the writer has been fortunate in obtaining the cooperation of various experts, including, particularly, Messrs. H. J. Quayle and Theodor Eder.

Following this article are a few miscellaneous notes on truck-crop insects, the first two giving additional information in regard to the principal asparagus pests treated in Part I, the last furnishing additional observations on the water-cress insects treated in Part II, with notes on the first injurious occurrence of the destructive pea moth and of a western root-maggot in the United States.

F. H. Chittenden.

CONTENTS.[a]

[a] The seven papers constituting this bulletin were issued in separate form on March 16, April 23, and August 31, 1907, and on January 27, January 28, May 8, and July 19, 1909, respectively.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

ERRATA.

Page 2, line 19, for *1861* read *1869*.
Page 2, footnote [a], for *160* read *46*.
Page 18, line 11, for *1893* read *1903*.
Page 18, line 22, for *letter* read *latter*.
Page 65, line 15 from bottom, for *fresh air-slaked* read *freshly slaked*.
Page 68, line 8, for *6* read *50*.

INDEX.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

I. THE ASPARAGUS MINER.
NOTES ON THE ASPARAGUS BEETLES.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

II. THE WATER-CRESS SOWBUG.
THE WATER-CRESS LEAF-BEETLE.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

III. THE CRANBERRY SPANWORM.
THE STRIPED GARDEN CATERPILLAR.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

IV. THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

By E. D. BALL, Ph. D., *Special Field Agent.*

V. THE SEMITROPICAL ARMY WORM.

By F. H. CHITTENDEN and H. M. RUSSELL.

VI. THE HOP FLEA-BEETLE.

By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Special Insect Investigations.*

VII. MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS

By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Stored Product Insect Investigations.*

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1910.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

I. THE ASPARAGUS MINER.
NOTES ON THE ASPARAGUS BEETLES.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

II. THE WATER-CRESS SOWBUG.
THE WATER-CRESS LEAF-BEETLE.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

III. THE CRANBERRY SPANWORM.
THE STRIPED GARDEN CATERPILLAR.

By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

IV. THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

By E. D. BALL, Ph. D., *Special Field Agent.*

V. THE SEMITROPICAL ARMY WORM.

By F. H. CHITTENDEN and H. M. RUSSELL.

VI. THE HOP FLEA-BEETLE.

By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Special Insect Investigations.*

VII. MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Stored Product Insect Investigations*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*

C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*

R. S. Clifton, *Executive Assistant.*

Chas. J. Gilliss, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

Truck-Crop and Stored Product Insect Investigations.

F. H. Chittenden, *in charge.*

H. M. Russell, C. H. Popenoe, D. K. McMillan, H. O. Marsh, E. G. Smyth, Thos. H. Jones, *agents and experts.*
E. D. Ball,[a] *special field agent.*
E. G. Titus,[a] I. J. Condit, H. S. Heller,[b] W. B. Parker, *collaborators.*

---

[a] Resigned June 30, 1909. [b] Resigned January 31, 1910.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., January 25, 1910.

SIR: I have the honor to transmit herewith, for publication as Bulletin No. 66, seven papers dealing with certain insects injurious to truck crops. These papers, which were issued separately during the years 1907 and 1909, are as follows: The Asparagus Miner and Notes on the Asparagus Beetles, by F. H. Chittenden; The Water-Cress Sowbug and the Water-Cress Leaf-Beetle, by F. H. Chittenden; The Cranberry Spanworm and the Striped Garden Caterpillar, by F. H. Chittenden; The Leafhoppers of the Sugar Beet and Their Relation to the "Curly-Leaf" Condition, by E. D. Ball; The Semi-tropical Army Worm, by F. H. Chittenden and H. M. Russell; The Hop Flea-Beetle, by F. H. Chittenden; Miscellaneous Notes on Truck-Crop Insects, by F. H. Chittenden.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

The present publication comprises a series of articles which have been issued in seven parts and are now brought together as a single bulletin. It relates to a line of investigations begun in 1896, the earlier results of which were published in previous bulletins of the present series, in Yearbooks of the Department, and in circulars of the Bureau. The title, "Some Insects Injurious to Truck Crops," is used in a wide sense and includes insects injurious to sugar beet, since the same class of insects which affect this important crop also attack table beets and spinach.

The initial article is the first treatment that has been given to the asparagus miner in a Government publication. The second article, entitled "Notes on the asparagus beetles," is a sequel to a general article on the asparagus beetles which appeared in the Yearbook for 1896. It places on record all important new localities to date, and furnishes similarly the latest information in regard to remedies. The importance which has been assumed by the water-cress sowbug since 1902 has necessitated the preparation of a publication covering this species, with suggestions for its control. The subject of water-cress insects has never been considered in a Department publication hitherto, and similar treatment of the water-cress leaf-beetle to that furnished on the sowbug follows. The cranberry spanworm is given monographic treatment not hitherto furnished for it. It is an omnivorous feeder, and has attracted attention on various crops, and especially on asparagus and strawberry. A similar article on the striped garden caterpillar, also an omnivorous form, completes Part III of the bulletin.

The article representing Part IV is a detailed consideration of the sugar-beet leafhopper and of other affiliated species in their relation to the "curly-leaf" condition of the sugar beet. It was prepared by Dr. E. D. Ball while special field agent of this Bureau in Utah; he has been engaged on this work for a number of years. The semitropical army worm is the subject of Part V. It was the most troublesome insect on truck crops in Florida during 1907, and was given detailed study from every possible standpoint by the authors. In the experiments with remedies, which were conducted by the junior author, Mr. H. M. Russell, a series of 15 trials was performed, proving that a spray of arsenate of lead is far superior to Paris green under local conditions. The final article of the series, entitled "The hop flea-beetle," has been a subject of study for a number of years. Its treatment is monographic to date, and, while some of the data furnished are preliminary in character, it will constitute a basis for future work on the same species. This insect is given the name of flea-beetle because of the local name, "hop flea," used in the hop-growing region of the Pacific coast, but it is also a pest in sugar-beet fields and in urious to rhubarb, radishes, and other truck crops. In the preparation of the article the writer has been fortunate in obtaining the cooperation of various experts, including, particularly, Messrs. H. J. Quayle and Theodor Eder.

Following this article are a few miscellaneous notes on truck-crop insects, the first two giving additional information in regard to the principal asparagus pests treated in Part I, the last furnishing additional observations on the water-cress insects treated in Part II, with notes on the first injurious occurrence of the destructive pea moth and of a western root-maggot in the United States.

F. H. Chittenden.

CONTENTS.[a]

[a] The seven papers constituting this bulletin were issued in separate form on March 16, April 23, and August 31, 1907, and on January 27, January 28, May 8, and July 19, 1909, respectively.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE ASPARAGUS MINER.

(*Agromyza simplex* Loew.)

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

The stalks of asparagus are frequently attacked by insects, and in recent years have been reported considerably injured by the larva or maggot of a minute black fly to which the name asparagus miner has been given. The larva mines under the epidermis of the stalk, and when it has transformed to the puparium or "flaxseed" stage the thin outer skin becomes more or less ruptured and the presence of the insect is easily detected. It operates more abundantly near the base of the stalks and penetrates below the surface of the ground to a depth of 7 or 8 inches. During the year 1906 this species attracted considerable attention by its abundance in some of the principal asparagus-growing sections of New England and it bids fair to become a pest of considerable importance. It was first noticed on asparagus

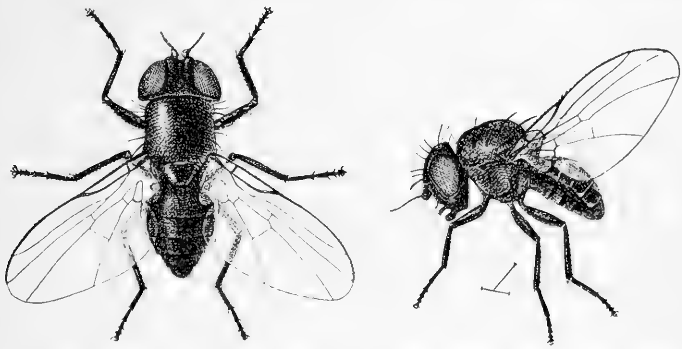


Fig. 1.—*Agromyza simplex:* Fly, dorsal view at left, lateral view at right. Highly magnified (original).

in 1896, ten years earlier than the present writing, prior to which time nothing was known of its habits. It is a native species and evidently restricted to asparagus as a food plant. Until the year 1906 it had not been recognized as doing injury to cutting beds, although attack had been observed in various sections. The mines of the larvæ about and below the bases of the stalks are frequently so abundant that they have the effect of girdling, so that the injured stalks can be readily pulled from the ground.

DESCRIPTIVE.

The parent insect is a two-winged fly (fig. 1), metallic black, with large prominent head and eyes, and clear wings, the wing expanse being about one-sixth of an inch (4 mm.).

The larva (fig. 2, *a*) is about one-fifth of an inch long and milk-white in color. Like other maggots, it is footless, large at the posterior extremity, and tapering toward the head.

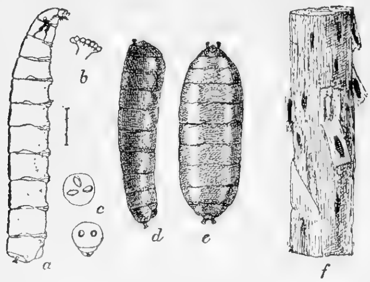


FIG. 2.—*Agromyza simplex: a*, larva, lateral view; *b*, thoracic spiracles; *c*, anal spiracles; *d*, puparium from side; *e*, same from above; *f*, section of asparagus stalk, showing injury and location of puparia on detached section; *a-e*, much enlarged; *f*, slightly reduced (original).

The puparium (fig. 2, *d*, *e*) is not unlike the "flaxseed" of the pernicious Hessian fly, with which it has been aptly compared. At a little distance, also, it suggests a Lecanium scale. This stage is remarkable because of its peculiar flattened and curved position, as seen from the side. It is red in color, and measures about 3.5 mm. in length and about 1 mm. in width.

The egg has not been observed.

This species belongs to the dipterous family Agromyzidæ, and was described by Loew in 1869,[a] the locality being given as "Middle States."

DISTRIBUTION.

In its injurious occurrences this species appears to be limited to the eastern United States, from New England to Tennessee. From available data it is quite obvious, however, that it may be destructive over a considerable territory, including a large portion of Massachusetts and Connecticut, Long Island, the District of Columbia, Pennsylvania, and Tennessee. As it is recorded from New Jersey, it is probably injurious there, although no reports of injury in that State have reached this office. In time it will doubtless attract attention in intermediate points and in States farther north and west. It has also appeared in asparagus beds in California.

HISTORICAL AND BIOLOGICAL NOTES.

In May, 1897, and afterwards this fly was observed in abundance by the writer on terminal shoots of asparagus, particularly at Cabin John, Md. Two weeks later no more flies were seen, but June 26 they reappeared and were then usually seen *in copula*. It was surmised at the time that this second appearance indicated the first new generation of the year and its abundance on asparagus seemed to show that it lived in some manner at the expense of that plant. Examination of asparagus plants at that time, however, failed to show attack. The facts which have just been narrated were published in 1898.[b]

---

[a] Diptera Americæ septentrionalis indigena, Centuria octava 84, p. 46.
[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., p. 62, 1898.

In 1900 we received complaint of injuries in the District of Columbia, and from Knoxville, Tenn., and in the meantime the species came under the observation of Mr. F. A. Sirrine, who has stated[a] that work was first observed in asparagus fields on Long Island in 1896. This statement is made in a bulletin of six pages, which represents all that was known of the species at that time.

Late in September, 1900, word was received from Mr. Frederic Voigt, Tennallytown, D. C., of injury to the stalks of asparagus on his and a neighboring truck farm. When the writer visited the field, however, although injury was apparent on the outer skin of some stalks, no living specimens could be obtained, only the dried puparia being in evidence at this time. October 2 of the same year, Mr. Samuel M. Bain, University of Tennessee, Knoxville, Tenn., sent a stalk of asparagus showing the work of this miner upon the skin, and, October 27, specimens of the dried puparia.

February 18, 1901, Mr. T. Miles Brous, Bustleton, Philadelphia, Pa., wrote that this insect, which he accurately described, seemed to cause much greater trouble than the common asparagus beetle. A neighbor had lost two or three new beds of asparagus on account of its ravages.

By the writer's direction, Mr. F. C. Pratt visited a large truck farm at Brookland, D. C., where asparagus was one of the main crops, June 18, 1902. Asparagus was still being cut for market, but volunteer plants were growing here and there in fields of corn, cantaloupe, and potatoes, between rows. A few flies were seen on terminal shoots of asparagus that showed wilting, and many volunteer plants were found badly infested, most individuals having transformed to pupæ. Although stems break off just below the ground, the entire colony of insects below that point is left with sufficient moisture and nourishment for their maintenance. The puparia were present in great numbers underneath the outer skin of the root, and as many as nine puparia were counted in a space only an inch long on one stalk. The stalks below the point of injury appeared to be perfectly sound. Larvæ also were found in rotting stalks that broke off just below ground.

During 1905 Mr. Ralph E. Smith reported this species as becoming abundant in California, though not of any great importance at that time. His description of the insects' manner of work leaves no doubt as to the identity of the species.[b]

RECENT INJURY.

During September, 1906. Messrs. J. B. Norton and A. D. Shamel, of the Bureau of Plant Industry, furnished stems of asparagus from Concord, Mass., showing severe infestation by this species, many

[a] Bul. 189, N. Y. Agric. Exp. Sta., p. 277, Geneva, 1900.
[b] Bul. 165, Univ. of Cal. Agric. Exp. Sta., p. 96, 1905.

puparia being present under the mined outer skin. In the neighborhood of Concord, a very important asparagus-growing region where hundreds of acres are devoted to this crop, the infestation was practically absolute, the insect being found even as abundantly as the common asparagus beetle, being present wherever rust was found, as also where no rust was present. The specimens submitted were about the average as regards the degree of infestation, some plants showing injury 7 inches below the surface.

Severe injury was reported on the farms of Mr. Frank Wheeler and Mr. Charles W. Prescott, at Concord, Mass. The growers in that region had never noticed this insect until Mr. Shamel's examination showed that its injuries were extensive. Later Mr. Shamel reported finding infestation in every field and patch of asparagus which he visited in Massachusetts and Connecticut, particularly at Suffield, Granby, and Hartford, Conn., and he believed attack to be widespread.

October 26, 1906, Mr. Ralph E. Smith wrote, by request, that the conditions under which this asparagus miner was found in abundance in the yellow stalks of asparagus in California, as reported by him in an article on Asparagus Rust Control,[a] had prevailed for two or three years. The insect was always very abundant at the base of these yellow, dying stalks, although the injury was attributed to the "centipede," reported as wireworms on a previous occasion.[b]

REMEDIAL MEASURES.

Witn our present knowledge of the life economy of this species, two methods of control suggest themselves as of greatest value, and it may be that they will prove all that is necessary under ordinary conditions.

(1) In spring permit a few volunteer asparagus plants to grow as a trap crop, to lure the fly from the main crop or the cutting beds for the deposition of her eggs. After this has been accomplished the trap crop should be destroyed by pulling the infested plants and burning them with their contained puparia. The time to pull the plants will vary according to locality and somewhat according to season also. The second and third week in June would be about the right time in and near the District of Columbia. On Long Island this work should be done a week or two later. In the northernmost range of this insect—for example, in Massachusetts—the last of June and the first of July would probably be a suitable time.

(2) The second generation can be destroyed in like manner by pulling old infested asparagus stalks as soon as attack becomes manifest and promptly burning them also.

---

[a] Bul. 172, Univ. Cal. Agric. Exp. Sta., p. 21; [b] Bul. 165, 1. c.

If this work were carefully done over a considerable area, it would leave little necessity for other methods, since it would do away with these insects in the vicinity and leave few to be dealt with another season; unless, indeed, this insect has an alternate food plant. The cooperation of neighboring asparagus growers and thoroughness are essential for success.

This method will operate also against the rust which is now present in many fields infested by the miner.

NOTES ON THE ASPARAGUS BEETLES.

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

Since the publication of the writer's general article on the asparagus beetles in the Yearbook for 1896,[a] many notes on their distribution and destructive occurrences have been published. Some additional data were published soon afterward.[b] The following brief review of the subject is submitted as a sequel to those articles and a summary of the further dissemination of these pests in a decade of years.

THE COMMON ASPARAGUS BEETLE.

(*Crioceris asparagi* L.)

The predictions made by the writer in regard to the future distribution of the common asparagus beetle have been completely fulfilled as regards its western spread, although it has not as yet been reported as far south as Kentucky. Mr. J. G. Sanders, however, informs the writer that it has been established about Columbus, Ohio, since 1903, and Mr. Charles Dury, Cincinnati, Ohio, reported this species at Indian Hill, about 7 miles from that city, on asparagus beds in 1905. Hundreds were observed during June. The customary injury was noticed, and plants appeared as though scorched with fire. In 1897 the species was observed to have continued its spread westward along Lake Erie, and was then known in nine counties in northeastern Ohio. The following year it was first noticed in western Virginia. In 1898 also it was reported to have been present at Benton Harbor, Mich., since 1896. By 1899 it had made its appearance in Canada, accompanied by the twelve-spotted species, in the Niagara River region.

It is interesting to note that in 1900 the present species, which had been rapidly increasing its range in the East, including New York, after occurring in injurious numbers in Maryland, was apparently totally destroyed by the hot spell of July and August that occurred in the District of Columbia and neighboring parts of Virginia and Maryland; whence the conclusion that this condition prevailed to a considerably larger extent than came to the writer's personal notice. In 1901 Dr. James Fletcher noted that the species, though present in the Niagara district, had not increased to the extent that was feared. It had spread to Guelph, Ontario, that year, and did much damage about St. Catharines. In 1904 its occurrence around Toronto was

[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 341–352.

[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., pp. 54–59, 1898.

noticed. It was reported also 40 miles west of Chicago, Ill. It has become very generally distributed in asparagus-growing districts in New York State, and has reached Glens Falls, which approximates its northernmost limit in this country. In 1905 we received complaint of this insect as a pest in Illinois, at Park Ridge, and of its occurrence about Chicago. Reports from Michigan showed that it had been present there in 1904 in the vicinity of Ada, about 10 miles from Grand Rapids, and that it was a pest in that vicinity.

Although the data given above indicate that the species is now well distributed throughout the Upper Austral region, for some reason its occurrence in Indiana has not yet come to our knowledge; nevertheless although there are naturally many uninvaded localities, it is undoubtedly established in that State, most probably near Lake Michigan.

As an example of its manner of distribution, it might be noted that in May, 1905, the beetle was found for the first time in Warrenton, Fauquier County, Va., a little farther inland than it had ever been noticed in that section. Yet this species has been permanently established in the adjoining Alexandria County for many years.

August 8, 1905, Mr. Ralph E. Smith wrote of the occurrence of this species in California, stating that during two seasons it had been very abundant at Bouldin Island, the principal asparagus center of that region. As Mr. Smith was familiar with this insect and its occurrence on the Atlantic coast, there is little doubt that his identification is correct. In the winter of 1904 to 1905 Bouldin Island was flooded and remained under water for over a year. It had just been reclaimed and there were no signs of the beetles. There is, therefore, a possibility that the insect was exterminated in that region, and this includes the State, if the occurrence of the species was only local.

The dying out of this asparagus beetle in small localities where it has not become thoroughly established is not without precedent, as its recorded occurrence at Rock Island, Ill., many years ago, has been verified by specimens now in a Chicago museum, properly labeled as collected there by the late A. Bolter, an experienced collector of Coleoptera. Indeed, it would seem that few vegetable-feeding insects are more subject to extermination in a limited locality not contiguous to one also infested than is the present species.

October 26, 1906, Mr. Ralph E. Smith, at the writer's request, reported the status of this species in California. He wrote that during the summer he found the beetles again, and that they were very abundant in fields near Oakley, Cal. It could not be stated that the insect was of general occurrence in the State, but apparently it existed only in a few scattered colonies. As previously reported the colony at Bouldin Island appears to have been exterminated by flood, and the Oakley occurrence was the first that Mr. Smith had noted since. In most of the asparagus acreage of the State the insect was not yet present.

Mr. Franklin Sherman, jr., has kept a careful record of the occurrence of this species in North Carolina, and informed the writer, on the occasion of a visit in 1906, that it is common in the east-central part of the State in the trucking belt, and especially abundant at Raleigh, Wake County, Goldsboro, Wayne County, and Warsaw, Duplin County.

In order to make the present account of the known distribution of this species as complete as possible, inquiry was made of the official entomologists of the States of Kentucky, Iowa, Missouri, Nebraska, and Minnesota, all of whom reported that the occurrence of this species in their States had not been brought to their attention. Mr. James G. Moore, however, assistant in horticulture at the University of Wisconsin, Madison, Wis., stated that the asparagus beetle had been found in Wisconsin, but he had no special data on its distribution.

REMEDIES.

With regard to remedies good results have followed the experimental use of arsenate of lead. This insecticide has come into very general favor in recent years, and in the correspondence of this office we have for some time advised its employment against most leaf-feeding beetles, like the asparagus beetles. In Connecticut Dr. W. E. Britton [a] has made a practical test of this remedy on asparagus plants, spraying them from all four sides in succession because of the slight leaf exposure as compared with most other plants. The day following treatment (June 4) many dead beetles and larvæ were found on and under the plants. A few had survived and were feeding, but ten days later only a few living larvæ could be found, and the beetles did not again become abundant on the plants during the summer. The same amount of good might be accomplished with scarcely greater expense by spraying from opposite sides and repeating just before the time for the last generation to develop and in time to check the beetles before they go into winter quarters.

In Pennsylvania Prof. H. A. Surface,[b] in a series of experiments with Paris green and arsenate of lead, applied to asparagus plants the first week of June, 1905, found that not more than 50 per cent of the insects were killed when Paris green and lime were used. With lead arsenate 90 per cent were killed, while in one experiment, by the addition of resin soap, which is used as an addition to an insecticide to

---

[a] Rept. Conn. Agric. Exp. Sta. f. 1903 (1904), pp. 275, 276.

[b] Monthly Bulletin, Div. of Zool., Pa. State Dept. Agric., Vol. IV, May, 1906, p. 8.

enable the poison to adhere better to smooth plants, 100 per cent of the insects were killed on the 50 plants treated. In this case the arsenate of lead was used at the rate of about 1 pound to 24 gallons of water, and 2½ pounds of soap were added.

Arsenate of lead has been used with satisfactory results on asparagus at the rate of 1 pound in 16 to 24 gallons of water. Additional experiments are necessary to ascertain the exact amount of the poison that can be used economically to produce the best effect. In Professor Surface's experiments evidently only a single spray was applied.

THE TWELVE-SPOTTED ASPARAGUS BEETLE.

(*Crioceris 12-punctata* L.)

Nearly every year since 1896, when the distribution of the twelve-spotted asparagus beetle was recorded by the writer,[a] the appearance of this species has been noted in new localities in the United States, until it is now well distributed westward and especially northward.

In 1898 Dr. J. B. Smith stated that it then occurred throughout the State of New Jersey "south of the shale from the Atlantic coast to the Delaware." The following year (1899) it was recorded by Dr. E. P. Felt from different counties in New York, and as far west as Buffalo. In some places the species was abundant, while in some near-by localities it could not be found, showing that it was still locally distributed through New York. It was afterwards recorded present in Albany, Batavia, Leroy, Syracuse, Riverhead, Oswego, Center, Glendale, Richmond Hill, Penfield, Elmira, Geneva, Ithaca, and about Brooklyn, N. Y. It was also stated to occur in the Niagara district in Canada as far back as Hamilton, Ontario.

An interesting point in regard to the occurrence of asparagus beetles in the Niagara peninsula was that the two species appeared to have arrived almost simultaneously in that region, but that the twelve-spotted form was by far the more common one. In after years different observers noted its further spread in Canada, commenting upon the fact that it led the common species in becoming diffused by natural means. By 1902 it had appeared in Connecticut, at New Haven, and later in other parts of that State.

Since some writers on these asparagus beetles have overlooked the author's second article[b] it may be well to mention that facts additional to those printed in the writer's original article are given therein, including a description and illustration of the egg and its manner of deposition, and what is practically a complete account of the life history of the species, the insect being found to develop and to feed where possible almost exclusively on the berry, although the beetles attack young asparagus shoots before the berries appear.

[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 350–351.

[b] Bul. 10, Div. Ent., U. S. Dept. Agric., pp. 57–59, 1898.

The young larva.—The freshly hatched larva has not hitherto been described. It may be briefly described as follows:

Head rounded, nearly twice as wide as long as seen from above; thoracic plates distinctly separated at the middle, with the intervening space yellow; legs infuscated, clear whitish at sutures. General color very pale yellowish, nearly white, and the surface much wrinkled. Length 1 mm., width 0.35 mm.

U. S. D. A., B. E. Bul. 66, Part II. Issued April 23, 1907.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE WATER-CRESS SOWBUG.

(*Mancasellus brachyurus* Harger.)

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

During the past three years this isopod has attracted very considerable attention because of its occurrence in troublesome numbers in water cress (*Nasturtium officinale*) grown for market in portions of Virginia, West Virginia, and Pennsylvania. The species is purely aquatic, thus differing from our common dooryard sowbugs, which, although most abundant in moist locations, are strictly terrestrial. It belongs to an entirely different family, the Asellidæ, which contains three genera, mostly fresh-water forms, inhabitants of streams, wells, pools, and lakes.

DESCRIPTIVE.

This species is so distinct from the more common sowbugs (Oniscidæ) that a brief description will suffice. Its general appearance is shown, dorsal view, in figure 3. The body is much depressed, and the legs are long and strong. Seen from the side, it is decidedly shrimplike. The peculiar structure of the antennæ may be noticed in the illustration. They terminate in long flagella, composed of many joints. When mature this sowbug attains a length of 13 or 14 millimeters, or a little upward of half an inch, and is a little more than twice as long as wide, and gray in color. This creature is not an insect, but a crustacean, and therefore classed with crayfish and crabs. A detailed description is given by Miss Richardson,[a] who briefly mentions McKees Spring, Gaylord, and Lexington, Va., as localities where this sowbug was "reported injurious to water cress."

By recent correspondence we have obtained necessary information in regard to the habits and manner of operation of this sowbug, and we have also been successful in ascertaining what promises to be a very perfect remedy for the pest in its occurrence in streams and in spring water. It appears to affect cress only below the surface of the water, attacking the roots and lower leaves, and cutting off the stems

[a] Monograph of the Isopods of North America. By Harriet Richardson. Bul. 54, U. S. National Museum, Washington, 1905, pp. 411–412, figs. 460–461.

near the bottom, causing bunches of the plant to float. In portions of streams where these sowbugs have been found most abundantly they are frequently seen crawling in a thick mass at the bottom. They feed, so far as known, exclusively on cress, not being reported as attacking any other form of vegetation.

REPORTS OF INJURIOUS OCCURRENCES.

This sowbug has been observed as a pest since 1902. Our first report of its pernicious habits was made in 1904, when we received specimens through Mr. J. W. Bryan, Anacostia, D. C., from Halltown, W. Va., where it was very injurious to water cress.

In March, 1905, Mr. Powell Arnette reported injury at Gaylord, Va., to cress grown in spring water. The sowbugs were always found in the water and did not attack cress above the surface. After destroying the last vestige of cress in one of his ponds they remained on the bottom "a foot deep," crawling about on the mud.

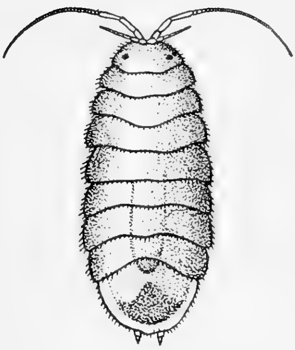


FIG. 3.—The water-cress sowbug (*Mancasellus brachyurus*). Enlarged (after Richardson).

During 1906 (June 18) Mr. John H. Reed, Carlisle, Pa., wrote in regard to this species and its destructive work on water cress in his locality. Specimens were received August 11. The sowbug was observed principally on the roots and lower leaves, crawling up along the stem and cutting off the leaves. August 10 Mr. George C. Jordan, Washington, D. C., sent specimens from Basic City, Va., stating that this "water bug" was devouring his cress beds, and, since a million or more were colonized on the plants, there would be no crop at the rate they were reproducing. When the plants were lifted the sowbugs were observed to drop from them.

METHODS OF CONTROL.

Three ways of controlling this species are suggested. The first and most important consists in a method of growing the water cress so as to eliminate injuries by the sowbug. The second falls under the head of direct remedies, and none of these has as yet given satisfactory results. The third consists in the use of fish or fowls as destroyers. This last means of eradicating the pest has not yet had a fair trial.

The following description of a successful method of disposing of the cress sowbug has been placed at our disposal by Messrs. B. Bryan

& Son, who are practical cress growers and have had several years' experience with the pest:

A METHOD OF GROWING WATER CRESS TO DISPOSE OF THE SOWBUG.

The damage done by the sowbug to water cress has made it our greatest enemy in cress growing, and only after fighting it for four years have we succeeded in finding a way to keep down its numbers so as to be sure of a crop. As cress is ordinarily grown—in lakes or streams of spring water anywhere from 6 inches to 3 feet in depth—it seems impracticable to apply any insecticide. At first we tried to catch the bugs with wire-netting traps placed where the whole stream of water had to pass through them, but the bugs remained among the cress, and we caught only about 20 per cent.

Later, in using copper sulphate to kill moss in the cress, we found that it also killed the sowbugs, snails, etc., when applied freely. Further experiments, however, proved that bluestone could not be applied in deep running water any better than the insecticides previously tried, and when applied in shallow or still water it injured the cress.

The method we are employing at present to fight the sowbug is largely a matter of arrangement of cress beds (see fig. 4), and can be used only where the bottoms of the beds can be graded and drained or where level land adjoins

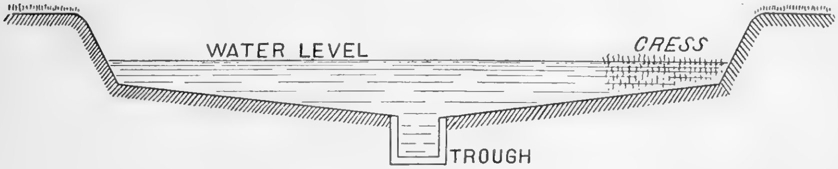


FIG. 4.—Cross section of cress pond showing arrangement for avoiding damage by the water-cress sowbug.

the source of the water supply. We dug long trenches in level land, making them 16 feet wide and about 15 inches deep. Lengthwise they were graded to give a fall of 3 inches in 100 feet, and crosswise to make the center of the trench several inches deeper than the sides. In the center and running the full length of the trench a trough made of three 10-inch boards was sunk below the bottom of the trench in such a way that all of the water might be drained out of the trench through it. Then, with the upper and lower ends of the trench and trough arranged to be opened or closed, the trench could be filled or emptied at will and the flow of water regulated up to 8 inches in depth over the cress. Of course fertile soil was put in the trenches and the cress could be planted either before or after the water was turned in.

With cress beds arranged as above, manipulation to dispose of the sowbugs is simple. By cutting off the water supply and allowing the water to pass out at the lower end of the trench, the sowbugs will collect in the trough, following the receding water, as they can live only in water. No little puddles should remain among the cress, as the bugs will collect in them instead of in the trough. It will be found necessary, also, to use boards to walk on in gathering the cress, as prints of one's boots in the beds would make holes for the bugs to shelter in. The bugs do not move until nearly all of the water is drawn out of the trench. Thus they are collected in a small amount of water in the trough and can then be readily killed with a liberal amount of bluestone, either solid or in solution.

To make the work thorough, water should not be turned into the trench again for twelve or twenty-four hours, in which time the few bugs left among the cress stems will die or find their way to the trough. The trenches can be cleared of bugs in warm weather as frequently as desired, but less danger is done the cress crop if the work is done just after gathering the cress.

The same method of disposing of the sowbugs could be used in greenhouses in the winter, but cress grown in the open air could not be exposed in freezing weather, making the remedy inapplicable in cold weather.

We have not used water in these trenches deeper than 10 inches, and are not able to say how a larger or more rapidly flowing supply of water would act, nor have we grown winter cress in them, as our water supply is insufficient for that purpose.

OTHER REMEDIES.

About the only other remedies which we have been able to suggest are the use of a substance, such as sulphate of copper or chlorid of lime, which might be placed in the water to destroy the pest. As the former has already been tested by Messrs. B. Bryan & Son (see page 13), it need not be mentioned further.

Mr. John H. Reed states that a grower at Healing Springs, Va., has a remedy consisting of a poisonous material which is placed in the water, but he does not know the ingredients nor whether there would be danger to stock drinking the water below the spring. He writes also of the possible use of chlorid of lime. A tank of bleach composed principally of chlorid of lime ran into a creek at Mount Holly Springs, Pa., killed everything that was living in that stream for about half a mile downward, but did not poison stock that drank the water. The bleach came from a paper-mill tank which had burst. If chlorid of lime is tested it should be used on a very small scale at first to note the effect on plant life. It is apt to be harmful to trout and other fish present.

Mr. Reed also suggested the employment of ducks to destroy the pest, but this would necessitate the abandonment of cress culture for a season, as the ducks would injure the condiment both by eating it and by fouling the water.

Among other remedies, we have recommended draining off the water where possible and exposing the sowbugs to the drying effects of the sun.

FISHES AS A POSSIBLE MEANS OF DESTROYING THIS ISOPOD.

In response to inquiry, the following information was received from the Bureau of Fisheries, through Mr. Lawrence O. Murray, Acting Secretary, Department of Commerce and Labor, in regard to the fishes which might be found useful in the destruction of this aquatic isopod in its occurrence on water cress:

Among the fishes which would probably prove most useful for this purpose and with which it is suggested that the Department may wish to experiment are the fresh-water killifishes *Fundulus notatus*, *F. diaphanus*, and *F. dispar*. The first occurs from Michigan to Alabama, Mississippi, and Texas, and is rather common in small lowland ponds. The second is found from Maine to North Carolina in river mouths, in the Great Lakes, and in practically all of the small lakes in the upper Mississippi Valley. The third occurs in smaller lakes and ponds from northern Ohio to Illinois and south to Mississippi. Specimens of each of these species could be obtained at any one of several small lakes in the northern part of Indiana.

It is probable that some of the catfishes might also be useful in this connection, and it is suggested that it might be worth while to try one or more of the small species known as "mad Toms," belonging to the genus *Schilbeodes*. One or more species of this genus can be found in almost any small, sluggish stream in Pennsylvania, Virginia, and West Virginia.

The writer believes that carp should prove of value in keeping down this cress sowbug, there being one drawback, however, that the carp must be watched to see that they do not develop too rapidly and that they do not attack the cress or make the water muddy. Catfish have been tried and found wanting in the case of the water-cress leaf-beetle, which will be considered elsewhere (pp. 16–20).

THE WATER-CRESS LEAF-BEETLE.

(*Phædon æruginosa* Suffr.)

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

INJURIOUS OCCURRENCE.

Among plant-feeding native insects which have recently appeared in new rôles is a little blackish leaf-beetle, *Phædon æruginosa* Suffr., which was reported for the first time as injurious to water cress (*Nasturtium officinale*) in Pennsylvania, in 1903.

During September Mrs. Hannah B. Hannum, Brandywine Summit, Pa., sent larvæ and adults of this species, with statement that they were devastating her water-cress pond. Both larvæ and beetles fed chiefly on the lower side of the leaves. In confinement they continued feeding, attacking the stalks also. The larvæ all reached development about the same time, being fully matured September 11 and 12, on the last of these two days crawling about the rearing jar and ceasing to feed. The pupal period was not observed, but it probably lasted ten days or a fortnight, as the weather was cool. The beetles continued for some time in our rearing cages, frequently pairing, but depositing no eggs.

August 19, 1904, Mrs. Hannum sent additional specimens of this species in the beetle and nearly grown larval stages. It was noticed that the beetles did not swim rapidly, but steadily, and they were seemingly not discomposed by being somewhat out of their natural element. It seems probable that they fly from plant to plant, and like most beetles undoubtedly are able to float for many hours, and perhaps even swim short distances until they reach a landing place. September 13 our correspondent sent still another lot of this species, mostly beetles, but a number of larvæ were included.

Specimens of the larvæ of a syrphus fly accompanied this sending and probably fed at times on the small larvæ of the beetle.

DESCRIPTIVE.

The beetle.—This species belongs to the tribe Chrysomelini of the family Chrysomelidæ. It is classified in our publications on the Coleoptera of America north of Mexico with Plagiodera, but European systematists place allied forms in the genus Phædon Latr., which now comprises seven species occurring in our country. They are very small semiglobose forms. The outline is oval, with the thorax narrowed anteriorly and the apex margined. The elytra have eight punctate striæ, with a short subsutural and submarginal row of punctures. The third joint of the tarsi is emarginate apically.

The present species measures a scant one-eighth of an inch in length (3 mm.), is shining bronzy black, and has the elytral intervals apparently smooth, but in reality faintly rugulose when highly magnified, while the thorax is microscopically reticulate. The original description appeared in 1858.[a]

The egg.—The eggs have not come under observation. They probably resemble those of the European *Ph. armoraciæ* L., described by Fryer as "elongated oval and of a dark orange color."

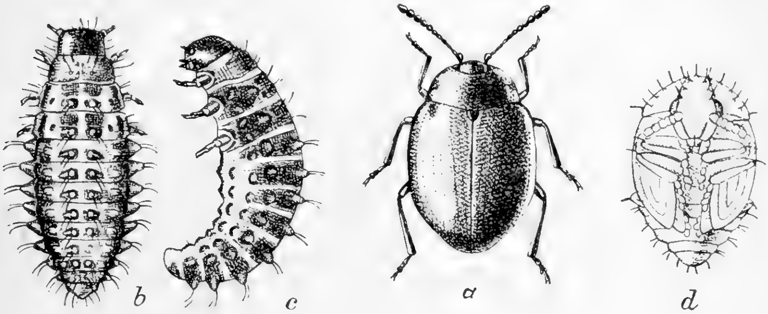


FIG. 5.—The water-cress leaf-beetle (*Phædon æruginosa*): *a*, adult; *b*, larva, from above; *c*, same, from side; *d*, pupa. Enlarged twelve times (original).

The larva.—The larva appears somewhat like that of a related genus, Galerucella, only that it is very much smaller. It is about three or four times as long as wide, depending upon whether it is somewhat contracted or fully extended. The head is subtruncate in front, with the antennæ lateral (in preserved specimens). The head is shining black, and the remainder of the body very dark brown or brownish black relieved by lighter areas between the segments. The first thoracic segment is a little wider than the head; the second considerably wider than that, and the third widest, being nearly as wide as the first two abdominal segments. The second abdominal is widest, and at the same time the widest part of the body. The surface is sparsely covered with long hairs placed on piliferous tubercles, which are arranged some distance apart, as shown in figure 5, *b*. The tubercles on the sides of the dorsum are sometimes very prominent, and the larva is able to extend these, possibly, at will. From the abdominal segments large tubercular sections bearing hairs at their summit extend on each side. The anal segment is pale, like the ventral surface, which bears dark piliferous tubercles. Length, 5 mm.; width, 1.2–1.5 mm.

[a] Ent. Zeitung, Stettin, Vol. XIX, pp. 395, 396, 1858.

The pupa.—The pupa is illustrated by figure 5, *d*, which will answer better than a verbal description. The color is yellow, and the length is slightly less than that of the adult.

The distribution of this species is probably moderately wide and additional study must be given this subject. At present we know of its occurrence in the District of Columbia, in Massachusetts, and probably in West Virginia.

LITERATURE.

Brief mention of the occurrence of this leaf-beetle as an enemy of water cress in Pennsylvania in 1903 was made by the writer,[a] but Mr. Frederick Knab, of this office, mentioning the same species as *Plagiodera viridis*, has recorded[b] its occurrence in great abundance upon water cress near Springfield, Mass., in 1902. The identity of the species in question has been verified by the comparison of specimens, and Mr. Knab's record was evidently made on the assumption of Crotch[c] that *æruginosa* was merely a variety of *viridis.*

HABITS OF THIS AND A RELATED SPECIES.

We can not at the present writing give an approximate statement of the life history of *Phædon æruginosa*, and hence must depend on what is known of the related *Ph. armoraciæ*, which is common to both continents.[d] This latter has evidently been introduced into this country, but its habits have apparently not been studied here. It is known in England as the blue beetle and mustard beetle,[e] and is of considerable importance locally, in some seasons ravaging entire fields of mustard, cress, cabbage, and kohlrabi. It passes the winter as adult, reappearing in spring on cruciferous plants. Fryer stated that in the three years prior to 1881 the Isle of Ely, England, suffered from the ravages of this species, entire fields being injured. Mustard was attacked at about the time of the formation of the seed pod and after the stalks were stripped nearly to the cuticle the beetles transferred their attention to kohlrabi, which they completely consumed, at first attacking the leaves and afterwards the bulbs, leaving nothing but bare stalks.

The water-cress leaf-beetle is doubtless no exception to the general rule among most Chrysomelidæ and other species of Phædon, in laying its eggs on the under side of the leaves. Both larvæ and

---

[a] Ybk. U. S. Dept. Agric. f. 1903 (1904), p. 564; [b] Entomological News, March, 1903, p. 89; [c] Crotch, Proc. Acad. Phila., 1873, pp. 54, 55; [d] *Phædon armoraciæ* L. syn.: *Plagiodera cochleariæ* Panz., Gyll.; *Phædon betulæ* Küst. It is not the same as *cochleariæ* Fab. [e] Fryer and others have given accounts of this species in The Entomologist (Vol. XIV, pp. 44, 187, etc.).

adults attack the cuticle of the stem after feeding on the leaves, as has been noticed in the case of *armoraciæ*. E. A. Fitch has observed the partiality of the latter for water cress and other crucifers which grow in watery places and mentions the destruction of an entire crop of horseradish.

Kaltenbach[a] records, according to Gyllenhall and his own observations, *Veronica beccabunga*, *Cardamine amara*, and *Cochlearia armoracia* or horseradish as food plants, and states that the larva undergoes metamorphosis in the earth, the pupa state lasting fourteen days. Cornelius[b] is cited as having observed two generations, the spring generation being found in May and June and the second in September. Thomas H. Hart records the water starwort of England (*Callitricha verna*) as another host plant. T. R. Billups,[c] an entomologist as well as truck grower, mentioning this species as *Phædon betulæ*, states that it is "one of the greatest insect pests the market gardeners around London have to contend with." Our American species undoubtedly hibernate as adults and appear in early spring under boards and similar shelter.

METHODS OF CONTROL.

How to successfully control this insect under ordinary conditions is quite a problem. Paris green was tried by our correspondent, mixed with flour and sprinkled over the plants when the dew was on, and this reduced the numbers of the insect somewhat. Owing to the moist condition of the plants, however, the flour formed a paste which stuck like glue, and it was therefore abandoned. Applied in water it rolled off the plants. We were not informed if this application was made with a spraying machine. If the plants were sprayed lightly with a fine spray, it might answer, or, better, Paris green dry with only 20 parts of flour, or plaster or air-slaked lime. An arsenical should not be used within about a week of the time of cutting the cress for market. In the case of Paris green there is practically no danger of poisoning even if it were used later, as the washing which is given the cress will carry away all perceptible traces of the poison.

If conditions should be such that the pond or stream in which water cress infested by this species is growing could be completely overflowed, it would cause the insects to rise to the surface, and in the case of running water would wash them downstream. Flooding alone might not entirely solve the problem, as these beetles are able to survive considerable immersion.

When the cress is grown in sufficiently large bodies of water ex-

[a] Pflanzenfeinde, p. 26; [b] Stett. Ent. Zeit., 1863, p. 123; [c] The Entomologist, Vol. XIV, 1881, p. 236.

periments should be made with some of the fish mentioned on page 15 as possibly useful for destroying cress insects. Ducks might also be found valuable. Catfish were tried, but without avail.

Mrs. Hannum has recently written that she attained the greatest success by growing the water cress in running water which carried the beetles away. In cold weather it was necessary to plant in houses where the cress did well until the coming of warm and dry weather, when the beetles would sometimes clean it out almost entirely, leaving only the roots. By tearing the cress out of the houses and in ponds which were not exposed to running water she could replant her beds, and hoped in time to get rid of the pest.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE CRANBERRY SPANWORM.

(*Cleora pampinaria* Guen.)

By F. H. Chittenden,

Entomologist in Charge of Breeding Experiments.

A brownish spanworm has been observed by the writer during recent years on asparagus in the District of Columbia in such numbers as to indicate that it is especially attached to this crop, at least in this region. In consideration of the fact that so few insects attack asparagus, the accompanying account has been prepared. The species appears to have attracted no attention since 1884,[7] [a] when it was considered in relation to its appearance in cranberry bogs. From material recently collected, several facts hitherto unrecorded have been gained, and there are a number of unpublished notes of the Bureau showing a tendency on the part of the species to become omnivorous. At any rate it is not confined to cranberry, as the name given above would imply, nor to strawberry, as might be inferred from another name, "brown strawberry spanworm," which has also been given it. The list of food plants which will presently be furnished shows a considerable range. Owing to the fact that the insect has not often been observed concentrated on any single crop, little mention of it has been made in literature by economic writers. Cranberry is a favorite food plant, and is sometimes injured to a considerable extent, especially in Massachusetts.

DESCRIPTIVE.

This insect belongs to the lepidopterous family Geometridæ, the larvæ of which are well known under the common names of spanworms, measuring-worms, inch-worms, and loopers.

The moth which produces this spanworm is quite variable in color and markings. The average expanse of wing is from a little less than an inch to upward of an inch and a fourth (22–32^{mm}), but may exceed this, attaining, according to Dr. A. S. Packard,[4] a measurement of an inch and a half. The ground color of living specimens is pale

[a] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 27.

leaden gray, and of old mounted material a duller gray, thickly diffused with black and brown dots and other markings more or less constant, forming irregular lines across both fore-wings and hind-wings. On both there is a marginal regular scalloped black line and within this a strongly dentate or zigzag white line. The general pattern of the wings varies considerably from that shown in figure 6, *a*, which represents the female. The color of the body is similar to that of the wings. The first abdominal segment is white above.

The sexes can be readily distinguished by the antennæ. Those of the female are filiform and tessellated and those of the male rather strongly pectinate, or feathered. The structure of the latter is shown at *e* and *f*, figure 6.

"It may be known," says Packard, "by the very distinct line at the base of the abdomen, the basal wing beyond being usually white, and the underside of the wings having a broad marginal shade, while the third line on the fore-wing is deeply but quite regularly sinuate and near the costa acutely dentate."

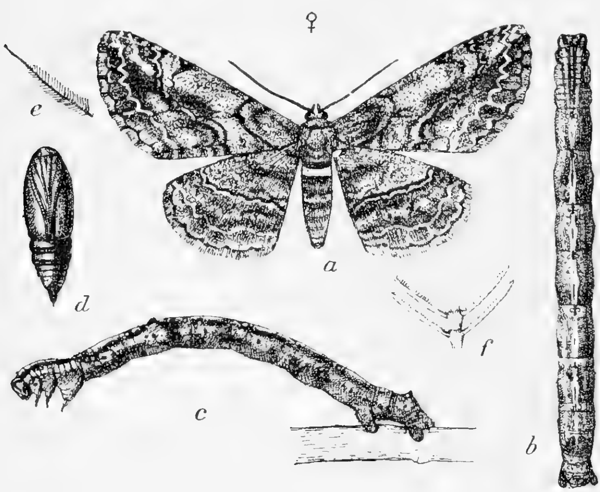


FIG. 6.—The cranberry spanworm (*Cleora pampinaria*): *a*, Female moth; *b*, larva, dorsal view; *c*, larva, lateral view; *d*, pupa; *e*, male antenna; *f*, enlarged joints of same. All enlarged; *e*, *f*, more enlarged (original).

A number of synonyms are credited to *Cleora pampinaria*. It has indeed received five specific names. As three of these were given by Guenée, it is of itself indicative of the variation of the moth. The list follows:

Boarmia sublunaria Gn., Spec. & Gen., IX, 248 (1857); *B. frugallaria* Gn., Spec. & Gen., IX, 246 (1857); *B. collecta* Wlk., Cat. Brit. Mus., XXI, p. 397 (1860); *Cleora tinctaria* Wlk., Cat. Brit. Mus., XXI, p. 486 (1860); *Boarmia fraudulentaria* Zeller, Verh. zool.-bot. Ges. Wien, XXII, p. 492 (1872); *Cymatophora pampinaria* Pack., Mon. Geom., p. 432 (1876).

The egg appears not to have been described.

The larva.—The larva resembles those of other geometrids in being of elongate form, about nine times as long as wide, with the three pairs of thoracic or front legs bunched closely together near the head, and in having only two pairs of prolegs, or unjointed legs, at the opposite extremity. The color varies to a considerable extent from mottled pale yellowish to brown, often with an olivaceous or greenish tint. Those which have been recently captured in the District of Columbia are reddish brown, mottled, streaked, and lined with lighter yellowish, red, and black. The head is strongly marked with transverse irregular black bands. The thoracic segments are marked above by a pair of thin median longitudinal lines. The second abdominal segment bears on the dorsal surface a pair of prominent, widely separated, mostly black tubercles, but in some individuals these are wanting. The penultimate segment also bears above a smaller pair of black tubercles. The larva when full grown measures an inch to upward of an inch and a fourth in length ($25–33^{mm}$) and the greatest diameter is about one-eighth of an inch (3^{mm}). The singular construction of the legs, or rather the lack of the intermediate legs usually present in caterpillars of other families, is the cause of the peculiar motions of the spanworms in crawling about in search of food, which have given them their popular names. When in motion a larva extends its body to full length, then brings the posterior legs close to the anterior ones, causing the body to loop in the center. The body is then stretched out again, these actions being repeated alternately.

When this spanworm is in repose it attaches itself to the foliage—for example, to the stem of asparagus—by means of its anal pair of legs and stretches out its body rigidly and at an angle so that its natural colors harmonize with the foliage or with the landscape. On this head Doctor Smith has remarked that on a section of cranberry bog on which this species is feeding the observer may stand in the midst of thousands of them and see none until something starts them into motion. Then it appears almost as though the entire bog were alive. As the spawnworms hang somewhat tenaciously to their food plants, they are undoubtedly present frequently in numbers without anyone being the wiser.

The half-grown larva is described by Doctor Forbes.[s]

The pupa, shown, ventral view, in figure 6 at *d*, is of robust form, light greenish brown in color, and a little less than half an inch in length (12^{mm}) and about a third of that (4^{mm}) in width.

DISTRIBUTION.

The wide distribution of this insect is shown by the following list of localities, based upon Doctor Packard's list, where the authorities for each locality are given: Maine; Amherst, Cape Cod, Cotuit, Natick, Mass.; West Farms, Center, Albany, and Brewster, N. Y.; Philadelphia, Pa.; Lansing, Mich.; Dayton, Ohio (Pilate); Glencoe, Nebr.; Cadet, Mo.; Centralia and elsewhere in Illinois; Washington and Brookland, D. C.; Georgia; Calhoun, Dawson, and De-mopolis, Ala.; Lake Bearsford, Florida; Bastrop County and elsewhere in Texas.

The above localities indicate a distribution ranging from the transition life zone through the upper to the lower austral. The occurrence of the species in Florida, Alabama, and Texas would indicate that it is to be found throughout the Gulf region. The insects observed by Glover were stated to appear in the Carolinas, Georgia, and Florida in early October.

BIOLOGIC LITERATURE.

The spanworm under consideration was described under the name of *Boarmia pampinaria* by Guenée in 1857.[2] In 1876 Dr. A. S. Packard gave a detailed description of the moth, with a consideration of its distribution and remarks on the larva and pupa, the former being stated to feed on pear.[10] In 1881 Dr. G. H. French[6] had a note on the larva observed feeding on willow and geranium; larvæ transformed to pupæ September 16 and October 2, and the imagoes issued April 17 of the following year. During the year 1883 this species was observed by Dr. J. B. Smith,[7] then a temporary agent of this office, doing injury at Cotuit, Mass. During that year the spanworms were so abundant in the cranberry bogs in that vicinity that their numbers could be compared only to the army worm (*Heliophila unipuncta* Haw.). In the case in question they began in a space about a rod square, devoured that, and spread in a direct line across the bog. The number of moths that would have been produced from these insects should they have been permitted to transform was described as being "frightful." A rather full account by Dr. S. A. Forbes followed in 1884,[8] in which the statement was made that the larva was found in midsummer feeding on leaves of strawberry in southern Illinois. Larvæ obtained August 1 pupated on the 11th, and the moths emerged on the 22d, giving eleven days as the pupal stage at that season. Larvæ collected September 6, about half grown, were believed to represent a second generation. The larva of this species came under the observation of the writer on asparagus first in 1897.[11] In 1899 Doctor Lugger[12] stated that the caterpillars were found on apple and blackberry, and that there were at least two generations annually.

As this is one of the commonest species of its genus, of wide distribution, and authentically determined as living on cotton, there seems little doubt that it was the type of Glover's account of "the larger spanworm," figured and described in his accounts of insects frequenting the cotton plant, published in 1856[1] and again in 1878.[5] A curious blunder was made by M. D. Landon, who figured this species as the "cotton caterpillar (*Noctua xylina*)" in 1865,[3] this illustration being a crude copy taken from Glover's first or 1856 account of this spanworm.

UNPUBLISHED OFFICE NOTES.

June 5, 1879, we received from Mr. William Trelease, then at Dawson, Ala., larvæ found feeding on cotton. June 12 a larva kept under observation changed to pupa, and on June 26 the moth issued, this individual having passed 14 days as pupa. The same year the moth was reared on several occasions from material obtained on red clover in the District of Columbia by Messrs. Pergande and Howard. June 28 the moth issued from the pupa. August 15 the larva was observed feeding; changed to pupa August 25, and issued as moth March 1 of the following year. August 29 the larva was observed feeding; changed to pupa September 4, the moth issuing March 22 of the next year.

February 6, 1880, we received from Lake Bearsford, Fla., from Prof. J. H. Comstock, a larva obtained on orange.

There are also reared specimens of moths in the U. S. National Museum bearing labels showing the rearing of moths and occurrence of larvæ on different plants, as follows: On locust, May 6, 1893, District of Columbia; hickory, November 24, 1894, Cadet, Mo., and August 4 of the same year on pear, locality presumably the District of Columbia. There is also a specimen labeled "on guava," probably from Florida.

August 6, 1904, specimens of this spanworm were received from Calhoun, Ala., where they were found feeding on cotton and were mistaken for the cotton leaf-worm (*Alabama argillacea* Hbn.). The adult issued August 29. Larvæ were about full-grown when received, August 9, and it seems probable that they underwent a short stage of æstivation before transforming to pupæ, as the pupal stage is less than 20 days in midsummer.

During the first two weeks of October for several years larvæ have been observed on asparagus grown in the District of Columbia, the species appearing in moderate numbers. The first moth that has been reared from October-collected larvæ appeared in January, and others appeared in February. As this was in confinement the dates were not natural ones.

LIST OF FOOD PLANTS.

It is, as previously remarked, owing to the omnivorous habit of this species, causing a distribution of attack, that noticeable injury has not been ascribed to it elsewhere than in cranberry bogs. It is common enough in the vegetable and truck garden, but not confined to any particular place on the farm, occurring in orchards, on forest and shade trees, and on other plants. The list of observed food plants includes asparagus, strawberry, blackberry, ornamental geranium, apple, pear, orange, willow, hickory, cranberry, honey locust, cotton, clover, and guava. As a rule the larvæ confine themselves to the foliage of these plants, but Glover states that they sometimes feed upon the petals of the flowers of cotton, although doing little harm to the general crop.

THE INSECT'S LIFE HISTORY.

Our knowledge of the life history of this species is somewhat incomplete. The repeated rearing of moths in early spring and the occurrence of larvæ in the latter part of June in Massachusetts as recorded by Smith, as also in the District of Columbia and elsewhere as late as October, noted by the writer and others, show at least two generations in the Northern States, while the record of the occurrence of the moths in March in Texas (by Belfrage) would indicate that in the Gulf States there may be an additional generation. It would seem practically impossible for larvæ hatching from eggs deposited in early spring to require until late October to attain maturity, hence the natural inference of two generations for a climate like the District of Columbia. The cranberry growers of Massachusetts claim two generations for that State, one appearing as larvæ in June and early July, the other in the latter part of August.

The eggs are unknown, and the periods of egg and larva have not been ascertained, but the pupal condition has been observed to be passed, for the first generation, in from 11 to 14 days, while the over-wintering pupa consumes five or six months in the District of Columbia, a shorter time farther south, and a longer time northward.

The date of the appearance in the North of the first moths has not been learned positively nor the natural time of emergence of the first new generation of moths.

NATURAL ENEMIES.

Doctor Smith[7] has stated that the larvæ of this spanworm are checked by parasites, but that in some localities almost every year they become numerous enough to be destructive. In some years, however, in the cranberry bogs of New Jersey they are not seen at all, showing great scarcity, due probably in part, at least, to natural causes. Only one parasite for this species is known, namely, *Exorista boarmiæ* Coq., a tachina fly reared at this Department from Cotuit and other localities in Massachusetts several years ago.

REMEDIES.

This species is not difficult to control on asparagus or other truck crops. As it feeds in free exposure on the foliage, spraying with Paris green or arsenate of lead will destroy it, and when either of these insecticides is used for the asparagus beetles it will kill all of the spanworms which may be present. The Paris green may be used at the rate of 1 pound to about 100 to 150 gallons of water, and the arsenate of lead at the rate of about 1 pound to 25 to 50 gallons of water. The same remedies will apply equally well to the occurrence of this species in cranberry bogs.

BIBLIOGRAPHY.

1. GLOVER, TOWNEND. Report Commissioner Patents, p. 92, Plate VIII, fig. 4, 1855 (1856).

   Probably this species. Appears in Carolinas, Georgia, and Florida early in October and feeds upon the petals of the cotton flower; larva and adult described and figured.

2. GUENÉE, M. A. Species Géneral des Lépidoptères, Vol. IX, Phalénites, pp. 245, 246, 248, 1857.

   Original description as *Boarmia pampinaria* from near Baltimore, as *B. frugallaria* from Georgia, and as *B. sublunaria* from North America.

3. LANDON, M. D. Rept. Comm. Agr. f. 1864 (1865), p. 90.

   Erroneously figured as the "cotton caterpillar (*Noctua xylina*)."

4. PACKARD, A. S. Report U. S. Geological Survey Terr., Hayden, Vol. X, pp. 432, 442, Plate XI, fig. 20, 1876.

   Technical and detailed description of moth; synonymy; distribution and note on larva and pupa, the former feeding on pear.

5. GLOVER, TOWNEND. Cotton and its principal injurious insects < Washington, D. C., Plate VII, figs. 6, 7, 8, 1878.

   Figures larva, chrysalis, and moth; found early in October in Georgia feeding on flowers of the cotton plant.

6. FRENCH, G. H. Papilio, Vol. I, p. 82, 1881.

   Notes on larva found feeding on willow and geranium.

7. SMITH, J. B. Bul. 4 (o. s.), Div. Ent., U. S. Dept. Agr., pp. 26–28, 1884.

   A two-page account in reference to injuries to cranberries; description of larva; referred to as *Cymatophora pampinaria*; remedies.

8. FORBES, S. A. Thirteenth Rept. State Entomologist Illinois, pp. 76–78, 1883 (1884).

   A rather full account. Larva found frequently in midsummer in southern Illinois feeding on leaves of strawberry; description of larva, pupa, and imago (quoted from Packard).

9. FORBES, S. A. Trans. Miss. Valley Hort. Soc., Vol. II, p. 235, 1884.

   Quotations of first two paragraphs of No. 8.

10. PACKARD, A. S. Fifth Report U. S. Ent. Commission, p. 654, 1890.

    Included in a list of insects affecting honey locust (*Gleditschia triacanthos*).

11. CHITTENDEN, F. H. Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 61, 1898.

    An unknown geometrid larva feeding on asparagus; subsequently ascertained to be this species.

12. LUGGER, OTTO. Fourth Rept. Entomologist State Exp. Station Minn., pp. 187, 188, fig. 188, 1898 (1899).

    Notes on the moth; caterpillar found on the apple and blackberry. Short general account.

13. SMITH, J. B. Farmers' Bulletin 178, U. S. Dept. Agriculture, pp. 19–21, 1903.

    Account of injuries to cranberry, life history, and remedial measures.

THE STRIPED GARDEN CATERPILLAR.

(*Mamestra legitima* Grote.)

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

A strikingly beautiful black and yellow striped caterpillar is frequently found in gardens, and occasionally in such numbers as to attract attention. It is a general feeder, like most of its kind, but is somewhat partial to asparagus, cruciferous plants, peas, and other leguminous vegetables. Its occurrence in the District of Columbia in some numbers, especially on asparagus, has permitted a study of the species, which adds somewhat to what has previously been published. Only a few short notices of this insect have appeared in publications of the Department of Agriculture or elsewhere, to the writer's knowledge. The following somewhat brief account is therefore presented.

This species is a noctuid, related to the cutworms, and is congeneric with the zebra caterpillar (*Mamestra picta* Harr.). The moth was originally described in 1864,[a] the species at that time being known from the middle and eastern States, where it was stated to be common. It is also recorded as occurring in the northern States. Evidently, considering its numbers in the Gulf region, it may be found in most States east of the Mississippi River Valley.

DESCRIPTIVE.

The moth is quite prettily marked, as can be seen by referring to figure 7, *a*. The prevailing tint of the fore-wings is a light lead color, marked with velvety-black and brown spots, the pattern varying somewhat but usually about as figured. The lower wings are fawn colored, with dusky margins, and the veins are moderately prominent. The females, as is usual with this group, have the abdomen as illustrated, while the males have abdomens with bushy tips. The wing expanse is a little more than an inch and a quarter.

The eggs.—No description of the egg is available at the present writing.

The larva is also a pretty form and its markings recall the zebra caterpillar. It will be noticed by the figure (fig. 7, *b*, *c*) that there is considerable difference, however, and the two species are not at all likely to be confused by anyone who carefully examines them. The present species has a larger and wider head and is darker than is usual with the common zebra caterpillar. The appearance of the head from in front is shown at *d*. The stripes with which the body is

---

[a] *Apamea legitima*, Proc. Ent. Soc. Phila., Vol. III, p. 82.

ornamented are black and yellow, as with the zebra caterpillar, but the lateral stripe is divided into two portions, the upper one lighter than the lower, and the entire lateral surface when marked consists of regular stripes, whereas in the other species these stripes are broken up.

The pupa, when mature, is nearly black in color, and has the appearance illustrated (fig. 7, *e*). It measures about five-eighths of an inch in length, including the tips.

BIOLOGIC NOTES.

This species was briefly mentioned as having been found by the writer in the larval condition on asparagus at Marshall Hall, Md., in October, 1896.[a] At that time it was impossible to ascertain whether or not it bred from eggs deposited on this plant, but later observations conducted in company with Mr. F. C. Pratt during the first and second weeks of October show conclusively that such must be the case, as larvæ were found in the greatest abundance on three large patches of asparagus at Brookland, D. C. They usually occurred singly, but occasionally in pairs.

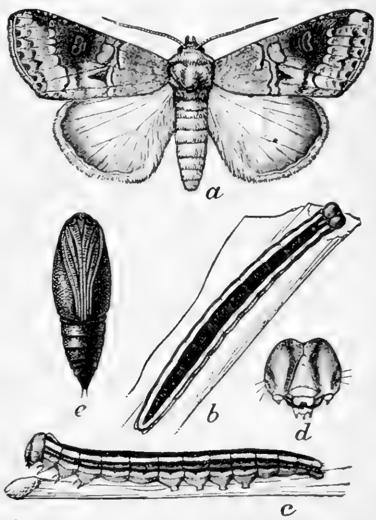


FIG. 7.—The striped garden caterpillar (*Mamestra legitima*): *a*, Adult; *b*, larva from above; *c*, same from side; *d*, head of same from front; *e*, pupa. All natural size except *d*, which is enlarged (from Howard).

During the heat of the day, in the moderately cool and seasonable Indian summer weather usual at Washington at that time of the year, many larvæ would be found stretched out upon dry sprigs of asparagus, and in spite of their bright colors they would easily have escaped the observation of anyone without experience in insect collecting. The larva, in fact, furnishes a good example of protective coloration. An individual would be in plain sight, and then if one's eyes were directed elsewhere for a moment it would sometimes be difficult to find it again, although it might be within a foot of the observer.

Larvæ obtained October 7 and later were kept feeding on asparagus in our rearing cages until the third week of October, when they descended to the earth and soon afterwards assumed the pupal condition. The exact date of the assumption of the chrysalis form was not ascer-

[a] Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 60.

tained, but it was about the 21st of October, which would give a period for the pupa of ten months, as the moths of this lot began issuing August 21.[a]

One individual transformed to pupa October 17 and the imago issued August 24 of the following year.

October 15, 1898, the larva was brought to the writer by Mr. P. H. Dorsett, from his greenhouse at Garrett Park, Md., where the species was feeding on the foliage of violet. The same year, November 3, this larva was found rather abundantly by Doctor Howard in tobacco fields in southern Virginia, near the North Carolina border line, upon the leaves, which in some cases were badly ragged.[b] The first moths issued in July.

During 1900 and 1901 correspondence was had in regard to this caterpillar with Mr. H. Walter McWilliams, Griffin, Ga., who sent specimens, as also larvæ of the so-called cotton cutworm (*Prodenia ornithogalli* Guen.), with which the insect was associated in both years. The caterpillars were noticed there in greatest numbers during November, and both species were reported as destroying a number of garden crops, among which were cabbage, collards, turnip, ruta-baga, rape, peas and related plants, as also some other vegetables. Mature larvæ were seen as late as the last week of November.

Among other office records are two which also have a bearing on the biology of this species. One of these was made by Mr. Theo. Pergande, who found the larvæ in the District of Columbia feeding on blackberry and on flowers of a goldenrod (*Solidago* sp.). The other is a short note by Mr. F. M. Webster upon the rearing of the moth in spring from the seed pods of milkweed (*Asclepias incarnata*), near Lafayette, Ind. "The larva appeared to subsist upon the seeds, the pods being attached unopened to the wrecked plant."[c]

October 21 the larva was found at Washington, D. C. We have no further records in regard to the habits of this species other than the capture of moths in the District of Columbia July 25, August 22 and 25, and September 2, and there are specimens also in the U. S. National Museum from Lewis County, N. Y., July 4, collected by O. Meske, and others from New Jersey without definite locality. The species is also said to occur at Portland, Oregon. It is interesting to note that among these specimens are inflated larvæ and mounted heads labeled "pretty cutworm," which might be termed a manu-

[a] The rearing jar was kept under somewhat unnatural conditions, at times too warm and dry, but the effect of one condition might have been counteracted by another, and the date of issuance of the adults was not far from that which would be assumed in nature—more likely earlier than otherwise.

[b] Yearbook U. S. Dept. Agric. for 1898, p. 142.

[c] Insect Life, Vol. II, p. 382, 1890.

script name, as I do not find this insect mentioned under this cognomen in print. With present knowledge of the species it can not properly be classified as a cutworm.

Among the files of the Department of Agriculture there are a few notes which are of interest as showing the cycle of periods from egg to about the last stage of the larva. These notes were made in 1882 by Mr. Albert Koebele, and the mounts which were made with them are not sufficiently fresh for description. From these notes the following is taken:

Moths collected at sirup, near the District of Columbia, September 16, were placed in a rearing jar with grass, where two batches of eggs were laid between 11 and 12 o'clock at night, one of these being deposited around the stem of grass.

September 18 the eggs hatched, showing the egg period to be only 2 days. On the 21st the larvæ had completed the first molt, making the first larval instar 3 days. September 23 the second molt was observed, which gives 2 days as the second larval instar. September 27 larvæ changed their third skin, leaving 5 days as the period of the third instar.

October 1 the fourth molt occurred, making 4 days for the fourth instar. By October 9 all the larvæ had changed the fifth skin, when they developed cannibalistic tendencies and were removed to a larger jar. The period of this instar was 8 days. The remaining larvæ refused to eat and finally died, so that the complete life cycle could not be ascertained.

NATURAL ENEMIES.

Soon after bringing larvæ in from the field some were noticed to be dying from fungous attack. In the asparagus fields *Estigmene (Leucarctia) acræa* Dru. and *Dissosteira carolina* L., the salt-marsh caterpillar and Carolina locust, respectively, were also dying in considerable numbers, and it was conjectured that the disease might have originated with these and spread to the Mamestras. After the diseased caterpillars had been frequently removed, however, the fungous attack abated. Specimens of infected larvæ were referred to the Bureau of Plant Industry, and the fungus was identified by Mrs. Flora W. Patterson, assistant pathologist, as an undescribed species of Verticillium. At another time larvæ which showed signs of disease after capture were examined by Mrs. Patterson, who recognized the presence of the fungus *Sporotrichum minimum* Speg. A larva, when placed with diseased insects, including some of its own species, did not contract the fungous disease, from which it seems probable that the disease is not readily communicable, and hence of no use as a possible means of destroying this species.

SUMMARY OF HABITS.

From present knowledge of the caterpillar two generations annually are indicated, although only one has been observed. Moths have been reared by the writer in July and August and they have been captured out of doors during the same months and in September. From available data it would appear that an average life history would be about as follows: Egg period, 3 to 5 days; first larval instar, 3 days; second larval instar, 2 days; third, 5 days; fourth, 4 days; fifth, 8 days, and pupal stage, 7 to 10 months. Hibernation occurs in the pupal stage.

The observed food plants include asparagus, cabbage, collards, turnip, ruta-baga, rape, peas and related plants, greenhouse violet, tobacco, grass, and blackberry. Of wild plants, golden-rod and milkweed have been observed, the larva attacking the flowers of the former and the seed pods of the latter.

METHODS OF CONTROL.

Although the early habits of this species as it occurs in the field have not been observed, there is no doubt that, like the zebra caterpillar, the young when first hatched are gregarious for some time, and hence may be easily discovered and destroyed by mechanical means or by arsenicals. All of the caterpillars of this class readily succumb to arsenical poisons, and for this species in its occurrence on asparagus and some other plants arsenate of lead is to be preferred. It may be used at the rate of about 1 pound combined with 15 to 25 gallons of water or Bordeaux mixture. If an adhesive resin soap, such as resin fish-oil soap, is added, it makes this mixture all the more permanent, and a single application is then all that is necessary. Paris green may be used in the same manner at the rate of 1 pound to 100 or 150 gallons of water. It is evident that this species, like the zebra caterpillar, does no particular harm as a rule in its first generation, but is much more abundant in the second or late fall generation, when certain plants are injured by it. Owing to the difficulty of locating the larger larvæ, it is evident that hand-picking would not be applicable for them in their later stages.

U. S. D. A., B. E. Bul. 66, Part IV. Issued January 27, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

By E. D. Ball, Ph. D.,
Special Field Agent.

INTRODUCTION.

Ever since the introduction of the sugar beet into the intermountain region more or less loss has resulted each season from a condition called "curly-leaf," or "blight." (See Pl. I, fig. 1, *j*; Pls. II, III; Pl. IV, fig. 1.) Around Grand Junction, Colo., the beet growers have suffered frequent losses from this source. Supt. George Austin, of the Utah Sugar Company, reported a serious loss around Lehi, Utah, in 1897. In 1903 the beet crop in Sevier County, Utah, was somewhat injured, the next year the damage was worse and more widespread, while in 1905 it extended throughout the State of Utah and the adjoining portions of Colorado and Idaho.

Until 1905 the condition had been looked upon as a result of some fungous or bacterial disease, or due to a soil or climatic condition. During that season it was noticed for the first time that a leafhopper (*Eutettix tenella* Baker) was present in large numbers in the fields where this damage was the worst, and the writer, in connection with his duties as entomologist of the Utah Agricultural Experiment Station, commenced an investigation of the insect and its relation to the damage. It was then too late to work out its life history, so most attention was paid to a study of its relation to the "curly-leaf" condition and to experiments with remedies. This investigation was continued in 1906 and 1907, in cooperation with the Bureau of Entomology, and the life history was worked out. Owing to the small number of insects appearing these two seasons, little more was done with remedies, but many new facts were learned in regard to methods of attack and the causes of the injury.

The writer's attention was first called to the "curly-leaf" in August, 1900, by Prof. F. H. Shaw, then chemist of the Grand Junction (Colo.) Sugar Factory. A careful examination was made at this time and again in succeeding years, but no explanation was found for this condition. These examinations were, however, always made late in the season after the curly-leaf character had become general and after the greater number of insects had disappeared. Examination of the beets always revealed a few specimens of *Eutettix tenella* along with other leafhoppers and miscellaneous insects, but never in sufficient number to cause suspicion.

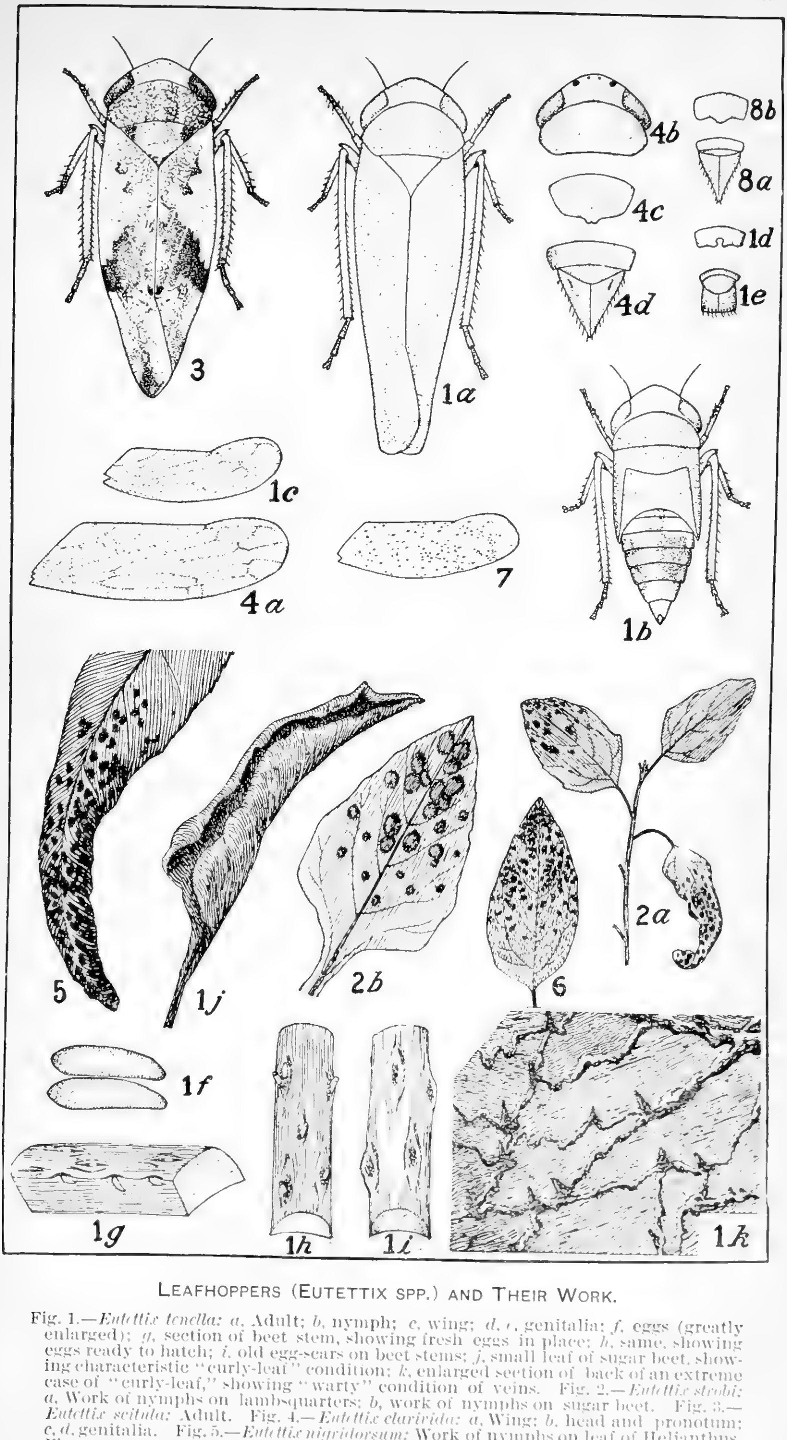
Late in June, 1905, reports began to come in to the Utah experiment station of the appearance of an insect in the beet fields of the southern and central portions of the State, and on July 8 the writer, in company with Mr. George Austin, visited the fields around Lehi and there found the beet leafhoppers, associated with smaller numbers of false chinch bugs (Nysius) and leafhoppers of the genus Agallia, causing serious damage to the young plants, especially in the late-planted fields.

From the size of the beets and the number of the beet leafhoppers present when first examined in 1905, the prediction was made that the insects would not be able seriously to retard the further growth of the beets. This prediction was based on the ordinary amount of damage done by insects of sucking habits. That the number of insects found would be able to injure or even seriously retard a very young beet was recognized, but that the same number could have any appreciable effect on large beets was contrary to all expectations based on a knowledge of similar attacks by Nysius, Agallia, and other sucking insects.

The trouble soon afterwards appeared in the Cache Valley, Utah, and was under observation there throughout the remainder of the season, while several trips were made to various parts of the State. Wherever it appeared it gradually grew worse, and although the year 1905 started with everything favorable in the early season, the Utah beet crop fell below the average about 75,000 tons. This, however, did not anywhere represent the entire loss, as both sugar content and purity of the beets harvested fell far below the average, entailing further loss to the sugar companies and bringing the total to more than half a million dollars.

In Sanpete and Sevier counties, in the southern part of Utah, a large part of the acreage was abandoned early in the season, while the rest barely paid the expense of harvesting. In Utah County the crop varied from a total loss on a few late fields to a full crop, with an average of more than a half crop harvested. In the Cache Valley, in the northern part of the State, the loss was about one-third in tonnage, and in Weber and Boxelder counties less than that.

In 1906 a very small number of leafhoppers appeared, and, as the season was cool, even where they were most abundant little damage was done. A careful study was made of the life history and distribution of the species, and a number of tests were made of its injury to the beets.



LEAFHOPPERS (EUTETTIX SPP.) AND THEIR WORK.

Fig. 1.—*Eutettix tenella:* *a*, Adult; *b*, nymph; *c*, wing; *d*, *e*, genitalia; *f*, eggs (greatly enlarged); *g*, section of beet stem, showing fresh eggs in place; *h*, same, showing eggs ready to hatch; *i*, old egg-scars on beet stems; *j*, small leaf of sugar beet, showing characteristic "curly-leaf" condition; *k*, enlarged section of back of an extreme case of "curly-leaf," showing "warty" condition of veins. Fig. 2.—*Eutettix strobi:* *a*, Work of nymphs on lambsquarters; *b*, work of nymphs on sugar beet. Fig. 3.—*Eutettix scitula:* Adult. Fig. 4.—*Eutettix clarivida:* *a*, Wing; *b*, head and pronotum; *c*, *d*, genitalia. Fig. 5.—*Eutettix nigridorsum:* Work of nymphs on leaf of Helianthus. Fig. 6.—*Eutettix straminea:* Work of nymphs on leaf of another Helianthus. Fig. 7.—*Eutettix insana:* Wing. Fig. 8.—*Eutettix stricta:* *a*, *b*, Genitalia. (Author's illustrations.)

THE BEET LEAFHOPPER.

(*Eutettix tenella* Baker.)

DESCRIPTIVE.

The adult (Pl. I, fig. 1, *a*) is a small, pale yellowish-green species, little larger than an Empoasca or Typhlocyba, with which it might easily be confused in the field were it not for the stouter build and greater activity. When fresh or when flying this leafhopper appears almost white, and for this reason it has often been called the "white fly." (Wing, Pl. I, fig. 1, *c*; genitalia, Pl. I, fig. 1, *d*, *e*.)

The eggs (Pl. I, fig. 1, *f*) are white, elongate, slightly curved and tapering at one end, and are thrust into the leaf stem in a slightly downward direction. At first they are scarcely visible (Pl. I, fig. 1, *g*), but as the stem grows they are pushed out with the opening up of the injured spot until at hatching time they are often half free (Pl. I, fig. 1, *h*). After the eggs hatch, the egg scars continue to enlarge and remain throughout the season as irregular, elongate, craterlike swellings (Pl. I, fig. 1, *i*). The eggs are deposited on all parts of the leaf stem, usually one in a place. In the cages they were often placed close together, very likely in this case by different insects, however, and a number were inserted into the midrib and secondary veinlets of the leaf and a few into the leaf margin near the base.

The nymphs (Pl. I, fig. 1, *b*) are very active, pale creamy white or variously colored forms. The commonest form is pale creamy in color with a brown saddle on the middle of the abdomen and various mottlings on the prothorax and wing-pads. Some have the same pattern with a reddish ground color, more are creamy yellow, and occasionally one is seen with a broad and somewhat irregular dark stripe down the back. When small the nymphs will be found most commonly down in the unfolding leaves at the center of the beet, but as they grow older they spread out over the plant.

FOOD PLANTS.

The original food plant of this species is still in doubt. In the spring it was found on greasewood (Sarcobatus), sea-blite (Dondia), several species of Atriplex, Russian thistle, and rarely on other plants of these two families occurring on the waste land. As these places dried up, most of the leafhoppers went to the sugar beets in the areas under observation. In one case, however, the species was found in some numbers on greasewood during egg-laying time, which would suggest this plant as its original host. Its known distribution is all within the area in which this plant is abundant.

DISTRIBUTION.

This leafhopper is apparently a native of the southwestern part of the United States. It has been collected from about the region of Denver, Colo., south along the edge of the mountains, through New Mexico, and west through Arizona, Utah, and southern Idaho to the coast in California and Oregon. Though confined to the mountain region, its distribution is restricted to the lower levels, and it is never taken on the mountains themselves. From this region it has not spread very far up to the present time. It was taken at Fort Collins and Lamar, Colo., in 1901—in one case 100 miles north of its known habitat, on wild plants, and in the other an equal distance east, but was rare in both situations. In Utah it has spread to the northern line of the State and into Idaho as far as that particular beet area has been extended, while it has not as yet been taken from the wild plants north of Ogden, Utah.

LIFE-HISTORY STUDIES.

Search was made for this species as soon as the growing season commenced in the spring of 1906, but no specimens were discovered in the Cache Valley, Utah, up to the time the beets came up. A trip to Sevier County, Utah, at the time the very earliest beets were just showing (April 22) failed to disclose a single individual, either in the beet fields or in waste places or hedgerows adjacent to the beet-growing districts. The first specimens discovered this season were found at Thompsons, Utah, May 3, feeding on Russian thistle, and a few days later the insect was found on the same plant and on an annual saltbush (Atriplex) at Grand Junction, Colo.

Beet fields were examined at Grand Junction, Colo., May 8, and in Utah at Lehi, May 9; Smithfield, May 12; Garland, May 13; Lehi, May 17; Corinne and Penrose, May 22; and Provo and Lehi, June 1, without finding a single leafhopper on any of them. The beets were not up at Lehi on May 9, nor at Smithfield, but the fields were examined carefully, especially where weeds were beginning to appear. Fields at Logan, Utah, were under observation during all this time and up to July 1, but no leafhoppers were found.

RECORD AT LEHI, UTAH.

On June 21 a field was examined at Lehi in which there was an average of one or two leafhoppers to a beet. They were all adults and two-thirds of them females. The beets in this field were from 6 to 10 inches across, and no sign of injury was observed. On examining the other fields in the valley a very much smaller number of leafhoppers was found. Some fields had one individual to 10 beets, while some had none at all. The average would not have been more than one leafhopper to 25 beets. They were most numerous on the higher, drier fields, and on the early beets. Two patches of very late beets close to the first one visited had no leafhoppers at this time.

Eight females from this field were dissected, and fully developed eggs were found in each one, 9 in one, 7 in another, and from 2 to 4 in each one of the others. Only large eggs could be seen with the lens used, and probably some of these were crushed while being removed. The fact that all females had fully developed eggs and that there were more females than males indicated that these adults had been out a long time and were not new ones of a brood that had just flown in from surrounding wild land.

On June 29 a few were found in the late beets, but no nymphs were found anywhere.

July 10 the adults were present in about the same numbers as before, the females still containing eggs, and a few very small nymphs were found.

July 23 the adults were slightly less numerous, and the nymphs from small to one-third grown and quite abundant. A few of them were nearly grown, but no fresh males could be found. More nymphs were found on the early beets, more "curly leaf" on the late ones.

August 3 the nymphs were mostly about two-thirds grown, some were small, and some full-grown. Large numbers of adults of the new brood were out, about half of the leafhoppers being adult at this time.

August 14 the adults were abundant. The leafhoppers were nearly all adults or large nymphs, but a few small nymphs were still to be found.

On August 29 the insects were mostly adult, males being still in the majority, but there was still quite a number of full-grown nymphs. Many females were dissected and a few found that had from 4 to 7 large eggs, but the rest had no sign of any. These few were probably the last remnant of the over-wintered brood of females.

September 12 the adults were still common and more males than females were taken by sweeping. Large nymphs were still present in small numbers. Ten females were dissected, but no eggs found, and the abdomens were all small. Evidently there was to be no egg laying for some time, probably not that season.

Note.—The season opened unusually late at Lehi in 1906, and these dates would be from one to two weeks late for an ordinary season.

RECORD AT MONROE, UTAH.

In Monroe, Sevier County, the season opened early, and the beets were nearly all planted in April. An examination April 22, as mentioned above, failed to discover a single leafhopper.

On June 26, on a second visit, nearly all the beets were in fine shape, with leaves touching in the rows, and only lacking a few inches of touching across rows. The leafhoppers were present in every patch, both adults and very small nymphs, and occasionally a larger nymph was seen. Mr. Fred Gould, field superintendent, said that he had observed the adults for some time. There were more leafhoppers on the older patches than on the late planted ones, indicating that they had migrated in before the younger beets were far enough advanced to attract them.

On July 25 the leafhoppers had increased in numbers, averaging from 10 to 20 to a beet on the earlier patches. Adult males were common, showing that the nymphs had commenced to change to adults again. All stages of nymphs were still common, however.

On September 14 the numbers of leafhoppers were beginning to decrease. Several countings gave an average of 7 males to 5 females and 5 large nymphs. The dissection of a number of females showed no eggs developed as yet, and there seemed little doubt that they would hibernate.

OTHER RECORDS IN UTAH.

A field belonging to a Mr. Irons at Moroni, Sanpete County, was visited June 27, and an average of one leafhopper to every two beets was found. Mr. Irons, who is a very careful observer, said that they had been there for some time. A careful search was made for the nymphs, but none was found. This was by far the worst infested field in the county, the average being less than one insect to ten beets.

July 26 adults and nymphs were about equally common, and few of either.

In the Cache Valley and the rest of the northern end of the State the leafhoppers did not appear in sufficient numbers to enable one to make any life-history notes. On this account all cage experiments were transferred to Lehi.

CAGE EXPERIMENTS, LEHI, UTAH.

The field observations on life history were all checked by cage experiments (Pl. IV, figs. 2, 3). Cages 1 to 3 were failures, through the adults escaping from the material used. Later a very fine silk scrim was used and proved satisfactory for the life-history work, but was too closely meshed to obtain normal temperature and moisture conditions inside. All cages were run in pairs on similar beets, one with insects and one without, as a check on the injury to the beet.

Cages 4 and 5 (glass globes upon beets about 8 inches in diameter).—On July 10, 16 adult leafhoppers, 12 of which were females, were introduced into cage 4. Previous dissections had shown that all females were bearing eggs, and the presence of a very few small nymphs in the field proved that the earliest ones began depositing eggs some time before. It was therefore expected that some of the females introduced would begin depositing at once.

On July 23 these cages were examined, and in the one containing the leafhoppers the stems were found to be fairly covered with egg scars. Two of the stems were removed and preserved, and found to contain 161 eggs—not more than one-sixth of the total number present. A number of females were seen in the cage, but no nymphs.

July 27 the stems showed still more egg scars, and there was quite a number of small nymphs that had apparently been out several days. The insects had been in the cage only seventeen days, so these eggs must have hatched within thirteen to fifteen days from the time of laying, under the conditions found in the cage. Another stem was removed and preserved, and the rest left as before.

On August 3 another stem was removed. The eggs had almost all hatched by this time. Some had dried up and a few were found just ready to hatch. A few were sticking out of the stalk and looked quite fresh, but were probably infertile. Some of the leaves had wilted and died, and the remainder were literally alive with small to half-grown nymphs, together with a few adults, no doubt the remaining parents.

These half-grown nymphs were no doubt those hatched between July 23 and 27, and would thus be between eight and eleven days old, roughly indicating a nymphal period of between sixteen and twenty-two days under these conditions.

On August 14 this cage was visited again, and the beet found dead and dry. From appearances it had been dead several days. The few leafhoppers that survived were adults and large nymphs. They were so few in number that it was impossible to tell whether they were the surviving parents or a new generation, so they were released.

Cages 6 and 7 (silk scrim 2 feet square).—On July 23, 18 nymphs varying between one-third and two-thirds grown were introduced into cage 6. These were intended to represent the larger ones found in the field at that date.

On July 27 no adults could be seen.

On August 3 most of the nymphs had changed to adults. This period of eleven days was, then, more than one-third and slightly less than two-thirds of the nymphal period. This gives about the same result as the test in cage 4.

Cages 8 and 9 (silk scrim with glass top).—On August 3, 40 leafhoppers were introduced into cage 8; of these 23 were females.

apparently all fresh, 10 were males, and 7 were large nymphs, the aim being to get as many of the earliest ones of the maturing brood as possible without introducing any belated ones of the parent brood. By this method it was hoped to get the succeeding brood, if there was to be one, as soon in the cages as it appeared in the field, and thus establish a minimum time between broods.

On August 14 this cage was examined, and all leafhoppers seen were adults. There were no signs of egg scars or of damage.

On August 30 but few leafhoppers could be seen, and no egg scars or damage.

On September 12 the leafhoppers were almost all gone, and no eggs had been laid, either in the cage or field, and dissection showed that the females had no visible eggs in the abdomen up to date. It was thought at this time that the adults would lay eggs in the fall and then die. Accordingly a new lot was started, as shown below.

Cages 10 and 11 (large lantern globes).—On August 30, 30 leafhoppers were introduced into No. 10, of which 12 were females. In No. 11 one female and several males were introduced. On September 12 no egg scars could be found in either cage.

Cages 13 and 14 (silk scrim with a glass top).—On September 12, 20 leafhoppers, nearly all of which were females, were placed in cage 13.

On October 20 the field of beets was harvested. The cages were removed and the beets labeled and sent on for examination. Each leaf and stem, and even the parts of the beet itself protruding from the ground, were examined carefully, but no sign of any egg scars could be found on these beets or on those from the previous cages. Many of the leafhoppers were alive at the time the cages were removed, and there seems to be no doubt that they must hibernate as adults.

SUMMARY OF LIFE HISTORY.

By the time the beets were thinned the leafhoppers began to appear in the fields and by the middle of June were well distributed. They gradually increased in numbers for some time after this. Egg laying began at Lehi, Utah, late in June and continued until late in August, each female depositing about 80 eggs, the period of deposition extending through several weeks, the greater number of the eggs, however, being deposited in the ten days preceding the middle of July. The nymphs appeared in small numbers by July 10, and were still to be found in small numbers in September. A great majority of them emerged from the eggs the last ten days in July and changed to adults some twenty days later. The first adults appeared from these nymphs the last of July and continued to increase in number through August. The egg stage in the cage experiments was between thirteen and fifteen days; the larval stage between sixteen and twenty-two days.

ECONOMIC RELATIONS.

The first fact observed in 1905 was that different fields were affected very differently, and much time was spent in studying conditions in an attempt to discover just what combination of factors was necessary to produce the "curly-leaf," so fatal to the beets. Even in the worst fields examined there would be here and there a beet that was apparently untouched and growing as usual, while in the best fields only here and there could an affected one be found.

As a result of the season's observations there seemed to be little question that the "curly-leaf" condition was the result of the attack of the leafhoppers combined with the effect of a very hot, early season.

In many places it was noticed that along the edges of the fields where the beets had any shade—such as would be furnished by a hedgerow, or even by a vigorous stand of sweet clover on a ditch bank—there would be a marked difference for the first few rows. In Sevier County, where many of even the early-planted fields were abandoned and where the rest averaged from 2 to 4 tons per acre, one field was seen that did not show much damage and yielded 12 tons per acre. This field had a block of tall poplar trees on the south and a row of equally tall ones on the west side. In other places it was observed that the fields that were the weediest had better beets than those that had been well cultivated. Under ordinary conditions the results in all these cases would have been just the reverse, and the only explanation that seemed plausible was that the shade of the trees and of the weeds kept the ground from becoming quite so hot and thus allowed the beets to overcome the effects of the leafhoppers. In ordinary practice the beets are not irrigated until they have made considerable growth; thus the taproot is forced to descend for water, and a long, symmetrical beet results, while if watered too soon the beets are short and sprangly. In one place, in 1905, it was found that the water had escaped from a ditch and irrigated one corner of a field much earlier than it had been applied to the rest, and this corner was the only place that was not seriously affected with the "curly-leaf." In another place the water supply failed just as they started to irrigate the field, and the remainder was not irrigated until a week later. The difference in the amount of "curly-leaf" on these beets showed plainly to the end of the season just how far the early water reached. At first these differences were attributed to the effect of the early water on the beet itself, but on further investigation a number of fields was found where subirrigation was depended upon entirely and where, ordinarily, fine beets were raised. In these fields the taproots of the beets were found to extend into a stratum of saturated soil and yet the beets were badly affected and continued to grow worse throughout the season. The only explanation found for that condition was that, while the beet had plenty of water, still the top soil was dry and dusty, and the ground was as hot as in an ordinary field, while in the fields that were irrigated early the evaporation from the moist surface kept the temperature down until the beets were large enough to shade the ground. This would also explain the fact that everywhere in the State, except in Sevier County, the late beets were affected much worse than the early ones. In other portions of the State the early beets were large enough to shade the ground in the rows by the time the hot weather and leafhoppers appeared. In Sevier County, on the other hand, the hot, dry weather came on earlier and the leafhoppers were so much more numerous that even the earliest beets could not withstand their attack when exposed to the full force of the sun.

The unusual numbers of the beet leafhopper were apparently largely the result of a winter and spring favorable for the preservation of insect life, as almost all injurious insects were present in increased numbers during that season (1905). The leafhoppers had, however, evidently been increasing for several years and had even before this reached destructive numbers in Sevier County, as the beet growers there had been suffering increasingly from what they called "blight" for two years previous to this, and this increase in the number of insects, followed by a winter favorable to their survival, resulted in the outbreak of 1905.

The leafhoppers were present in every field examined in Utah that season, and occurred in the greatest abundance in the areas in which the "curly-leaf" was worst. The average number of adults of the over-wintered brood to a beet varied from 3 or 4 up to 10 or 15, and probably even more than that in Sevier County, judging from the number found there later. No serious damage was done where there were only the smaller numbers, and even where the damage was worst it seemed to depend more upon how early they appeared and the temperature and moisture of the locality at that time than on the actual number above an average of possibly 5 or 6 to a beet. In 1906 they appeared in very small numbers. The field at Lehi, Utah, where the experiments were conducted, was by far the worst found, and here they averaged only about 1 or 2 to a beet, while the average of the valley would not have been more than 1 to every ten or fifteen beets, and the average of the State was even less.

A field in Boxelder County, Utah, was examined in August, 1905, in which the leafhoppers had recently appeared in large numbers, averaging 100 or even 200 in some places to the beet. The beets were large enough then to shade the ground, and the field was well irrigated from that time on. Almost no curling of the leaves could be found in this field, and in the fall the yield was nearly up to the average. This was the only field examined in which the leafhoppers did not appear until after the adults had hatched out. On the other hand, many fields were examined in which the leafhoppers had been present early in the season but had almost disappeared after the nymphs had matured, and yet in these fields the curling continued to develop throughout the season and the beets grew worse instead of recovering.

Spraying with kerosene emulsion was tried on a field in the Cache Valley, Utah, in 1905. This field contained numerous adults and nymphs in all stages. Four nozzles were used, each one set about 18 inches above the row and pointing obliquely down and forward, and just in front of them a bar drew the beet tops over and caused the leafhoppers to jump just as the spray struck them. An emulsion diluted with 15 parts of water had little effect on the adults, and only killed a few of the smaller nymphs. Most of the nymphs would kick about on the ground and some would become quite still, but a little later most of them would recover and hop away. An emulsion diluted with 8 parts of water produced the same effect on the adults that the weaker dilution did upon the nymphs, and killed the majority of the nymphs that it struck. Many of the latter would, however, escape the spray on account of the broad leaves of the beet, and the results were not considered entirely satisfactory.

In the cage experiments it was expected that the number of leafhoppers necessary to cause "curly-leaf" on different-sized beets would be ascertained, but owing to the fineness of the gauze necessary to hold them the temperature and moisture could not be controlled and no "curly-leaf" was produced.[a] The damp conditions of the cages also made it difficult to keep the insects for any length of time.

In one experiment 16 leafhoppers, 12 of which were females ready to deposit eggs, were placed on a beet with a top 8 inches in diameter

[a] This manuscript was originally prepared and submitted at the close of the season of 1906. Some revision was made to include the important facts of the work of 1907, but the main discussions, including the above paragraph, were written in 1906. Since that writing "curly-leaf" has appeared in cages arranged by Prof. E. G. Titus in joint investigations with the writer. Mr. H. B. Shaw, assistant to Dr. C. O. Townsend, in charge of Sugar Beet Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, has also succeeded in producing "curly-leaf" under experimental conditions. He writes me under date of October 23, 1908, that curly top or "curly-leaf" appeared in the cages on the experimental plat at Garland, Utah, in which he introduced the beet leafhoppers, and that later he sent a number of leafhoppers to the office of Sugar Beet Investigations, Bureau of Plant Industry, where 6 of them were placed in a cage with 11 young beets, 9 of which showed distinct symptoms of "curly-leaf" within five weeks after the insects were introduced.

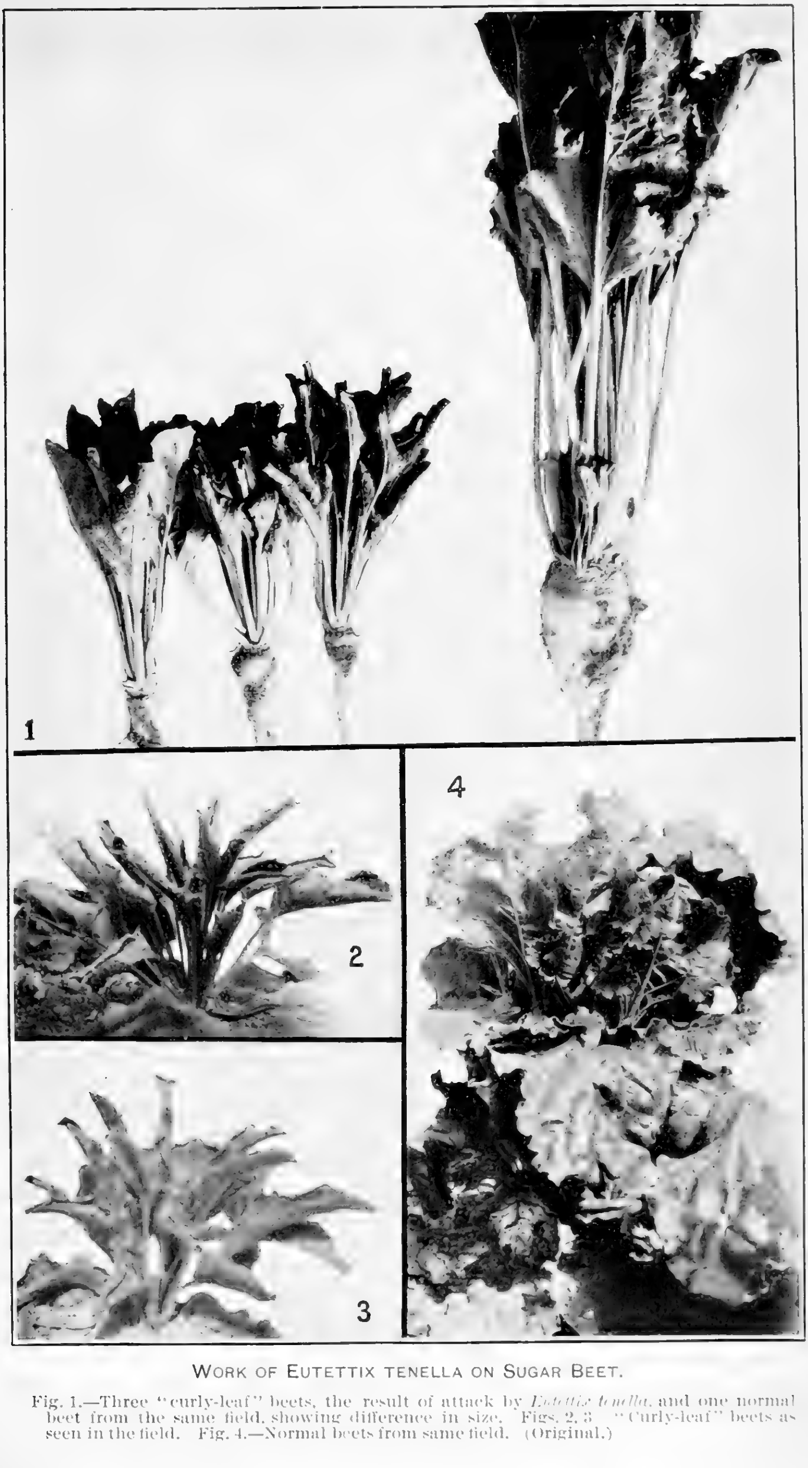
and consisting of a dozen or more leaves. Over another beet of the same size a check cage was placed. Seventeen days later the eggs had just begun to hatch, and already the beet in the cage without any hoppers was nearly twice the size of the first one. The beet on which were the leafhoppers continued to grow for a week or more, then practically stood still, and on the seventeenth day it was apparently smaller than when examined five days before. Seven days later a large number of nymphs had hatched out, the outer leaves were dead, and the rest looking sickly; ten days later than this the cage was examined again and the beet was dead and dry, while the beet in the check cage had again doubled in size. Twelve leafhoppers and their eggs stopped the growth of a beet in less than two weeks, and they, together with their progeny, killed it in less than two weeks more. The same number of adult specimens of Agallia, Nysius, or Empoasca would scarcely have made an impression on a beet of that size.

CHARACTERISTICS OF "CURLY-LEAF."

The first symptom of "curly-leaf" or "blight" of the beet is a thickening of all the smaller veinlets of the leaf, giving it a roughened appearance on the underside. This is followed by a curling of the edge (Pl. III, fig. 1) and a final rolling up of the leaf (Pl. I, fig. 1, *j;* Pl. II, figs. 2, 3; Pl. III, fig. 2), the upper surface always being rolled in. As this progresses the small veinlets grow still larger and more irregular, knotlike swellings appear at frequent intervals (Pl. III, fig. 2), and in extreme cases little nipplelike swellings appear, extending to a height of nearly one-fourth of an inch (Pl. I, fig. 1, *k*). This will be noticed first upon a medium-sized leaf, gradually spreading to the younger ones, while at the same time the beet almost stops growing and a large number of fibrous roots are sent out (Pl. II, fig. 1). These roots are not confined to two irregular lines as in a healthy beet. The beet often continues in this way throughout the season, in bad cases it shrivels and dies, while in a few instances there is a partial recovery and a new set of leaves, though the sugar content remains very low.

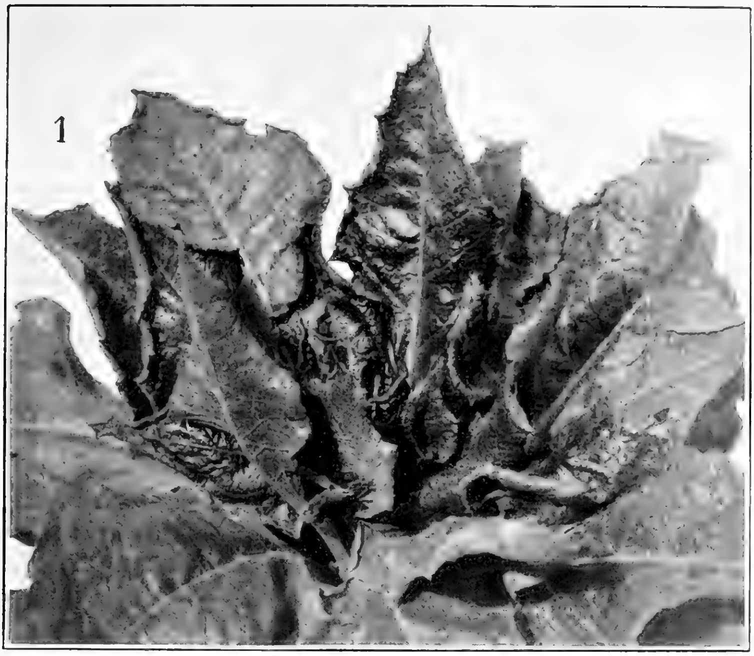
Many of the species of this genus of leafhoppers produce a discoloration or distortion of the leaves of their food plant. This appears to be of the same nature as the work of the gall-forming species, and is a process little understood. The wrinkling and folding of the leaves by some of the species is very similar in appearance to the work of some gall-forming aphides. Some species also produce a change in color similar to that produced in many galls.

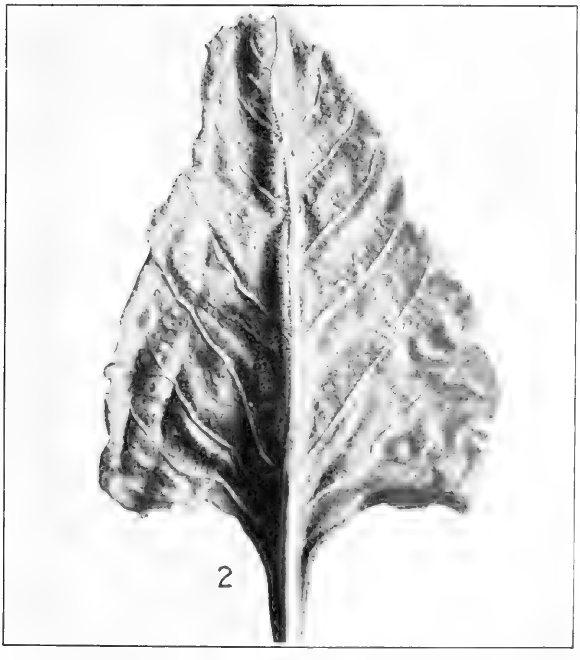
In the case of *Eutettix strobi* (Pl. I, fig. 2 *a*, *b*) and *E. scitula* on the Chenopodium or on the sugar beet and of *E. nigridorsum* and *E. straminea* (Pl. I, fig. 6) on the Helianthus the discoloration appears as



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—Three "curly-leaf" beets, the result of attack by *Eutettix tenella*, and one normal beet from the same field, showing difference in size. Figs. 2, 3.—"Curly-leaf" beets as seen in the field. Fig. 4.—Normal beets from same field. (Original.)





WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A large beet becoming "curly." Fig. 2.—Back of a leaf affected by "curly-leaf," showing "warty" condition and curled edges. (Original.)

soon as the little nymphs begin to feed, and this is soon followed by the distortion of the leaf in a certain definite way in each case. That this is not caused by the mechanical injury of the puncture or due alone to the loss of sap seems to be abundantly proved by the fact that the Chenopodium is often attacked by other sucking insects in much larger numbers without producing either the red pigment or the gall-like distortion. The fact that a certain characteristic color and appearance are always produced by a given species, no matter whether on a Chenopodium or on a sugar beet, and that the color and form vary for the different species of the same genus even when working on the same plant, would indicate that there is some definite agency back of it all. It has also been noticed that in all this group the greatest amount of damage is done in hot, dry situations.

Whether or not the "curly-leaf" condition is entirely the result of the change in the beet caused by the attack of the beet leafhopper is still an open question, but that there is some relationship between the leafhopper attack and the "curly-leaf" does not seem to admit of a doubt in the light of the facts brought out in the investigations. The amount of damage in a given valley was directly proportional to the number of leafhoppers present, the injury appeared only after the appearance of the leafhoppers, and the "curly-leaf" condition is known to occur only on beets growing within the range of this insect.

Attention was not called to the damage early enough in 1905 to ascertain whether or not the "curly-leaf" appeared before the first appearance of the nymphs. At Lehi, Utah, the "curly-leaf" appeared very soon after the first nymphs. In the Cache Valley, Utah, the nymphs were common by the time the first curling was noticed. In 1906 very careful watch was kept in all parts of the State for the very first sign of leaf-curl, and in no case did it appear (except on the mother beets) until after the nymphs began to hatch out. In fact, in almost every case examined the cast skins of nymphs could be found on the back of curled leaves, while on healthy beets these were very seldom found. In all observations of both years more leafhoppers were found on the curled beets than on others. At first this was thought to show a gregarious habit in the adult, but it may be due to the fact that a given female lays most of her eggs on a single plant and the nymphs tend to remain there. In *Eutettix strobi* and the other leaf-curling forms, where the nymphs are brightly colored and depend on their discolored spots for protection, it is not unusual for a given nymph to pass its whole life on a single leaf, or on two or three adjoining ones; in most cases but a single nymph will be found on a plant, and sometimes the adult and the nymphal skin of each stage may be found under a single leaf. It is very likely that the same habit persists in *Eutettix tenella* and that this fact, in part at least, accounts for one beet being badly affected while the adjacent ones are unharmed. In the case of *Eutettix strobi* and its allies, where most of the leaves of a small plant are affected by the distortion, the plant usually shrivels up and dies, but where only one or two leaves on a large plant are distorted the plant does not appear to be affected at all, and in no case does the color appear in any of the new leaves. In several cases small beets have been seen in which every leaf has been deformed by the work of *strobi*, and they had apparently stopped growing.

In the case of the "curly-leaf," however, the abnormal condition apparently spreads from leaf to leaf until finally the whole plant is affected, even though the leafhoppers may have disappeared before the process is complete. This was abundantly demonstrated by the mother beets set out in the spring of 1906. These beets were selected from the best-looking beets of 1905, and would naturally have been ones that showed little or no effect of the "curly-leaf" the season before. In every case observed the first leaves sent up by these beets were as curly as the average of the year before, and most of them formed stunted lettucelike heads, and later withered and died. Some, however, survived through the season, and a few sent up stunted blossom stalks, but as a seed crop they were an entire failure. This curling took place before any leafhoppers were found in the beets, and in rows adjoining young beets that were not at all affected and did not become affected during the season. This would indicate that the agency, whatever it may be, that causes "curly-leaf" remained in the beet itself over winter and was transmitted to the first leaves in the spring.

In early September, 1907, the sugar-beet region around Spreckels, Cal., was visited by the writer and a number of cases of what was commonly called "blight" or "curly-leaf" were examined. These, however, proved to be quite different in character from the "curly-leaf" condition caused by *Eutettix tenella.* The leaves of the beet were found to be covered with pale spots, the edges were turned down instead of up, and the whole appearance was quite different. A careful search was made over many acres for specimens of *tenella*, but none was found; instead a species of Empoasca was always found associated with this appearance of the beets. The matter will be discussed further in connection with that species (p. 51).

OTHER RECORDS.

Prof. E. G. Titus reports that on a trip through the sugar-beet regions of the West in September, 1904, he found *Eutettix tenella* at La Grande and Echo, Oreg. At La Grande little damage was done, while at Echo one field of 10 acres was so seriously injured by what

WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A field of beets destroyed by "curly-leaf." Figs. 2, 3.—Cages used in the life-history experiments. (Original.)

was then called "blight" that it was not harvested. Many of the beets had died and the rest were small and stunted, while the leafhoppers could be swept up in numbers.

In California "curly-leaf" conditions were seen by Professor Titus at Oxnard and Spreckels and reported to be quite serious on the higher lands back of Salinas. Whether this was the true "curly-leaf" or the type found there this year was not determined.

In August, 1907, another trip was made by him through the same territory and a few specimens of *Eutettix tenella* taken at Payette, Idaho. Little damage was being done that season, but field men reported considerable loss in 1905 in both Payette and Blackfoot, Idaho. A few *E. tenella* were taken at Union, Oreg., and Echo, Oreg., in August, 1907, only slight damage showing in either place. Large nymphs were taken with the adults.

In California a number of places were visited by Professor Titus in August, 1907, but no specimens of Eutettix taken. In September another trip through the California districts was made, and a few specimens of *E. tenella* were taken at Chino on the 13th. No very definite cases of "curly-leaf" were noticed.

ECONOMIC SUMMARY AND PROPOSED REMEDIES.

The "curly-leaf" condition or "blight" of the sugar beet, as it occurs in Utah and the surrounding region, appears soon after an attack of the beet leafhopper (*Eutettix tenella* Baker). Its severity is conditional upon the number of insects present, upon the time of their appearance, upon the size of the beets, and upon the temperature of the surface soil, together with the temperature and moisture of the surrounding air.

More should be known about the places of hibernation and early spring history of this insect. It could not be found in the rubbish around the fields in early spring, and only a few specimens were found in waste places up to the time they appeared on the beets. When once the place where the greater number of them pass the winter is discovered, it may be possible to destroy them there or on their spring food plants before they migrate to the beets. After they have appeared on the beets it will be necessary to be very prompt in the matter of remedies if the injury is to be prevented. A thorough spraying with kerosene emulsion at a strength of 1 part of the stock solution [a] to 5 parts of water would destroy most of the insects that it hit, and by using a drag in front of the nozzles to turn the leaves over and cause the insects to jump, most of them could be reached. Where the insects

[a] For directions regarding the preparation and use of kerosene emulsion see Farmers' Bulletin 127, U. S. Dept. of Agriculture, pp. 20–21, and Circular 80, Bureau of Entomology.

were coming in in numbers this spray would need to be followed by a second one 10 days later.

Several mechanical devices have been used to catch different leafhoppers, and no doubt several of these could be used against this insect with advantage. The tar pan, or "hopper-dozer," drawn over the beets two or three times in the first few weeks would capture a large number of them. The females, before the eggs are laid, are quite heavy and do not jump or fly as readily as the males and would be easily caught. A modified form of this machine, consisting of a couple of tarred wings to be drawn along on each side of a row of beets, while a drag agitated the tops and caused the insects to fly, would probably capture more than the simpler tar-pan.

If the insects appeared while the beets were quite small, they could be largely destroyed by rolling when the weather was cold or damp and the insects sluggish.

A number of preventive measures may be used to assist the beets in withstanding the attack of the leafhoppers. In some sections early planting will produce beets large enough to shade the ground by the time the beet leafhoppers appear, and thus reduce the temperature below the danger line. In a few places, like the Grand Junction district in Colorado and Sevier County in Utah, early planting alone would not avail, as the insects appear soon after the earliest beets come through the ground. For such sections early and frequent irrigations would assist in keeping the ground cool until the beets grew large enough to shade it and thus take care of themselves.

All preventive measures will depend for success upon some method of controlling the temperature in the field so that the ground may not be hot and dry at the time the leafhoppers appear.

BIBLIOGRAPHICAL REFERENCES.

1895. Gillette, C. P., and C. F. Baker.—A preliminary list of the Hemiptera of Colorado. <Bul. 31, Colo. Agric. Exp. Sta., p. 100.
On sugar beets in Colorado. Mention as *Thamnotettix tenellus* Uhl. MSS.

1896. Baker, C. F.—New Hemiptera. <Psyche, Vol. VII, Suppl., p. 24.
Species described from New Mexico as *Thamnotettix tenellus* n. sp.

1900. Forbes, S. A., and C. A. Hart.—The economic entomology of the sugar beet. <Bul. 60, Ill. Agric. Exp. Sta., pp. 423, 523.
On sugar beets in Colorado. Mention as *Eutettix tenella* Bak.

1903. Chittenden, F. H.—Yearbook U. S. Dept. Agric. f. 1902, p. 730, 1903.
Mention. "Reported as injurious to sugar beet in Arizona."

1906. Howard, L. O.—Yearbook U. S. Dept. Agric. f. 1905, p. 630, 1906.
Injury in Utah. Mention as *Eutettix stricta* Ball.

1907. Ball, E. D.—Report of the entomologist. <16th Rept. Utah Agric. Exp. Sta., p. 16.
Character of injury and damages in 1905. Mention as *Eutettix tenella* Bak.

1907. Ball, E. D.—The genus Eutettix. <Proc. Davenport Acad. Sci., Vol. VII, pp. 27–94, Pls. I–IV.
A systematic and economic review of the group, with original illustrations.

OTHER LEAFHOPPERS.

Seven species of leafhoppers of the genus Eutettix besides *tenella* are known to have definite food plants related to the sugar beet, and several more, the food plant of which is not known, will probably be found to have similar habits. All of these species will no doubt be found on the sugar beet as fast as its cultivation is extended into the regions where these insects occur. The following species of Eutettix are already known to occur on the beet, and are arranged in about the order of their present importance.

Eutettix strobi Fitch.—The nymphs of *Eutettix strobi* are thickly spotted with red, giving them a strongly reddish appearance. They are found on *Chenopodium album* (Pl. I, fig. 2, *a*) and are confined strictly to the underside of the leaf. The attack produces a red discoloration and a curling of the leaf, which serves as a double protection for the insect. There are two broods in a season, the nymphs appearing in late May and early June and maturing from the middle of June into July. The adults of this brood are common from the middle of June through July. Nymphs appear again late in July, from which adults appear late in August, and more commonly in September. This species was carefully studied through the first brood in 1906. Then the area under observation was pastured and the record lost. The Colorado records agree with last year's work for the first brood, and furnish data for the second one. Prof. Herbert Osborn [a] first called attention to the red coloring of the leaves. It has been noticed many times since. This is, no doubt, the *Allygus* sp. of Bruner.[b] Forbes and Hart have mistaken the nymph for that of *Phlepsius irroratus* Say.[c] The larva of *P. irroratus*, however, is brownish and fuscous and lives on the ground. *Eutettix strobi* has been found on beets (Pl. I, fig. 2, *b*) in a number of places in Colorado and Utah, nearly all of them, however, around the margins of fields. In one place the insects had appeared on the beets when they were quite small, and had been numerous enough to deform every leaf on a number of beets and entirely stop their growth.

Eutettix scitula Ball (Pl. I, fig. 3).—*Eutettix scitula* is a white species with a brown saddle and brown pronotum. The nymphs are of a powdery pink color and live on the underside of the Chenopodium leaf in the same way that those of *Eutettix strobi* do, except that the discolorations are lighter. This species is apparently two-brooded. The first brood has been carefully worked out, but only adults have been observed in the fall. The broods appear about the same time as those of *E. strobi*. This is a western species occur-

[a] Science Vol. X, p. 166, 1887.
[b] Bul. 23, o. s., Div. Ent., U. S. Dept. Agric., p. 17, 1891.
[c] Bul. 60, Ill. Agric. Exp. Sta., p. 424, 1900.

ring in Colorado and Utah and has been found on sugar beets only at Grand Junction, Colo. The adults of the species are almost invariably found on poplar trees, and it seems probable that the eggs are deposited on twigs of the trees and that the nymphs drop to the ground to find a home on the Chenopodium. The adults of *Eutettix strobi* and *E. seminuda* are often found on trees and may have the same habit. In the case of *E. strobi* and *E. scitula*, nearly all instances of bad infestation have been near trees. In the case of *E. scitula* these have been poplars, but two of the worst instances of injury from *E. strobi* were alongside apple trees.

Eutettix seminuda Say.—*Eutettix seminuda* is a white insect with a brown saddle. It occurs from Kansas east to the Atlantic coast. The nymphs are pale, with a brown saddle on the abdomen and some brown on the thorax. Nothing is known as to their native food plant, but from the close relationship to the preceding species it is likely that it will prove to be a Chenopodium. There are two broods in a season, the first one appearing slightly earlier than in the case of *E. strobi*. *Eutettix seminuda* has been reported on beets in Illinois. It does not occur in the West, where the writer has worked on beets.

Eutettix clarivida Van Duzee (Pl. I, fig. 4, *a*, *b*, *c*, *d*).—*Eutettix clarivida* is a green species with four black points on the margin of the vertex. It occurs very commonly on the shad scale (*Atriplex confertifolia*) and on one or two other species of the same genus in the arid regions. It has been found on beets at Grand Junction, Colo. The nymphs are green, with two black spots on the vertex. The life history is not known.

Eutettix insana Ball (Pl. I, fig. 7), *E. albida* Ball, and *E. pauperculata* Ball occur on different species of Atriplex in the arid regions, and may be expected to occur on the beets.

Eutettix stricta Ball (Pl. I, fig. 8, *a*, *b*) is an Arizona species and the nearest relative of *E. tenella* that we know. There is probably more danger from this than from any other species of the group, if the sugar beet should be introduced within its range.

All the species of Agallia in a given section will be found attacking the sugar beet more or less. Several of the species seem to be almost omnivorous in food habits, but where they do show a preference it is for the relatives of the beet. For two of the species (*cinerea* and *bigeloviæ*) a definite food plant is known, and in both cases they are close relatives of the beet. The species of Agallia are divided into two groups, based on structural and life-history characters. In one group, which includes *sanguinolenta*, *uhleri*, *cinerea*, and *bigeloviæ*, they seem to prefer warm and rather dry situations, the adults hibernating and spreading over the beet fields in the spring in time to lay their eggs and produce their single brood of young there.

Agallia sanguinolenta Prov. is the most abundant species of the genus in the western country and is found in all fields. Together with *A. uhleri* this species has been observed to do considerable damage in the Arkansas Valley, in Colorado, and around Lehi, in Utah. The nymphs appear early in June and mature in the last half of July and the first half of August, a few running on through the month.

Agallia cinerea Osborn and Ball is found almost exclusively on the "shad scale" of desert regions, and from this adults often fly to near-by fields of beets. It was common at Grand Junction and Loma, Colo., and at Monroe, Utah. Under the hot desert conditions the nymphs appear in June and mature the last half of July, while on the beets they do not mature until some time later.

Agallia bigelovia Baker occurs in abundance on a tall species of sea-blite (Dondia) growing on alkaline soil, and has been found in the beet fields at Grand Junction and Palisades, Colo.

Agallia quadripunctata Prov. and *A. novella* Say belong to the other group of the genus and pass the winter as partially grown nymphs, which change to adults in late May and June. The nymphs appear again in August and develop slowly until fall, when they hibernate. These two species and *A. sanguinolenta* are discussed by Osborn and Ball (Iowa Experiment Station Report for 1897, p. 112), the nymphs and adults being figured and the life histories given. The dates given there are, however, too early for western conditions. This group thrives best in damp situations where rank vegetation abounds, and will not do any serious damage to beets unless planted alongside places of this character, from which the nymphs can migrate in early spring. By the time the adults are mature and ready to fly, the beets are well started and beyond their injury.

Empoasca sp.—A large number of adults of a small green *Empoasca* were found on sugar beets at Spreckels, Cal., in early September by Prof. E. G. Titus and the writer. The beet crop was not seriously injured, but a number of beets were found in which there was a slight curling of the leaves resembling "curly-leaf," except that in this case the edges of the leaf turned down rather than up, and the surface of the leaf, instead of being roughened, was covered with small pale spots. This pale spotting of the leaves is quite characteristic of the injury of the Empoascas and their relatives and is commonly seen on apple and rose leaves. The insects were all adults at this time, so that it was impossible to be certain that they had bred on the beets, but from the appearance of the leaves it is probable that they had. The nymphs of nearly all of this group are slender, pale-greenish forms and are found mostly on the underside of the leaf, while the white spots caused by their punctures show more plainly on the upper surface.

Professor Titus reports finding an Empoasca common on beets at Chino, Cal., in August, 1907, and states that the beet leaves showed the characteristic spotted appearance, but that no curling was noticed. In his trip in 1904 Empoascas were noticed in several places in California, and quite serious damage from "blight" or "curly-leaf" was found in a few places, but the particular nature of the injury was not observed.

The Empoascas nearly all pass the winter as adults, hibernating in rubbish and sheltered places near their food plants. In the spring they feed on anything that offers until their food plants start, and then they gather on them, laying eggs in early summer. The young nymphs feed on the underside of the leaf and are quite active and keep out of sight.

Spraying with kerosene emulsion, 1 part of the stock solution to 8 parts of water, proved to be a satisfactory remedy for an Empoasca on potatoes in Iowa some years ago, and no doubt could be used on the beets with success. Burning off rubbish around the field in the late fall would probably reduce their numbers.

CONCLUSIONS IN REGARD TO "CURLY-LEAF."

As a result of the above investigations, it appears that there are at least two distinct kinds of "curly-leaf" that have been confused under one name. One, in which the leaves become rough and warty and curl up and in which the beet is stunted and does not recover; the other, in which the leaves remain smooth but show numerous pale spots and in which the edges turn down, and in which, as far as known, the injury is confined to the leaves attacked. The first-mentioned kind of "curly-leaf" occurs from Grand Junction, Colo., west to the Pacific coast and is the one that has been seriously injurious in the intermountain region. This condition is brought about by the attack of the beet leafhopper (*Eutettix tenella*), and will, no doubt, be confined, for some time at least, to the southwestern part of the United States, the native home of this insect. The second kind of "curly-leaf" has been found in California quite commonly, and doubtless will be found to occur sparingly at least in the eastern part of the United States, or wherever an Empoasca attacks the sugar beet.

Besides these two types of this injury it is quite possible that in rare cases other types with still other causes have been seen and not recognized at the time as distinct. Investigations in the California field have been so meager that it is impossible to say as yet which type has caused the greatest injury. In the intermountain region, where most of the work has been done, practically all the injury is known to have been caused by the first type.

U. S. D. A., B. E. Bul. 66, Part V. Issued January 28, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE SEMITROPICAL ARMY WORM.

(*Prodenia eridania* Cram.)

By F. H. Chittenden and H. M. Russell.

INTRODUCTION.

During the summer of 1907 a smooth or hairless caterpillar (*Prodenia eridania* Cram.) related to the cotton cutworm came under the observation of the junior author at Orlando, Fla. It was observed attacking the foliage and, in many cases, the stems and fruits of all forms of garden truck grown in that vicinity, the list including tomato, potato, sweet-potato, eggplant, pepper, okra, collards, and cowpeas. The infestation was of considerable severity, and great injury was done in fields and gardens in that and in some other regions of Florida, notably at St. Augustine and on the west coast of the Manatee River. What is believed to be the same species was reported injurious in Porto Rico by Mr. W. V. Tower. Aside from a brief notice which has been made of the present invasion there does not appear to be any other record of the injurious habits of this species; hence the following account has been prepared for publication by the senior author. The chapters on recent injuries, natural enemies, and experiments with remedies have been compiled from the junior author's notes. The technical descriptions of the egg and larva have been prepared by Dr. H. G. Dyar, while other assistance in the preparation of this article is duly acknowledged in its proper place.

In ordinary seasons the species under consideration confines itself largely to weeds, among which are the poke-weed, spiny amaranth or careless weed of the South, and a wild Solanum. It has habits different from those of the northern cutworms and can scarcely be classified with the climbing cutworms, although it has the climbing habit. It has a decided tendency to travel in armies like the army worms and is practically confined to semitropical regions. It is remarkable as being injurious throughout the warm season and breeding continuously, there being evidently at least four generations a year in nature.

DESCRIPTIVE.

The adult is a noctuid moth, and while the larva is quite readily referable to the genus Prodenia, the moth has little of the appearance of our other two North American species.[a]

The moth.—The adult or moth has a wing expanse of nearly 1½ inches (33–38mm); the fore-wings are dull gray, sprinkled and dotted with brownish and black scales forming a pattern as shown in figure 8, *d*. There is considerable variability in these markings, some individuals having a strongly marked reniform spot, a very prominent blackish posterior marginal line, and a similar black line

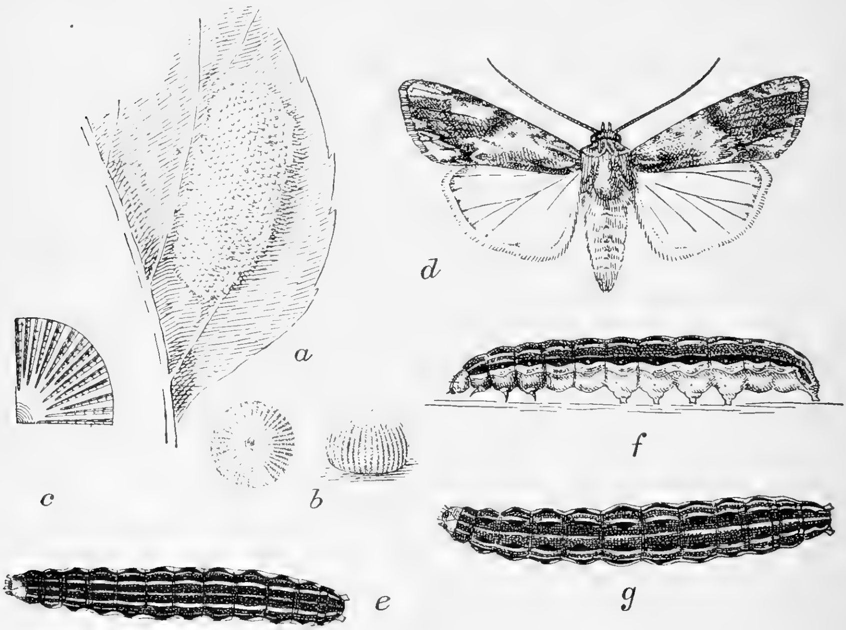


FIG. 8.—The semitropical army worm (*Prodenia eridania*): *a*, Egg-mass on leaf; *b*, egg, much enlarged, showing lateral view at right and top at left; *c*, section of egg; *d*, moth; *e*, dark form of larva nearly grown; *f*, *g*, larva, full-grown. *a*, *d–g*, Enlarged; *b*, highly magnified; *c*, more magnified. (Original.)

on the latero-posterior margin. Individuals also occur in which there is a straight, broad, jet-black dash or band beginning at the middle of the fore-wing and extending to the lateral margin. This is the *nigrofascia* of Hulst. The hind-wings are pearly white above, this pearly luster being still stronger below. The body is brownish gray and the antennæ are yellowish brown.

The darkest forms of this species are marked very much as in the genus Acronycta.

The eggs.—The eggs are deposited in irregular masses, as shown in figure 8, *a*, closely placed together, sometimes in two layers and

[a] *Prodenia ornithogalli* Guen. ("cotton cutworm") and P. *commelinæ* S. & A.

covered with whitish down, from the body of the female. They are distinctly green when first deposited and have the appearance illustrated at *b* and *c*.

The larva.—The caterpillar resembles that of the other two species of Prodenia sufficiently to be naturally referred to that genus, and it is subject to similar variation in color. The ground color is dark grayish in pale individuals and nearly black in the dark forms. These latter, especially when approaching maturity in the penultimate stage, are sometimes so dark as to resemble Mamestra. The body is ornamented with a narrow, slightly interrupted, median yellow longitudinal dorsal stripe, a similar slightly wider dorso-median stripe, and a wide and brighter yellow substigmatal stripe, which becomes obscured in the thoracic segments of the penultimate stage. In the very dark forms the triangular velvety dorsal spots characteristic of the genus can scarcely be seen, and in the paler forms they are seldom as distinct as in the other two species. When full-grown the larva measures about an inch and a fourth to an inch and a half in length (25–37^{mm}), and the width varies from one-fourth of an inch to a little larger. The head measures nearly 2.5^{mm}.

The mature larva is illustrated at *f* and *g* of figure 8 and a dark form nearly grown at *e*.

The pupa.—The pupa resembles closely that of *Prodenia commelinæ*. The head and abdomen are well rounded. The color is mahogany-brown, with the head, spiracles, and anterior edges of the abdominal segments darker. The surface is smooth and shining, with the anterior edges of the abdominal segments finely punctured. The anal segment terminates in a two-spined cremaster-like process. Length, 16–18 ^{mm}; width, 5–6 ^{mm}; length of head to end of the wing-cases, 10^{mm}.

The following technical description of the egg and larval stages was kindly contributed by Dr. H. G. Dyar.

TECHNICAL DESCRIPTION OF THE EGG AND LARVAL STAGES.

The egg.—Hemispherical, smooth, pale green, shining; ribs very fine, obscure, numerous, ill-defined, radiating from the micropyle; cross-striæ imperceptible. Diameter, 0.6^{mm}. Laid in a patch, covered by a thin layer of whitish wool.

Stage I.—Head rounded, bilobed, mouth pointed, shining greenish-black; eyes black, mouth brown; width about 0.3^{mm}. Body robust, uniform, joint 12 slightly enlarged, feet of joints 7 and 8 a little smaller than the others and not used in walking; translucent greenish, cervical shield, leg plates, thoracic feet, anal plate, and the large round tubercles shining black; tubercles i and ii of joint 12 in a square; setæ rather coarse, moderate, black, simple.

Stage II.—Head rounded, slightly bilobed, the vertex level with joint 2, shining luteous, blackish shaded over the vertices of the lobes; ocelli black, mouth brown, width, 0.4^{mm}. Body somewhat thickened at joints 5 and 12, feet normal, equal; greenish luteous, cervical shield and anal plate blackish infuscated;

tubercles rather large, low-conical, black; leg shields slightly smoky; tubercle vi present; a large red blotch around tubercles i and iv on joints 5 and 12; setæ short, black, stiff; traces of a white dorsal line showing especially by the cut between the red blotches at tubercle i of joint 5; no other lines.

Stage III.—Head rounded, the vertex just within joint 3, pale reddish over the lobes and sides, luteous on the face, shining, very small in proportion to the body; width, 0.6^{mm}. Body robust, slightly thickened at joint 5, more so at joint 12; feet normal; pale green; a straight dorsal and a subdorsal white line and traces of a broken lateral one; subventral region slightly pale, without defined line; tubercles small, black; a large, vinous, somewhat elevated blotch on tubercles i and iv on joint 5 and on tubercle i on joint 12, more diffusely about the spiracle on joints 11–12; anal feet reddish; cervical shield small, infuscated, cut by three white lines; anal plate blackish; thoracic feet blackish, abdominal ones greenish.

Stage IV.—Head rounded, rather quadrate, not notched, the clypeus high, vertex even with joint 2; pale red, paler on the clypeus, ocelli and antennæ dark; width 1.0^{mm}. Body robust, thickened at joints 5 and 12; feet equal; blackish olivaceous, dorsal and subdorsal lines straight, yellowish white, edged with vinous dottings; traces of a lateral line; subventral region paler below the spiracles, especially after joint 5; large blackish-red blotches at tubercles i and iv on joint 5 and on joint 12 and tubercle i and stigmatally on joints 11–12; white dotting in the ground color most conspicuous stigmatally; thoracic feet black, abdominal ones pale, anal pair reddish.

Stage V.—Head quadrate, rounded, slightly bilobed, shining light red-brown, the clypeus high; ocelli and setæ black; width, 1.6^{mm}. Body thickened at joints 5 and 12, feet equal, normal, the abdominal ones pale, slightly infuscated, the thoracic ones black-ringed; dark gray to black, strigose-dotted with white; dorsal line narrow, subdorsal broader, straight, even, yellowish white, centered with reddish mottlings, cutting the sooty-black cervical shield, but not the anal plate; a quadrate black patch between the lines on joint 5, a small angular one next the subdorsal line on all the other segments, large on joint 12 and shaded across; a narrow white-dotted lateral line, scarcely different from the dots of the ground color; subventral band straight, yellow-white, broad, broken at joint 5, reddish-filled around the spiracles, black spots at tubercles iii with a distinct white dot below; subventral region of thorax blackish, of abdomen paler, white-dotted.

Stage VI.—Head rounded, quadrate, about as high as wide, slightly bilobed, the vertex level with joint 2; clypeus high and large; red-brown, darker reticulate, mouth parts concolorous, ocelli black; width 2.1 to 2.4^{mm}. Body robust, cylindrical, tapering from joint 5 to joint 2, the head small; joint 5 slightly, joint 12 distinctly, enlarged and abruptly tapered to joint 13; black, strigose-dotted with white; cervical shield deep black, white-dotted, cut by three white lines; anal plate similar, small, cut by the dorsal line only; dorsal line narrow, black-dotted and broken, yellowish white, reddish on the centers of the segments; subdorsal line broader, straight, yellow-white, reddish centered on the segments, with a median row of gray dots, but not incised on the margins; a row of segmental black triangles above it, free of white dots, largest on joint 5, the one on joint 12 now scarcely larger than that on joint 11; upper half of the lateral area grayer, with many white dots, lower half blacker, with few dots on joints 5 to 13, separated by a row of brighter dots representing the lateral line; on joints 2 to 5 this distinction is weakly developed; spiracles in a blacker shade with a white dot above tubercle iv; substigmatal band broad, even, undulate, weak and broadly gray, centered on joints 2 to 5, fading out at joint 5, sharply reappearing at joint 5 posteriorly, then pale yellow, centered with blackish mottlings at the centers of the segments and red above these; subventral region black-shaded, strongly so on joints 2 to 5, weakly on the abdomen, white-dotted, paling to the venter; thoracic feet dark brown, the abdominal ones pale brown, shining; a single cylindrical, round-tipped neck gland reaching to the end of the labial palpi; crochets of abdominal feet in a single row, dark; tubercle iv slightly above middle of spiracle on joint 7. [Harrison G. Dyar.]

ORIGIN AND DISTRIBUTION.

This is a Lower Austral form and probably of tropical origin. In the National Museum are specimens from Cocoanut Grove, Crescent City, and Orlando, Fla. The species is also recorded from Tallahassee, and reported from St. Augustine and the region about the Manatee River in Florida. From Texas we have specimens from Bosque County (Belfrage) and Dallas, and there are specimens collected at Pernambuco, Benito Province, Brazil, by Mr. Albert Koebele. Dr. J. B. Smith records the insect from Georgia and Central and South America, and Grote records it from California. This indicates a range extending from Brazil to Mexico, Central America, and the Antilles, and from Florida westward through the Gulf region and Texas to California.

LITERATURE AND HISTORY.

Considering the fact that this species is really common in the South and that it feeds gregariously and voraciously, it is somewhat remarkable that it has not hitherto attracted attention by its depredations. The moth was described by Pierre Cramer in 1782.[1 a] Its natural food plants were known to Smith and Abbot, who wrote of it in their classic work published in 1797.[2] The illustration accompanying that work, though over-colored as usual, depicts a perfectly recognizable moth of this species but a too-brilliant and light-colored larva. Light and dark forms of the moth are figured. The species is mentioned as *Phalæna phytolaccæ* and is compared with the related *Prodenia commelinæ* and *Laphygma frugiperda*, which form the subject of the two plates and pages immediately preceding the account of *phytolaccæ*.

As Smith and Abbot's work is not accessible to many, the following copy of their account of this insect is republished:

PHALÆNA PHYTOLACCÆ. Poke-weed moth.

Phytolacca decandra. Linn. Virginian poke-weed.

Ph. *Noctua* spirilinguis cristata, alis deflexis: primoribus fusco striatis puncto obscuro margine postico nigro maculato; anteriori punctato.

---

[a] Numbers in superior type refer to corresponding numerals in the appended bibliographical list (p. 70).

Feeds on the Poke, Careless, &c. It went into the ground July the 5th, and came out the 16th. I once met this caterpillar in such abundance, that among a great quantity of Poke plants there was scarcely a single leaf untouched; most of these caterpillars, however, were fly-blown by a kind of *Ichneumon*. The moth is rare.

This is allied to our *Ph. frugiperda* and *Commelinæ*. Between the under wings of all these there is the greatest affinity. Their *pupæ* too are of a similar bright red color, and their smooth-striped caterpillars have much resemblance to each other.

RECENT INJURIES AND BIOLOGIC NOTES.

On May 14, 1907, this species was observed on the leaves of tomato in the truck garden of Mr. C. M. Berry, at Orlando, Fla., where it was eating holes in the leaves. Numbers of plants, here and there, were infested and in most cases the entire plant was injured. The same larva was observed on pokeweed (*Phytolacca decandra*), and afterwards on spiny amaranth (*Amaranthus spinosus*). By May 20 the larvæ were scattering and had grown rapidly, some being an inch long. While young, these larvæ feed on the underside of the leaf, but with larger growth some were noticed feeding on the upper surface as well.

May 24 an egg-mass was found on a leaf of the spiny amaranth, laid in two sections on the under surface, one on each side of the midrib. One mass had hatched at this time and the larvæ were beginning to eat pinlike holes through the leaf.

On July 3 a field of Irish potatoes was found to be very badly infested by these larvæ. They were now nearly full-grown and had stripped the potato vines, many being observed crawling away from the field in all directions. On one side they infested a garden at least 600 feet away, and were feeding upon eggplant, pepper, okra, and castor-oil plants.

Some interesting notes were made on the abundance of this species in this potato field. On a single young plant of Amaranthus, 41 larvæ were counted, and as many as 314 on a plant measuring 6 feet in height. A careful estimate of the larvæ on 10 plants of careless weed, not over 6 feet in height, gave a total of 1,300 individuals. (See fig. 9.)

To illustrate the voracity of these larvæ, where any potatoes were exposed, they were soon covered by the larvæ and the entire contents eaten out so that they were rendered worthless in about ten minutes. About this same date, July 3, the larvæ were reported making quick work of amaranth; whenever a branch became broken from any cause, larvæ entered at the break and excavated tunnels several inches in length. Pokeweed was entirely stripped of leaves, the stalks and the shoots being eaten off at the outer end. Potatoes dug at this time were frequently found full of holes, the work of these larvæ. The following day, July 4, the amaranth was almost completely denuded, illustrating the rapid work of this species when in large numbers (see figs. 10, 11). By July 8 the larvæ had almost completed their work in the field, after having eaten everything clean. Many were full grown and had commenced to enter the ground. July 9 the potato field was stripped, the vines were dead and dry, and the larvæ had almost disappeared. The ground was full of pupæ, none of them at a greater depth than 4 inches, and in

FIG. 9.—The semitropical army worm (*Prodenia eridania*); Work of larvæ on "careless weed" in potato field; 311 larvæ were on this plant when photographed. (Original.)

many cases only 2 inches. Upon digging into the hills, it was found that they did not average more than four good-sized potatoes to the hill, and in many cases these had been rendered useless by the inroads of the larvæ. (This crop averaged small because of late planting.)

Many larvæ were found feeding on sweet potatoes at Mr. John M. Cheney's place at this time, most of them still in young stages. A few fully matured larvæ also were found, showing the overlapping of the two generations; in fact, observations conducted both in the field and at the insectary at Washington, D. C., show that this species is undoubtedly a continuous breeder, as in the case of the variegated cutworm (*Peridroma margaritosa* Haw.), the larvæ being present in the field throughout the long summer season of the South.

July 30, by request of the county commissioner, Mr. H. H. Dickson, the junior author went to the County Home and found a sweet-potato patch badly infested, thousands of larvæ present, and the leaves turning brown and drying out. Superintendent Harris stated that an earlier brood did great damage to cowpeas, but this could not be verified by specimens. In the sweet-potato field the larvæ started on the south side and, after stripping the first four or five rows, moved over to the next rows and eventually infested the entire

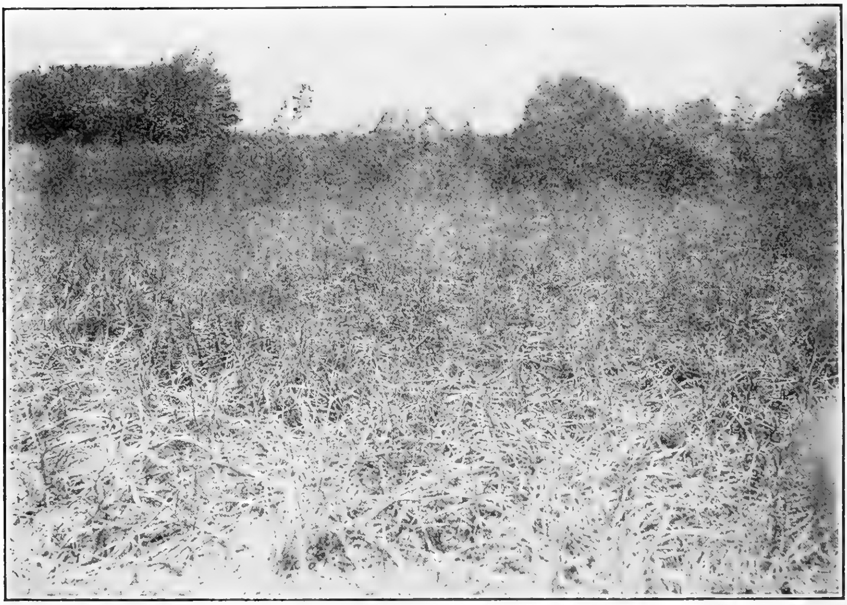


FIG. 10.—The semitropical army worm (*Prodenia eridania*): Field of late Irish potatoes showing vines entirely stripped by larvæ; Orlando, Fla., July 6, 1907. (Original.)

field. A Mr. Porter, near the County Home, reported 5 acres stripped in three days after the larvæ were noticed at work, these having started at one side of the field and swept it clean. The larvæ of a third generation were observed at Mr. Cheney's place at this time; most of them, however, had already gone into the earth to transform.

August 3, adults that had pupated about July 25 began to emerge. Thus the pupal period occupied about nine days. At this time a number of young larvæ were noted feeding upon amaranth, wild Solanum, and castor-oil plants. When disturbed they dropped and hung by threads.

By the first of September Mr. Cheney's patch of sweet potatoes was entirely free from this insect, evidently owing largely to parasites and to the spraying with arsenate of lead.

August 30, 1907, Mr. Wm. Donnell, St. Augustine, Fla., reported that a cutworm, which he identified as this species, had been very destructive in that region, being especially abundant on beets, and

FIG. 11.—The semitropical army worm (*Prodenia eridania*) : Larvæ eating bark of "careless weed;" also nymph of *Podisus maculiventris*, predaceous on the larvæ. (Original.)

later affecting cabbage, carrots (by eating the tops), and some other plants, its operations being most noticeable at night.

Mr. E. L. Worsham, while employed by this Bureau, noticed this species on the west coast, near the Manatee River, in Florida, and reported it working quite extensively in that region in August.

On November 23, 1907, an egg-mass was found on pokeweed at Dade City, Fla., and December 2 another was observed, from which the larvæ hatched December 4. These molted between December 10 and 13, while being transported to Orlando, but soon died, as frost killed off the food plants.

July 25, 1908, Mr. H. H. Dickson asked for a remedy to apply against the larvæ on sweet potatoes at the Orlando Truck Farm.

Egg-masses received May 24, 1907, hatched at that time and the larvæ entered the earth in the rearing cage June 19. In dry sand the pupæ were found at a considerable depth, but in moist sand they were found barely under the surface.

July 8 larvæ in the rearing-cage were almost full grown. Larvæ hatching from egg-masses, and others a few days old, were also found in abundance on sweet-potato plants. As soon as hatched they separate, feeding on the leaf on which the egg-mass was laid, perforating the underside full of minute holes, and leaving only the upper epidermis, which turns brown. On growing larger they separate, as in the case of most caterpillars, except those of peculiarly gregarious habit, and soon become widely scattered. Even when abundant it is common to see eight or a dozen on the underside of a single leaf, and frequently as many as an hundred. Occasionally a nearly full-grown larva feeds on the upper side of a leaf. In many cases large larvæ were found hiding during the day at the bottom of furrows.

June 15, 1908, the larvæ of this insect were found to be very abundant at Orlando, Fla., in one part of the town feeding on pokeweed, and in another on amaranth.

EARLY RECORDS.

Among the records of the Bureau of Entomology is one of May 22, 1887, when larvæ and pupæ were received from Mr. E. A. Schwarz with report that the species was very injurious to the eggplant at Cocoanut Grove, Fla.

In September, 1905, Mr. F. C. Pratt sent to the Bureau a large colony of the larvæ found feeding on pokeweed at Dallas, Tex., the moths from which began to issue September 26.

LIFE-CYCLE PERIODS AND GENERATIONS.

Larvæ mailed from Orlando, Fla., July 3, arrived at Washington, D. C., July 5 and began to enter the earth for pupation the following day. On the 16th two had transformed to pupæ, on the day following three more, and the remainder transformed within a week. This experiment shows a pupal period of about 9 days, allowing 1 day for the larvæ in the earth before pupating. The weather was quite hot. In a cooler temperature in August the pupal period required 11 to 13 days.

The moths hatched from different lots were separated and the egg-period observed. In one case this lasted from August 8 to 12, or

4 days, and in another case from July 18 to 22, or 4 days. In the first instance the temperature averaged between 76° and 80° F. and in the second from 80° to 88° F. Evidently this is the maximum period.

As regards the duration of the entire life cycle, it was noticed that eggs deposited July 3 produced caterpillars on the 9th, or in 6 days. These penetrated the earth, being full-grown, on the 26th, making the entire life period of the larvæ 17 days. They began to issue as moths August 5. This gives a total period for the life cycle of 31 days for extremely hot weather. In an ordinary outdoor summer temperature the period would be about 35 days, or 5 weeks.

Our rearing records are not quite as accurate as could be desired, owing to unfortunate conditions at the insectary and to three changes in the office force during the time when the insect was under observation. There were, however, positively four generations here, and about the same number was observed at Orlando. There is also the possibility of an earlier fifth generation in nature. The exact periods for the appearance of these should be recorded in the field.

NATURAL ENEMIES.

The unusual abundance of this species at Orlando, Fla., during the season of 1907 afforded a most excellent opportunity for the study of its insect natural enemies. These came under observation as early as May and were still abroad as late as August, appearing to increase somewhat as the season advanced.

PARASITES.

The parasitic species observed were seven in number; the predaceous enemies, six.

Ophion tityri Pack. (?)—Issued July 17–August 1.

Limnerium sp.—Issued May 25–30.

Meteorus sp.—Issued July 11–August 2.

Chelonus sp.—Issued July 6, 1908.

Spilochalcis spp.—The Meteorus was attacked by two species of secondary parasites of the family Chalcididæ. These issued August 2 from the peculiar brown cocoons of the Meteorus.

Winthemia quadripustulata Fab., a moderate-sized tachina fly, is also a parasite on the larva of this species. Adults issued August 8 but did not appear abundant. Of a lot of larvæ taken at random from different portions of a field, upward of 50 per cent bore tachina-fly eggs. Evidently a large percentage fail to hatch.[a]

---

[a] A small fly was also observed feeding on the pupæ. It is *Aphiochæta nigriceps* Loew, one of the Phoridæ, which comprises species of scavenging habits and not parasitic.

PREDACEOUS ENEMIES.

Calosoma sayi Dej.—The larvæ of the carabid beetle *Calosoma sayi* were observed in considerable numbers and were reared to adults. They were first noticed July 6, when they were quite abundant in the furrows between rows of sweet potato. They were found concealed by the vines, feeding on the larvæ of the Prodenia, and after sucking out the juices of one larva they immediately attacked another. The adults issued in our rearing cages August 11.

Polistes annularis L.—The large brown wasp *Polistes annularis* was observed July 2, flying quite commonly in sweet-potato fields. One was watched which alighted on a leaf and began searching for prey, after the custom of such wasps. The search was continued from plant to plant and from leaf to leaf until a Prodenia larva was located, when it was at once seized behind the head and chewed into a shapeless mass. Other wasps of this species were also seen on fence posts dragging Prodenia larvæ about with them.

It is interesting to note that Mr. F. F. Crevecoeur, Onaga, Kans., reports having seen this wasp being carried away by the asilid robber-fly, *Deromyia ternata* Loew.

Stiretrus anchorago Fab., var. *diana* Fab.—The blue-and-red and the uniformly blue forms of the soldier-bug *Stiretrus anchorago*, which are common in Florida, were observed in numbers attacking the Prodenia larvæ in July.

Podisus maculiventris Say.—During July the spined soldier-bug was seen preying upon the Prodenia larvæ. (See fig. 11.) In one instance 18 nymphs were counted on a single amaranth plant infested by the cutworm. The length of the life cycle of this species from hatching (not from egg-laying) was determined to be 16 days in hot July weather.

Apateticus (*Eupodisus*) *mucronatus* Uhl.—July 17, and again in December, 1907, this pentatomid bug was observed preying on the larva of this species of Prodenia at Orlando, Fla. It is considered a rare species and this is probably the first observation which has been made on its habits.

Owing to the obscurity of the host insect in the past, no records can be found of any of these parasites or of other natural enemies which affect it, but in Smith and Abbot's work mention is made of a species of " Ichneumon " which attacks the larva (see p. 58).

Pontia rapæ L.—July 22, 1907, the young larvæ of the imported cabbage worm, which had hatched out on cabbage used as food for *Prodenia eridania* Cram. in our rearing cages at Washington, were observed feeding on the eggs of the latter.[a] The cabbage worms were between one-quarter and three-eighths of an inch in length at this time.

A FUNGOUS DISEASE.

Empusa sp.—September 8, 1907, a few Prodenia caterpillars, which were found dying of a fungous disease in our rearing cages, were referred to the Bureau of Plant Industry for identification of the fungus. Mrs. F. W. Patterson stated that it was a species of Empusa.

METHODS OF CONTROL.

The arsenical poisons are effective against this army worm under ordinary conditions. Experiments performed at Orlando, Fla., however, brought out the fact that Paris green, on account of the frequent rains which occur at the height of the principal outbreaks in the infested regions of Florida, such as Orlando, is almost ineffective and it is therefore necessary to use arsenate of lead. Owing to the greater adhesiveness of the latter it remains on the plants when the former is washed off.

Paris green, arsenate of lead, and a special preparation which may be called adhesive copper arsenite, were tested, the last by request of its inventor. It was used in experiments Nos. 8, 10, and 11. A barrel sprayer, fitted with Vermorel nozzle, was used for a number of these experiments, but for most of them a knapsack sprayer of fine quality was employed. Sweet potatoes were sprayed in every case except in experiment No. 5, where collards were also sprayed, and the work was usually begun between 8 and 10 a. m. in bright sunlight. Spraying experiments commenced July 12 and were continued until August 7.

Experiment No. 1.—July 12, infested plants were sprayed with a solution of Paris green, 5 ounces, and freshly slaked lime, 5 ounces, in 50 gallons of water. The spraying was done in the morning and rain fell before noon. The next day when the field was examined the larvæ were found uninjured and practically no poison remained on the leaves. The experiment was therefore a failure.

Experiment No. 2.—July 12, Paris green, 8 ounces, and freshly slaked lime, 1 pound to 50 gallons of water, were sprayed the same day and with the same results.

Experiment No. 3.—July 17, Paris green was sprayed as in No. 2. Again rain fell hard and steadily before noon, with the same results as in experiments 1 and 2.

---

[a] This would seem to furnish at least one reason why this important insect has been able to supplant its American cousins such as *Pontia napi* L., *P. protodice* Bdv. & Lec., and *P. monuste* L., all of which feed on crucifers and are called cabbage butterflies or "worms."

Experiment No. 4.—Arsenate of lead, 2 pounds to 50 gallons of water, was used. Rain fell as before, resulting in partial failure of the experiment, the poison being washed off before it had time to dry thoroughly.

Experiment No. 5.—July 20, arsenate of lead was used as in experiment No. 4. Collards were also sprayed. Rain did not ensue for at least six hours, giving the spray time to dry on well in the warm sun. The following day it rained hard for several hours, but the next day the spray was found to be as thick on the sweet potatoes as when first put on, in spite of two partially rainy days. The poison was nearly as thick on the collards. An examination of the infested plants two days after spraying showed that only 25 per cent of the caterpillars were killed, but July 23, a day later, few large larvæ remained on the plants, showing that as soon as they have eaten sufficient poison they are killed.

July 29, when the rows sprayed with arsenate of lead were again examined, they were found in much better condition than the check or unsprayed rows, few larvæ being seen feeding, while dead ones were plentiful.

Experiments Nos. 6 and 7.—July 20, a sweet-potato patch was sprayed with Paris green, 8 ounces to 50 gallons of water. As in the case of experiment 5, no rain fell for about six hours; therefore the poison dried on well, as previously. The following day it rained hard for several hours, with the result that by July 22 the poison was all washed off and only a few dead larvæ were found. All of the Paris green experiments were failures, since the rain washed the poison off either before it could dry or after it was well dried on the plant.

Experiment No. 8.—July 23, the adhesive copper arsenite (combined with dextrine and glucose) was used at the rate of 1 pound to 100 gallons of water and applied as in previous experiments. The following day no results were observed, but the foliage was not burned. At the end of a week no good was accomplished and the experiment was pronounced a failure.

Experiment No. 9.—July 25, plants were again sprayed with arsenate of lead, 2 pounds to 50 gallons of water, the conditions being as in experiment No. 5. Rain at 12.45 p. m. washed off the poison, consequently the spraying was a failure.

Experiment No. 10.—July 25, plants were sprayed with the copper arsenite mixture; 10 ounces to 50 gallons of water were applied as in experiment No. 8, an equal quantity of lime having been added. The spray did not show well on the foliage and was invisible when dry. It does not remain in suspension as well as Paris green and much residue remains in the tank. July 28, a few dead larvæ were found on the vines and only a few live ones, but the same conditions were observed on the check rows. The experiment was an absolute failure.

Experiment No. 11.—July 29, plants were sprayed with copper arsenite mixture at the rate of 15 ounces to 50 gallons of water. In this case 1½ ounces of copper arsenite and 1 quart of thick lime were used with 5 gallons of water. Two days later the spray showed better than in experiment No. 10 because of an abundance of lime and was very finely and evenly applied to the leaves. Four larvæ were dead on a few plants examined against 32 living Prodenia and 3 living sweet-potato sphinx-moth larvæ (*Phlegethontius convolvuli* L.).

August 6, this spray still remained on the foliage, seeming to adhere well, but the experiment was a failure in killing larvæ.

Experiment No. 12.—July 29, plants were sprayed with arsenate of lead, 3 pounds to 50 gallons of water, applied as in previous experiments with lead arsenate. There was no rain for 24 hours. On a few plants examined three days later 41 dead larvæ were found and 49 living, an observed death rate of less than 50 per cent. It should be pointed out at this time, however, that it is difficult to find dead larvæ, as they sometimes dry up or crawl away.

August 2, the vines were almost free from larvæ. The experiment was pronounced very successful.

Experiment No. 13.—July 30, arsenate of lead, 2 pounds to 50 gallons of water, was used without ensuing rain. In some rows examined August 1 about 20 per cent of the larvæ were dead; in others 48 per cent, 54 per cent, and 61 per cent were killed in two days. August 5, these rows appeared entirely free from larvæ unless closely inspected, when only 5 or 6 could be found to a row. These might have crawled from unsprayed weeds or other plants.

Experiment No. 14.—July 30, arsenate of lead, 3 pounds to 50 gallons of water, was used. Three days later 84 per cent of the larvæ under observation were destroyed, the rows being quite clean. In both of these experiments, 13 and 14, many dead larvæ were found in rows *not* sprayed, as many as five rows away from the sprayed ones.

Experiment No. 15.—August 7, arsenate of lead, 2 pounds to 50 gallons of water, was sprayed by a laborer, under supervision. It rained at 1 p. m., but the spray remained on the leaves in large amounts and, for having been applied by an inexperienced hand, was well distributed. In this experiment, for some reason, the first four rows sprayed at one filling of the tank produced quite a number of burned leaves. This was attributed to a possible mistake in weighing out the chemicals. It did not, however, permanently injure the plants.

Caterpillars in the last 4 experiments, supposedly of the third generation, were very small, not over one-fourth or one-third of an inch in length. As a consequence they were quickly killed, large numbers of them being found dead soon after spraying. Forty-three dead larvæ were found in a furrow beside one plant which contained 29 dead larvæ. In another place 112 dead larvæ were counted in 3 feet of furrow.

RÉSUMÉ OF EXPERIMENTS, AND CONCLUSIONS.

Experiments 1, 2, 3, 6, and 7, in which Paris green was used at the rate of 5 to 8 ounces in 50 gallons of water, were failures because in each case the rain which followed the application washed off the poison.

Experiments 4 and 9, in which arsenate of lead was used at the rate of 2 pounds to 50 gallons of water, were also failures for the same reason.

Experiments 8, 10, and 11, in which copper arsenite was used at a rate of from 10 ounces to 1 pound in 50 gallons of water, failed, not because of burning the foliage, as was feared, but because the insects were not killed.

Experiments 5, 12, 13, 14, and 15, in which arsenate of lead was the insecticide employed at the rate of 2 to 3 pounds in 50 gallons of water, were successful in each case.

The results of this series of fifteen experiments show conclusively the superiority of a spray of arsenate of lead to one of Paris green when applied under suitable conditions. It is in every way more effective and more satisfactory than the latter, as Paris green is so likely to be washed away by the frequent rains of the wet season of Florida. These remarks apply practically to all cutworms, caterpillars, and other larvæ which devour truck and related crops in central Florida or similar regions.

ADHESIVE COPPER ARSENITE MIXTURE.

The preparation of copper arsenite used in the experiments that have just been reported was stated by its inventor to be free from soluble arsenious acid and to possess the adhesive properties found in no other adhesive insecticide. It was stated to be composed of 36 per cent dextrin and 4 per cent gum and was prepared to be used in conjunction with lime in the proportion of 1 part by weight to from 4 to 6 parts of lime—either dry or in solution, according to the foliage to be tested. The inventor also expressed his confidence that this insecticide would prove a most economical one for general garden and other use, as the loss by wind and rain would be reduced at least 50 per cent and the first cost of the article would be about half that of Paris green or arsenate of lead.

Samples of this mixture were submitted to Mr. J. K. Haywood, Chief of the Miscellaneous Laboratory, Bureau of Chemistry, who furnished the following analysis, August 7, 1907:

Analysis of 4551 Misc.

	Per cent.
Moisture	4.85
Total arsenious oxid	40.42
Total copper oxid	24.87
Gum and dextrin (approximate)	20.00
Acetic acid and other undetermined	9.86
Total	100.00
Soluble arsenious oxid	11.36

(10 day water ext. method.)

From the above analysis the sample evidently consists of about 20 per cent gum and dextrin and 80 per cent Paris green. The amount of soluble arsenic is very high and would undoubtedly give rise to serious trouble.

SUMMARY.

The semitropical army worm is a smooth or hairless noctuid caterpillar, *Prodenia eridania* Cram. It feeds normally on weeds, such as the pokeweed and spiny amaranth or "careless weed" of the South, and is confined to semitropical America as a pest. When it becomes unduly abundant it attacks the foliage and, in some cases, the stems and fruits of all forms of garden truck growing in its habitat, the list of known food plants including tomato, potato, sweet potato, eggplant, pepper, okra, collards, and cowpeas. In its habits it is similar to the cutworms, having also the climbing habit, and when extremely abundant it migrates in armies like the common army worm, whence the name.

Experiments show that the egg period may be passed in a minimum of 4 days, the larval period in 17 days, and that the entire life cycle, in an outdoor summer temperature, would be about 35 days or 5 weeks; also, that there are four generations and possibly five produced in a year, the insect breeding practically continuously during the warm season. In ordinary years the species is largely controlled by natural enemies, of which seven are parasitic and six predaceous.

A series of fifteen experiments was conducted against this species in Florida during 1907, which shows conclusively that a spray of arsenate of lead is the best remedy, being much superior to Paris green when applied under local conditions. It is in every way more effective, chiefly because less likely to be washed away by the frequent rains of the wet season in that region. It is best applied at the rate of 2 or 3 pounds in 50 gallons of water, and applications must be renewed when the insects again become numerous, as the latter are apt to spread from unsprayed plants.

BIBLIOGRAPHICAL LIST.

1. CRAMER, PIERRE.—Papillons exotique, Vols. III & IV, p. 133, pl. 358, fig. E. & F. (2), 1782.

Description and figures of both varieties of moths.

2. SMITH, J. E. and ABBOT, M. J.—Lepidopterous insects of Georgia, Vol. II, p. 193, pl. 97, 1797.

Described as *Phalæna phytolaccæ* with brief account of habits. Figures of moth and larva.

3. GROTE, A. R.—Bul. Buff. Soc. Nat. Sci., Vol. II, p. 28, 1873.

Listed as *Xylomiges phytolaccæ* (S. & A.) and recorded from California and Atlantic District.

4. MORRISON, H. K.—Proc. Acad. Nat. Sci. Phila., p. 62, 1875.

Technical description as *Actinotia derupta* n. sp., from Texas, September 21. Briefly compared with *phytolaccæ* S. & A.

5. GROTE, A. R.—Can. Ent., Vol. XI, pp. 205, 206, 1879.

Received from Texas and referred to *Prodenia phytolaccæ;* characters, etc. No excuse for Morrison's *Actinotia derupta.*

6. HULST, G. D.—Bul. Brooklyn Ent. Soc., Vol. III, p. 77; Vol. IV, p. 7, pl. 1, fig. 9, 1881.

Described as *Leucania nigrofascia* from one specimen taken by Koebele at Tallahassee, Fla.

7. SMITH, J. B.—Catalogue Noctuidæ Boreal America, p. 169, 1893.

Bibliography; synonymy and distribution.

8. [Chittenden, F. H.]—Yearbook U. S. Dept. Agr., 1907 (1908), p. 545.

Brief unsigned notice of injury to truck crops in Florida.

In Smith's catalogue of Noctuidæ,[7] fifteen references are given to this species, but as only a few of these are of interest in connection with the present account, the reader is referred to that list. The more important references are listed above.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE HOP FLEA-BEETLE.

(*Psylliodes punctulata* Melsh.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Special Insect Investigations.

INTRODUCTORY.

A minute, metallic blackish flea-beetle, *Psylliodes punctulata* Melsh., known by different local names, has been reported in recent years as doing very extensive injury to the hop plant and considerable injury to sugar beet. Since 1904 it has been reported in numbers on sugar beets grown in several localities in Idaho, Utah, and Colorado. In the Northwest, and particularly in British Columbia, it does serious damage in hopyards, and has been especially destructive since 1903. During the past three years, indeed, this species has become unusually abundant, with the result that in the Chilliwack and Agassiz Valley hop-growing regions of British Columbia it has accomplished damage which has been estimated by Mr. H. J. Quayle as about 80 per cent of the crop. Mr. Theo. Eder informs the writer that this means a cash loss of not less than $125,000 in that district. The species during that period has been the subject of considerable correspondence between this Department and persons practically interested in the growing of hops in the affected region.

The insect has received the name of rhubarb flea-beetle, from its common occurrence, especially in the East, on rhubarb. In the West it is called the hop flea-beetle, or "hop flea," or simply "flea," and in literature it has received mention as the punctulated and the small-punctured flea-beetle.

While the species is not known to be of the highest importance as a sugar-beet pest, the probabilities are that it may become so, and at the present time it is probably the most important hop pest in the entire world. The incorporation of some new matter, gained from conversation with Mr. Theo. Eder and by correspondence with Mr. H. J.

Quayle, has added much to the value of the present paper. Although the species is much more serious as a pest in British Columbia than in the United States, it is likely to become important throughout the Pacific coast region where hops are grown. Mr. Eder represents the E. Clemens Horst Company, which owns extensive hop-yards in British Columbia, and has already expended considerable sums in investigation and experiments. The hop flea-beetle is now abundant practically on the border line between British Columbia and the State of Washington, and threatens our own industries. It is, therefore, advisable that everything possible concerning it should be made public before its appearance in the spring, although there are several points in its life history still to be worked up.

DESCRIPTIVE.

The hop flea-beetle (fig. 12) is a member of the tribe Halticini, family Chrysomelidæ, and resembles other flea-beetles in its strongly

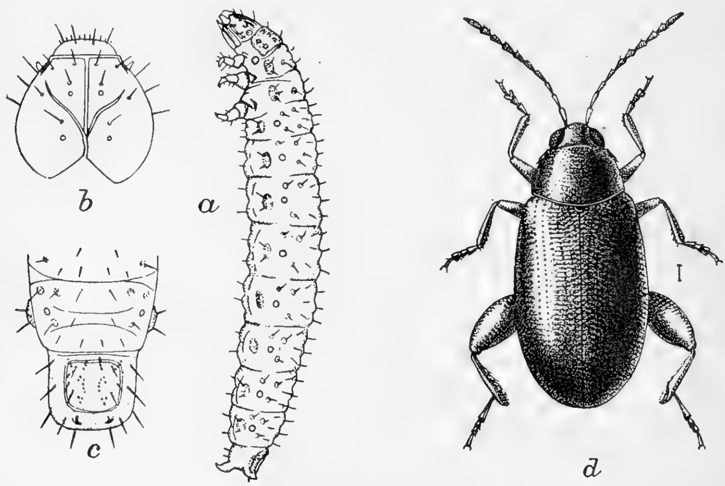


FIG. 12.—The hop flea-beetle (*Psylliodes punctulata*): *a*, Larva; *b*, lower surface of head of same; *c*, upper surface of anal segments of same; *d*, beetle. *a*, *d*, Much enlarged; *b*, *c*, more enlarged. (*a–c*, After Carpenter; *d*, original.)

developed hind thighs. It is of oval form, with a greenish tinge, brassy blackish, and punctulate or finely punctured, whence its specific name. The femora, tarsi, and basal joints of the antennæ are pale yellowish. The punctulations of the thorax are particularly fine and appear as if made with the point of a very fine needle. The punctures of the elytral striæ are closely placed, almost crenate. The beetle is only about one-tenth of an inch (2^{mm}) in length and less than 1^{mm} in width. The male is particularly distinctive, having the first joint of the anterior tarsi broadly dilated and the last ventral segment sinuate each side, while the middle of the disk near the apex has a semioval depression.[a]

The species was first described in 1847.[1] [b]

DISTRIBUTION.

The hop flea-beetle is a native American species, quite distinct from any species found on hops in England or on the Continent.

The collection of the U. S. National Museum and the published records and specimens before the writer show the species to be generally distributed in the northern United States and southern Canada, from the Atlantic to the Pacific. It does not appear to occur south of Nebraska. The list of known localities follows: Cambridge, Mass.; Dundee, Ithaca, Long Island, Staten Island, and New York, N. Y.; New Jersey, generally distributed (Smith); Pittsburg, Pa.; Marshall Hall and Cabin John, Md.; Marquette, Detroit, Grand Ledge, and Byron, Mich.; University, N. Dak.; Lincoln and Omaha, Nebr.; Fairfield, Wyo.; Denver, Longmont, Grand Junction, Delta, Montrose, Paonia, and Ft. Collins, Colo.; Logan, Garland, Lehi, Salt Lake, and Park City, Utah; Elko, Nev.; Blackfoot, Idaho; San Francisco, Martinez, Monterey, Huntington Beach, Pasadena, and Chico, Cal.; Tenino, Wash.; Astoria and Marion, Oreg.; Agassiz, Sardis, and Vancouver, British Columbia; Northwest Territory; Manitoba; and "Assiniboia" (now Saskatchewan).

RECENT INJURIES.

September 16, 1903, the late Dr. James Fletcher first reported this species injuring hops in British Columbia.

During 1906 Mr. Theo. Eder wrote from San Francisco, Cal., under date of April 9, that hop growers were troubled considerably in some sections by "hop fleas," or flea-beetles. May 29, specimens were received from Perkins, near Sacramento, Cal., which proved to be the species under consideration. August 13, Mr. Hugh F. Fox, New York, N. Y., sent specimens and transmitted a report from Mr. Geo. Heggie, manager of a large hopyard, the Stepney ranch, owned by Sir Arthur Stepney, at Enderby, B. C., where this pest was very injurious. Mr. Heggie wrote as follows:

> We have been sorely troubled this year in our hopyard with the "hop flea-beetle," which attacks the young vine and leaf as soon as they appear above the ground, and eats out large holes in the leaf, resulting in the plant being

---

[a] In the very closely related *Ps. convexior* Lec. the last ventral segment of the male is convex and not impressed. The latter species is, moreover, larger, broader, and more convex, and the elytral striæ are not impressed.

[b] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 91.

impoverished in vitality and the growth thereby seriously retarded. We were troubled with them last year [1905], but not to the same extent, and had them till after hop picking. In the middle of July they were so numerous that the ground was fairly alive with them. They go into the ground in the evening and come out again in the morning, and there has been no spray found to have any effect without killing the plant.

Substantially the same form of injury was reported during the same year at Agassiz, B. C., by Mr. John Wilson in a letter to Doctor Fletcher. Writing September 7, 1906, Doctor Fletcher stated that this species had been enormously destructive in British Columbia, one correspondent reporting the loss of many thousands of dollars. He estimated his crop as possibly 70 bales, whereas he should have had 250.

Writing of this species, January 30, 1907, Dr. E. D. Ball, while working in cooperation with the writer, stated that it was by far the most injurious species on sugar beet in Utah. It was found everywhere and was apparently the most common species in early spring. It was observed hibernating around the edges of fields, in patches of dead mustard, along ditch banks, and in similar places. Where ditches were covered with patches of roses these seemed to furnish a favorite retreat. These clumps grew to a height of 2 or 3 feet and were very dense, and from them one could see the injury to the beets radiating in every direction, the affected area growing wider and wider as time went on. In early spring this species fed on almost anything that came to hand, but its injury to beets was practically all done at the time the plants were first appearing through the ground or within a few days thereafter. Cases were observed where the rows of young plants could be seen the entire length of the field one day, and two days later scarcely a beet plant could be found, the beetles having eaten the tender stem, causing the tops to fall off and the beets to die. Frequently they attacked beets just as the latter were pushing through the ground. Hundreds of acres had been destroyed in this way, injury varying greatly in different years and in different localities.

Great damage was done near Logan, Utah, where the hedge mustard was overrunning the fields. At Lewiston, Utah, at the northern end of the same valley, injury was also severe, although there was little of the common black mustard.

The destruction of a crop by this species does not necessarily entail a complete loss, as the growers replant. The late plants, however, are not, as a rule, as good as the earlier ones, and the weeds get such a start that the land is hard to cultivate. After the beets had reached a leaf diameter of 3 or 4 inches no material injury was noticed, although the beetles continued to appear in the fields throughout the season. Beetles were observed July 20, 1906, at Cache Junction, Utah, enormously abundant on a form of hedge mustard along the railroad tracks, feeding on the half-grown seeds. Single plants were seen on which a double handful of beetles could be taken at one stroke of the net.

In a letter dated July 20, 1908, the E. Clemens Horst Company, Perkins, Cal., wrote of extensive injury by this species, and as this letter contains much of interest it is transcribed herewith. The writer is greatly indebted to the same company for the excellent photographs from which the ten half-tones illustrating this article are taken.

> We are extensive growers of hops on the Pacific Slope, California and Oregon, and also have about 600 acres of hops in two ranches in British Columbia. For the past three years we have been very much molested in British Columbia by a variety of flea-beetle that seems to take an especial liking to hop foliage and eats the young, tender shoots as they come out of the ground, and also the developed and partly developed leaves of the vines after the same are above ground. There are two other growers in the same section that were bothered one or two years previous to ourselves, and as they had some foreign varieties of hops we at first supposed the insects had been imported from England in the roots. Since, however, we have found that the same insect has been in the neighborhood in very small numbers for quite a long term of years. Our crops in British Columbia suffered quite a bit last season, but this year are very nearly a total failure. From the one place, Chilliwack, B. C., containing 278 acres, we do not expect to reap a harvest of more than 600 bales, whereas we should have from 2,500 to 3,000 bales. From the other place, Agassiz, B. C., we do not expect over 250 bales of hops, whereas we should have 2,250 to 2,700 bales. This will give you some idea of the inroads made by the insect and the resultant loss to persons engaged in hop growing when their yards are attacked by these pests. Of course we readily understand that it would be somewhat out of the ordinary for your Department to attack this problem inasmuch as it is out of the United States, but inasmuch as the pests are now so numerous within about 20 miles of the United States boundary and only a short distance from the Washington State hopyards we believe it is well worth your consideration. Just imagine for a moment the loss that would fall to the numerous growers of hops in the States of Washington, Oregon, or California, if this pest should not be held in check, and would migrate to these sections. We have definite knowledge of their already having spread as far as Sumas Junction, which is on the boundary line between the United States and Canada, where they are attacking cabbage, potato, beets, and other root crops, though the damage done here is not nearly as bad as in the hop fields. * * *

A badly damaged hopyard is shown in figure 13.

During 1908 injury from the hop flea-beetle was reported by Mr. W. W. Stockberger, of the Bureau of Plant Industry of this Department. He mentioned the cases already cited and one reported by Mr. Robert Maitland, of Agassiz, B. C., the latter stating that the ravages of this insect would almost destroy the prospect for a crop during the season. Mr. John Wilson, Agassiz, B. C., who complained of this species in earlier years, reported, under date of July 11, as follows:

The flea-beetles have been so numerous that they have stripped every portion of the yard this season. I have noticed these last three days that they are all disappearing, but they all disappeared last season about this time and a second brood came about the middle of July.

This "second brood" was probably merely the first-developed generation of the year.

This species has also come under the observation of various other collectors and observers. During 1906 Mr. Frederick Maskew, while working under the writer's direction in southern California, took it generally in many beet fields. Mr. E. G. Titus, while coöperating

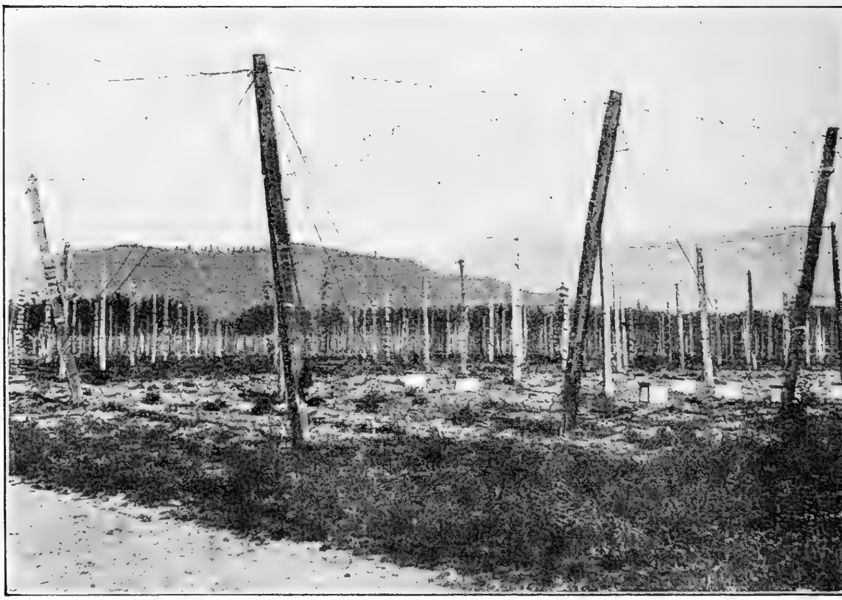


FIG. 13.—View of hopyard, showing how completely the hop flea-beetle keeps down the vines. Note occasional vine that grows up. Agassiz, B. C., June 24, 1908. (Original.)

with this Bureau in the investigation of sugar-beet pests, found it abundantly, and many of the locality records given under the heading "distribution," in California, Utah, Idaho, and other States are from specimens collected by him on sugar beet in 1905, 1907, and 1908.

Writing of this species in July, 1908, Mr. I. J. Condit stated that the beetles were then very common in the vicinity of Chino, Cal., on *Chenopodium album* and *C. rurale*.

METHODS OF ATTACK, FOOD HABITS, AND GENERATIONS.

This flea-beetle affects both surfaces of a leaf, gnawing through the skin and devouring the pulp, usually leaving the skin on the opposite side entire; this later becomes discolored, forming yellowish-brown freckles as the leaf grows and expands, the skin at this point in time becoming torn and frequently showing holes. When the beetle occurs in moderate numbers the leaves (fig. 14) become riddled, as by fine shot, the punctures being most obvious after the plants have made some growth. In its attack on hops it frequently causes the leaves to look like a mass of network or more or less completely strips the vines of leaves, as shown in figures 15 and 16. As is the case with flea-beetles in general, this species does most harm to young plants. When the beetles occur in considerable numbers they are capable of doing great damage in a comparatively short time, completely devouring the young and tender leaves as fast as they come up.

FIG. 14.—Hop leaves, showing work of flea-beetle. (Original.)

Injury is most noticeable on hops, sugar beet, rhubarb, and some other vegetables.

The beetle is a general feeder, the list of its food plants including, among vegetables, rhubarb, beet, cucumber, turnip, radish, cabbage, mustard, and potato. It feeds also on hops, red and white clover, nettle, dock (Rumex), lamb's-quarters (Chenopodium), pigweed and tumbleweed (*Amaranthus retroflexus* and *A. græcians*), hedge mustard, and common wild-growing black mustard. The probabilities are that, as all of these plants are affected by the adult beetles, a considerable proportion of them serves as food for the larvæ. On this head Mr. Quayle has written that the eggs, larvæ, and pupæ were taken at a depth of from three to six inches from the surface of the ground in hop fields and that the larvæ apparently feed on the roots of hop as well as those of other plants growing in the yards. Since it is well known that the beetles occur in other regions where hops do not grow there must be other larval food plants. It would be interesting, and is important, to ascertain exactly what plant, or plants, is the favorite with the larvæ.

Fletcher,[11] in writing of this species, says that in Canada there are two generations a year, the first appearing in June and the second in August. The generation appearing in August is with little doubt the newly developed first generation, and, reasoning from analogy, i. e., from what we know of related flea-beetles, it is this generation of the beetle that hibernates; thus the so-called "first generation" is simply that same generation reappearing the following spring and early summer

FIG. 15.—Work of flea-beetle after vines are grown. (Original.)

As to hibernation, Piper[6] and Doane[8] have recorded that the beetle passes the winter under stones or rubbish, in which respect it resembles practically all other species of American flea-beetles, and that with the first warm days of spring the beetles emerge from their winter quarters and immediately commence feeding voraciously upon their various food plants.

The following account of the life history and habits of the species in the worst affected locality in British Columbia has been kindly furnished by Mr. H. J. Quayle, who has also given an account of remedial experiments which supplement those previously furnished by conversation with Mr. Eder; indeed, without the information supplied by these two gentlemen this article would be quite incomplete. Before transcribing Mr. Quayle's account it may be well to draw from it, according to the statement of Mr. H. Hulbert, Sardis, B. C., that this species made its first appearance as a hop pest in British Columbia in 1894 and that it has been of great importance for five years, or since about 1903. In regard to Mr. Hulbert's statement that the beetles disappear about June 1 and reappear the last of July, it is obvious that during that period the larvæ are maturing, the pupæ are formed, and the beetles of the first, or new, generation appear.

The following account of the life history and habits of this species as it occurs in British Columbia is taken from Mr. Quayle's manuscripts:

LIFE HISTORY AND HABITS.

The adult.—The beetle appears very early in the spring and, according to reports, patiently awaits the coming of its food plant. This early attack of the beetle as the plants are bursting through the ground and before the leaves are fully expanded is one of the things that makes control work difficult. Before the hops appear the beetles are known to attack the nettle, and often completely riddle the leaves. They also attack other plants, and have been seen, and evidence of their work noticed, on potato, mangel, beet, turnip, dock, lamb's-quarters, pigweed, and red as well as white clover. None of these plants is attacked, however, in preference to hops and it is rarely that they are found at this season on anything but hop vines. In one or two cases they were observed in some numbers on potato, at a considerable distance from hop vines. On a small field of hops that was deserted last year on account of this flea-beetle and planted to clover, the leaves of the latter were considerably eaten.

The first appearance of the beetles in this section, according to Mr. Hulbert, was fourteen years ago, and they have been attacking his hops for the past five years. The beetles jump very readily when disturbed, but fall to the ground, usually not far from the base of the vine. Experiments to determine the power of jumping, which is an important factor in control work, indicate that they may not jump more than a foot in the vertical and about a foot and a half in the horizontal.

FIG. 16.—Trained hop shoots stripped by flea-beetle. (Original.)

Feeding occurs almost entirely on the upper surface of the leaves, where they eat out small, nearly round holes about one-eighth of an inch in diameter. This is continued until the leaf is reduced to a network and finally nothing but the main ribs remain. Many of the vines grew to a height of three or four feet, then the foliage was completely stripped off, leaving the dead stalks, which may still be seen in the fields. Many of the vines are thus killed to the ground. Strings were put in place in 1908 in anticipation of the usual crop, but were taken down and saved for another year, as the vines that started afterward were too late to make a crop. Cultivation was stopped and a thousand sheep were imported from California by the Horst Company to feed in their yards.

The beetles, with their more or less cone-shaped bodies, readily make their way through anything into which they can get their heads, and our experimental cages [fig. 17], which were covered with cheese cloth, had to be re-covered with calico. They also make their way through the soil with little difficulty. Experiments to determine this point consisted in burying them at different depths, enclosed in tin cylinders. In two days the beetles appeared through 2, 4, and 6 inches of loose soil, but did not appear from these same depths where the soil was made compact by tamping.

The egg.—A few eggs have been taken on the hop roots about 4 inches below the surface. Obviously, these are most difficult to find and can not be detected at all without a magnifier. To more easily obtain the eggs and younger stages, tin cylinders, 8 inches in diameter and 2 feet high, have been sunk to a depth of 8 inches in the ground, some enclosing hop vines and others in the open field. Large numbers of beetles have been liberated in each of these, and they will be taken up with the soil intact in the tins in two, three, and four weeks, and the soil carefully examined for eggs and larvæ. Beetles taken in mating, and enclosed in vials with earth at the bottom, have laid eggs in from eight to ten days.

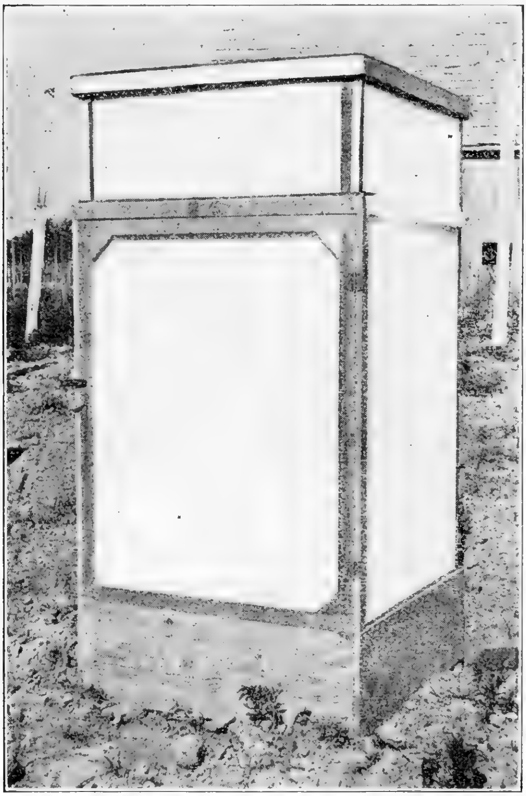


FIG. 17.—Breeding and control cage in place over a hill. (Original.)

The larva.—Larvæ of what the writer believes to be this flea-beetle have been taken from 2 to 4 inches below the surface, both around hop roots and in the spaces between the vines away from any hop roots. While most of the larvæ have been taken about hop vines, I think that they are not restricted, in feeding, to the roots of the hop exclusively, since some have been taken in spaces between the hop vines and also because of the wide distribution of the beetle, both in the United States and in the valleys of the Chilliwack and Agassiz, away from any hopyards. Search about the roots of the nettle and other plants growing along the borders and roadsides failed to reveal any larvæ.

The pupa.—We have also taken pupæ of what was considered this flea-beetle. Transformation to the adult was, of course, necessary to establish this positively and some of the pupæ taken to the laboratory duly transformed. These were taken about the hop roots 3 or 4 inches below the surface.

Both larvæ and pupæ, when sought at the same time, were extremely scarce, and sometimes an hour's search would result in finding nothing. Earlier in the year would undoubtedly be a more opportune time for getting the younger stages, but our rearing-cage experiments, starting with the beetles in mating, should give us ample material for the study of the younger stages. The scarcity of the larvæ at the time when sought is attributed by the writer to the fact that it was too late for the large numbers of spring and too early for those expected to appear about six weeks later, according to reports of previous years. Those few which were obtained are probably late individuals of the last brood.

Two other kinds of larvæ are taken commonly in the ground, these being wireworms and carabid larvæ. Many of these are very small, just about the size of our flea-beetle larvæ, and the wireworms, when first hatched, are of the same white color, but both of these forms of larvæ can be readily distinguished from the flea-beetle larvæ. The few pupæ obtained are undoubtedly those of what we consider the flea-beetle.

Development.—From all accounts this flea-beetle keeps emerging continuously throughout the season, though there are periods when the beetles occur much more abundantly than at others. Last year Mr. Hulbert stopped using the tarred boards June 1, when practically all of the beetles had disappeared. They did not reappear until the last week in July, when the jarring method was resumed. This year (1908) he continued the use of the tarred boards up to the second week of July, this difference over 1907 being attributed to the cold wet season. According to this, the next lot of beetles may not appear before the last of August of the present year. Beetles have been seen breeding continuously during the past two weeks, though not abundantly, one pair being seen out of seventy-five or one hundred beetles. Beetles are usually present in considerable numbers in the fall, when the hops are mature, and do much direct injury to the product.

NOTES ON OTHER SPECIES.

A few remarks in regard to the larval habits of our other American and some European species of Psylliodes may be interesting. The writer has several times observed the beetles of the equally well-known *Psylliodes convexior* Lec. in numbers on shepherd's purse (*Bursa bursa-pastoris*) in June near the District of Columbia, and it is probable that this is the larval food plant. Until the publication of Mr. Quayle's article[12] there was no record of any of our four species having been reared; hence, the natural conclusion that they were root-feeders. In Europe no less than forty-nine species of Psylliodes are recognized in a recently published catalogue,[a] and the habits of those which have been studied indicate a preference for cruciferous plants, although several are attached to widely different groups of plants. Thus among European species are the hop flea-beetle (*Ps. attenuata* Koch), the potato flea-beetle (*Ps. affinis* Payk.), and a species which is mentioned and figured by Taschenberg[b] as the "raps-erdfloh" (*Ps. chrysocephala* L.). The last is very abundant and has been known for years to attack edible cruciferous crops. It has been recently treated (1906) by Mr. Geo.

[a] Reitter, Catalogus Coleopterorum Europæ, pp. 572–574, 1906.

[b] Praktische Insekten-Kunde, Pt. II, p. 303, fig. 79. Bremen, 1879.

H. Carpenter as a cabbage pest in an article in which the larva is described and illustrated in detail. As to its biology Mr. Carpenter[a] reaches the conclusion that the female beetle lays her eggs on the underground part of the stem and that the young larva burrows through into the interior and feeds in the central tissue of the stem and taproot until mature. The papal stage lasts about three weeks and is passed in an earthen cell just beneath the surface. The natural larval food plant is evidently a wild crucifer.

LOCAL CONDITIONS AND NATURAL INFLUENCES.

Inquiry was made of Mr. Eder during his visit to Washington, D. C., in December, 1908, as to the local conditions in the infested area. From what was learned through him it would appear that the insect's occurrence in such great numbers in the hopyards of British Columbia was due to the equable temperature and to the humidity, which keeps the soil practically always sufficiently moist for the operations of the larvæ feeding beneath the surface.

There can be no doubt, from the writer's observations of our eastern flea-beetles, that these are largely held in check, especially in regions like the District of Columbia, by the extremely dry heat of midsummer. At the time that the flea-beetles are developing as larvæ or undergoing their transformation the ground is nearly baked by the heat during the day and softened only by dews at night. The conditions are very different in British Columbia, and there are, moreover, no other natural causes known which might assist in depleting the numbers of the little pest.

Among natural agencies only a single species of insect has as yet been discovered preying upon this flea-beetle, a hymenopterous parasite which was known to Fitch[2] and which he mentions as a "Chalcidian." It is evidently a species of Perilitus, probably the same species, *schwarzii* Ashm. (?), as has been encountered by the writer on other species of flea-beetles of the genera Epitrix and Phyllotreta. It develops within the body of the adult or beetle. It is not known if this species occurs also in the Pacific region. If not, it might be possible to introduce it.

Fitch's observations and conclusions are interesting, since we have no reason to doubt his theory. Briefly he observed on June 4, 1863, two flea-beetles pairing on a leaf of rhubarb. Presently a parasite alighted near them. It darted upon the back of the female, appearing to be inserting its sting in the tip of her body, whereupon she gave a leap and they both disappeared among the foliage. Fitch conjectured that the "chalcidian" was an egg-parasite of the flea-

[a] Journal of Economic Biology, Vol. I, pp. 152–156, Pl. XI. London, England, November, 1906.

beetle and that the eggs of the latter were so minute that the larval parasite required several of them to nourish and bring it to maturity, as observed of an egg-parasite of the Hessian fly. The parent, watching her opportunity, deposits an egg internally in the ovaries of the flea-beetle, or in the passage-way therefrom, and the parasite larva, taking up its residence there, consumes the eggs of the flea-beetle, one after another, as they develop, whereby none of them will be extruded until after the parasite has attained its growth. In conclusion he writes, "Most singular and truly wonderful as such a provision of nature would be, it is the most probable conclusion I am able to arrive at from past observations."

METHODS OF CONTROL.

Correspondents who have inquired for a direct remedy for use against this species have been advised to experiment with all of the usual flea-beetle remedies. These are, in brief, arsenate of lead. arsenate of lead with resin-fishoil soap, Paris green with and without Bordeaux mixture, Scheele's green, arsenite of lime with soda, dry Paris green with air-slaked lime, Bordeaux mixture alone, and kerosene emulsion. According to Messrs. Eder, Quayle, and others, most of these remedies have been tested more or less completely without being found to be thoroughly effective, owing to the great numbers of the flea-beetles and the rapidity with which the tops of the hop vines grow. All remedies that have been employed have been directed against the beetles only. Unless the hop plants are sprayed nearly every day it is practically impossible to keep them covered with any poison so as to entirely protect them from the ravages of the "fleas." Among other substances tested were tarred boards and sheets, as for leafhoppers. On account of the employment of cheap labor, chiefly Hindu, mechanical and hand methods were found of some value. Snuff was found effective on a small scale and finely powdered tobacco, such as is now on the market as an insecticide, is to be tested.

According to Messrs. Quayle, Eder, and others, the difficulties encountered in the economic treatment of this species are due to two causes: (1) The continual emergence or appearance of the beetles, rendering any method that has yet been employed, such as an arsenical or contact spray, or any mechanical means of capture, such as jarring, of only temporary value, and (2) the extremely rapid growth of the young hop vines, making frequently repeated applications of a spray or other direct remedy a necessity.

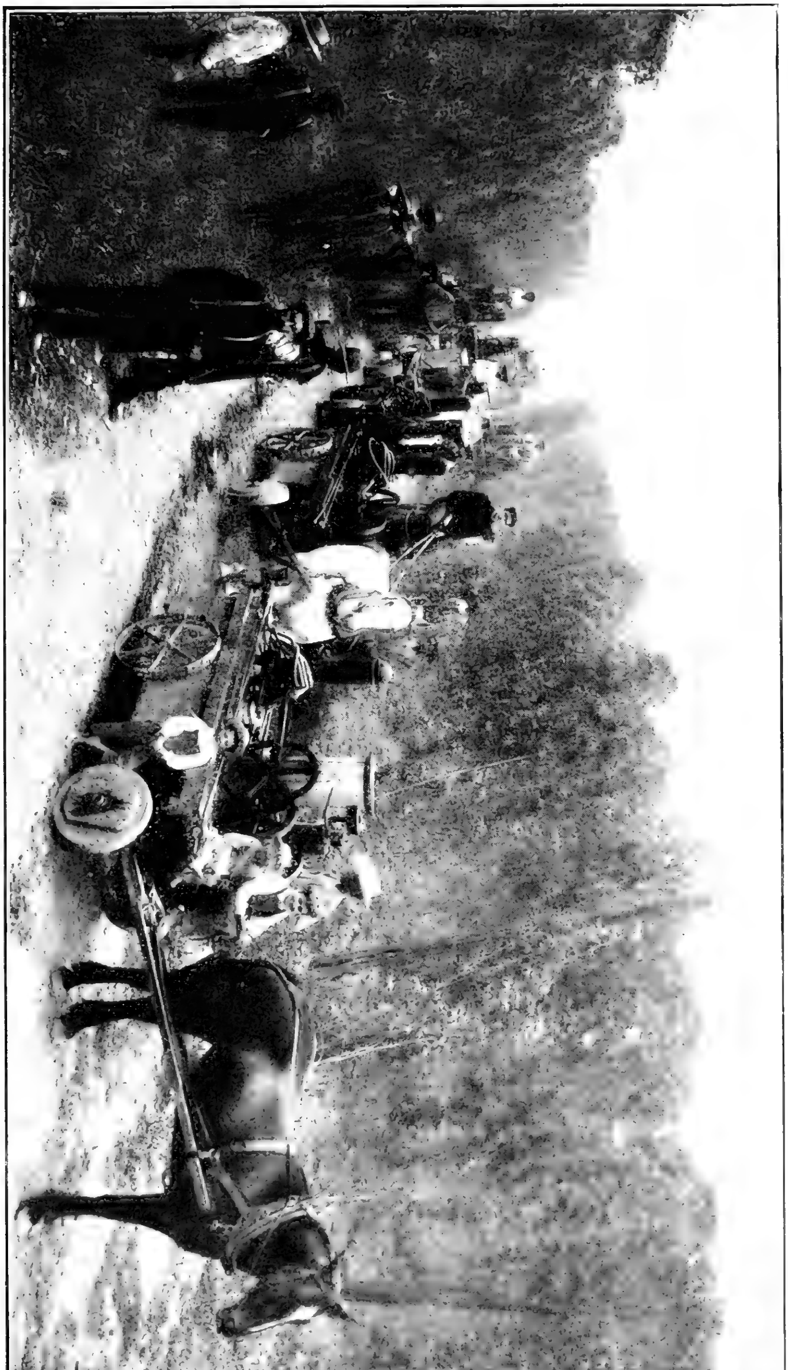
ARSENICALS.

Arsenate of lead.—Arsenate of lead, applied at the rate of about 1 pound in from 20 to 50 gallons of water, is advised for use against the hop flea-beetle. Being more adhesive, this mixture, when sprayed upon the plants, sticks more firmly to the leafage than Paris green, and is also very much less likely to produce scorching or burning; indeed, it has been used at 1 pound to 10 gallons of water on some of the hardier plants, such as potato, without injurious effects. This is, however, not advisable, owing to the extra cost, provided that a weaker solution will accomplish the object. Moreover, scorching is apt to follow its use at this rate on some plants, especially when these are exposed to the direct rays of the sun. The adhesiveness is still further enhanced by the addition of about the same amount by weight of resin-fishoil soap as of the arsenical employed. Mr. Wilson reported that arsenate of lead, applied at the rate of 4 pounds to 40 pounds of Bordeaux mixture, was inadequate, yet Mr. Quayle reports that used at the rate of 5 pounds to 50 gallons it will kill a large number of the beetles, although many take to the new growth that is constantly appearing, or apparently carefully avoid those places on the foliage that have a good coating of poison. The failure of these two arsenicals must be attributed, in large part, to unsuitable spraying apparatus; either of these applications should kill insects on hops, as they have both been found effective, according to Fletcher, against this same beetle on rhubarb in the Northwest Territory and Manitoba.

Dry Paris green.—Mr. Thos. Cunningham reported that very little impression was made by an arsenical spray in the region just mentioned, but stated that Paris green dusted on the plants seemed to produce better results. It was applied by means of a Leggett powder gun. Even then some trouble was experienced; in fact, as the arsenical dust or so-called " dust spray " struck the vines the " fleas " hopped to the ground. " In all my experience with insecticides," he says, " I have never seen anything which will approach the fleas in resistant power."

Paris green spray.—Paris green, being the most readily obtainable insecticide, was advised by this Bureau when information as to remedies was requested. When properly prepared and applied, according to the directions furnished in Farmers' Bulletin No. 127, this insecticide should have no deleterious effect on the hop or other plants affected. It was advised that other food plants growing in the vicinity, such as rhubarb, turnips, and weeds, should be sprayed with the solution.

Regarding its efficiency in hop fields Mr. John Wilson, in a report to the late Doctor Fletcher, stated that when applied at the rate of from 4 to 8 ounces, in combination with Bordeaux mixture, made according to the 4–4–40 formula, or in 40 gallons of water, it was not successful.



SPRAYING APPARATUS USED IN HOPYARDS IN BRITISH COLUMBIA. (ORIGINAL.)

For use against this species in its occurrence on field and garden crops in Washington State, Messrs. Piper and Doane have advised Paris green. The former states that he obtained excellent results by using Paris green liberally but that it is necessary in the treatment of young plants to apply the remedy as soon as attack by the beetles is noticed. Both the wet and the dry methods are advised, as well as the addition of Bordeaux mixture.

Other arsenicals.—Other arsenicals advised in such cases are arsenite of lime with soda,[a] which has the merit of being as effective as Paris green and lime and far cheaper, and Scheele's green, which is similar to Paris green and is employed in the same manner.[b]

SUMMARY ON THE USE OF ARSENICALS.

To sum up the directions for the use of arsenicals, it should be stated that arsenate of lead should take first place because it can be purchased already combined in paste form, and especially because it contains a smaller percentage of free arsenic (60 to 70 per cent), and is therefore less likely to produce scorching or burning; and, moreover, being adhesive, it remains on the plant longer.

Paris green, when combined with lime and water, or with Bordeaux mixture, is almost equally as good as arsenate of lead, and is more readily obtainable in most markets, the ingredients being purchasable practically anywhere. It is quicker in action, but not so adhesive.

The number of sprayings will naturally depend upon the locality and seasonal conditions; possibly it may be necessary to spray every few days when the plants are quite young and the beetles are most abundant. Later there should be longer intervals between sprayings.

Dry mixtures are as a rule not in the same class with the sprays, as they can not be applied so economically, do not so thoroughly cover or adhere so closely to the leafage, and are more apt to cause burning to delicate foliage. Dry Paris green mixed with air-slaked lime in the proportion of about 1 part of Paris green to 10 or 20 of lime is sometimes used, but is less effective, and frequently much of the material is wasted in applying it.

The spraying apparatus used in the hopyards of British Columbia is shown in Plate V and figure 18, the second illustration showing a crew spraying hops through the rows.

CONTACT SPRAYS.

Among the contact sprays tried during 1908 were whale-oil soap, 1 pound of soap to 10 gallons of water; kerosene emulsion, $\frac{1}{4}$ pound

[a] Prepared in accordance with instructions in Farmers' Bulletin No. 283, p. 37.

[b] Discussed in the publication quoted, as also in Farmers' Bulletin No. 127.

soap and 1 gallon of kerosene to 25 gallons of water; resin, 1 pound to 16 gallons of water; and black leaf tobacco extract, 1 gallon to 65 gallons of water. Of these Mr. Quayle says that the last seemed most effective, with kerosene emulsion next, and that none of these sprays in the given proportion injured the foliage at all.

It is entirely possible to kill most of the beetles well hit by the spray, but many escape between clods in the soil or are protected by the vine or are concealed in the growing tip. The percentage killed, however, will be satisfactory, but this [treatment] must be repeated so often that the operation becomes laborious and costly.

While kerosene emulsion and whale-oil soap are practically never advised as standard remedies for mandibulate or chewing insects,

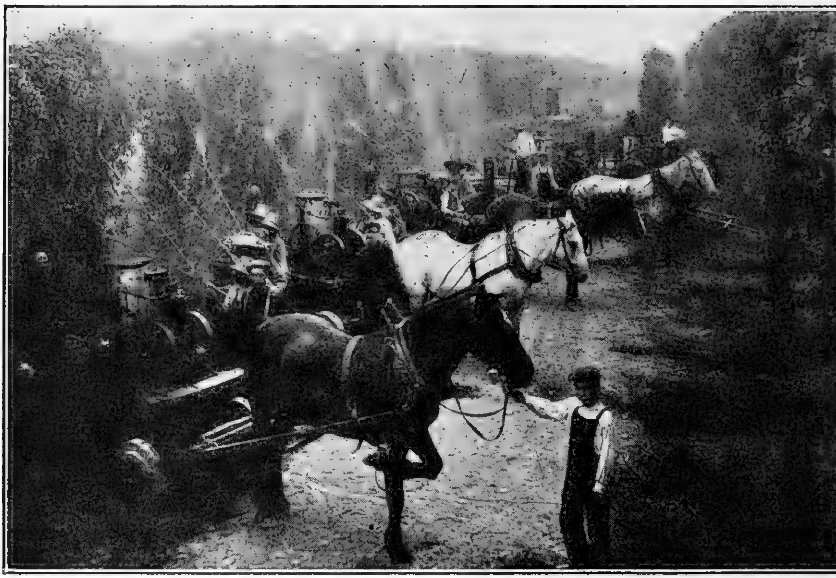


FIG. 18.—A crew spraying hops in British Columbia. (Original.)

such as this flea-beetle, both are employed in the infested territory against the hop aphis, or "louse," and therefore the hop grower is familiar with their preparation and use. It has been ascertained that when these are used against the hop aphis the flea-beetles coming into contact with the emulsion are killed. The probabilities are that kerosene emulsion properly prepared and applied in the affected regions will be considerably less expensive than a tobacco extract, and it is possible to make a tobacco extract which would be comparatively cheap. In recent experiments made under the writer's direction at Norfolk, Va., whale-oil soap, used at the rate of about 1 pound to 10 gallons of water, employed against aphides, has proved quite as effective and as economical as kerosene emulsion, considering the fact that unskilled laborers are likely to make imperfect emulsions and waste the material in applying it. With competent help, and other things being equal, kerosene-soap emulsion should be the more economical spray. It would be well to continue the use of kerosene emulsion at varying rates, including the rate that has been already used and up to 1 pound of soap and 1 gallon of kerosene emulsion to 30 gallons of water. It is possible that if the emulsion were diluted with 10 gallons of water still better results might be obtained, but if labor is cheap the weaker solution, other things being equal, should prove to be the more economical preparation.

BORDEAUX MIXTURE.

Bordeaux mixture, as has been known for years and frequently demonstrated, is a powerful deterrent against flea-beetles and other leaf-beetles, and its use should be continued. Since, as appears to be demonstrated by the observations of Mr. Quayle, this flea-beetle is quite discriminating in taste, it would be well to apply Bordeaux mixture over a considerable surface and use Paris green or arsenate of lead for the remainder of a field, i. e., to spray the majority of the plants in such manner that those which reject the Bordeaux mixture on treated plants would resort to those sprayed with Paris green or arsenate of lead. It should be determined which of these two insecticides has the greater deterrent effect against flea-beetles.

MECHANICAL AND CULTURAL METHODS.

Trap crops.—The great fondness displayed by this species for rhubarb suggests the use of the latter between rows, e. g., in the vicinity of woods, as an attraction or lure for the beetles, it being believed that the beetles will concentrate on these plants and thus give the crops an opportunity to grow to a sufficient height and strength to be able to resist the ravages of the pest. Since certain cruciferous crops are also attacked, such as turnips, it is further suggested that these and other varieties like swedes and rutabagas, rape, and mustard be employed. In the mild climate of the infested region all of these can be grown during the winter, and it seems probable that kale will be found equally effective. Beets, especially mangels, are grown in the affected region and tests should be made with these as trap crops, as also with sugar beet in regions where this crop can be grown profitably.

Rolling the fields.—One of the remedies attempted against this flea-beetle in its occurrence in beet fields, as reported by Doctor Ball, consists in the use of rollers. He reports that "running a corrugated roller over the field as soon as the damage is first discovered seems to have a very good effect. Just why, is not so clear, possibly because it loosens the ground, breaking up any crust that may have formed, and allows all the beets to get through at one time and in this way some of them get ahead of the beetles. The farmers think it kills the beetles. Cleaning up hedge-banks and rubbish around the fields has been recommended and appears to have had a good effect. It is a lamentable fact that a field that is slightly weedy when the beets appear will not be injured as badly as one that is free from weeds, which probably accounts for the fact that replanted beets are rarely destroyed."

The use of fertilizers.—Where fertilizers are used the plants are undoubtedly aided in recovering from attack by this flea-beatle, but fertilizers are not remedies. Possibly where mineral fertilizers are applied heavily they might have some effect on the larvæ, but it is doubtful if a sufficient amount of an irritant salt would remain in the earth to destroy any large percentage of larvæ at the time when those which have just developed from the egg or have just molted are feeding on the roots. It is worth mentioning, however, that Mr. Theo. Eder noticed that when a fertilizer consisting of 3 per cent nitrogen from nitrate of soda, 12 per cent potassium oxid (K_2O) from muriate (chlorid) of potash, and 9 per cent phosphorus pentoxid (P_2O_5) from superphosphates was applied there were practically no flea-beetles. This fertilizer, however, was considered too expensive, owing to the cheapness of hops in the affected region of British Columbia.

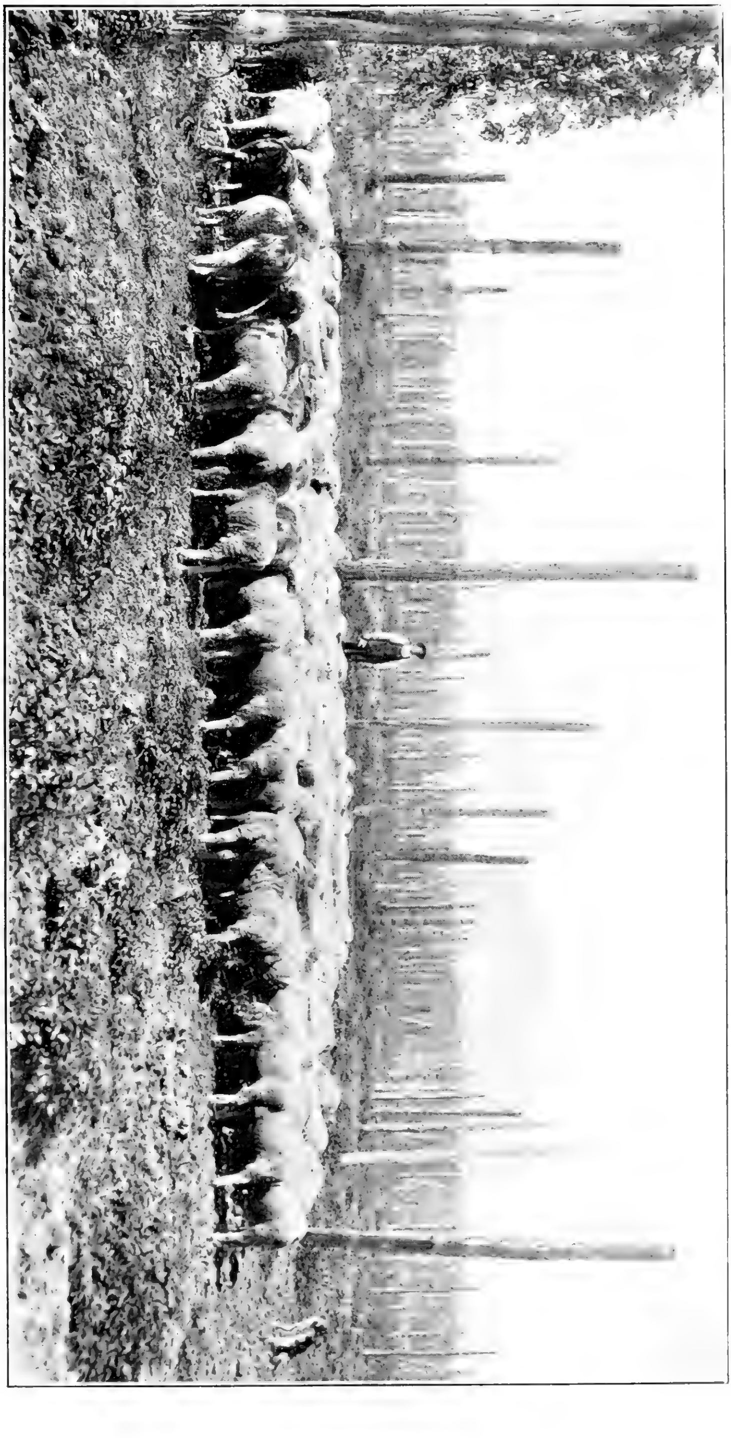
Irrigation.—Irrigation has been suggested and, on the authority of Prof. E. G. Titus, the flea-beetle, when it is working on sugar beets, can be driven away during irrigation by disturbing the beets, thus causing the beetles to jump into the water and be swept away.[a]

Tarred catchers.—Tarred sheets, boards, or similar contrivances on the plan of "hopperettes," in use against leafhoppers, have been employed in the infested region for capturing the flea-beetles. Mr. Hulbert reports having destroyed large numbers by catching them on tarred sheets as they fell from the vines after being disturbed. Mr. Quayle also reports success with a "catcher" which he describes substantially as follows:

> The receptacle used consists of a stout canvas about 3 feet by 4, to which is nailed, on the under side, three strips of boards with one at right angles, to keep the canvas taut. A handle is fastened to two of these strips to project upward and backward, by means of which the apparatus is operated. This is lifted from vine to vine and the beetles jarred off with wisps of hay. Usually two men work together on the same row, the two canvases placed together on each side of the vine.

---

[a] Bul. 67, Bur. Ent., U. S. Dept. Agr., p. 112, 1907.



HOP FIELDS FROM WHICH TRAINING TWINE WAS REMOVED IN JUNE OR JULY, PHOTOGRAPHED IN AUGUST.

Beetles abated somewhat the last of July and hops began to put out new shoots. Weed growth kept down by sheep pasturage. Hop-leaf growth pastured very close in fall. (Original.)

This method captures a satisfactory percentage of the beetles and should be comparatively inexpensive. But unfortunately the repeated operations which are necessary bring the cost to a high figure. It cost Mr. Hulbert last year approximately $1.25 per acre for each operation. He went over his vines six times, and some parts of the yard eight or ten times. He expected to go over it at least twice more, so that the total cost would be from $10 to $15 per acre.

In figure 19 a portion of a hop field is shown which illustrates the tarred "boards" in place for use. The flea-beetles are dusted off of the vines upon these tarred receptacles with wisps of hay, as

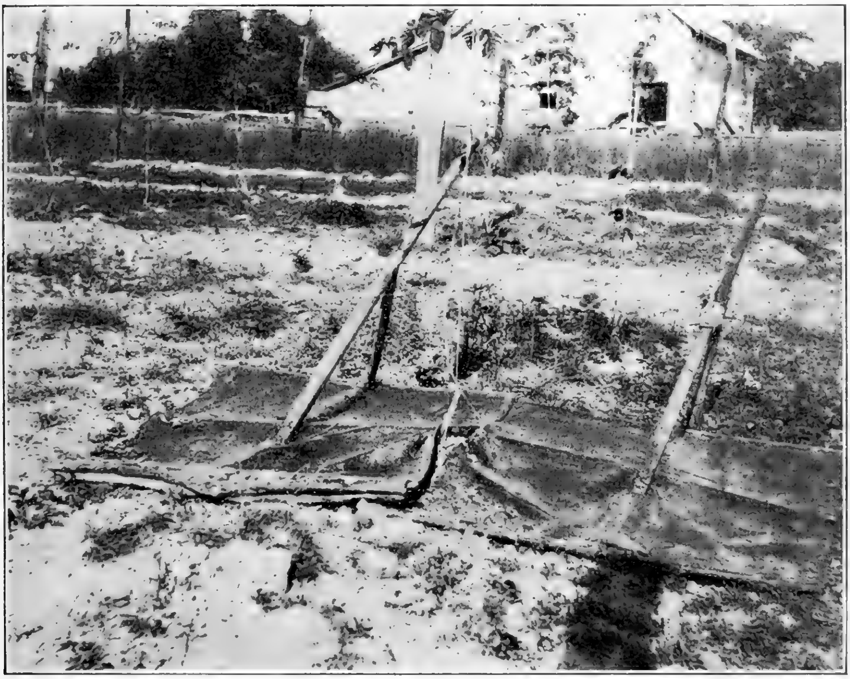


FIG. 19.—Portion of hop field with tarred boards in place. Flea-beetles are dusted with wisps of hay from the vines onto tarred boards. (Original.)

described above. All of the vines were tanglefooted, but the flea-beetles went up the poles and crossed over on the wires overhead until the tanglefoot was applied. Plate VII illustrates the method of capturing the hop flea-beetle on tarred horse sledges, also by shaking the vines. Millions were captured in this way.

CLEAN CULTIVATION.

Frequent stirring of the soil and other cultural operations seem, as yet, to be of no appreciable help, according to Mr. Quayle, and the kind of soil also seems to have little or nothing to do with the abundance of the beetles, which are found in light, sandy, and heavy soils. Mr. Quayle further says:

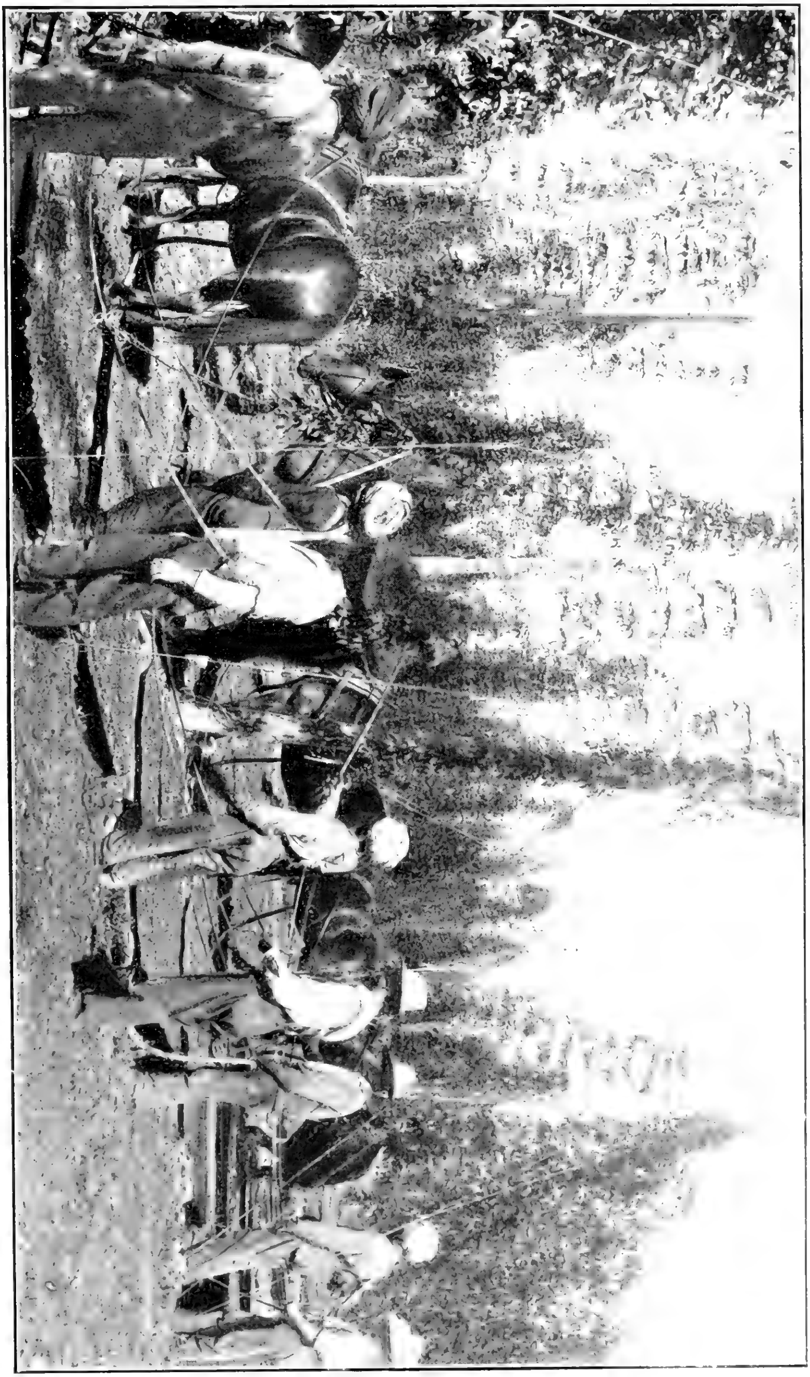
> The control measures which have been tried have been necessarily directed entirely against the adult or beetle, and considering the rapid growth of the vines and the continuous appearance of the beetles no effective and practical remedy has yet appeared. With further work on the younger stages it may be possible to find here a vulnerable point of attack.

One of the most promising remedies for this as well as other insect pests is the employment of clean methods of culture. Since it has been found that the flea-beetles ensconce themselves in any available shelter, such as the cracks in the hop poles, even although these may have no bark remaining, it has been thought desirable to dip the poles in a preparation which will not only close the cracks but which will also repel the pests. Fuel oil, a grade of crude petroleum, is being tried, according to Mr. Eder, since it can be purchased as low as 2 cents a gallon. Tar might serve the same purpose and should act as strongly as a repellent and close the cracks more closely and would not be so disagreeable to handle. The poles are dipped into the boiling fuel oil, but the tar would also have to be heated very hot before dipping.

It is customary to plow thoroughly and to cultivate where possible so as to keep down the weeds, and this method of tillage must, of course, be continued, as the insects find food in weeds of the kind which have been mentioned in the opening paragraph, viz, dock, lamb's-quarters, pigweed, and the like, and also cruciferous weeds. If, by preventing the insects from hibernating in the hop fields in débris, the fields can be practically freed from them, the next step is to prevent their hibernating in near-by timber, as there can be little doubt that in such places are their favorite winter quarters. It is practicable in many cases to cut down small sections of timber in order to accomplish this purpose.

In answer to the question as to the remnants after the hops are picked, Mr. Eder informed the writer that the expedient of cutting the tops and destroying them by burning led to the discovery that the beetles enter into the hollow stalks, remaining in hibernation there in great numbers. With the discovery of this habit he will permit remnants to remain as long as there is any prospect of the insects' trying to obtain winter shelter in them, and then will have all débris burned at about the time of the first frost. One method of destroying field remnants and weeds, by sheep pasturage, is illustrated by Plate VI.

The writer has suggested the addition of burlap wrapped about the poles which have been treated with tar or which do not have an odor strong enough to repel the insect. This will attract the insects for hibernation, and can be removed after the first frost, or there-



METHOD OF CAPTURING HOP FLEA-BEETLES ON TARRED HORSE SLEDGES BY SHAKING THE VINES; MILLIONS CAPTURED IN THIS WAY. (ORIGINAL.)

abouts, and thrown into hot water, and after drying will be available for use in other seasons.

If, with another year's experience, we could ascertain how best to control the insect, either by killing the beetles with arsenate of lead or other arsenical, kerosene emulsion, or whale-oil soap, or by destroying the larvæ in the ground, the problem would be partially solved. One, two, or perhaps even three of these remedies might be used in combination and excellent results obtained. In any case, if we can partially control the insects by any one of them we should not forget that cultural remedies, and especially clean culture, are the most valuable remedies that can possibly be employed against insect pests. Indeed, with many species, if cultural practices were properly followed out, with the cooperation of our neighbors, insecticides would in the course of time, after the balance of nature had been restored, seldom be needed save in case of severe outbreaks, which are likely to occur more or less spasmodically with most of our noxious insects.

LITERATURE.

A complete bibliography of this species is appended and only a brief review of published accounts need be given. The original description of the species appeared in 1847,[1] and it was not until twenty years later that we had any record of the insect's habits. In 1867 Fitch[2] wrote a two-page account regarding injury to cucumber, rhubarb, and radish, furnishing notes on a parasitic natural enemy. In 1884 our first account of injury to hops, a brief one, was written by Dr. J. B. Smith.[4] These accounts were followed by one from Piper[6] on injuries to certain truck crops in Washington State in 1895 and by Doane[8] of similar injuries in 1900. The writer[7] noted the abundance of the species on rhubarb near Washington, D. C., in 1897. Forbes and Hart[9] have given a brief account of the insect from the standpoint of its injuries to sugar beet in Illinois, and Fletcher[10, 11] published two accounts of the species in 1904 and 1907, respectively. In 1908 was published H. J. Quayle's article,[12] in which first mention is made of the larval habits of the insect.

BIBLIOGRAPHY.

1. Melsheimer, F. E.—Proc. Acad. Nat. Sci. Phila., Vol. III, p. 166, 1847.
   Original description from Pennsylvania as *Haltica punctulata* n. sp.
2. Fitch, Asa.—11th Rept. Ins. New York, pp. 38–40, 1867.
   A 2-page account with mention of food plants and a parasite; observed feeding on cucumber, rhubarb, and radish.
3. Fitch, Asa.—Ill'd Ann. Reg. Rural Affairs, 1867–8–9, Vol. V, p. 204, 1873.
   A brief note, with mention of attack on cucumber and melon.
4. Smith, J. B.—Bul. 4, o. s., Div. Ent., U. S. Dept. Agr., p. 50, 1884.
   Mere mention of occurrence in hopyards, where the beetles eat small holes in the leaves, doing no great damage.
5. Horn, G. H.—Trans. Amer. Ent. Soc., Vol. XVI, pp. 310, 311, 319, 1889.
   Revised technical description, distribution, and systematic bibliography.

6. Piper, C. V.—Bul. 17, Wash. State Agr. Exp. Sta., pp. 55, 56, 1895.

Short general account, with list of food plants. Species stated to be "by far the most destructive flea-beetle in the State" [of Washington].

7. Chittenden, F. H.—Bul. 9, n. s., Div. Ent., U. S. Dept. Agr., p. 22, 1897.

Short note on abundant occurrence on rhubarb near Washington, D. C.

8. Doane, R. W.—Bul. 42, Wash. Agr. Exp. Sta., pp. 11, 12, figs. 2, 3, 1900.

A 2-page general account with two original illustrations.

9. Forbes and Hart.—Bul. 60, Univ. Ill. Agr. Exp. Sta., p. 472, 1900; 21st Rept. State Ent. Ills., p. 124.

A brief account; on sugar beet in Illinois.

10. Fletcher, Jas.—Rept. Entom. and Bot. Canada for 1903 (1904), p. 177.

Mere mention as affecting hops at Sardis, B. C., in noticeable numbers.

11. Fletcher, Jas.—Rept. Entom. and Bot. Canada for 1906 (1907), p. 215.

Account of injuries in the Fraser River Valley, B. C., in 1906, with quotations from John Wilson, Agassiz; Thos. Cunningham, Vancouver; and H. Hulbert, Sardis, B. C., which include experiences with remedies.

12. Quayle, H. J.—Journ. Econ. Ent., Vol. I, p. 325, October, 1908.

A short article, with notes of injury in British Columbia; account of habits, all stages, including the egg, being taken 3 to 6 inches from the surface of the ground, larvæ feeding at the roots of hop and other plants growing in the yards; list of food plants, and difficulties of applying remedies.

SUMMARY.

The hop flea-beetle, a minute, black insect, feeds on various succulent plants. It does serious damage to hops in British Columbia and less injury to sugar beet and vegetable crops in the Pacific coast region.

Its life history is only partially known, but all stages have been found about the roots of hops and the larva probably feeds on most of the same plants as the adult. It is feared that this species may become an important hop-pest in Washington and Oregon, and it doubtless does more injury to beets than is generally accredited to it. Injury is most severe to young plants, but on sugar beet the operations of the beetles throughout the season undoubtedly have a deleterious effect and necessarily decrease the yield.

The abundance of the beetles when they appear early in the season on young plants, their constant reappearance, and the constant new growth of the plants from day to day make it difficult to apply direct remedies with more than temporary benefit. Where the hops are sprayed with kerosene emulsion or whale-oil soap for the hop aphis the numbers of the beetles are lessened. Among measures which give promise of value are the institution of clean methods of cultivation, including deep fall plowing, treating hop poles in such manner as to prevent the beetles from hibernating in them, and clearing all remnants from fields so as to leave them as bare as possible to prevent the beetles from sheltering there in winter. Arsenate of lead, Paris green, kerosene emulsion, whale-oil soap, and Bordeaux mixture should receive further tests, as should the employment of trap crops in the manner advised in this article.

U. S. D. A., Bul. 66, Part VII. Issued July 19, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

By F. H. Chittenden, Sc. D.,

In Charge of Truck Crop and Stored Product Insect Investigations.

SUCCESSFUL USE OF ARSENATE OF LEAD AGAINST THE ASPARAGUS BEETLE.

During the first week of June, 1908, Mr. W. A. Orton reported the common asparagus beetle (*Crioceris asparagi* L.) very injurious at Takoma Park, D. C., and made some experiments with arsenate of lead with complete success. Directions for application, as given in Circular 102 of this Bureau, were followed. The first application was made with 1 pound of arsenate of lead to 20 gallons of water and the second a week later, as the plants had grown rapidly in the meantime and a great many new larvæ had hatched. The second application was made at the rate of 1 pound to 15 gallons of water. The first application destroyed most of the insects, but after a few days a considerable number had developed. These appeared to have been all killed the day after the second spraying. Neither spraying seemed to injure the plants in the least, but the liquid adhered in fine drops to the foliage and was visible there for some time. An unsprayed plat on a neighbor's place was considerably injured by these insects, and up to July 1 no more had appeared on Mr. Orton's crop. He pronounced the treatment very effective. The work was done with a compressed-air machine or autospray.

Mr. Edward A. Eames, Buffalo, N. Y., writing of the value of arsenate of lead as a means of combating the common asparagus

Note.—The accompanying Part VII includes short notes on some of the insects which have been treated in earlier parts of this bulletin and notes on two insects not hitherto recorded as injurious in the United States. To the former class belong notes on the asparagus beetles and the asparagus miner, species considered more in detail in Part I, pages 1–10, and notes on water-cress insects in addition to what has been published in Part II, pages 11–20. To the second class belong notes on the injurious occurrence of the pea moth in the United States and a short account of a new western root-maggot.—F. H. C.

beetle, stated that the larvæ of this species threatened to devour his this year's spring-set asparagus to the ground. But after one thorough spraying with arsenate of lead it was difficult to find any but dead larvæ on the plants. Successive sprayings were of course necessary, because the beetles continued to come from neighboring gardens to deposit eggs on the plants and because the developing plants continually presented fresh unsprayed foliage for larval food.

Mr. Eames stated positively that arsenate of lead adhered well, even through several rains, just as its various promoters claimed—a fact which justifies its use in any case even at more initial cost than other poisons which might be used. He also expressed the view that asparagus growers generally should be impressed with the fact that, because of the tendency to spray only once, additional information should be given of the value of extra applications. In conclusion, he stated that he believed arsenate of lead was a specific for this class of insects.

Our correspondent is undoubtedly right. It seems to be as nearly a specific for asparagus beetles as anything that can be obtained, provided it is applied according to directions and that applications are repeated as often as necessary. The trouble is that many truck growers, after spraying a single time, consider that the matter should then be dropped, and if the desired result is not produced, i. e., if the trouble is not wholly stopped, the spraying is condemned or at any rate the insecticide is discontinued, while all that is necessary for the entire season is a second or third application.

A NOTE ON THE ASPARAGUS MINER.

The asparagus miner (*Agromyza simplex* Loew) was reported by Mr. I. J. Condit in the vicinity of Antioch, Cal., August 19, 1908, where the common asparagus beetle was also abundant. The miner was said to be equally numerous and stalks showing infestation were received. The miner-infested stalks could generally be detected by their roughened appearance near the ground.

This species was also taken by Mr. Condit at Oakley and it seems probable, since the common asparagus beetle is found in both localities, that it is becoming generally distributed in California. In one place at Oakley Mr. Condit observed the miner quite common on some stalks, but it did not appear to be equally common over the entire ranch.

During October, 1908, the writer observed this species well established on asparagus in the vicinity of Portsmouth, Va. In October, also, Mr. J. B. Norton reported very severe injury to asparagus in the vicinity of Concord, Mass. The roots of the plants were not only girdled, but the miners worked up the stalks some inches above the ground.

INJURIOUS OCCURRENCE OF THE PEA MOTH IN THE UNITED STATES.

Prominent among the injurious occurrences of the year 1908 was the discovery of the pea moth (*Enarmonia nigricana* Steph.) for the first time in the State of Michigan. August 10 we received from Mr. J. E. W. Tracy, Bureau of Plant Industry, specimens of the larva of this species and its work in growing peas and pods from Charlevoix, Mich.

Mr. Tracy wrote that he obtained the specimens on that day and some days earlier and that Mr. E. W. Coulter and others in that vicinity knew nothing of the identity of this insect, which was causing them considerable concern. The caterpillar first showed itself in very small numbers four or five years before, but it had increased rapidly until the year of writing, when 15 per cent of the peas were ruined. The insect appears to start operations by eating the embryo stem and then moves along the pod until it makes its exit and disappears. Early varieties of peas were the worst sufferers in the affected district. At the time of writing our correspondent found a less number of living larvæ than previously.

This appears to be the first record of the appearance of this insect in the United States, although it has been known as a pest in Canada for several years and has undoubtedly been present in our Northern States, where peas are grown, without having been recognized as anything new or unusual.

A two-page account of this species has been published by the writer in Bulletin No. 33, pages 96–98, which includes a brief illustrated description of the moth and larva and a consideration of the distribution, nomenclature, history, habits, and remedies.

This insect first came to notice near Toronto, Ontario, in 1893, and notices of its ravages in Canada were given in several subsequent years by the late Dr. James Fletcher in his report as entomologist and botanist of the Dominion of Canada. It is an importation from the Old World and is well established in New Brunswick and Nova Scotia as well as in Ontario, and is also recorded from Manitoba.

The name of this species was omitted from the Dyar catalogue of Lepidoptera, but is included in Smith's Check List of Lepidoptera under No. 5702. In most publications the species is mentioned as *Semasia nigricana*.

A NEW WESTERN ROOT MAGGOT.

August 16, 1907, Mr. E. M. Ehrhorn sent from San Francisco, Cal., some radishes, the roots of which were affected by a maggot. The adults were reared September 3 to 20 and were referred to Mr. D. W. Coquillett for identification. They were first mistaken for *Pegomya cepetorum*, because of the very close relation of the two species, but when more material of both sexes was obtained they were seen to be different. Mr. Coquillett states that some individuals have the bristles practically as in *cepetorum*, but in the males the median black stripe of the abdomen is continuous. This material corresponds so well with Stein's description[a] of *Chortophila planipalpis* as to leave no reasonable doubt of the species. The type locality is Idaho. The insect will therefore be known as *Pegomya planipalpis* Stein, and may be called the western radish maggot. Another lot of the maggot was received from the same source October 1, larvæ and pupæ both being present. From this lot adults issued November 1 to 21.

November 21, 1908, we received from Mr. Charles Heise, Aberdeen, Wash., a section of turnip mined by larvæ which are probably of this species, as also a number of puparia. Our correspondent stated that his observations showed that the maggot works on onions as well as on turnips. As we do not know to the contrary, and do not know positively of the occurrence of any onion maggot in that State, this surmise may be correct. It remains to be verified or disproven. The seed-corn maggot (*Pegomya fusciceps* Zett.) occurs in that region and is more apt to be the onion-feeding species.

Two natural enemies of this radish maggot have come under observation and have been identified by Mr. J. C. Crawford, as follows:

Aphæreta sp.—September 3, 1908, many braconids of a species of the genus *Aphæreta* emerged from material in which this root-maggot was breeding in infested radish from San Francisco, Cal. It is a small species, shining black in color, with dusky wings and yellow legs. In some specimens there are 21 joints to the antennæ on one side and 22 on the other. It is very similar to the type of *muscæ*, but is larger.

Polypeza sp.—This species was reared from its host October 10, 1907, and appears to be undescribed.

NOTES ON WATER-CRESS INSECTS.

The water-cress leaf-beetle.—May 2, 1907, Mr. J. W. Bryan brought to this office from Halltown, W. Va., specimens of the water-cress leaf-beetle (*Phædon æruginosa* Suffr.), present in the beetle and larval forms, the larvæ at that time about half grown. The beetles were beginning to die and a fungus attack was noticed when received. Numerous individuals of the beetle and one larva were parasitized by the fungus. The fungus was tentatively determined by Mr. Haven Metcalf, Bureau of Plant Industry, as *Entomophthora sphærosperma*. If this identification is correct, there can be no doubt that the fungus attacked the insect before death, and may therefore be a factor of value in its natural destruction.

[a] Berl. Ent. Zeitschr., Vol. XLII, pp. 234–235, 1897.

Since the publication of the writer's preliminary articles on the water-cress leaf-beetle and sowbug in the present bulletin (pp. 11–20) it has been noticed that earlier accounts of the related European *Phædon betulæ* L., known as the mustard beetle and "blackjack," were made by Miss E. A. Ormerod, who furnished several references with illustrations in her manual.[a] From this account it appears that injury was first noticed, at least in England, in 1854, to white mustard crops near Ely. Another account of this insect is given in the same author's report for 1886.[b]

The water-cress sowbug.—April 16, 1907, Mr. C. A. Killinger, Shippensburg, Pa., sent specimens of the water-cress sowbug (*Mancasellus brachyurus* Harg.) in different stages, stating that it was destroying his water cress, working on the leaves under water, cutting them close to the stem. If the cress is light or does not grow fast, as happens in winter, they also work on the stems and roots, cutting the plants loose and causing them to float downstream. Our correspondent thought that this species was brought to that section from Virginia.

Experiments conducted with lime in a small spring the previous summer succeeded in killing most of the sowbugs, but plenty of them remained at the time of writing. The lime, however, burned the cress, causing it to turn yellow.

December 23, 1908, Mr. F. W. Houston, a grower and shipper of water cress at Lexington, Va., wrote of this species, inquiring for literature and a remedy. He stated that he had a spring under cultivation that was infested with the water-cress sowbug, and later—March 11, 1909—he sent specimens. In this connection he wrote as follows:

> I have a spring under cultivation which has been infested by them for several years. I fought them for a time by putting the water into ditches and exposing the rest of the cress bed to the sun. In these ditches I would make frequent applications of lime; this, of course, was done during the early summer, after the shipping season closes. It seems to kill all of the sowbugs, but when I put the water into the beds and reset the cress, hauling it from an uninfested spring, it was not long until the "bugs" were again noticed, and in a short time they were as thick as ever.

Mr. Houston was advised that in the case of the old beds the water should be drawn or turned off and that the cress should be completely destroyed and the spring reset with uninfested cress.

---

[a] Manual of Injurious Insects and Methods of Prevention. London, 1890, pp. 151–156.

[b] Report on Injurious Insects for 1886, pp. 59–60.

INDEX.

O

6, 1907-11
.S.D.A.