BULLETIN No. 29—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY.

THE FALL ARMY WORM AND VARIEGATED CUTWORM.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST

BY

F. H. CHITTENDEN,
ASSISTANT ENTOMOLOGIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., July 18, 1901.

Sir: I have the honor to transmit herewith the manuscript of a paper entitled "The fall army worm and variegated cutworm," prepared with his customary thoroughness by Mr. F. H. Chittenden, of this Division. The insects are both important crop pests and of wide distribution, the former ranging from the West Indies to the Great Lakes, the latter cosmopolitan, but while known to entomologists, general farmers, and truck growers for many years, their life histories have never before been made out. This complete account of these species will be of great interest to the economic entomologists of the country, and it contains ideas and suggestions of much practical value. I recommend the publication of this paper as Bulletin 29, new series, of this Division.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The season of 1899 was marked by extensive outbreaks of the fall army worm (*Laphygma frugiperda* S. & A). During that season it was as injurious perhaps as any other insect, as it was destructive to a much longer list of crop plants and over a vast area of territory; in short, this attack was unprecedented in the insect's history. The species is common in most seasons and familiar to practical workers in entomology and to observing persons interested in agriculture, but, although it has been known as injurious for many years, its full history has never been investigated in all its details in any single locality, nor have any very complete accounts been published concerning it.

It was hoped during the season of 1900 to ascertain certain points as to the insect's life habits and economy that might have a bearing upon the practical treatment of the species as it occurs in the field and garden. For this reason many facts in relation to its biology learned during the season of 1899 were withheld from publication to await further observations. The season of 1900 was a disappointment as regards opportunity for the study of this insect, it seemingly having disappeared, at least as a pest, throughout the country. This experience is confirmatory of an opinion, held by the writer for some time in regard to this and several other species of similar distribution and of probable southern origin, that certain atmospheric and other conditions destroy them in such great numbers in their more northern range during the late fall and in the winter that few of the insects are left to propagate the species the following season, and that, when these more northern localities become restocked with large numbers of the insects, such reproduction has been due mainly to the flight of moths from southern localities where these conditions have not prevailed, and where they multiply in more nearly normal numbers in swamp land and similar locations.

It is to be regretted that the missing data can not be supplied, as it seems unwise to delay the publication of the ascertained facts awaiting more favorable conditions for observations which may not again offer for a year or two, or perhaps longer. The present account is as complete as can well be furnished at this time, and it is presented herewith in connection with a report of a similar outbreak of a cutworm which occurred during the season of 1900. That season was remarkable for cutworm outbreaks in various portions of the country. Most prominent of the species concerned in injury was the variegated cutworm (*Peridroma saucia* Huebn.), this species in fact replacing the fall army worm as the injurious army worm of that year. Injury was to a still longer list of crop and other useful plants, but was somewhat more restricted than in the case of the fall army worm, although more or less damage was inflicted over a considerable portion of the United States and Canada, indicating that infestation was more general than reported. The principal losses were sustained on the Pacific slope from northern California to British Columbia.

The life history of the variegated cutworm is somewhat better known than that of the fall army worm, but something remains to be learned of both species.

The fall army worm and variegated cutworm differ considerably in habits, as also in distribution, for, whereas, the former feeds normally upon grasses, grains, and other Gramineæ, and less seldom injures garden vegetables and other plants except when driven to attack them by hunger, the latter is a regular inhabitant of the garden. Both are of growing importance as pests, and, as such outbreaks are apt to recur in the near future, it is desirable to place on record all known facts in regard to them.

F. H. C.

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THE FALL ARMY WORM AND THE VARIEGATED CUTWORM.

INTRODUCTION.

The history of economic entomology shows that nearly every year there are outbreaks of one or more species of caterpillars, which, from their habit of migrating in great numbers, have come to be familiarly termed "army worms." The normal habit of these caterpillars is the same as that of others of their kind, which includes cutworms. In ordinary seasons they feed chiefly on the grasses or weeds on which the parent moth has laid her eggs, or they may be present and feeding in our gardens, fields, and pasture land in small numbers, doing so little damage that their presence is not noticed. No class of insects however, are more subject to fluctuation in numbers in different seasons. When, therefore, for any reason their numbers become unduly increased, they first devour every form of vegetation that is palatable to them growing in their immediate neighborhood, and when this food has become exhausted they march in armies in search of other means of sustenance.

In recent years several army-worm outbreaks have been observed and recorded. The year 1896 was marked by an unprecedented outbreak of the true army worm; the year 1899 by a similar incursion of the fall army worm, and in 1900 the variegated cutworm became the most destructive of these species.

In 1899 the fall army worm ravaged a considerable portion of the United States east of the Rocky Mountain region. This species feeds by preference on grasses and related plants, and so frequently assumes the migratory habit that it has come to be classified as one of our principal army worms, second only to the army worm proper (*Leucania unipuncta* Haw). The unusual and widespread abundance of the fall army worm during the season mentioned, and in many States where it had not previously been known as the cause of serious trouble, was the more remarkable since not a single specimen of this insect was received the previous year from any of our many correspondents, although a few individuals were noticed by the writer and others in the vicinity of the District of Columbia, and because so few outbreaks have been reported since that year, one of these also in the District of Columbia.

Although the species is to be found ordinarily everywhere in the eastern half of the United States, and it is tolerably well known, particularly in the South, as distinct from the true army worm, even to those not well versed in entomology its life history has not been thoroughly investigated in any single locality to the writer's knowledge. A search through available literature fails to show that the larva has been described in its various stages.

A third species of caterpillar, the spotted cutworm (*Noctua c-nigrum* Linn.), was also at work during the season of 1900, doing, however, less injury than the other species mentioned. Reports show that this insect was unusually destructive in Indiana and Connecticut and along the northern shore of Lake Ontario, where it seemed to take the place of the variegated cutworm which was so injurious in the western part of Canada. The species was also rather more abundant than usual in Maryland and Virginia. As with the two preceding species, it was destructive to all sorts of garden and root crops, and in one instance, observed in Connecticut, assumed the army-worm habit.

A preliminary notice of the injurious occurrences of the fall army worm was given in Bulletin No. 23 (n. s.), and similar articles on the variegated and spotted cutworms were published in Bulletin No. 27.

The two species which form the basis of the present publication have not the same origin, and are therefore of quite different distribution. It follows as a matter of course that a corresponding dissimilarity exists in their life economy.

The fall army worm is undoubtedly of Southern origin, and proof will be furnished to show that in its constant endeavors to obtain a permanent footing farther north than its natural range it is thwarted every few years by meteorologic conditions, the extreme cold of our more Northern States causing its death in great numbers in its hibernating quarters. On this hypothesis it would seem that the reappearance of the species in years after its destruction is to be accounted for by migrations of the moths from the South northward. The variegated cutworm, there is little doubt, is a foreign introduction, and was probably brought from the Old World at an early date, as the species has been known to naturalists for a considerable period.

Outbreaks of these and other species which travel in armies are frequently the cause of extreme alarm among farmers, fruit growers, and others whose crops are infested, and there is usually considerable apprehension of the reappearance of these insects in future seasons. As a consequence, it happens in army-worm seasons that the Division of Entomology of this Department and the entomologists of the various experiment stations are besieged as to the probabilities of further attack and the means to be employed in the destruction of the insects, so that a repetition of injury the next season can be averted.

It should be stated for the benefit of the general reader that the term army worm has been applied to several insects which have the habit of congregating and migrating in great numbers. The common army worm and the wheat-head army worm are common forms. A few other species which occur in North America should be added. Among these are the erratic army worm (*Noctua fennica* Tausch.), which is known as the black cutworm in ordinary seasons; the cotton army worm, known commonly as the cotton worm (*Aletia argillacea* Hbn.), and the forest tent caterpillar so-called (*Clisiocampa disstria* Hbn.). All of the species mentioned belong to the Noctuidæ, with the exception of the last, which is a Bombycid. A name that has recently been proposed for this last is the forest army worm.

All of these species differ considerably in habit, and in order to prescribe the proper remedies it is necessary to have a thorough understanding of the insects' habits; in fact, frequent inquiry is made by those interested in the subject as to the full life histories of these species.

While it is matter of entomological history that a repetition of general outbreaks by army worms, or species referred to as such, seldom follow in successive years, still it is wisdom to guard against such a contingency, and, at the first intimation of the presence of the insects in numbers, to institute radical measures for their suppression. To those skilled in entomology there is little difficulty in recognizing the moths as well as the larvæ of these species, and this it is confidently believed will be facilitated by the illustrations and descriptions which are here given; but it is advised that those who feel unable to determine these insects beyond peradventure promptly send the material found to some one competent to make correct identifications, so that appropriate measures of control may be adopted without delay.

In the case of the irruptions of the fall army worm in 1899, and its scarcity the following year, there are reasons, which have been briefly mentioned and which will presently be set forth in greater detail, that we can assign for depletion in numbers following injurious attack. But the life economy of the variegated cutworm is so different that no reason for the lessening of the numbers of this insect during the present year (1901) can be conjectured other than that parasites, and perhaps some other natural enemies which were observed at work late in the season of 1900, would have, at least locally, a beneficial effect. It is possible, however, that diseases, either fungous or bacterial, might have been present in many of the regions over which the insect ranged in destructive numbers last year without their coming under the notice of anyone capable of determining them, and it is perhaps possible also that the condition of the weather in the Pacific States, in Kansas, and in some other States where this cutworm was especially destructive might have operated against overmultiplication.

These are points that remain to be studied in the life history of both the fall army worm and the variegated cutworm.

The occurrence of the fall army worm in numbers so far north as the District of Columbia in 1900 is somewhat indicative of a repetition of attack, for, although the species has apparently been practically killed out in the locality of this irruption, farther south conditions more favorable to the insect's development have been met with, and it may be that outbreaks will again occur in the near future. The early occurrence of this species in Texas in April, 1901, is still more suggestive, and it may be that this is the precursor of outbreaks through the Southern States.

Of the variegated cutworm it has already been stated that there are no reasons, except the historic fact that repetitions of severe outbreaks seldom happen in successive years, why this insect should not be troublesome in 1901 as it was in the previous year, although it is improbable that the attacks, if any occur, will be so serious as those of 1900. Whether or not either of these species becomes injurious during the next year or two, it is well, to employ a hackneyed expression that has been much used lately, "in time of peace prepare for war." It is desirable, therefore, to have a proper understanding of these species, that remedies may be applied in time and that the future may not witness the very serious losses that were encountered through the ravages of these two insects, the one in the East, in 1899, and the other in the far West, in 1900.

THE FALL ARMY WORM.

(*Laphygma frugiperda* S. & A.)

The fall army worm, or grass worm as it is also called in the South, like the common army worm, feeds normally on grasses and grains and certain forms of weeds, particularly such as belong to the Gramineæ or grass family, but will attack in its seasons of abundance almost any form of vegetation that is encountered in its line of march. At such times it becomes a pest in garden and orchard, on lawns and in greenhouses, as well as in pastures and in fields of grain. In most years it seems to be particularly destructive to winter wheat and other cereals, grasses, and other graminaceous plants, but it often does damage earlier in the season to various other crops. It especially attacks young corn in a very similar manner to the corn-ear worm, the young larvæ devouring the tender folded leaves and, as they increase in size, sometimes burrowing into the heart and destroying the forming ears.

The moths are nocturnal, and their eggs are deposited in clusters on grasses or other food plants, and (when these insects occur in abundance) often also on the leaves and twigs of trees, on the outer walls of buildings, and in similar locations.

The larvæ are frequently so dark in color as to readily escape recognition except when they are moving in numbers, particularly as it is their normal habit to conceal themselves during the daytime deep under grasses and to feed mostly at night, or at least not in the heat of the day.

A feature of this insect's attack, and one from which it derives its popular name of fall army worm, has always been emphasized, viz, that it seldom travels in numbers or does appreciable injury except in the fall. It is seldom noticed, therefore, except in the extreme South, earlier than the first of August, while the outbreaks of the common army worm usually occur prior to that time and seldom later.

There is practically no doubt that there are two or three generations of this species produced each year in its normal range, and, in seasons which favor its development, each succeeding generation usually becomes more destructive than that which preceded it; hence its great abundance late in the season, when it causes most destruction.

The infested territory during the season of 1899 comprised a very considerable portion of the United States east of the Rocky Mountains, injury extending from portions of New York and New Jersey southward through Florida to Cuba and westward to Texas, and extending from there to Kansas, Nebraska, Ohio, Indiana, and Illinois. Infestation was rather general, perhaps more so than reported, along the Atlantic coast. It was also quite severe in some regions in the West.

DESCRIPTION OF THE MOTH.

The moth which produces the fall army worm is a member of the Noctuidæ, the same family as that of the true army worm, *Leucania unipuncta*, which includes the parents of the cutworms. These two moths, however, are quite unlike each other, *Laphygma frugiperda* being more nearly related to the genus Prodenia than to Leucania.

The moth is quite variable, there usually being in most lots two distinct forms. What appears to be the commonest form, at least the present year about the District of Columbia, is shown in the accompanying illustration (fig. 1 *a*). The fore-wings are rather dull grayish-brown above, and show in this color variety a pattern more or less similar to the one figured. The hind-wings are glistening white, with rosy reflections; the posterior portion of the border is more or less infuscated near the fringe, which has an inner dark line at this point; and the veins of this portion of the hind-wings are dark and distinct. In the more ornamental form of the moth the fore-wings have the appearance shown at *b*. In this form the insect looks very much like an owlet moth of the genus Prodenia, bearing particular resemblance to *P. ornithogalli*. The fore-wings are mottled or variegated with black and white, reddish-brown, and sometimes with pale bluish, yellowish, and other tints. The expanse of the fore-wings is from an inch to an inch and three-eighths. The great variability in the colors of adults appears to be unexplained, as extreme varieties of both forms figured may be found issuing from the same lot of larvæ and, indeed, probably from the same batch of eggs.[1]

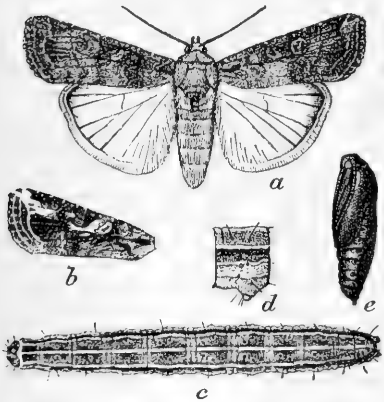

FIG. 1.—*Laphygma frugiperda*: *a*, moth, plain gray form; *b*, fore-wing of Prodenia-like form; *c*, larva extended; *d*, abdominal segment of larva, lateral view; *e*, pupa, lateral view—*d*, twice natural size; others enlarged one-fourth (author's illustration).

BRIEF DESCRIPTIONS OF THE EARLIER STAGES.

Since detailed technical descriptions of the egg and the different stages of the larvæ are presented, shorter popular descriptions, with

[1] It was noticed in a fairly large series of this moth reared by the writer during 1899 that the dull gray-colored individuals were mostly females, while the orna-

the accompanying illustrations, will suffice for practical purposes for the identification of these stages.

The egg.—At *a* of figure 2 the egg is shown above from the side, very much enlarged, and from above in the lower figure. The diameter is about half a millimeter, or about one thirty-second of an inch; but as the eggs are deposited in clusters of from 50, 60, and more, they may readily be detected in the exposed places on blades of grass and on leaves selected by the parent for their deposition. The surface is ribbed, as illustrated, and the color is dull white, with a pearly luster. The whole egg mass is covered with mouse-colored down from the body of the parent.

The newly hatched larva.—The larva when first hatched is quite unlike the full-grown caterpillar, the head being much larger in proportion and the body more hairy, presenting the appearance shown at *c* of figure 2. Its general aspect at this stage is nearly black, but after feeding the young larva becomes greenish, taking this color from the food which it has eaten. In this illustration the larva is necessarily shown lighter than in nature, in order that the hairs and markings may be seen.

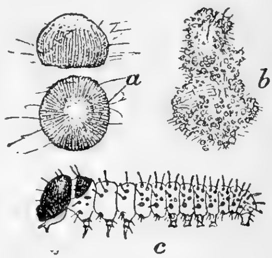

Fig. 2.—*Laphygma frugiperda: a,* egg from side in upper figure; *b,* from above in lower figure; *c,* newly hatched larva; *a, c,* much magnified; *b,* somewhat enlarged (original).

The mature larva.—The same variability observed in the coloring of the mature insect is seen in the caterpillars. When full grown they measure about an inch and a half in length. The larvæ resemble the common army worm in many particulars, and especially is this true of the lighter forms.

The body is striped on a ground color which varies above from pale yellowish-brown, dull dark olivaceous or purplish-brown, to black, more or less strongly streaked and intermixed with dull yellow. Three thin stripes of pale yellow extend along the dorsal surface through the thoracic shield to the anal extremity. The dorsal or middle line is nearly straight, and the subdorsal ones are feebly sinuate with the prominence of each segment. On each side there is a broad yellow undulating line, more or less strongly mottled with red, particularly in the vicinity of the abdominal legs. The ventral or lower surface is paler, varying from dull yellow to greenish, sometimes very

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mental or Prodenia-like forms were represented chiefly by males. In response to inquiry as to whether this rule held good in series from other sources, Dr. John B. Smith wrote, under date of February 3, that such was not the case, and that there are some localities where only the dull forms have been found, and others where only bright forms are obtained, but that where the two forms occur together in one locality it is quite possible that the Prodenia-like forms may be mostly males. Both sexes, however, may be found in both forms.

strongly mixed with red. Even in the darkest forms the striæ shown in the illustration (fig. 2 *c*, *d*) can as a rule be readily made out. The striated appearance, however, is usually weaker than in the larva of the common army worm, and the larger and more prominent black piliferous tubercles and the hairs proceeding from them with which the body of the fall army worm is marked will alone serve to distinguish this insect from the army worm proper. In the latter the piliferous warts are minute and inconspicuous and the hairs so short that the body appears nearly smooth by contrast. The fall army worm is the smaller and slenderer and the entire body, including the head and cervical shield, is usually much darker.

An illustration of the army worm is presented at figure 3 for comparison.

The head also presents good characters for the separation of these two larvæ. That of the fall army worm is smaller in proportion to the length of the body, nearly black, and with a white inverted Y-shaped mark in front not possessed by the army worm. These differences may be easily recognized by comparison of the heads of the two species shown in figure 4 at *a* and *b*.

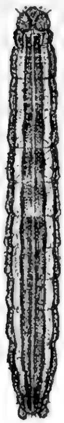

FIG. 3.—*Leucania unipuncta:* larva—about one-third enlarged (original).

FIG. 4.—*a*, head of larva of *Laphygma frugiperda;* *b*, of *Leucania unipuncta*—both enlarged (original).

The pupa.—As shown in the illustration (fig. 1 *e*), the pupa differs but little from that of the army worm, save in its smaller size. It is of the usual form and shining mahogany-brown color of cutworm pupæ, lighter when first transformed and darker when approaching maturity. The anal segment ends in a pair of minute spines. The spiracles and a considerable proportion of the integument surrounding them are larger and much more prominent than in the pupæ of the army worm, this character appearing to be sufficient to distinguish between the two species at this stage. The length is about five-eighths of an inch (13–16 ^{mm}).

TECHNICAL DESCRIPTIONS OF THE EGG AND LARVA.

[By Harrison G. Dyar, Ph. D.]

Eggs in a close double layer, one above the other, more or less covered with fine gray down from the moth; spherical, well-rounded, the base a little flatter than the apex, uniform; vertical ribs numerous, about 60, small, joined by distinct crossbars nearly as large as the ribs themselves and forming rectangular or slightly hexagonal areas; above, the ribs do not diminish till near the vertex, where they become converted into reticulations, smaller toward the micropyle; color, pearly pink; diameter, 5 mm.

Stage I.—Head rounded, bilobed, about as high as wide, clypeus triangular, half as high as the head, without perceptible paraclypeal pieces; labrum quadrate and with the mandibles projecting; shining jet black; antennæ moderate, pale; setæ short, pointed; width .25 mm. Cervical shield straight before, rounded behind, jet black, bearing 4 setæ on each side; two more (of which one is scarcely visible) detached posteriorly, laterally; prespiracular and subventral tubercles single-haired; anal plate semicircular, dusky blackish. Body whitish, slightly translucent, tubercles large, round, black, with very distinct, short, black, pointed setæ. Arrangement normal, no subprimaries; on joints 3 and 4, ia and iia small, ib and iib large, all well separated and equally spaced; iv and vi single-haired; on the abdomen i, ii, and iii large, equal, i and ii on joint 12 approximately in a square, iv behind the spiracle and with v as large as the dorsal ones. Leg shields small, quadrate, black; ventral tubercles minute, also black. Feet of joints 7 and 8 slightly smaller than those of joints 9 and 10. After feeding the larva becomes green from the food.

Stage II.—Head round, slightly bilobed, shining black; width .4 mm. Body as before, a little thicker, and joints 12 more distinctly enlarged; cervical shield black; anal plate not cornified, pale like the body, shaded with gray on the sides. Color whitish, with faint traces of dorsal, subdorsal, lateral, and stigmatal lines. Tubercles large, black, and distinct as before, the subprimary ones present. Hairs short, stiff, black. Thoracic feet black, the others pale, with dark shields.

Stage III.—Head round, shining black, the sides covering the eyes and sutures of clypeus, pale luteous; width .65 mm. Shields and tubercles shining black, tubercles large, setæ coarse and black. Body greenish gray, dorsal and subdorsal lines whitish, straight, narrow, and even; ground color darker laterally, ending in a blackish shade touching tubercle iv, defined on the ventral side. A broad, pale, substigmatal band; subventer grayish green, shading to the scarcely paler venter. Body uniform, joint 12 very slightly enlarged.

Stage IV.—Head black, paraclypeal pieces and labrum pale whitish, sides no longer pale, but filled in with black mottlings; rounded, slightly bilobed, shining; width 1.1 mm. Cervical shield black, bisected, not strongly cornified; anal flap dusky; tubercles large, black. Body greenish gray, dorsal, subdorsal (at tubercle ii), and traces of narrow lateral lines pale, as before; substigmatal line broad, white, mottled with greenish and divided by a central band of this color. Feet dusky; setæ distinct, black, rather long.

Stage V.—Head rounded, slightly bilobed; clypeus large, the paraclypeal pieces nearly attaining the vertex; mandibles prominent; brown-black, sides mottled with pale, especially posteriorly, paraclypeal pieces white, as also the vertical suture; labrum pale, width 1.8 mm. Body cylindrical, normal, joint 12 very slightly enlarged, feet nearly equal. Above dark brown, a little dotted with pale, venter more greenish, but also brown mottled. Dorsal line pale, nearly obsolete except on the thorax and anal plate; subdorsal line distinct, white, straight, a little broken on joints 12 and 13; stigmatal band broad, sharply edged, not inclosing the spiracles, white, nearly filled in with dark red mottlings. Feet all dusky; cervical shield sooty black, not strongly cornified, cut by dorsal and subdorsal lines; anal plate dusky, with two white spots, formed by the broken dorsal line; tubercles distinct, black, with short, stiff, black setæ.

Stage VI.—Head rounded, bilobed, clypeus large, the paraclypeal pieces reaching three-fourths of the distance to the vertex; brown-black, sides posteriorly mottled with pale, sutures white, all as before; width 3 mm. Body as before, joint 12 very slightly enlarged, feet equal. Blackish brown above, varying in shade, the lateral space tending to be darker, as also a space each side of the dorsal line; venter pale greenish, densely mottled. Dorsal line whitish, as broad as the subdorsal and regular, but much fainter; subdorsal line mottled with pinkish, straight. The pale mottlings of the body are heavier between tubercles i and ii and across tubercle iii, suggesting obsolete lines. Slight black streaks bordering the subdorsal line below. Substigmatal band broad, sharp, the edges a little irregular, white, filled in with pale red mottlings. Feet all dusky; cervical shield black, very narrowly cut by white dorsal and subdorsal lines; anal plate dusky, cut by pale dorsal line, with a constriction anteriorly. Tubercles cornified, distinct, dark brown, largest on joints 12 and 13; tubercle iv on joint 5 is opposite the upper corner of the spiracle, on joints 6 and 7 below the middle, on 8 at the middle, on 9 above the middle, on 10 at the upper corner, on 11 low down halfway between the spiracle and tubercle v, and on joint 12 opposite the lower corner of the spiracle. Setæ short, rather stiff, dark.

DISTRIBUTION OF THE SPECIES.

The distribution credited by Dr. Smith (Bul. 44 U. S. Nat. Mus., p. 168), taken together with divisional records of occurrence, shows that this insect is generally distributed from Canada and Maine south to Florida and the other Gulf States, and west to Colorado and Montana. It is known also in Jamaica, Brazil, and Cuba.

Judging by the locality list cited above, which was published in 1893, it would seem probable also that the insect has widened its natural range since that time, as it was stated to occur westward only as far as Kansas and Nebraska, and Maine was not included among the northern localities. It was troublesome about Chicago, Ill., for the first time in 1899, and recently has been reported by different entomologists from several northern regions. These include Kittery and Orono, Me. (reported, respectively, by Messrs. Thaxter and Slingerland), and St. Anthony Park, Minn. (Lugger). The most western locality in Montana is Miles (Davis), and in Colorado, Fort Collins (Gillette). The most northern locality in New York State is Number Four (Lintner).

This insect is undoubtedly native to North America as well as South America and indigenous to the United States. Its occurrence in Brazil and in Central America and its greater abundance in semitropical portions of the United States would indicate that it was originally, although not in very recent times, a tropical species. At present it is more at home in the Southern States, in the Lower Austral zone, where unusual opportunities are afforded for its increase in swamp land, among wild rice and rank grasses, but it is also thoroughly acclimatized nearly throughout the Carolinian portion of the Upper Austral zone, and appears to be gradually working its way northward, the extreme northern localities mentioned being located well within what is considered the Transition zone.[1] It is evidently destined to further invade

[1] The mere record of the capture of this insect in the most northern localities noted can scarcely, in the writer's opinion, be taken as positive evidence of its establishment there. It would seem more plausible that the insect had not bred in such

the Transition zone in course of time, although it will probably not be injurious much north of the Upper Austral for many years to come.

NAMES OF THE INSECT.

Few native species of insects have had applied to them a greater variety of common names. Beginning with the first name proposed by Smith and Abbot of corn-bud-worm moth, we have grass worm and grass caterpillar applied in the fifties, and in later times wheat cutworm, army cutworm, grass worm, southern grass worm, army worm, fall army worm, Daggy's corn worm, and grass army worm. To this list was added during 1899 by Nebraskans "alfalfa worm," and by Floridans "buck worm."

The scientific nomenclature includes: *Phalæna frugiperda* S. and A., *Trigonophora frugiperda* (Geyer), *Laphygma* (misspelled *Laphrygma*) *frugiperda* (Guenée), *Laphygma signifera* Walk., *Prodenia autumnalis* Riley, and *Laphygma macra* Gn. (misspelled *machra* by Glover).

REPORTED OUTBREAKS IN 1899.

In addition to the outbreaks which will be here recorded it should be said that the list of localities, although considerable, by no means shows the extent of the ravages of this pest. Many correspondents reported "*the* army worm" in their vicinity, and many requests were received for circulars of information concerning the army worm where there was little doubt that the fall army worm was the species concerned.[1] No specimens of the insect were received from many such correspondents; hence the list of localities, which would considerably augment that which will be presently given, must necessarily, for scientific accuracy, be omitted.

The first reported instance of injury during the season of 1899 was from Mr. M. Cronly, who wrote, June 19, of damage to the rice crop in the vicinity of Wilmington, N. C. Specimens accompanied this letter, as also all other reports which will be here cited.

July 6 Mr. W. T. Hopkins wrote that this species was present in large numbers at Cherry, N. C., doing much damage to corn, rice,

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localities, but had flown there from farther south. We know this to be the case with the cotton worm, which is sometimes to be found in great numbers in New York, and even in Canada, while there is no reason for believing that it breeds farther north than the northern border of the cotton belt; in fact it is almost certain that it does not breed north of there. It is possible, also, that the fall army worm dies out every year or two in the coldest localities in which it breeds, owing to the rigors of winter weather, but is restocked in after years.

[1] *Leucania unipuncta* was received with reports of injury during the year 1899 only from single localities in each of four States, Kentucky, South Carolina, Louisiana, and Virginia.

peas, and grass, extending its depredations over a considerable territory and in some places completely consuming young corn. It was impossible to use Paris green at this time, as the corn was too tall for the purpose, and the larvæ were, moreover, all over the ground and over all vegetation in the neighborhood.[1]

During the latter half of July the writer observed this insect in considerable abundance in the unfolded leaves and young ears of corn at Marshall Hall, Md., and in great numbers on grasses in the experimental plats of the Department grounds, being particularly injurious on the creeping bent (*Agrostis stolonifera*), which it practically destroyed.[2]

During August many reports of injury were received. The first was from Mr. C. A. Hart, Urbana, Ill., who sent larvæ found at Arcola, in the same State, feeding on leaves of corn. On the 5th Mr. E. D. Sanderson brought larvæ received from Mr. A. T. McCallum, Red Springs, Robinson County, N. C., with report that they were injuring corn, millet, sweet potatoes, cowpeas, and other vegetables at that place. On the 22d Mr. W. H. Stennett wrote concerning this species, inclosing a clipping from a Chicago daily, and reporting the appearance of the caterpillars simultaneously at Chicago and at Evanston, Ill.[3] Injury in Chicago was most marked upon lawns; larvæ were also observed to attack white clover, and were noticeable on young blue grass.

August 24 Mr. Adam Wechsler, New Glatz, Prince George County, Md., brought larvæ that were ravaging a field of sowed corn in that vicinity and were spreading into a field of spinach. Mr. Wechsler expressed the belief that he would probably lose both crops. The same day Col. Wright Rives, Rives, Md., reported attack on millet at his place, the insects being so abundant as to cause fear that they

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[1] Our correspondent stated that it had been very wet in his vicinity all of the preceding year and until late that spring, after which the rain had been very light and insects of various kinds had been unusually troublesome, but what bearing those conditions could have had on the enormous numbers of the insects is not obvious.

[2] A feature of this latter outbreak was that injury was at first believed to be due to the work of the sooty corn-root webworm (*Crambus caliginosellus* Clem.), the only insect that could be found July 17, when the attention of the writer was first called to the injury. A small grass-feeding billbug, *Sphenophorus parvulus* Gyll., was also present in large numbers and in all stages, as was also a minute wireworm, *Monocrepidius bellus* Say. Specimens of white grubs in the first stage (*Lachnosterna* spp.) were also taken. Injury was undoubtedly due mainly to the fall army worm, although the root webworm and billbug were also in sufficient numbers to make their presence felt. This is a good example of what is often to be found where only a single species is reported as responsible for injury.

[3] From Mr. Stennett's letter and from the newspaper account it appears that this invasion of caterpillars was preceded by one of the milkweed butterfly, *Danais archippus* (*Anosia plexippus*), which species was described as descending in a cloud in certain parts of the city.

would destroy the entire crop. The following day Mr. Charles Deering, of Chicago, Ill., wrote concerning the outbreak previously noted in that city and suburbs. The grass upon his own lawn, of perhaps 2 acres, seemed quite dead in parts that lay mostly in the sun. The same day Mr. Joe V. Walz, Evansville, Ind., wrote concerning an attack of this species on corn in his vicinity, the farmers there complaining that this was a new species of corn worm. It was described as attacking and boring into the center of the stalks and eating out the heart. August 29 we received a telegram from the Evanston Press, Evanston, Ill., stating that the army worm was destroying lawns in that city. Request was made for information for publication, and the reply by the writer, who was at that time in charge of the Division, was published in the Evanston Press for September 2. The same day word was received from Hon. G. W. Koiner, Richmond, Va., that this species was destroying corn and millet near that city. On the 31st of August Dr. W. W. Anderson, Statesburg, S. C., wrote that these caterpillars were eating up the grass and destroying the hay crop, as well as garden vegetables, all over the State. The caterpillars were said to be much more numerous than usual.

September 7 we received specimens from Dr. A. D. Hopkins with information that the species was destructive in lawns in Morgantown, W. Va. The following day Mr. H. Meislahn, Clarcona, Fla., reported that this insect, locally known as "buck worm," was attacking "Teosinte" (*Euchena mexicana*), a useful graminaceous forage plant resembling Indian corn. The same day Mr. W. K. Westone, Congaree, S. C., reported that it was very destructive to upland rice in that vicinity. It was stated that the habit of the larva was to attack the foliage of the rice in its tender state, afterwards eating the heads and destroying the grains. September 11 Mr. G. L. Grant, editor of the Florists' Weekly Review, Chicago, Ill., sent specimens of the egg masses, together with moths, with the report that the eggs had been deposited in large numbers on the side of a stone wall. The moths had also invaded a greenhouse and covered the plants with eggs.

October 4 we received from Mr. Thomas I. Todd, Athens, Ga., larvæ of this species, together with others found injuring the leaves of the turnip crop of that vicinity. Later he wrote that the "worms" were so numerous as to almost cover the public roads. Nearly all when observed were traveling west or southwest. On the 13th we received larvæ from Mr. Warren Knaus, McPherson, Kans., with the statement, conveyed in a letter of October 17, that they were very destructive to growing wheat near Conway, Kans. October 28 Mr. J. C. Vida, mayor of Camajuani, Matanzas, Cuba, sent specimens with the report that this species was concerned with two other caterpillars, both evidently native to Cuba and unknown to us, in a severe attack upon pasture land as well as young tobacco.

November 4 Dr. E. P. Felt, Albany, N. Y., reported, on the authority of Mr. M. F. Adams, that there had been injury to lawns at Buffalo, N. Y.

In January, 1900, Mr. Webster informed the writer that the fall army worm had been injurious in Ohio the previous fall, and named Haverhill, Scioto County, Buck Run, Adams County, and Urbana, Champaign County, as localities in that State where the insect had been reported in destructive numbers.

February 3, 1900, Prof. J. B. Smith wrote that this insect had been injurious in New Jersey the previous season and for the first time in his experience. It attacked clover, grass, and wheat.

The fall army worm became the subject of some newspaper comment, and quite a number of newspaper paragraphs, in addition to those which have been cited, appeared in reference to the pest, particularly in Chicago dailies. In one of these the insect was identified as the boll worm, *Heliothis armiger*; and the "kissing bug" was stated to be an effective destroyer of the "worms." In some instances injury was confused with that of certain caterpillars which infested fruit and shade trees. In some other journals published farther west, however, the ravages of this insect were noticed, and the identification vouched for by entomologists.

According to Press Bulletin, circular series No. 2, University of Nebraska, by Prof. W. D. Hunter, which reached the writer after the reports previously recorded, injury was very severe in that State, particularly to alfalfa, whence the name "alfalfa worm," which became very generally applied to the caterpillars. The species was identified from Johnson, Gage, Nemaha, Saline, Fillmore, Douglas, Washington, and Dodge counties, and was also reported from Boyd and Dawson counties. In some localities the alfalfa fields suffered the loss of the third cutting. Many beet fields were attacked, also those of corn, Kafir corn, wheat, oats, cabbage, and grasses. Cowpeas, millet, and other general and truck crops, according to Prof. E. D. Sanderson, were infested in that State.

The editor of the Indiana Farmer stated in his issue of September 2, 1899, that the fall army worm was reported in the corn fields and gardens within 4 miles of Indianapolis in large numbers. In a subsequent issue, September 9, it was reported on the authority of A. C. Harvey that this insect had made its appearance at New Lafayette, Ind. The larvæ started from a piece of oats ground which had been plowed up for wheat: the army had crossed into a tender millet patch and devoured it, and was at the time of writing in buckwheat.

In the Ohio Farmer of November 2, 1899, complaint was made by a correspondent of injury to wheat by this species at Haverhill, Ohio. "The worms" were doing much damage, taking "the fields clean as they go." An answer to this letter was given by Mr. Webster, with short notes on the insect's habits and suggestions as to remedies.

A list of localities where injuries were noticed in the State of Illinois during 1899, together with a short general account of this species, was given by Messrs. Forbes and Hart in Bulletin No. 60 of the University of Illinois Agricultural Experiment Station (pp. 497, 498, 1900). The actual localities in Illinois where attack was observed include, besides Chicago and its suburbs, Quincy, Meredosia, Arcola, Urbana, Villaridge, and Champaign.

A brief report of the occurrence of the fall army worm in Nebraska in 1899 was given in the Thirteenth Annual Report of the agricultural experiment station of that State (1890, pp. 47, 48). The actual list of localities infested included Tecumseh, Beatrice, Crete, Hastings, Fremont, Northbend, Gothenburg, and Butte, and the crops infested included alfalfa, sugar beets, rye, white clover, and blue grass. At Northbend and Gothenburg the "worms" were reported as destroying grass growing on lawns.

Writing May 12, 1900, Mr. N. L. Willet, Augusta, Ga., stated that this species was injurious in that locality the previous summer, doing a great deal of serious damage, principally to velvet beans grown as a forage crop. On the 19th of the same month Mr. G. G. Hood, China Spring, Tex., reported this species in his vicinity. He stated that this insect, with the common army worm (*Leucania unipuncta*), specimens of which he sent, had been present in his section the preceding year after a rainfall of 30 inches the first of July. They stripped the alfalfa fields and did considerable damage to wheat, young corn, and sorghum.

OCCURRENCE IN 1900.

Stranger still than the occurrence of the fall army worm in 1899 was its apparent nearly complete disappearance the following season. Up to September 17, when the writer captured a single moth at a light in this city, no word had been received from any of our correspondents of the occurrence of this insect, in spite of numerous inquiries in regard to it. In all perhaps upward of seventy people had been written to in regard to possible injurious occurrences in 1900, and, although many of our correspondents were good observers, the insect was not seen by them.

October 12 we received information from Mr. W. R. Beattie, of the Division of Botany, that an insect which he had mistaken for the boll worm was doing great damage to corn on the Potomac Flats, near the Department of Agriculture. The species concerned in the injury proved to be *Laphygma frugiperda*, present in all stages at this time and in the greatest abundance, the corn plat infested being a complete ruin. The fact had first been noticed about the middle of September, but from the appearance of the leaves and stalks it was obvious that the insects had begun work a little earlier. Another and an unrecorded food plant was observed—the chick-pea (*Cicer arietinum*), which was being grown experimentally in a near-by plat. All of the pods of the last-mentioned crop were empty, and in some cases larvæ of this species were present in them, though the principal damage was doubtless due to the boll worm or corn-ear worm (*Heliothis armiger*), which was also present.

Attack was noticed in the same locality also to crab-grass, rutabaga, hollyhock, and lambsquarter (*Chenopodium album*).

In Bulletin 186 of the Michigan State Agricultural College Experiment Station, bearing date of December, 1900, and issued in 1901, page 30, Mr. R. H. Pettit makes mention of a similar small outbreak of this species at Chatham, Alger County, Mich., on corn, which he states was badly affected upon the station grounds, the insect entering the ear and burrowing into the kernels, both when they were in the milk and later, in the same manner as is done by the corn-ear worm.

OCCURRENCE IN 1901.

In 1901, Mr. Darden Edgar, Edgar, Dewitt County, Tex., sent larvæ, which were about three-fourths grown at the time of their receipt, May 4, which he had found attacking stalks of young corn in the usual manner described in previous accounts of this species. Some were found in the "buds" and some in the stalks. The species had not been noticed in that locality in previous years by Mr. Edgar, who is a good observer, and although the larvæ did not occur in great abundance in that vicinity at the time of writing, it seems quite probable that this occurrence is a precursor of more severe attack and that a later generation may do serious damage in the Southern States, at least locally, and that the insect may even spread northward to regions where it was destructive in 1899.

Mr. W. J. Young also wrote in regard to injuries in Louisiana, stating that the insect was noticed nearly every year, but had not been so destructive since 1882 or 1883. It was noticed in several different parts of a field where the larvæ had literally eaten the leaves off of 40 acres of sugar cane ranging from small shoots to cane 2 feet high. A piece of corn just tasselling was cleaned of every leaf, and in 20 acres of young corn they ate the entire heart or "bud" out. They burrowed into a great many stalks of corn at the first and second joints from the ground, disappearing into the stalks. The ground was described as being at this time "just full of them changing from the worm to the moth." Some neighbors complained of the same trouble, and on some plantations where there was nothing growing but cotton the worms ate that. August 25 our correspondent sent specimens of the moth from Whiteville, La., with report that the larvæ had apparently disappeared entirely at this time. The cane, however, was permanently injured. About 60 per cent of the wrapper blades were dead to the ground, but the lower eyes on the cane had sent out sprouts, showing an entire deterioration of that part of the stalk.

August 24 Mr. Sam. P. Saltus wrote of injury by this species, stating that it did much damage in the vicinity of Gillisonville, S. C., to grass intended for hay. In a patch of 4 acres sown in peas, also to be cut for hay, all the grass was destroyed in about two days, but the pea vines were left untouched. The same was noticed in fields of cotton.

HISTORY AND LITERATURE.

The original description of the fall army worm appeared in Smith and Abbot's Natural History of the Lepidopterous Insects of Georgia (1)[1] in 1797, or one hundred and two years before the time of the last general outbreak. Even at that early date it was recognized that the species was a very destructive one, Guinea corn and other kinds of grain being then known as food plants, the larva being stated to feed on the bud or main shoot of the plant within which it lives. This account, which includes suggestions as to remedial treatment, is illustrated by a colored plate showing the different stages and the two common varieties of the adult.

The economic literature of this species is very considerable and an effort will therefore be made to confine references to such publications as bear upon the history of outbreaks of the insect or upon its life history and habits.

It was not until the year 1855 that the insect appeared to have again attracted attention by its ravages, although there can be no doubt that it was injurious from time to time in different portions of the Southern States during that period. In that year Townend Glover, in his report on cotton insects (3), gave a fair account of this species, paying particular attention to ravages in the State of Georgia in 1854. Mention is made also of injury in 1845, reported by a Colonel Whitner at Tallahassee, Fla., to grass, corn, sugar cane, and upland rice. Glover's notice of injury refers particularly to grass, young grain, and cotton, and he stated, among other things, that "instances had been known in which these caterpillars, urged by necessity, actually devoured stalks of fodder that were stored away for winter consumption. Deep ditches cut in the earth to stop them were immediately filled up by the multitudes which fell in and perished, while eager millions still rushed over the trembling and half-living bridge formed by the bodies of their late companions, bent on their mission of destruction and devastation."

During the year 1868 three accounts appeared by Joseph B. Lyman, M. D. Landon, and the late C. V. Riley. The account of the first

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[1]The numbers in parentheses ( ) refer to corresponding numbers in the bibliographical list appended.

writer appeared in Cotton Culture (4), the species being designated as "the army worm." The illustration furnished, however, shows that *Laphygma frugiperda* was the insect under discussion. The account of the second author mentioned is made under the head of "The grass caterpillar," and refers to the now well-known habit of this larva of being frequently found in cotton fields, where it does little damage, provided weeds, grasses, or other vegetation more palatable to it are present for it to feed upon. He states that the insect was the source of much amusement on his plantation of Helena, Ark., during 1867. The gist of the story is that Mr. Landon was congratulating himself upon having the grass and weeds devoured by this insect in his cotton field, when to his disappointment no sooner had the grass worm finished its mission and left the rows clean than the cotton worm made its appearance, presumably in great numbers, although this does not appear clear from the published statement. Dr. Riley's first account was published in his first report as State entomologist of Missouri (7) under the name of "Wheat Cutworm." Injury was noted to wheat, oats, and grasses and only in the State of Missouri.

In succeeding years Dr. Riley reported injuries in various localities. In 1870 (American Entomologist, Vol. II, p. 43), in joint authorship with B. D. Walsh, he made brief mention of this species, proposing for it the name *Prodenia daggyi*, but without description. Subsequently (l. c., p. 329) he made mention of ravages by this insect in many parts of Missouri and Illinois during that year, and furnished figures of the larva. Later (l. c., p. 340) mention was made of injuries at Ottawa, Kans., and Eureka, Mo., and still later (pp. 363–365) the moth was figured and described in detail under the name *Prodenia autumnalis* in a fuller account. The last two articles mentioned were incorporated in one in the Third Missouri Report, published in 1871 (12).

In Glover's report, as Government entomologist for 1872 (13), brief mention was made of injury during that year by this insect to corn, grass, and pea crops in Georgia.

In 1878 Dr. Cyrus Thomas (16) gave a short account of this species, referring to an outbreak in about the year 1873 in Washington County, Ill., when "sad havoc" was done to winter wheat.

In the year 1881 Dr. Howard visited the rice fields in the vicinity of Savannah and Atlanta, Ga., and Columbia, S. C., where injury was noted to other crops than rice, larvæ being observed eating grass, cabbage, strawberry, and bean plants. At this time remarkable evidence of cannibalism was noticed, in one locality the older worms destroying the younger ones by hundreds, and this when plenty of other food was at hand (23).

In 1884 there was a considerable outbreak in Illinois, as described in detail by Prof. S. A. Forbes in his report as State entomologist for that year (27), and in Kansas as reported by Prof. F. H. Snow (26). The first-mentioned account is the most complete published to date, and includes a revision of the literature, description of the different stages, observations on the life history, natural enemies, and a consideration of preventives and remedial treatment.

The occurrence of this species in 1885 and 1889 at Lafayette, Ind., was noted by Prof. F. M. Webster in 1890 (30).

In 1892 an outbreak in Louisiana was brought to the attention of Prof. H. A. Morgan, of the experiment station of that State (38). Corn and pea crops were destroyed that year by immense numbers of the caterpillars, particularly along the Black and Ouachita rivers.

The species was unusally abundant and destructive during the autumn of 1896 and in the late spring and early summer of 1897 in Florida, and was the subject of a six-page bulletin by Mr. A. L. Quaintance, at that time entomologist of the experiment station of that State (44).

Mr. Hunter's press bulletin, which bears date September 23, 1899 (47), on this insect has already been mentioned, and subsequent accounts which have not been referred to will be duly cited in the bibliographical list which concludes the present article.

DIVISIONAL RECORDS OF INJURIES AND OCCURRENCES.

The Divisional records of injuries by the fall army worm prior to 1899, showing the wide distribution and great injuries done by the insect, are extensive, though somewhat incomplete in the earlier notes made.

December 5, 1878, Mr. William J. Jones, Virginia Point, Tex., mentioned the occurrence of this species in his vicinity, but with no notes as to injury. The same is true of the receipt of specimens of the eggs, January 27, 1880, from Prof. J. H. Comstock, taken at Jacksonville, Fla.

August 27, 1881, we received larvæ from Dr. Howard, from Savannah, Ga., with report that there were millions of them crawling about in the vicinity at that time. August 29, Dr. Howard sent material from Columbia, S. C. October 22, we received complaint from Mr. D. H. Bradley, Pickens Court-House, S. C., of what was with little doubt this species, and of injuries to fodder, cotton, grass, etc. November 12 of the same year we received larvæ from Mr. George E. Ladshaw, Pacolet Depot, Spartansburg County, S. C., with report that this insect damaged corn in that vicinity.

September 11, 1883, we received specimens from Prof. J. E. Willet, Macon, Ga., with the report that they were observed on Bermuda grass, *Cynodon dactylon*, and had nearly denuded three-fourths of a bed of turf.

A considerable outbreak of the fall army warm occurred during 1884, as evidenced by Divisional as well as by published records. During May of that year we received caterpillars from Prof. A. J. Cook, Lansing, Mich., with report that they were doing fearful damage in parts of that State, "eating everything," and being often so thick that when walking over a meadow from a dozen to a hundred would be killed at each step. Subsequently we received another lot of material from the same source of what proved to be the black cutworm or erratic army worm (*Noctua fennica* Tausch.), which was evidently the principal species causing the injury referred to. August 9 we obtained moths of this species from eggs collected in the District of Columbia on the leaves of hickory. August 15 we received larvæ from Judge Lawrence C. Johnson, Holly Springs, Miss., with the statement that they injured the stalks of corn in that vicinity. August 19 larvæ were received from Mr. R. W. Jones, Oxford, Miss., who wrote that they were devouring all the grass in that vicinity. September 17 we received material from Mr. F. M. Webster, Oxford, Ind., the insect being reported injurious to young wheat. October 11 we received from Mr. E. W. Allis, Adrian, Mich., specimens with the report that the insects were doing considerable damage to early sown wheat. October 16 caterpillars were received from Mr. Eli C. Fisk, Havana, Ill., who stated that they were doing immense damage to young wheat, hundreds of acres having been destroyed at that time.

October 10, 1885, Mr. Warren Knaus, Salina, Kans., wrote that these larvæ were eating up the rye and doing apparent damage to wheat in that vicinity. November 20 of the same year we received from Mr. F. M. Webster specimens of this insect in all stages, bred from volunteer corn at Lafayette, Ind.

November 21, 1888, we received specimens of the eggs on a section of lemon leaf from Mr. C. J. K. Jones, Louisville, Ky., and November 18 of the next year we received from Mr. F. M. Webster specimens with the statement that they were feeding on corn. Both of Mr. Webster's notes are recorded in Bulletin 22 (o. s., p. 46).

October 11, 1893, Prof. R. H. Price, College Station, Tex., sent larvæ with the report that they were crawling over the ground by the million and eating "nearly everything."

No further reports of injury were received until 1897, when Mr. Cyrus W. Butler, St. Petersburg, Fla., sent larvæ early in July, where they were eating the leaves of sandspur grass and crawling about rapidly, as is their wont, in search of other food. It was observed that they did not touch beggar weed growing among the grasses. August 9 we received from Miss Louise Morris, Athens, Ga., larvæ with report that they were destroying violets and that thousands were observed in the surrounding grass. August 27 Mr. Charles H. Willson, Longridge, Berkeley County, S. C., wrote concerning this species, with the statement that it had appeared suddenly in the cornfields of that neighborhood and had eaten the grass clean; corn had not been injured to any extent, and at the date of writing the larvæ had disappeared. September 11 and 12 Mr. Orris A. Browne, Cape Charles, Va., wrote of injury to Scotch kale, stating that the insects, specimens of which he sent, and which included both this species and the common army worm, had gone over 20 acres of his crop.

The adult of this species issued during the third week of October from larvæ received from Mr. P. H. Dorsett on greenhouse violets at Garrett Park, Md., September 20 and 29, 1898.

REVIEW OF REPORTED OUTBREAKS.

Although in many years outbreaks were noted only in a single State, there is reason for believing that, in the earlier years particularly, injury was much more extensive than reported. A review of recorded outbreaks and those reported to this Division show injury in 1845 in Florida; in 1854 in Georgia; in 1866 in Kansas; in 1868 in Missouri; in 1870 in Missouri, Kansas, and Illinois; in 1872 a second irruption in Georgia; in 1873 a second outbreak in Illinois; in 1874 an irruption attributed to this species in South Carolina, Georgia, and Alabama; in 1881 a third outbreak in Georgia, and a more extensive one in South Carolina, from which we may conclude that Florida was probably also invaded at the same time. In 1883 still another invasion of Georgia was reported, and in 1884 we have record of the first known outbreak of any extent. The insect was noted that year in Michigan, Illinois, Kansas, Indiana, and Mississippi. The following year it made its appearance in destructive numbers in Kansas, and its occurrence was noted also in Indiana. In 1892 injury was noticed in Louisiana, and the following year in Texas. In 1896 an irruption occurred in Florida, and the following year again in that State, as also in Georgia, South Carolina, and Florida, injuries being particularly severe in the last mentioned State; but there is reason for believing that the outbreak was more extensive than reported, since small armies were noticed that year by the writer in the vicinity of the District of Columbia, indicating the probability of injurious occurrences between here and the Southern States.

The outbreak of 1899, as may readily be gathered by the perusal of the preceding paragraphs, was of greater severity than ever before noticed, and, judging by reports, perhaps as extensive as all other known injurious occurrences of earlier years combined. To briefly summarize the occurrences of the year 1899, it will be seen that irruptions were noted in the East and North from western New York westward to Indiana, and northern Illinois southward to Florida and Georgia and probably the remainder of the cotton States, westward again to Kansas and Nebraska. Complaints also reached us from Cuba.

In 1900 two comparatively small outbreaks of this species were observed at Washington, D. C., and at Chatham, Mich., as previously reported. In 1901 to date of going to press injurious occurrences have been reported in Texas, Louisiana, and South Carolina.

FOOD PLANTS.

Grasses, as previously stated, are the preferred and evidently original food plants of the fall army worm, but when the caterpillars have bred in unusual numbers and have exhausted the grasses and are traveling in armies in search of new food they are less discriminating in taste, being able to subsist on nearly any kind of succulent vegetation that may be encountered in their line of march, including even the leaves of trees.

Cereals are next in order after grasses as larval food plants, corn being a prime favorite, while rice, wheat, rye, oats, millet, and Kafir or Guinea corn are often severely injured. Barley, for some reason, does not appear to have suffered much from attack. The "worms" are especially fond of young and tender grasses and grains, and infestation is more frequently noticed on newly planted winter wheat and other cereals following grasses or cereals in rotation of planting. Crowfoot and crab grass are noted as favorite grasses in the South, and millets are much affected everywhere. Creeping bent was preferred to any other plant on the Department of Agriculture grounds in 1899.

It is apparent that the species has become, perhaps from periodical overmultiplication necessitating frequent migrations, somewhat of a general feeder even in nature. Among other field and forage crops injury has been noted to sugar cane, buckwheat, alfalfa, clover, cowpea, chick-pea, velvet bean, sugar beets, cotton, tobacco, and teosinte (*Euchena mexicana*). Few instances are on record of the caterpillars subsisting to any extent upon weeds other than Gramineæ. Purslane is mentioned as a food plant by Riley (8th Mo. Rept., p. 48).

Attack on cotton has frequently been noted, but according to observation this is scarcely a favorite food. The insects merely attack cotton when grasses or cereal crops in the immediate vicinity have been consumed, seldom effecting much damage. Grasses growing between rows of cotton and other crops are often attacked, and the insect in such cases can be considered as rather beneficial than otherwise, provided its numbers are not such as to exhaust this food and drive it to attack useful plants.

Pea vines among garden vegetables constitute a choice food, and we have records of injury to sweet potato, spinach, turnips, tomatoes, potatoes, cucumbers, cabbage, beans, and strawberries.

Vineyards are also subject to attack, the larvæ having been noticed doing great damage by gnawing around the stems and causing the bunches of grapes to fall.

Of fruit trees, attack to the foliage of peach, apple, and orange is recorded, and egg masses have been taken on the leaves of lemon, hickory, and sycamore. Riley has stated that even spruces are subject to attack. Of its occurrence on fruit trees, Hubbard (in speaking of its feeding on the orange) says that "although the young caterpillars eat the leaves to some extent, they soon find their way to some other and more succulent food plant." It is obvious, therefore, that the feeding of the fall army worm on the foliage of trees is quite exceptional, and due usually to the fact of the eggs having been deposited on the leaves of the trees, since mature larvæ are scarcely if ever seen on trees. There is a possibility that the maturing larvæ may attack the leaves of the trees when driven to it through scarcity of other food, but this is doubtful, since these larvæ prefer low-growing plants.

It would seem probable that it might be a matter of common occurrence for the species to invade greenhouses when unusually abundant on grasses and other vegetation in the vicinity, but our records show only injuries to violets among hothouse plants.

Instances of extreme foods are to be found when stacks of fodder are attacked, as instanced by Glover (5), previously mentioned.

It is not alone the leaves of plants that are injured, as was known in Smith and Abbot's day upward of a century ago. The caterpillars delight in eating into the hearts of their food plants, cutting into the still folded leaves of corn and even boring into the ears after the manner of the boll worm or corn-ear worm (*Heliothis armiger*),[1] devouring alike husk, silk, and unripe seeds.

OBSERVATIONS ON THE LIFE HISTORY.

The life history of the fall army worm, as previously intimated, has not yet been studied as carefully in any single locality as its importance as a pest deserves. Even the stage or stages in which the insect passes the winter were in doubt until 1900.

HIBERNATION.

That it did not hibernate in the egg condition in the latitude of the District of Columbia was proved by the writer in 1899. During September of that year we had under observation great numbers of egg masses on grasses and on the walls of buildings in the vicinity of grass, and every mass hatched. A lot which was kept in our insectory under

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[1] Like the boll worm and some species of cutworms, the fall army worm is inclined to be carnivorous at times, and even cannibalistic, devouring larvæ smaller than itself, and thus attacking its own species.

conditions suitable to the development of most insects, and which hatched from eggs deposited September 16, died after descending into the sand and while still in the larval condition. Another lot of larvæ received October 4 from Athens, Ga., gave forth adults during the second week of November. The consensus of opinion of writers on the subject is that the insect probably hibernates as pupæ, with a smaller percentage of individuals passing the winter months as adults.

A large number of larvæ were obtained from the field and divided into two equal lots, one being placed on grasses and weeds on the Department grounds, and confined by means of a large cover. The remainder were placed upon sand in a large rearing cage having the same sized cover and kept out of doors, where they were fed on fresh grasses and weeds from day to day. About a dozen of the second lot died while feeding, as a result of a cold spell with rain, which lasted for some little time, and the remainder, as far as could be ascertained, all perished as pupæ in their earthen cocoons before transforming to moths. Similarly, the lot placed on the ground transformed and entered the earth, but no moths issued.

It is practically proved that all egg masses deposited late in autumn produce larvæ, and in the most northern limits of the insect, where cold weather sets in much earlier, it is probable that of these larvæ only a very small percentage survive the average winter, and that the latest appearing generations in northern localities are the progeny, at least in many instances, of moths which have developed in, and migrated from, more southern localities earlier in the season.

From experience with four lots of the fall army worm under varying conditions and in different soils, the following deductions have been made in regard to pupation:

PUPATION.

When full grown the larvæ enter the earth to a depth of from a quarter of an inch to not more than an inch and a quarter, the average appearing to be about half an inch, the depth not varying at all according to the brood or the season, those transforming to pupa in late October and early November doing so at the same depth as others observed in August and September.

Pupation of all individuals observed in early fall occurred in little earthern cells, which were nearly erect or more or less inclined, the head in all cases being nearest the surface, and those observed in compact earth had smooth walls, made by the constant revolving of the pupa within; but occasionally pupæ were not thus protected. Most individuals which came under observation in cool October weather, and representing a later generation—in short, the last that can be produced in a region as cool as the District of Columbia—spun up more or less substantial cocoons of earth, lining them with an unusual amount of silk (for a Noctuid), from which fact alone it might be surmised that hibernation took place within them as pupa, even did we not know, as previously stated, that all eggs that have come under notice hatched during the fall, and sufficiently early to permit of the larvæ reaching full development.

Prof. F. M. Webster writes, May 13, 1901, that he had a similar experience with this insect, meeting with no better success in rearing the moth. He placed a large number of larvæ in a breeding cage, saw them feed and then go into the ground, but from that time onward they seemed to have totally disappeared, "as though an earthquake had swallowed them up." He further states that the records of the Ohio station do not show that this species was ever reared to the adult.

These experiences, it seems to the writer, are proof conclusive that the species, being a Southern one, is unable to withstand our winters and our sudden changes. It seems equally certain that hibernation takes place exclusively as pupa in a climate like that of Wooster, Ohio, and the District of Columbia and northward, since it is hardly to be supposed that a Southern species could survive the rigors of a Northern winter in the moth state.

NUMBER OF GENERATIONS.

The number of generations produced annually has been stated to be at least two (possibly three for central Illinois, according to Forbes), and three for the South. The number will vary according to climate and season, and the writer surmises that at least three generations are produced in a climate like that of the District of Columbia, and that four or more may develop farther south. This is a matter requiring investigation, particularly in the Southern States.

SUMMARY OF LIFE HISTORY.

Our limited knowledge of the life history of the fall army worm makes it impossible to present a complete summary, but the hypothetical life cycle is about as follows:

It has been stated that larvæ of the first generation appear in May and June (locality not mentioned), and this statement is undoubtedly true for some regions. The earliest appearance of the moths in any single locality does not appear to have been recorded, or if it has it has escaped the writer's observation.

The period of the egg has been ascertained only for October in moderately cool weather, and it is ten days. This period will vary according to temperature during the period of incubation.

The larval and pupal periods of the different generations remain to be observed, but the former we know must be subject to extreme variation and the latter will, judging from analogy, not be much different from the periods, that may in the future be observed, for the egg where pupæ and eggs are subject to the same atmospheric and other conditions.

Present knowledge indicates that the number of generations that are normally produced each year is two in the most northern range of this species (in years when it develops northward), three for central localities like central and southern Illinois and the District of Columbia, and probably four for the extreme South. We know, however, practically nothing of the development of this species in the Gulf States.

Hibernation, according to recent observations in the District of Columbia, takes place exclusively in the pupal state, and it seems probable that this is so elsewhere. The reasons for this statement are that eggs deposited in late autumn have invariably hatched, and that pupæ kept in the nearest obtainable natural conditions have not developed moths during winter. In a more favorable environment farther south hibernation would, without much doubt, have been successful, and the moths would have issued early in spring. Furthermore, had moths been obtained during winter from material under our observation it does not seem within the bounds of possibility that any would have sustained life in our variable climate.

NATURAL ENEMIES.

It has been stated with reason that there is perhaps no prominent injurious insect, at least none of the periodically destructive species, in whose economy natural enemies play so important a part as the common army worm; and this is to a certain extent true of quite a number of other pests with similar habits. It was natural to expect, therefore, that the fall army worm might, at least in its latest appearing generations, fall a prey to some natural enemy. For some reason, however, these natural checks did not materialize to any extent, at least with the exception of birds they were not at all active during the year of this outbreak in the vicinity of the District of Columbia. A different condition of affairs, however, obtained in some other localities.

ENEMIES OBSERVED DURING 1899.

Soon after the outbreak of caterpillars was first noticed on the Department grounds in 1899 a few English sparrows were observed on the infested plats; their numbers increased daily, and there is no doubt that in this particular place they depleted to a very considerable extent the numbers of this insect as well as of the others which were concerned in the injury. The sparrows were actually observed by Dr. Sylvester D. Judd, of this Department, in the act of devouring the larval fall army worms.

In a Chicago newspaper clipping received in August mention is made of an "outbreak of sparrows" in one portion of Chicago where they were attracted in thousands by "grub worms." It seems probable that they were also destroying fall army worms which were ravaging the lawns in that city at the time.

September 1 Mr. Deering, of Chicago, wrote that the larvæ had nearly all disappeared at that time, evidently having gone into the ground, and that birds, especially flickers, were very efficacious in lessening the numbers of the pest.

Among larvæ that were received at this office from Rives, Md., were a few that were parasitized, as was shown by the eggs of a Tachinid fly present on their bodies on or near the thoracic segments. From these the adults were obtained from the 4th to the 9th of September, and were identified by Mr. Coquillett as *Winthemia quadripustulata* Weid.,[1] or red-tailed tachina fly, a species of wide distribution in the United States and Europe and a well-known parasite of this pest. During the fall of 1884 at least 50 per cent of the larvæ collected in Illinois showed the eggs of this parasite.

This Tachina fly is figured herewith (fig. 5).

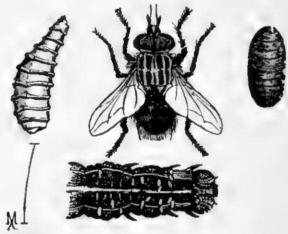

FIG. 5.—*Winthemia 4-pustulata* fly, with larva at left and puparium at right; fore part of the body of army worm with Tachina eggs attached below—somewhat enlarged (from Comstock.)

Until comparatively recent times the Tachina flies were generally believed to be among the most effective destroyers of the common army worm and related species, but observations have now shown the fallacy of this belief. On this head Dr. Howard has written[2] that he had searched for hours in grass fields overrun with army worms without finding a single specimen of the "worm" which did not bear upon its back the eggs of *Winthemia 4-pustulata*, but that a very large proportion of these eggs failed to hatch through the molting of the caterpillars attacked. He cites observations made by Professor Fernald and his assistants in their work upon the gypsy moth in Massachusetts. In the case of 235 caterpillars of this moth, which bore from 1 to 33 eggs on each individual, 226 produced moths, and only 4 of the dipterous parasites were obtained from the entire number. The caterpillar which had 33 eggs upon it molted before any of them hatched, and eventually emerged as a moth in good condition.

[1] This Tachinid is the same as described by Dr. Williston under the name *Exorista infesta* in Professor Forbes's report on the fall army worm (25, p. 65), and is also known to attack the common army worm and the larvæ of various cutworms and other injurious Noctuidæ and Bombycidæ. The list included up to 1896 fourteen hosts. This list is given in full in Bulletin No. 7, technical series, of this Division (pp. 21, 22), where also its distribution, characters, and synonymy are discussed.

[2] Tech. Series, No. 5, Div. Ent., p. 51.

OTHER PARASITIC AND PREDACEOUS ENEMIES.

The value of ants in interposing checks to the excessive increase of the fall army worm in the South was known in Glover's time, and especial mention is made of them in his report for 1855 (3). Ants are also mentioned by our correspondents as being efficacious in destroying this pest.

Of the operations of ants as destroyers of the "grass-worm" Glover says that on a plantation in the vicinity of Columbus, Ga., numerous colonies had formed their holes or nests in the road passing through the center of an infested field and here lay in wait for any unfortunate caterpillar which should be tempted to cross this dangerous path for a fresh supply of food.

First, one ant more vigilant than the rest would rush to the attack; then another, and another, until the poor caterpillar, entirely covered by its pigmy foes, and completely exhausted in strength by its unavailing efforts to escape, was finally obliged to succumb to superior numbers and die as quietly as possible, when the carcass was immediately carried off by the captors to their nests, or, when too heavy to be dragged away at once, they fed upon it as it lay in the road. This warfare was carried on every day as long as the grass-worms prevailed, and no doubt their numbers were diminished in this way to a considerable extent.

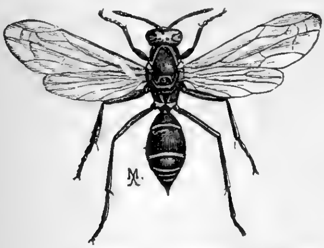

FIG. 6.—*Polistes bellicosus*—somewhat enlarged (Marx del).

Among other material obtained by Dr. Howard during 1881 were three parasites of this species, one of which has been identified by Mr. Coquillett as *Frontina frenchii* Will. The fly issued September 9 from Laphygma larvæ bearing Tachina fly eggs collected at Columbia, S. C.

Apanteles laphygmæ Ashm. MS. was reared August 29 and 30, 1881, from material received from Savannah, Ga.

Mr. Quaintance (40, p. 511) states that there are several species of wasps (*Polistes bellicosus* ? and others) that attack these larvæ, as also a species of Bombyliid, or bee fly, which was reared by him from the larvæ. *Polistes bellicosus* is shown in figure 6.

Limneria dubitata Cr. is mentioned as a doubtful parasite of the fall army worm (Insect Life, Vol. III, p. 158).

The larvæ of a Calosoma, specimens of which were received with a letter dated March 19, 1900, from China Spring, Tex., were observed by Mr. G. G. Hood feeding on the fall army worm. The species is perhaps the fiery ground-beetle (*Calosoma calidum* Fab.), which has been recorded by Professor Morgan to attack this caterpillar (38). The larva of *C. calidum* is shown in figure 7.

Euplectrus comstockii How., a common chalcidid enemy of *Aletia xylina*, or cotton worm, is recorded as a parasite of *Laphygma frugiperda*. From the latter host 25 individuals were reared from a single larva (4th Report U. S. Ent. Comm., p. 107). This chalcidid is shown in figure 8.

Only one bird other than the English sparrow appears to have been observed attacking this insect. On this head Lyman (6) said: "There appears to be no bird but the blue jay that will eat it."

The foregoing is a short list of known natural enemies of so common an insect. Future observations will doubtless show that there are many others such as we know attack the common army worm, among which are various predaceous ground beetles and mites.

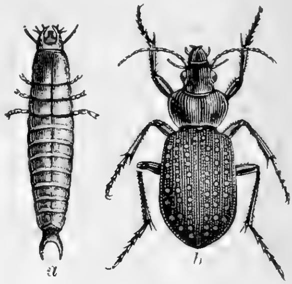

FIG. 7.—*Calosoma calidum.* *a* larva; *b* beetle. Natural size (from Riley).

Years of experience with the common army worm show the great efficiency of natural enemies in keeping down its numbers, serious outbreaks seldom occurring two years in succession.[1] The season of 1899, as previously noted, has shown that we can as yet place very little dependence on insect enemies against the fall army worm.

REMEDIAL MEASURES.

The fall army worm in its manner of life so nearly resembles, in many respects, the common army worm that, when it assumes the habit of traveling in armies, its ravages may be counteracted by a similar line of treatment. The remedies in vogue against the latter were discussed in the Annual Report of this Department for 1879 (pp. 189, 190), and in Circular No. 4, second series, of this Division (pp. 3, 4). As with the common army worm also, unfortunately, injury by this species is seldom detected until too late for the successful application of remedial or preventive measures.

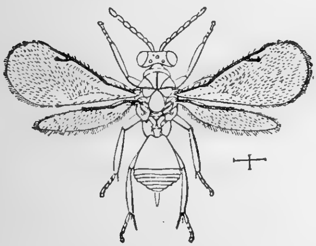

FIG. 8.—*Euplectrus comstockii*, much enlarged (reengraved after Comstock).

THE USE OF INSECTICIDES.

In the case of large armies in extensive fields, plantations, or gardens, poisons are of little value at the time when outbreaks are at their height. When the armies are first noticed the larvæ or "worms" are as a rule approaching maturity, they have effected much damage, and it is difficult at this stage to check them or prevent them from passing from one field, garden, or other tract to another.

[1] A few instances of such recurrence of attack are on record of the present species, *e. g.*, that of the years 1896 and 1897 in Florida.

As a natural sequence it follows that, although poisons are of value in many cases, we must place more reliance in preventives such as are to be found in cultural and mechanical methods.

The arsenicals.—The insects can be destroyed by different poisons, but too often such a course is apt to involve further injury or destruction of the crop infested. Wherever the arsenicals, such as Paris green or London purple, can be used in the form of a spray without injury to the crop as food for cattle or for market, these are indicated.

Certain persons have reported that Paris green and other insecticides employed were effectual in destroying the insects but also killed the plants affected. From experience with infested grasses which were under observation in the vicinity of Washington, we know that it is an easy matter to pass by the insect unrecognized and that the extent of the injury may also be unrecognized at the time when the insect's presence is quite obvious. It is quite probable, therefore, that the cases of reported injury attributed to insecticides were in reality due to the work of the insects themselves.[1]

Kerosene.—Lawns can be freed from the insects, at least in great measure, by the application of kerosene emulsion, followed with as copious a drenching as possible with water from a hose. It is perhaps needless to say that this remedy should not be employed in bright sunlight or on a hot day, but preferably toward sundown.

The value of remedial applications was testified to by some of our correspondents, among whom was Mr. Charles Deering, of Chicago, who wrote, August 25, that kerosene, soap and water, and Paris green, were each effective in killing larvæ near the surface, but when a water sprinkler was turned on, hundreds of active worms came up from the roots of the grass within an area of but a few feet.

MECHANICAL METHODS OF DESTROYING THE "WORMS."

Various mechanical and other measures have proved of value against the common army worm, and would prove effective against the fall army worm. In fields of young grain and on lawns many "worms" or larvæ may be killed by rolling with a heavy roll, preferably when the insects are at work early in the morning or late in the afternoon, toward dusk. In pasture lands and in fields that are injured beyond recovery, sheep or other cattle could be turned in in numbers with benefit, as they will crush the larvæ by trampling upon them.

Other methods of this nature that are in use against the army worm proper, and that will be found of value, include trenching or

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[1] In one case in particular there was no doubt whatever that the insects killed a plat of grass, although several of those who noticed the injury claimed that it was due to other causes. Had insecticides been applied these same persons, who, by the way, were not entomologists, would probably have claimed that the insecticides had caused the death of the grass.

ditching, or the plowing of deep furrows in advance of the traveling hosts to entrap the larvæ which will fall into them, and here they may be crushed by dragging logs or pieces of brush through the furrows. If feasible to fill the trenches with water, or if they become partially filled by rains, the addition of a very small quantity of kerosene, so as to form a thin scum over the surface of the water, will prove fatal to the caterpillars.

Sometimes barriers of fence boards are erected, and the tops smeared with tar or other sticky substances, to entrap the larvæ as they attempt to crawl over.

Clean cultural methods and rotation of crops.—Rotation of crops should always be practiced, as well as the burning over of fields in the fall, when they are too badly infested to recover from injury. Above all other precautions which it is necessary to take to secure immunity from attack is that of keeping the fields free from volunteer grain and wild grasses, since experience shows that these are the favorite breeding grounds of the insect; in other words, they attract the female moths for the deposition of their eggs, and when the larvæ hatching from these eggs have devoured the grain and grasses which grow in patches they are driven to cultivated fields for food. A perusal of the preceding pages will convince anyone that one of the most important sources of injury is the rotation of one cereal crop with another, or with grasses, and the planting of crops in fields that have been allowed to run waste to wild grasses and weeds.

As grasses and cereals are the crops most affected by the fall army worm, the soil should always be very thoroughly plowed before planting to any crop, particularly a similar one, and it is inadvisable (not alone on account of the fall army worm but on account of the numerous other common cutworms, wire-worms, and white grubs) to plant wheat, corn, or any other cereal in pasture land unless a crop which is not so subject to infestation by this insect intervenes.

Fall plowing.—From the observed fact that hibernation takes place in the pupal condition in the infested fields, it follows that fall plowing is the most valuable of all preventives of injury, and is therefore always to be practiced where suitable to the crop, soil, and other conditions. In the case of perennial crops fall plowing is not applicable. For alfalfa Mr. Hunter has recommended that the field should be thoroughly "disked," or cultivated with a disk harrow, when practically the same results will be obtained as would follow from plowing of other fields. For lawns a thorough going over with a long-toothed steel rake is the treatment recommended. Treatment of the soil by these methods serves to break up the cells in which the chrysalides are resting, as well as to destroy the insects in other stages in which they may be present in the fields.

Overflowing rice fields; late planting of wheat and rye.—Injury to lowland rice, as pointed out by Dr. Riley, is not apt to be severe, owing to the ability of rice growers to overflow their fields almost at will, while, if necessary, the negro hands employed in these fields can be sent through the fields to brush the "worms" from the plants into the water.

During the outbreak of 1884 in Kansas it was learned that the ravages of this insect could be prevented by postponing the planting of wheat and rye until between September 20 and October 20. This limit for planting, however, will be different in other climates, and will vary slightly with the weather encountered at this time of year.

OTHER MEASURES.

Preventive measures.—While the fall army worm has usually been observed to do its greatest injury in the autumn, the season of 1899 was quite an exception, as many instances of injury were noted in midsummer, and some even as early as June. This is one of the species of which "to be forewarned is to be forearmed;" hence, if careful watch is kept for the earliest appearing generations and remedial and preventive measures are at once employed, the injury which follows from later generations can be very largely diminished. The presence of many forms of cutworms on lawns can be detected by laying down sheets of cloth or boards at night and examining them in the morning, when these larvæ, if present, will be found adhering to the sheets or boards. This method of detection should be tried with the species under discussion.

Poisoned baits.—Where the caterpillars are found to be breeding in the ordinary numbers of cutworms in vegetable gardens, they may be destroyed by the use of poisoned baits and by other methods used in combating cutworms.

A consideration of these baits and other cutworm remedies is given in the concluding paragraphs of this bulletin.

BIBLIOGRAPHICAL LIST.

In the list which follows the writer has endeavored to present mainly references to such publications as have bearing upon the history, habits, and injuries of *Laphygma frugiperda*. Daily newspaper accounts and other publications cited in other lists, and which add nothing of apparent value to a knowledge of the species, are omitted. The list is chronological:

1. SMITH, J. E., and ABBOT, JOHN.—Natural History of the Lepidopterous Insects of Georgia, Vol. II, pp. 191, 192, Pl. 96. 1797.

   Original description as *Phalæna frugiperda*, with brief mention of habit of feeding on Guinea corn, and suggestions as to remedies. Colored plate of larva, pupa, and two forms of moth.

2. Guenee, Achille.—Noctuélites, Vol. I, p. 159, Paris. 1852.

Description of larva and imago and distribution.

3. Glover. Townend.--Report of Commissioner of Patents for 1855 (1856), pp. 77–79, Pl. VI, fig. 6.

General article under the heading "The grass caterpillar." Account of injuries to crops in Georgia in 1854, description of larva, pupa, and moth, with note of injurious occurrence in 1845. Original figure of larva, pupa, and moth.

4. Landon, M. D.—Report of Commissioner of Agriculture for 1864 (1865), pp. 89, 90.

A short account under the name of "grass caterpillar," in connection with injury to cotton.

5. Glover, Townend.—Monthly Report U. S. Depart. Agriculture, October, 1866, pp. 377, 378, figure.

A two-page general account, consisting in large part of a repetition of No. 3. Specific mention as *Laphygma machra*, with observation that it may prove to be *L. frugiperda* S. and A.

6. Lyman, Joseph B.—Cotton Culture, pp. 92–94, fig. 17. New York, 1868.

A three-page popular account under the heading "The army worm." The larva and moth figured are *Laphygma frugiperda*.

7. Riley, C. V.—First Report on Insects of Missouri, pp. 87, 88. 1868.

Mention under the heading "The wheat cutworm" of injury in 1868 at Allenton, Mo., and elsewhere to wheat, oats, grasses, etc., with description of the larva.

8. Walsh, B. D., and Riley, C. V.—American Entomologist, v. II, p. 43. November, 1869.

Reference to this insect in connection with a consideration of the boll worm and suggestion that it be called "Daggy's cornworm, *Prodenia Daggyi*."

9. Riley, C. V.—American Entomologist, v. II, p. 239. November, 1870.

General account with original illustration of the larva.

10. Riley, C. V.—American Entomologist, v. II, pp. 363–365. December, 1870.

A longer general account than the preceding of which it is in continuation, with original figures of the moth and description as *Prodenia autumnalis* n. sp.; also description of larva and pupa.

11. Riley, C. V.—Second Report on Insects of Missouri, p. 41. 1870.

Brief reference to this insect as "*Laphrygma frugiperda* Sm. and Abb.?" in connection with its resemblance to the army worm.

12. Riley, C. V.—American Entomologist, v. II, p. 340. October, 1870.

Answers to correspondents complaining of injuries at Ottawa, Kans., and Eureka, Mo.

13. Riley, C. V.—Third Report of Insects of Missouri, pp. 109–117. 1871.

A general consideration of the species with reports of injuries in 1870 in Missouri and Kansas, with technical description of the moth, larva, and pupa.

14. Glover, Townend.—Report of Commissioner of Agriculture for 1872, p. 118. 1874.

"In some localities [in Georgia] the grass caterpillar or grass army worm (*Prodenia autumnalis*) devoured the corn, grass, and pea crops in 1872."

15. Riley, C. V.—Eighth Report on Insects of Missouri, pp. 48, 49. 1876.

Brief consideration in connection with a longer account of the army worm proper. Species identified as the *Phalæna frugiperda* S. and A.

16. Thomas, Cyrus.—Seventh Report State Entomologist of Illinois, 1878, p. 97.

A short account and reference to injuries in Washington County, Ill., in about 1873.

17. French, G. H.—Seventh Report State Entomologist of Illinois, 1878, p. 219.

Brief general account.

18. Glover, Townend.—Manuscript notes from my Journal, Cotton, and the principal insects, etc., frequenting or injuring the plant in the United States, 1878. Pl. IX, figs. 9–12.

Copper plate illustrations of moths, larvæ, pupa, and cocoon, with brief notes on the insect's habits.

19. Comstock, J. H.—Report upon Cotton Insects, p. 180. 1879.

Quotes Glover as regards carnivorous habit of the larva.

20. Riley, C. V.—American Naturalist, v. XV, p. 751. 1881.

Brief mention of injury to rice in Georgia.

21. Thomas, Cyrus.—Tenth Report State Entomologist of Illinois, p. 138. 1881.

A brief description of the larva.

22. Riley, C. V.—Papilio, v. II, p. 43. March, 1882.

Note on nomenclature.

23. Riley, C. V.—Third Report of U. S. Entomological Commission, 1880–82, pp. 89–98. 1883.

Damage in 1874 to grass in Richmond County, S. C., Heard County, Ga., and Macon County, Ala., and attributed by Glover to *Leucania unipuncta* deemed likely to have been due to *Laphygma frugiperda* and not Leucania.

24. Riley, C. V.—Report of Commissioner of Agriculture for 1882, p. 138. 1883.

Short note on injuries observed in 1881 to rice fields and to other crops in the South with mention of the value of flooding as a remedy in lowland rice fields.

25. FORBES, S. A.—Circular, Office of State Entomologist, October 14, 1884. <Prairie Farmer, October 25, 1884. <Farmers' Review, October 30, 1884. (Not seen by the writer.)

26. SNOW, F. H.—Fourth Bien. Rept. Kans. State Board of Agriculture for 1883–84, pp. 609–611. 1885.

Accounts of injuries in four counties in Kansas in 1884.

27. FORBES, S. A.—Fourteenth Report State Entomologist Illinois, 1884, pp. 55–67. 1885.

Full general account including consideration of injuries in 1884, literature, nomenclature, description of larva and imago, distribution, life history, character and extent of injuries, natural enemies and prevention and remedy.

28. HUBBARD, H. G.—Insects affecting the Orange, pp. 150, 151. 1885.

Short general account with reference to the occurrence of the eggs and the feeding of the young caterpillars on orange leaves.

29. RILEY, C. V.—Fourth Report U. S. Entomological Commission, p. 353, pl. LXII, fig. 2. 1885.

A one-half page note in a chapter on species liable to be mistaken for the cotton worm.

30. WEBSTER, F. M.—Thirty-fifth Ann. Rept. Indiana State Board of Agriculture, 1885, v. 38, p. 197. 1886. (Author's Extra, p. 18. 1885.)

Included in a list of insects affecting the corn crop.

31. LINTNER, J. A.—Bul. New York State Museum of Natural History, No. 6, pp. 11, 14, 16, 20, figs. 18, 23. November, 1888.

Brief treatment in connection with injury by cutworms.

32. WEBSTER, F. M.—Bul. 22 Div. Entom., U. S. Dept. Agriculture, pp. 46, 47. 1890.

A six-line note on occurrence in 1885 and 1889 on corn at Lafayette, Ind.

33. [RILEY and HOWARD.]—Insect Life, Vol. III, p. 158. November, 1890.

Records the rearing of *Limneria dubitata* Cr. from *L. frugiperda* (?), Indiana, October 9, 1884.

34. WEED, H. E.—Southern Live-Stock Journal, October 15, 1891. (Not seen by writer.)

35. KELLOGG, V. L.—Common Injurious Insects of Kansas, University of Kansas, 1892, pp. 39, 40.

Popular economic account, reference to injury at Mineral Point, Kansas, in 1866 and 1870.

36. BRUNER, L.—Ann. Rept. Nebraska State Board Agriculture, 1891, pp. 249–252, 1892. <Do. for 1893, pp. 386–390.

A general economic account, including free quotations from Forbes.

37. Coquillett, D. W.—Insect Life, Vol. V, p. 312. July, 1893.

Mere mention of occurrence at light on flowers of *Yucca whipplei.*

38. Morgan, H. A.—Bul. 22, Louisiana Experiment Station, pp. 734, 735. 1893.

Brief notice of injury to corn in 1892. Larva of *Calosoma calidum* attacking the fall army worm.

39. Smith, J. B.—Bul. 44, U. S. National Museum, p. 168. 1893.

Systematic bibliography and synonomy.

40. Mally, F. W.—Bul. 29, Div. Ent., U. S. Dept. Agr., p. 30. 1893.

Abundant upon trap corn in June and July; mistaken for boll worm by planters.

41. Weed, H. E.—Bul. 36, Mississippi Agricultural Experiment Station, pp. 152, 153. November, 1895.

A short general economic account.

42. Smith, J. B.—Economic Entomology, pp. 297, 298. 1896.

Popular economic account.

43. Howard, L. O.—Bul. 33, Office of Expt. Stations, U. S. Dept. Agriculture, p. 346. 1896.<Farmers' Bulletin No. 47. 1897.

Reference to the occurrence of this insect in cotton fields.

44. Quaintance, A. L.—Bul. 40, Florida agricultural experiment station, pp. 507–512. July, 1897.

A general and economic account and report of destruction of grasses in 1896 and 1897 in Florida.

45. Coquillett, D. W.—Technical Series, No. 7, Division of Entomology, U. S. Dept. Agriculture, p. 25. 1897.

Records rearing of *Gonia capitata* DeG. and *Winthemia 4-pustulata* Fab. from this host.

46. Lugger, Otto.—Bul. 61, Div. Entomology, Agl. Exp. Sta. Univ. Minnesota, p. 218. December, 1898. (Fourth Ann. Rept. Do., p. 164. 1899.)

Short popular account.

47. Hunter, W. D.—Press Bul. Circular No. 2, Agric. Expt. Station Univ. of Nebraska, pp. 4, fig. 1. September 23, 1899.

A general economic account, with reports of injuries in Nebraska in 1899. Original illustration.

48. Webster, F. M.—Ohio Farmer, November 2, 1899, p. 340.

Answer to correspondent complaining of injury at Haverhill, Ohio.

49. Adams, M. F.—Ann. Rept. Buff. For. Assoc., p. 11. April 1, 1900.

Destruction of turf on lawns at Buffalo, N.Y. A few notes on the insect's habits.

50. Chittenden, F. H.—Bul. 23, new series, Division of Entomology, U. S. Dept. of Agriculture, pp. 78–85, fig. 19. 1900.

A general seven-page account preliminary to the paper here presented, and with particular reference to reported injuries in 1899. One original figure.

51. Webster, F. M.—Bul. 26, Division of Entomology, U. S. Dept. of Agriculture, p. 85. October, 1900.

Brief reference to injury in southern Ohio in fall of 1899.

52. Forbes, S. A., and Hart, C. A.—Bul. 60, Univ. Ill. Agric. Exp. Sta., Urbana, pp. 497, 498. August, 1900.

A short general notice, with especial reference to the occurrence of the species in localities which are mentioned, in Illinois, during 1899, with brief note on probable hibernation as pupa.

53. Bruner, Lawrence.—Thirteenth Annual Rept. U. S. Agl. Expt. Sta. Nebr., pp. 47, 48. 1900.

Brief notice of injuries in Nebraska in 1899, with localities and crops affected.

54. Chittenden, F. H.—Bul. 27, new series, Div. Entomology, U. S. Dept. of Agriculture, pp. 73, 74. May, 1901.

A short notice of this species, with particular reference to its injuries to the violet.

55. Pettit, R. H.—Bul. 186, Mich. State Agric. College Exp. Sta., December, 1900, p. 30. 1901.

Notice of injury to corn at Chatham, Mich.

56. Gillette, C. P.—Beet Sugar Gazette, July, 1900, Rept. No. 69, U. S. Dept. of Agriculture, pp. 86, 87. 1901.

Deals chiefly with remedies.

THE VARIEGATED CUTWORM.

(*Peridroma saucia* Huebn.)

This cutworm is usually to be found in some numbers nearly everywhere—in gardens, pasture land, vineyards, fields, and orchards, and even in greenhouses, as it is a general feeder and able to eke out a living wherever it may happen to be.

Even in ordinary seasons it appears to have little choice as regards the quality of its food—anything succulent, whether the leaves, buds, flowers, fruit, stalks, tubers, or roots of plants of the garden, field, or greenhouse, serving the larvæ as a means of sustenance. It does not appear to be especially fond of wild plants, and is not, like the fall army worm, an important enemy of grasses or grains, although it feeds sometimes upon both when other foods are not available. It is seldom noticed attacking weeds, appearing to prefer cultivated plants to others. It is one of the so-called climbing cutworms, often doing much injury to the foliage of fruit trees, and in seasons of exceptional abundance it assumes the army-worm habit.

There is little doubt, from reports that were received, that this habit was assumed in many localities where injuries were noticed. In fact, the variegated cutworm was so abundant during the season that it became quite generally known as the army worm in some regions, as, for example, in the Pacific States and British Columbia, where it was most destructive.

Injury, judging from report, extended from Maryland southward to Texas and westward to the Pacific coast. It was most pronounced in Oregon, Washington, and northern California, and was noted in various portions of Canada. The species was probably present in some numbers throughout practically the entire United States and Canada wherever truck crops were raised, although injury, as nearly always happens in the case of insect attack, was more or less local. The insect did not by any means confine itself to garden vegetables, however, but was very destructive to ornamental flowers, and the list of plants attacked included nearly everything that could be mentioned, only a few plants being noticed as exempt from injury.

The occurrence of this species in Canada was described by Dr. Fletcher as one of the most remarkable outbreaks of an injurious insect that had ever been recorded in that country, and this was about equally true in the States of Oregon and Washington. It is seldom that a year passes that this cutworm is not reported as the cause of more or less loss to the farmer, wheat grower, and florist, but the season of 1900 was by far the most remarkable in its history.

DESCRIPTION.

The moth.—The progenitor of this cutworm is a large, somewhat inconspicuous moth, the species belonging, as do other cutworms, to the family Noctuidæ. The fore-wings are pale grayish-brown, tinged with reddish and shaded about the middle and toward the outer margin with darker brown. There is considerable variability in the depth of color and in the markings, the latter being often suffused. A common form of the moth is shown (fig. 9, *a*). The reniform spot is some-

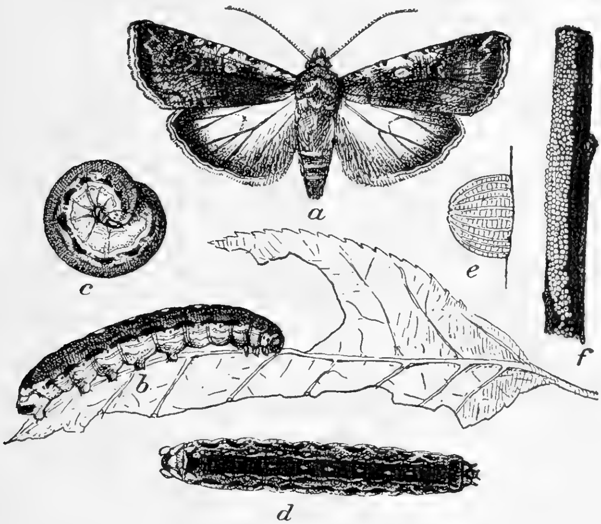

FIG. 9.—*Peridroma saucia:* *a*, moth; *b*, normal form of larva, lateral view; *c*, same in curved position; *d*, dark form, dorsal view; *e*, egg from side; *f*, egg mass on twig (after Howard).

times pronounced, as is also a rounded spot near the reniform and between it and the base of the wing.

The ground color of the hind-wings is iridescent or pearly white, strongly shaded about the margins with shining light brown, the veins being of a similar color and strongly marked. The head and thorax are of about the same general color as the fore-wings, while the abdomen is a little lighter and thickly covered with long paler pubescence which extends nearly to the middle. The wing expanse is about an inch and three-fourths (44 mm.), and the length of the body is about three-fourths of an inch (19 mm.).

The egg.—The egg is of the usual semiglobular form seen in the cutworm group of Noctuids. The outline is circular, the surface is strongly ribbed, the ribs, about 42 in number, radiating from the center and extending in points beyond the sides. These ribs are crossed by others which encircle the egg. The eggs are laid in regular masses and often in rows of about seven or eight, and to the number of sixty or thereabouts, and frequently along the twigs of fruit trees. An egg is shown in profile very much enlarged at *e* of figure 9, and from above in the lower portion of figure 10. The upper portion of the latter figure shows an egg mass of this moth as deposited upon a leaf of cowpea, while at *f* of figure 9 another mass is shown deposited upon a twig.

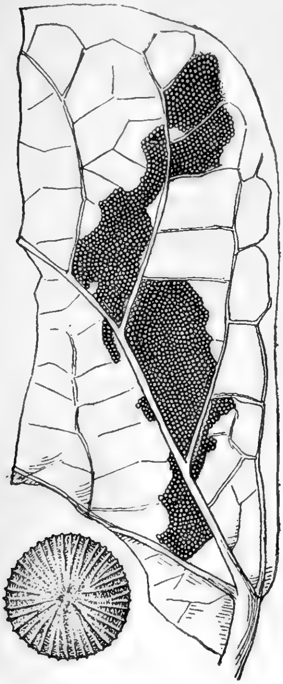

Fig. 10.—*Peridroma saucia:* Egg mass on cowpea leaf; egg much enlarged at left below (original).

The larva.—The larvæ when first hatched are green in color, with indistinct lines, and a very few scattered hairs, the head being black. They undergo several molts before reaching full maturity, but as all these different stages (five in number) have been described elsewhere they will be omitted. Rather complete descriptions are given in the late Dr. J. A. Lintner's fifth report on the insects of New York.[1]

At maturity the larva has attained a considerable size, measuring about one and three-fourths inches (45 mm.) in length and one-fourth inch (6 mm.) in width. At this stage the larva is even more variable than the moth, that shown in the illustration at *d* (fig. 9) being of the darkest form, drawn from a lot found injuring fruit trees. When the larva feeds on low-growing plants, such as celery, the color appears to be usually very much lighter, particularly in individuals that have passed the winter in the ground. An extreme pale form is shown at figure 11. The general color of the dark form is rather dull brown, often with a greenish tinge (which becomes purplish by inflation), finely mottled with gray and smoky black above. The ventral surface is much paler dull-gray, often with a carneous tint. The velvety, black, undulating, interrupted stripes with which the sides are ornamented, as also the row of short, longitudinal, black lines on each segment and the row of from four to six yellow, mediodorsal, rounded spots, which are more or less prominent on the second to the fifth to seventh segments, are all sufficiently shown at *b* and *d* (fig. 9). The

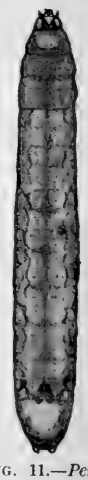

Fig. 11.—*Peridroma saucia:* pale form of larva—enlarged about one-fourth (original).

[1] A good general account, with bibliography up to that date (1889), will also be found on pages 200–206 of the same publication.

head is reddish-yellow in life, becoming pale-brown in preserved specimens, and is reticulated with red and black. A broad, incurved band of black runs from top to bottom each side of the inverted V spaces, forming a somewhat imperfect letter H. The antepenultimate segment is marked above with black velvet spots, and the anal segment is marked with a light, often reddish, nearly semicircular spot.

In the paler forms the markings are much fainter, with the exception of the red of the last segment.

The pupa.—The pupa does not present any characteristics particularly different from those of other cutworms. It is of the usual shining yellowish color when first formed, changing to dark mahogany brown toward maturity. The tip ends in a pair of minute spines.[1]

DISTRIBUTION.

Peridroma saucia is cosmopolitan; it perhaps originated in Asia Minor or southern Europe and is doubtless a direct and early importation from our parent country, since it has been recognized here for many years, as early at least as 1841, when it received mention by Harris. The recorded distribution abroad includes Great Britain and Ireland, western-central and southern Europe, Asia Minor, North Africa, Madeira, and Teneriffe. On this side of the Atlantic it is known from Canada and New England westward to California and British Columbia in the north, and southward through the Gulf region to Mexico, Guatemala, Costa Rica, and Panama in Central America, and Colombia, Venezuela, Brazil, Argentina, Chile, and Patagonia in South America.

It is injurious practically throughout the arable region of the United States.

REPORTS OF INJURY.

REPORTS OF CORRESPONDENTS IN 1900.

As this cutworm showed itself to be one of the most troublesome insects of the year 1900, and as no authentic list of food plants has ever been made out in shape for convenient reference, it has been deemed advisable to cite such occurrences as have come under observation during the past season somewhat in detail. The reports which will be cited were accompanied (in all except, perhaps, one instance), up to the middle of August, by specimens of larvæ, mostly approaching maturity.

May 12, 1900, Mr. G. A. Schattenberg, Boerne, Tex., wrote that this cutworm was doing damage in sweet pea, pansy, and asparagus beds in that vicinity. On the 23d of May Mr. H. J. Gerling, St. Charles, Mo., sent larvæ attacking rhubarb and radish, the two plants

[1] Dr. Lintner (l. c., p. 204) in describing the pupa, states that the anal tip is armed with a single short, black, curved spine.

about equally relished. May 25 this larva was found by the writer at work on young beets on the Department grounds. May 28 Mr. W. C. Hollowell, Barnes, Kans., wrote that this cutworm was devouring the corn in that county, and that there were hundreds of acres that were cut off. The larvæ began attack upon the blades, eating down the heart for 2 or 3 inches under the ground. This cutworm was described as devouring everything, including weeds of various kinds. One patch of potatoes had been completely stripped of leaves. The same day Mr. Warren Knaus, McPherson, Kans., sent larvæ with the report that they were doing considerable damage in McPherson and adjoining counties, eating all kinds of garden vegetables, and being especially destructive to alfalfa.

During June this species was sent to us on the 1st by Mr. W. H. Edwards, Coalburg, W. Va., as being concerned in injury to cabbage and tomato in that locality. The same day Mr. E. M. Wright, Eureka, Ill., sent this cutworm found on cabbage. June 5 Mr. Knaus, who is an entomologist of experience and reputation, reported that many individuals were found beneath pea vines and in a lettuce bed. He stated that this species attacks all garden vegetation except growing beans, and defoliates currant and gooseberry bushes and box elder trees. Potato vines were attacked, particularly in the vicinity of fields of alfalfa, which seems to be the principal host plant in that vicinity. Sunflower, hollyhock, and cocklebur were also attacked.

In July Mrs. Dora Hans, Quilcene, Jefferson County, Wash., wrote on the 17th that it was eating everything in the shape of garden flowers, and even grasses. The larvæ were described as cleaning everything to the ground, and at the time of writing were defoliating fruit trees. Tomatoes, onions, lettuce, potatoes, and other garden truck were also injured. On the 20th Mr. Ernst Stock, Chicago, Ill., reported that it was known as the army worm in that vicinity and had destroyed his lawn entirely the previous year.[1] It appeared to eat the roots of the grass so that the grass soon died. On the 21st Mr. A. J. Maise, Dora, Coos County, Oreg., made a report that this species was doing a great deal of damage in that section, destroying garden and other vegetation. July 23 Mr. Thomas Oswald, Wynooche, Chehalis County, Wash., wrote that this cutworm was a pest in that country, eating everything in the gardens. The insect had damaged hay fields very badly; it was observed also on cabbage. Some of the residents called it the army worm, but the caterpillars were not noticed traveling, although very abundant in some places. July 26 Miss Daisy Fowler, Burley, Wash., wrote that this insect was eating flowers and vegetables in that vicinity. Only the poppy seemed exempt

[1]The injury in 1899 was doubtless due to the fall army worm, as that species was very troublesome on Chicago lawns that year, as has already been stated.

from attack. The same day Rev. M. Eells, Union, Mason County, Wash., stated that this species, locally known as the "army worm," had, within two weeks, appeared there in great numbers and "seemed to be taking everything." Its appearance was noticed for the first time in the history of that region. Next day Mr. S. M. Pressey, Deer Harbor, San Juan County, Wash., sent larvæ with the report that they were very numerous and were eating and destroying everything green on his and neighboring farms. The larvæ devoured all kinds of fruit on the trees, also the leaves, and in some cases attacked the bark. They crawled into houses and wells, and "almost everywhere." Orchards were overrun with them as by a plague. July 28 Mr. E. E. Hogbery wrote that this species was playing havoc with potatoes and garden stuff in his section, Fishhawk, Oreg. The cutworms were described as being so thick on the ground in some places that our correspondent killed them under foot with every step he took. He believed that they would eventually attack everything green, and their presence was alarming the community greatly.

August 6 we received word from Mr. R. A. Easton, Dora, Oreg., that this insect was doing serious damage to crops in Coos County. Potatoes, tops and tubers, were eaten, as also other vegetables and clover. The same day we received from Mr. Richard C. Willis, Olga, San Juan County, Wash., a communication in regard to this insect. It had appeared there in great numbers and was eating up almost everything in the truck line. A locality known as East Sound was also invaded. August 9 Mr. Maise wrote that in that vicinity the damage was greatest in pastures and to potatoes, beets, and cabbage. In some localities the cutworms were troublesome on fruit trees, eating the fruit and cutting the bark around grafts. They were noticed traveling at night, and early in the morning dropped down on the ground and hid themselves away from view.

In a letter dated August 14, with accompanying specimens mostly in the pupal condition, Mr. Willis reported that the larvæ were eating all kinds of garden stuff—potatoes, tomatoes, beans, peas, beets, carrots, corn, cabbage, turnips, rutabagas, and onions, leaving only parsnip and squash. At the time of this writing they were busy upon field peas, potatoes, and clover, and were damaging prune, apple, and other fruit trees in spite of applications of tarred paper and bands of wool and cotton batting. They worked only at night, and when feeding could be heard at some little distance. On the 22d we received from Mr. J. A. McDonald a communication dated July 29 complaining of this species at Requa, Cal. The insect was stated to have made its first appearance that summer in that part of the country. The caterpillars fed on nearly everything, including fruit trees, of which they devoured both foliage and fruit. After eating potato vines they devoured the potatoes. In fields infested by them the ground was covered with their numbers. August 24 we received another communication from Mr. Willis, containing very complete notes on the plants affected on Orcas Island, San Juan County, Wash. In the case of attack on beets the stems were sometimes bored out and cut off at the surface of the ground, the leaves being eaten in some cases. The leaves of young cabbage were devoured, while of older cabbages the heart was usually attacked. Of turnips the green portions of the leaves were devoured, leaving only the stalks, the roots being eaten to a shell. The leaves and upper portion of the roots of carrots were devoured, and beans were injured by the cutworms boring into the pods, sometimes eating the beans within. Peas were similarly affected, young plants just before flowering being "eaten clean." The tops of onions were eaten off level with the ground, leaving only the roots. Of tomatoes the leaves and fruit were eaten, as were also the leaves of corn and the inside husks on the cobs. Entire lettuce plants were eaten. Only the leaves of potatoes were usually attacked, leaving the stalks, but the tubers were often eaten into and sometimes riddled with holes. The foliage of apple, pear, and plum was attacked and windfalls of fruit were eaten to the core; ripe fruit was greatly preferred to green. Squash and vegetable marrow were untouched. The same day Mr. Thomas Oswald sent pupæ from Wynooche, Wash., with information that the "old settlers" of that neighborhood were authority for the statement that this cutworm was present in that county thirty or thirty-five years previously, had been injurious for one year, and had not returned until 1900.

Writing September 1, Mr. Willis stated that toward the end of the month of August the cutworms had practically disappeared, only four being found on the day of writing. In a field that had been fall-plowed and left in fallow and had become grown up with weeds this cutworm was found to eat plantain, clover, and fireweed, the latter appearing to be the favorite food. Injury was complicated in the case of attack to onions, an unknown green caterpillar being associated with the cutworm. The latter severed the onion stalks above the ground, and individuals of the other species appeared to go down inside of a leaf and eat about the root.

As an instance of the numbers of this species, Mr. R. A. Easton, Dora, Oreg., writing September 18, 1900, stated that he had been informed that 202 of these cutworms had been dug up from a piece of ground only 1 by 2 feet in size.

September 20, Mr. Carroll Fowler, Berkeley, Cal., sent specimens of reared moths with the information that they were received from Mendocino County, and that the species also occurred in Humboldt County, in California. In the former county the caterpillars were stated to have destroyed several acres of onions, and afterwards 60 acres of garden peas. The moths emerged September 18.

NEWSPAPER NOTICES OF INJURIOUS WESTERN OCCURRENCES.

Through the kindness of Mr. V. K. Chesnut, the writer received some clippings from a Seattle (Washington) daily journal. One dated July 25, 1900, contained a column notice of this insect, identified as *Peridroma saucia*, with quotations from different persons who had suffered from its ravages. From these accounts it appears that the insect was first noticed in Seattle during the first week of July. One person reported that he had gathered two hundred "worms" from about the roots of a single cabbage plant, the stem of which was completely honeycombed. A like number was collected from under a shingle overnight.

Another newspaper from the same city published an account stating that the entire productive area of King County, in which Seattle is located, was being devastated. In this account it is stated that this cutworm "is migratory and travels across country as does the army worm of the East." General complaint was being made from all directions. In the city of Seattle this cutworm was destroying lawns, flower and kitchen gardens, and truck of all kinds; in the suburbs it was everywhere and destroying everything. In the country its ravages were general. "One day a field would appear perfectly free from it, and the next the worm would be swarming over everything. * * * It burrows in the earth and attacks the tubers of potato, destroying them as ruthlessly as it does the foliage. One potato was shown that had buried under its skin a half dozen big repulsive worms. The pest is no less a thing than a plague, and from the way it is starting out it will occasion untold damage to all kinds of crops."

It was stated in this account, among other things, that "it looks as if the farmers will have as serious a time with this new pest as they have ever had with the hop louse; certainly its appearance has created more general alarm than any pest that has ever made its appearance in the past."

The California Fruit Grower of August 11, 1900, had some notes on the occurrence of this species, which was stated to have appeared in different places in Washington and Oregon a little after the middle of July. The damage was greatest to garden vegetables, including late potatoes, but root crops, wheat, hops, and fruit trees were also damaged. The cutworm was described as being so ravenous that it ate clover at the roots. Tar applied at the base of the poles in hop fields protected hops. In the first ten or twelve days after the appearance of the pest about half of the entire vegetable crop was destroyed in some sections. At Fern Hill, Wash., the cutworms were eating fruit and leaves of pear trees; at Melbourne they were "cleaning up everything," half a dozen of the pests being present on every square foot of ground; at Kalama the cutworms were "doing great damage to all growing crops, climbing trees and nipping the fruit, eating potatoes in the ground as well as the tops."

INJURIES IN THE DOMINION OF CANADA.

Notice is given of a disastrous outbreak of this cutworm all through the Province of British Columbia during the season of 1900, by Dr. James Fletcher in his article entitled Injurious Insects in Ontario for 1900 (Thirty-first Annual Report Ent. Soc. Ontario for 1900 [1901], pp. 68, 69). Some notes are also given on this species in connection with its occurrence at Ottawa, Canada, it being stated, among other things, that it attacked garden plants and apple trees.

A still more elaborate report upon the outbreak of this species in the various provinces of Canada was given by the same writer in his report as entomologist and botanist of the Experimental Farms of the Dominion of Canada for 1900, pages 215–227. This includes detailed accounts of injuries similar to those that have been reported in the present bulletin in different localities in British Columbia, where injury was most severe, with briefer mention of the occurrence of the species in Manitoba and Ontario, where it was stated to have been more than usually abundant. The first intimation of the outbreak was received from Kelowna, British Columbia, in a letter dated July 9, and every day after this for more than a month letters were received by Dr. Fletcher, accompanied by specimens, as in the case of injuries reported to this office, all of which proved to be the species under discussion.

Injuries in Canada, as previously stated, were chiefly in British Columbia, and may be briefly summed up: At Kelowna, British Columbia, the tobacco crop was quite seriously injured. At Victoria and Lulu Island, Cowitchan, Chilliwack, and Saanich injury was also reported; "whole fields of carrots and other things were cleared off." In consequence of the exhaustion of Paris green in the Province and adjoining States the Canadian Government was telegraphed for 500 pounds of this insecticide. This was as early as July 30. The lawns about the government buildings at Victoria were swarming with these cutworms, and they were rolled, this having the effect of killing them by thousands. At Salt Spring Island it was noticed that some of the cutworms devoured those which had been poisoned. At Dog Creek potatoes were quite severely injured, and when the cutworms had finished eating the leaves of potatoes they began to cross a fence into a garden. A ditch was cut and water turned in, which had the effect of drowning them by thousands. This is sufficient evidence that the species had assumed the army-worm habit in that vicinity. Oviposition was noticed on the leaves of hops August 10. Injury in the locality mentioned was also noticed to peas and beans. The cutworms ate the ends of the pods and afterwards the contents. Of onions they ate the tops and then went down the stalks. Injury was mentioned at a locality designated as the 150-mile House; also at Horse Fly, Soda Creek, Quesnelle Mouth, and New Westminster.

Gardens generally were being destroyed in some of these localities, and nasturtiums were attacked. At Comox the cutworms were described as having attacked everything green, field and garden crops and house plants. Somewhat similar reports of injuries were received from Agassiz and Froek, and at Saanich grain crops were suffering. At Agassiz it was noticed that a species of cedar (*Thuja vervæneana*) was being eaten. Many of the cutworms were entering the ground at this last-mentioned locality July 27, preparatory to forming chrysalides. Mr. J. W. Webb, Maywood, Victoria, British Columbia, reported, under date of July 28, that whole crops were being entirely eaten, and that around five turnips in his garden he found 236 cutworms. Every flower bud of carnations was eaten, and dahlias were devoured to the stems. The insects had entered conservatories and tomato houses. Later injury was reported at Langley Prairie, Caslo, and Armstrong. In the last-mentioned locality the species was known as the army worm. At Nanaimo this cutworm was reported, August 13, as having traveled when food was scarce and having stripped nettles and thistles, and done injury to clover, as well as to mangels, potatoes, and turnips. Into these root crops they had bored whenever near the surface of the ground. At Okanagan Mission a copious irrigation proved a good method of controlling this cutworm.

An epitome of the occurrence of this species in the vicinity of Victoria, based chiefly upon the observations of Mr. J. R. Anderson, concludes Dr. Fletcher's account of injuries, in which the fact is brought out that attack was probable in Idaho. The potato crop was probably reduced one-third, and other root crops in proportion. The second crop of clover was almost entirely destroyed. From other accounts it seems that peas were severely attacked. In one instance the crop was lessened 50 per cent. Altogether the period of attack lasted from six weeks to two months. Caterpillars captured by Mr. Anderson were all in chrysalis by the end of August or the beginning of September, and a number of moths emerged in October.

INJURY DURING 1901.

During July, 1901, Mr. A. Lloyd Rockwell, Monroeton, Pa., sent on the 5th larvæ, with report that the species was attacking tobacco, moving about on the plant in the same manner as the common green tobacco worms. On the 6th Mr. J. F. Littooy, Everett, Wash., sent specimens of this cutworm, reporting its reappearance in that vicinity about the 1st of July. This was the date of the first active appearance, although larvæ had been noticed the 1st of April. It was also noted on cabbage from California. July 26 egg masses of this species were received from Mr. W. S. Stockbridge, Glencarlyn, Va., on apple twigs. At Tioga, Pa., according to Mr. C. L. Miller, who wrote on the 31st, these cutworms were proving a pest on tobacco and cucumbers.

INJURY IN GREENHOUSES.

The following reports of injury in greenhouses have reached this Division in the last few years, each communication having been accompanied by specimens:

December 19, 1894, word was received from the Florists' Exchange, New York City, that this species was very destructive to rose and carnation plants in greenhouses near that city.

April 29, 1895, through the American Florist, Chicago, Ill., a report was received that the cutworm was very destructive in greenhouses.

In 1898, Mr. John Spaulding, New London, Conn., writing April 12, stated that this cutworm bored into the calyx of carnation flowers and cut up the petals, and, but for the vigilance of his employees in hunting it nightly, it would have destroyed a bed 40 by 6 feet. October 26, moths were received from Mr. B. E. Scruggs, Campbell, Va. This cutworm was found on cultivated violets at that place. November 25 of the same year larvæ were received from Mrs. F. B. Boone, Charlottesville, Va., with the statement that they were found in violet-houses and ate the blossoms.

MISCELLANEOUS OBSERVATIONS.

In addition to the larvæ which have been mentioned as having been observed in the neighborhood of the District of Columbia and as having been received from correspondents, others were taken at intervals in and near the city of Washington during 1900—August 16 on squash and September 17 on plantain (*Plantago lanceolata*). Pupation of individuals received from the Pacific States began early in August, and by the middle of the month many had transformed. The first moth obtained issued August 25 from material received from Olga, Wash. From moths in confinement eggs were obtained August 27, which began hatching at 3 p. m. of September 6, the duration of the egg stage in this instance having been about ten days. From this lot larvæ matured October 3, or in twenty-seven days. Hence we may say that the larval stage in the warm weather of fall which prevails in the District of Columbia is about four weeks. When in ordinarily fine earth the larva constructs a quite firm cocoon, at least in the autumn. Possibly earlier in the season a less substantial one is made.

BIOLOGIC LITERATURE.

As this is one of the most destructive as well as best known cutworms of North America its economic literature is considerable. In European writings it is seldom noticed as injurious.

It was given its specific name by Huebner in 1816 (Samml. Eur. Schmett. Noct., p. 378), but is credited with having been first described and figured by Ernst & Engrammelle as *La Rubiconde* in 1790 (Papillons d'Europe, Vol. VII, p. 65, pl. 278, fig. 455). It appears to have been first recognized in this country, as previously noted, in 1841, by

Harris, who described it as new under the impression that it was native, giving it the name of *Agrotis inermis* or unarmed rustic moth (Rept. Ins. Mass. Inj. to Veg., 1841, p. 323).

This was the first of the twelve species of cutworms treated by the late Dr. Riley in his first Report on Insects of Missouri (1868, p. 72). It was reported as doing considerable damage to grapevines grown in cold frames. Mention was made of the finding of egg masses of this insect on twigs of apple and mulberry trees, the account concluding with descriptions of all stages, which were also figured.

In Departmental publications this species has received brief notice in the Annual Report for 1884 (pp. 298, 299), and in Insect Life it is mentioned in connection with injuries to carnations (Vols. II, p. 376, and IV, p. 405). In the case of injury last cited, 400 or 500 buds were destroyed in one greenhouse in less than a month. In the same publication serious depredations to potato, cabbage, and tomato plants in Arkansas are noted (Vol. III, p. 149).

In later years various accounts were given, one of the best by Dr. Lintner, who furnished a bibliography up to 1888, his account appearing the year following (Fifth Report Ins. N. Y., pp. 200–206).

A good account, with original figures, was given by Mr. M. V. Slingerland in 1895 (Bul. 104, Cornell Univ. Agl. Expt. Sta., pp. 579–584).

This species was considered in a paper entitled "Insects infesting carnations," and published by F. A. Sirrine in the American Florist for March 3, 1900, page 912. He stated that this cutworm, with the cabbage looper, was the worst of the transient pests in greenhouses where carnations were grown. Indications were that this cutworm enters forcing houses not by being introduced in the soil but through eggs deposited by the parent moth in the houses after transplanting.

An earlier account of injury by this cutworm to carnations was given by Dr. E. P. Felt (Country Gentleman, May 11, 1899). He stated that the leaves were not only considerably eaten, but the buds had also been excavated, and in one or two cases the cutworm was found nearly hidden in the almost empty calyx.

Since the present bulletin was prepared for publication Messrs. R. W. Doane and D. A. Brodie have issued a 16-page publication upon this insect as Bulletin 47 of the Washington State experiment station. The account in question has particular reference to the invasion of 1900, and includes, besides, a brief history of this species and its introduction, description of the different stages, and its life history, as far as known, the article concluding with a list of parasites and a consideration of remedies.

LIST OF FOOD PLANTS.

The list of plants on which this insect is known to feed can be inferred from the preceding to be a very long one, including as it does plants differing widely botanically as well as in flavor and texture.

In Europe it is comparatively innoxious, confining itself chiefly to weeds, such as chickweed (Stellaria), Litorella, plantain (Plantago), dock and sorrel (Rumex), Carduus and Centranthus, food plants reported by Kaltenbach, and others. When the species becomes unusually abundant in this country, injury appears to be about equally divided between garden and field crops and orchards, although garden vegetables are evidently the first crop to be attacked. In greenhouses it also does much injury, being one of the most annoying of the cutworms which attack plants grown under glass. The list of greenhouse and other ornamental plants affected includes violets, pansies, carnations, smilax, roses, sweet pea, hollyhock, sunflower, nasturtiums, and chrysanthemums. Grapes and lettuce are also much subject to injury when grown in cold frames. Of garden vegetables attacked are cabbage, turnips of different kinds, celery, lettuce, carrot, radish, beets, rhubarb, asparagus, onions, squash, potato, tomato, beans, peas, and bush fruits, including currant, gooseberry, raspberry, blackberry, and strawberry. Fruit trees of various sorts are sometimes divested of their foliage, as are also deciduous shade and forest trees. The list includes cherry, apple, pear, peach, prune, plum, cedar, mulberry, and box-elder. Of field crops it injures corn, wheat, timothy, and other grasses, alfalfa, clover, hops, and tobacco. Although not at all partial to weeds, it at times attacks nettle, thistle, dog fennel, fireweed, and several other kinds of weeds.

In its attack on cabbage it works in the same manner as the imported cabbage worm (*Pieris rapæ*), boring into the head and thus doing great damage. It cuts off the tender portions of almost all kinds of plants, including the heads of timothy. When it does not work in this manner it strips the leaves off its food plants. Mr. Slingerland, in writing of the injury by this species to chrysanthemums, states that a cutworm would climb a flower stalk and, upon reaching a blossom, firmly grasp the stalk just below with its prolegs, and then reach out as far as possible to the petals and eat them down to the base. The outer portion of the petals, which it could not reach, usually dropped to the ground.

While it is not probable that many succulent plants are exempt from attack, squash and other cucurbits, and the poppy, according to the testimony of our correspondents, are evidently distasteful, and would not be eaten provided more appropriate food was available. It is quite evident that this cutworm is capable of attacking any portion of a plant, as was witnessed during the year—flowers, buds, seeds, seed pods, leaves, tender stalks, tubers, roots, and even the bark of trees, particularly around grafts. It appears to prefer, as seems natural, flowers and tender leaves and seed-pods, and attacks other parts of a plant when the supply of the choice portions is exhausted. For example, after consuming the tops of such root crops as potato, turnip, onion, and carrot, all of which appear to be favorite food plants, this cutworm attacks the tubers or bulbs; and, after devouring the foliage of fruit trees, it gnaws the bark.

LIFE HISTORY.

HIBERNATION AND ÆSTIVATION.

In regard to the manner of passing the winter, Mr. Slingerland (l. c., p. 104) sums up what has been published regarding the insect, which he believes indicates that it winters as a pupa or moth, the eggs being laid in the spring, notwithstanding the fact that, according to Dr. Forbes, hibernation sometimes takes place as larva.

To write with certitude in regard to a point in an insect's life history like hibernation, one must have the insect under observation in different seasons and in different localities. Recent observations by the writer in the neighborhood of the District of Columbia show that here at least this species passes the winter in the larval condition, although probably also as moth, and even as pupa. Messrs. Doane and Brodie "carried the insect through the winter in the pupal stage" at Pullman, Wash. This is probably seldom the case about the District of Columbia.

Early in October, 1899, the writer found an egg mass of this species on celery at Brookland, D. C. It was kept in a moderately cool room and by the close of the month larvæ hatching from these eggs and fed on celery leaves had attained nearly full growth, all of them disappearing into the earth by the 3d of November except one, which was diseased, and which will be mentioned later. December 20 moths began issuing in great numbers and deposited eggs in large masses in the rearing jar. The eggs hatched January 8 and 11, but we were unable to rear moths from this lot. Larvæ were found at intervals in warm spells during the winter, where they had come up under boards and in similar places for feeding. It seems probable that in the southern range of this insect breeding is almost continuous.

What has been related is sufficient to show extreme irregularity in development. The observations conducted by Dr. Fletcher in Canada show quite conclusively that the insect at least attempts to hibernate as pupa, although the fact that it does so appears to remain to be ascertained. November 9 two pupæ were dug up at Ottawa which produced the moth ten days afterwards indoors. The ground was covered with snow at the time and it seems probable that under such conditions hibernation would have been successful.

A larva of this species was obtained at Cabin John, Md., feeding on cabbage, January 15, 1900. It continued feeding a few days and then descended into the earth and was kept under continuous observation until August 20, when it transformed to pupa. During all this time, a period of seven months, this larva partook of no food and at times appeared nearly dead, as it scarcely moved when disturbed. The imago issued September 10, the pupal stage having lasted twenty-one days.

This is a somewhat remarkable instance of prolonged æstivation, but not without parallel, a similar instance having already been recorded by the writer (Bul. 6, n. s., p. 88). In the instance cited protracted development occurred with the larva of *Ephestia kuehniella*, the Mediterranean flour moth. A similar irregular development has been noticed in *Cacœcia rosaceana*, the oblique-banded leaf roller.

While the larva above mentioned was under observation others were found and taken indoors for further study. One of these, taken March 23 under a board where it had fed on strawberry leaves, transformed to pupa April 20, the moth appearing about three weeks later, while other larvæ obtained a little later transformed to pupa May 11 and later, the first adult emerging May 31. The pupa stage in this case lasted ten days.

SUMMARY OF LIFE HISTORY.

From the summary of the life history of this species which has been made by Mr. Slingerland (l. c.), together with recent observations conducted by the writer, it is obvious that, although some data are missing, we have a fairly complete knowledge of the insect's life economy. Although it is very irregular in development, and is to be found practically in all stages throughout the year, at least in greenhouses and elsewhere indoors, it seems probable that as a rule this cutworm agrees with most others in passing the winter as larva, although hibernation takes place to a limited extent in the pupal and probably the adult conditions. In the State of Washington hibernation in the pupa state appears to be normal. From the fact that attack has been often noticed in May—for example, at St. Charles, Mo. (on the 23d, as previously recorded, and two days later at Washington, D. C.)—it is obvious that much injury may be done in spring by over-wintered larvæ. Dr. Riley was of the opinion that there were at least two and possibly three generations of this species produced in the latitude of St. Louis, and there is reason to believe that this will hold good for the District of Columbia and vicinity. Attack, then, of hibernated larvæ begins in a latitude like that of the District sometime in May. A second generation is produced which causes injury in July and August. The majority of these insects probably disappear toward the end of the month of August, but some of them transform to pupæ and afterwards to moths which lay eggs for an exceptional third generation. It seems probable that whatever is the life history it does not vary much throughout the region in which this species is injurious and we would expect to see the same or a very similar life history in Washington and Oregon, where this cutworm was so destructive during the past season. The last generation is produced so late in the season and is so small in extent that comparatively little injury is done. Of the cases recorded in previous pages, it would seem that injury is about equally divided between the first and second generations. This, however, is a matter that it would be difficult to decide, as it is impossible to separate the two broods.

Reports of injury during 1900 were almost continuous and were accompanied by specimens, as a rule at or near maturity, from May 12 to the first week of September.

The duration of the egg stage was noted in a moderately cool room, average temperature of 60°–68°, and ascertained to be three weeks. In midsummer this stage is, of course, much shorter. The larval stage probably lasts between three and four weeks, according to temperature, and the period of æstivation, as previously stated, may extend over seven months. The pupal stage was observed to be between ten and twenty-one days, and may be much longer when winter is passed as pupa.

NATURAL ENEMIES.

As with the army worm, and to a lesser extent with the 1899 outbreak of the fall army worm, much was expected, by those who had the variegated cutworm under observation, from parasitic and other natural enemies which often attack and destroy insects having the habit of periodically traveling in armies. With the fall army worm it has been shown that the natural enemies were somewhat of a disappointment, and the same was to a certain extent true in the case of the variegated cutworm in its occurrence in British Columbia, as elsewhere. Locally, however, natural enemies were of some service, and possibly more beneficial than observations go to show. It seems probable that in many cases destructive elements were at work that escaped notice.

Two of our correspondents previously mentioned, Messrs. Willis and Mayse, of Oregon, have written of the efficacy of chickens as destroyers of this cutworm. In one case chickens were turned into a garden, and they partly cleared the plants of the worms. Mr. Mayse stated that hogs and some birds were very fond of this cutworm, and were quite destructive to it.

From the latter correspondent also we received from Dora, Oreg., parasitized specimens, the parasites from which issued late in August, and proved to be, according to Mr. Coquillett's determination, the Tachina fly (*Phorocera saundersii* Will.).

From the same correspondent we received July 21 a *Peridroma saucia* larva upon which a larva of a Therevid was preying.

The Tachina fly (*Archytas analis* Fab.) issued June 25 from a pupa of this cutworm obtained from Eureka, Ill. The following day it was reared from *Leucania unipuncta* received from McPherson, Kans., where the variegated cutworm was also present during the year.[1]

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[1] This species is also parasitic on *Clisiocampa californica* Stretch.

From material received from Mr. Willis, Olga, Wash., a number of parasites of *Ichneumon capitus* Cr. issued during the last days of August and first of September. As near as could be estimated, fully 50 per cent of the pupæ received from our correspondent in one lot were parasitized by this Ichneumon fly.

Evidence was afforded March 2 that a common ground beetle, *Scarites subterraneous* Fab., preys upon the variegated cutworm. On that date a larva was found, under a board, that had evidently been killed by this insect, which was feeding upon it at the time of capture. All of the natural enemies of this cutworm which have been mentioned have come under observation during the season of 1900.

In Dr. Fletcher's article (loc. cit., pp. 225–227) two pages are devoted to the subject of parasites and predaceous enemies. At Victoria, British Columbia, three lots of larvæ were almost all destroyed by the maggots of a parasitic fly, Tachinid judging by the description. The presence of Tachina eggs on the heads of cutworms was reported at Salt Spring Island. A large black fly, presumably an Ichneumonid, was observed at Vancouver. One parasite was identified (*Meteorus vulgaris* Cres.) from British Columbia.

Two parasites identified as destroying this cutworm are placed on record by Messrs. Doane and Brodie (Bul. 47, Wash. Agl. Expt. Sta., 1901, p. 10). They are *Ichneumon maurus* Cr. and *Meteorus indagator* Riley. Three other species of Tachina flies are parasitic on the variegated cutworm. These are: *Chætogædia monticola* Bigot, *Gonia capitata* DeG., and *Winthemia 4-pustulata* Fab. The last mentioned has been figured in the paragraph on the natural enemies of the fall army worm.

A very large proportion of the larvæ received late in the season from the Pacific States died under conditions which would have been favorable to most caterpillars. It is not improbable that disease was present when the material was gathered, but of this we can not be certain, since it is a matter that would have to be decided by residents or at least persons temporarily resident in the infested sections, as larvæ confined in unnatural conditions for some time are apt to develop diseases which might not have affected them in the field. Their decease was probably due to the same cause as that noticed by Doane and Brodie, and by Fletcher in British Columbia—i. e., to bacteriosis. According to Dr. Roland Thaxter, who examined material from the latter source, cutworms are subject to *Empusa aulicæ*, and that authority on fungous diseases expressed the opinion that, if careful investigation had been made during the invasion, this or some other species of Empusa would have been found destroying them.

In British Columbia robins, crows, the blue jay, chickens, ducks, and pigs were reported to have been observed destroying this cutworm.

In the State of Washington chickens, turkeys, guinea hens, and other poultry, as well as crows, did good work in repressing this species.

METHODS OF CONTROL.

From what has been said in previous paragraphs the utility of domestic fowls and other animals is obvious. With proper judgment their services would save great losses that it might otherwise be difficult to avert.

Poisoned bait, a standard remedy against cutworms, is of value against this species under ordinary circumstances. To be effective it should be applied as soon as attack is noticed. It can be prepared in the ordinary manner by mixing. It is particularly valuable in cases where the direct application of poisons to a plant is impossible owing to the danger of poisoning persons or stock when it is used for food. There are two kinds of bait—fresh vegetable and bran mash.

Vegetable bait.—A good way of preparing a vegetable bait is to spray a patch of clover, pigweed, or some useless succulent plant that grows by the roadside or in fence corners, with Paris green, 1 pound to 150 gallons of water; mow it close to the ground, and place it while fresh in small heaps about the infested plants at intervals of a few feet. The later in the day that this can be done the better, as the material keeps fresh longer and the cutworms feed almost exclusively at night. Owing to the wilting of this bait, particularly in dry, sunny weather, it is advisable to cover each heap with a chip, shingle, or bit of bark for its protection against the sun's rays.

Bran mash.—What is known as bran mash or bran-arsenic mash is of equal value to a fresh vegetable bait, and, according to some, still more efficacious. Paris green, arsenoid, white arsenic, or in fact any arsenical can be used for poisoning this bait, and in its preparation, on account of the weight of the poison and the fact that it soon sinks to the bottom of the water when stirred, it is best first to mix the bran with water and sugar and then add the poison. The proportions are 2 or 3 ounces of sugar or a similar quantity of glucose or molasses to a gallon of water and a sufficient amount of bran (about a pound per gallon) to make, when stirred, a mixture that will readily run through the fingers.

Before planting a crop it is advisable to employ such bait, and for its perfect success the ground should be bare, which will have the effect of practically compelling the cutworms to feed upon it.

Protection of plants that are set out, such as tomato, cabbage, and others, started under glass, may be secured by placing about the base of each a tablespoonful of the poisoned bran or a small bunch of the poisoned vegetable. Sometimes it is feasible also to dip the plants in poison before setting out. Where it is possible, however, to spray grass or weeds which have grown up in fields about to be cultivated, this should be done, as it is an easy means for riddance of the cutworms and is less troublesome than the preparation and distribution of baits.

Protection of trees.—Numerous preventives of injury to fruit and other trees by climbing cutworms and other caterpillars with habits like the present species have been devised, and some have been found quite satisfactory. The method of protection in question consists, in brief, in placing about the trunk of each tree a band or ring of smooth or tarred paper, cotton batting, or adhesive substances, over which the "worms" can not crawl. The best of these is cotton batting, and in its application a good way is to cut thin sheets into strips 4 or 5 inches wide, long enough to reach around the tree and to be wrapped tightly to the tree at the bottom, so that the band rolls over the lower edge, standing out somewhat from the tree and forming a sort of funnel or cone-shaped mass of batting. These bands or collars, it is claimed, are effective for a whole season, as they become dry after being wet by rain. Adhesives are sometimes dangerous, particularly if applied to young trees.

Bordeaux mixture.—This fungicide, according to Messrs. Doane and Brodie, was tested recently against the variegated cutworm upon potato vines and asparagus. It was sprayed on as a remedy for blight, and it was discovered that the plants thus treated were free from attack by this cutworm. The use of this fungicide as a cutworm deterrent is certainly advisable. In any case, it should be used as a diluent for whatever arsenical is used.

Hand methods.—On some plants it is next to impossible to apply any but hand methods with good results. Experiments in Washington State during the season of 1900 demonstrated conclusively that in some cases it required less time to shake or brush the variegated cutworm off from affected plants than to destroy them by means of spraying or otherwise.

Greenhouse methods.—A few words should be said in regard to remedies to be employed in cases of greenhouse infestation by this cutworm. The poisoned baits are, of course, applicable here, and the hydrocyanic acid gas treatment of a greenhouse when employed for aphides and other insects will help to destroy these worms, especially when they are young. Its use can not be advised, however, for cutworms alone. In ordinary cases they can be held in check by hand-picking. It is the custom of some florists to hunt for them at night with a lantern, when they are feeding and can readily be discovered and destroyed.

Treatment as an army worm.—When the variegated cutworm assumes the habit of traveling in armies it should be treated in the same manner as advised against the fall army worm in preceding pages.

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BULLETIN No. 30, NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE DIVISION OF ENTOMOLOGY.

V.

PREPARED UNDER THE DIRECTION OF

L. O. HOWARD,

ENTOMOLOGIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

DIVISION OF ENTOMOLOGY.

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Artist: Miss L. Sullivan.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., July 25, 1901.

Sir: I have the honor to transmit herewith the manuscript of a bulletin which contains matter similar to that published in Bulletins 7, 10, 18, and 22 of the new series, namely, miscellaneous articles and notes which are too short for separate publication, but which are of sufficient importance to render an early printing desirable. I recommend the publication of this manuscript as Bulletin No. 30, new series, of this Division.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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SOME MISCELLANEOUS RESULTS OF THE WORK OF THE DIVISION OF ENTOMOLOGY.

V.

THE DIFFERENTIAL GRASSHOPPER IN THE MISSISSIPPI DELTA – OTHER COMMON SPECIES.

By H. A. Morgan.

INTRODUCTION.

The differential grasshopper has been known to occur in the Upper Mississippi Valley for many years, but its appearance in devastating numbers as far south as the State of Mississippi is of recent date. In 1890 and 1891 crevasses occurred on the east side of the Mississippi River between Rolling Fork and Coahoma, Miss. Plantations in this delta region around Hampton Station, on the Riverside Division of the Yazoo and Mississippi Valley Railroad, were inundated, and for a few years following grasshoppers appeared in destructive numbers; "Linden," "Glen Willow," and "Richland" plantations suffering the most. Though these attacks were more or less local and no urgent complaints were heard, the outbreak following an overflow of 1897 was attended by more serious and widespread injury. The results of an investigation of this latter outbreak, made during 1899 and 1900, are discussed in this article.

In Bolivar County, Miss., is located the famous Dahomy property (19,000 acres), which is perhaps the largest cotton plantation in the South. Upon this property, about 1 mile east of the Yazoo and Mississippi Valley Railroad, a basin consisting of about 300 acres exists. After the crevasse water of 1897 receded this basin remained flooded. The crevasses opening as late as the 28th and 30th of March and the water remaining upon the property for at least six weeks so delayed planting that no attempt was made to include the basin in the cultivation of 1897. It became a forest of weeds and a most favorable feeding and breeding ground for so sturdy and prolific a species of grasshopper as the differential. The spring of 1898 was favorable for early planting, and the basin, with the rest of the property, was ploughed, put in a state of thorough cultivation, and planted. Early in June rows of cotton adjacent to the ditches draining this basin were damaged by grasshoppers, but little attention was paid to the particular species, as the area attacked was considered insignificant. Nothing was done to suppress this miniature outbreak or to avoid a repetition of it the following year, but the situation was no more threatening than that witnessed on neighboring plantations a few years previous.

The vigor of the attack in 1899, spreading perhaps from different infesting areas for hundreds of miles, was unexpected, and no effort was made to check the young grasshoppers at the time when remedial measures are more or less effective. So little attention was paid to the grasshopper situation that the early molts had taken place and the nymphs had reached a considerable size before a condition almost equal to a plague was realized.

The ravages upon Dahomy began in and around the basin and spread in a northwesterly direction until more than 5,000 acres of corn and cotton were involved.

Mr. P. M. Harding, representing the owners of Dahomy, outlined in the following letter to the Hon. James Wilson, Secretary of Agriculture, the gravity of the situation:

VICKSBURG, MISS., *July 6, 1899.*

DEAR SIR: I sent you by express yesterday from Benoit, Miss., some specimens of corn and cotton stalks and other vegetation, together with a box of grasshoppers, for your examination, and in the hope that you may render us some immediate assistance in the matter of destroying the grasshoppers that are devouring our crops of cotton, corn, oats, millet, and pease.

I beg to explain that I represent the Equitable Company of New York, which has recently acquired the large plantations formerly owned by the late Mr. James S. Richardson, including what is known as the Dahomy property in Bolivar County, Miss., which consists of about 19,000 acres of land, with between 9,000 and 10,000 acres in cultivation, and which is the largest cotton plantation in the South. It is on this property that the grasshoppers are doing the greatest damage, and unless their ravages are terminated by some means at a very early date I am satisfied they will entirely eat up the crops.

The grasshoppers made their appearance on Dahomy early in the spring, feeding first on the vegetation along the sloughs, the edge of the timber, and on the ditch banks. I was on this property about three weeks ago, and found that while they were rapidly increasing in numbers they had done but little damage to the crops, eating a little young cotton at the end of the rows along the ditch banks, and here and there we saw where they had cut some of the stalks of corn at the ends of the rows, and they were about that time beginning to feed on the oats. My managers have been reporting from time to time of their increase, but not until ten days ago did they report that they were going away from the ditch banks and completely covering the fields.

I have just returned from this property, and beg to give you my observations concerning the damage done to the various crops, as follows:

Cotton.—They have totally destroyed 300 acres. What I mean by totally destroying this acreage is that they have eaten all of the foliage off of the stalks, killing the stalk completely, and on a large part of this 300 acres there is not a vestige of stalk left, the ground being as bare as when it was first broken up for planting.

There are 2,000 acres more that they are working on now and have damaged 50 per cent. They are eating the leaves and the forms or blooms, as well as the tender bark from off the stalks and limbs, causing the limbs and stalks to shrivel up and die, and if they continue their work ten days longer they will have completely destroyed the cotton on these 2,000 acres.

On the remaining acreage in cotton, there being a total of something over 5,000 acres, they have not as yet done any great damage, but it all lies contiguous and there are grasshoppers on every acre of it, though not in sufficient quantities thus far to do much harm.

Corn crop.—There are 150 acres totally destroyed, by which I mean to say that the grasshoppers have eaten the tassel and the silk from around the ear completely, which means that under these circumstances the corn can not mature. They follow the silk down into the ear and eat out the tender cob; they have also eaten holes through the shucks, and clear through the ears of corn, and in addition are stripping the corn of the blade. In riding through a patch of 100 acres I found the grasshoppers on the stalks all the way from the ground to the top, as well as on the blades, and numbers of them on the tassels. I counted as many as 30 on the tassels and 15 on some of the blades, averaging probably 25 to 50 grasshoppers to each stalk.

In addition to the corn that they have completely destroyed there are about 300 acres that they have partially destroyed, and there are some grasshoppers in smaller quantities in all of the balance, which balance has been damaged but little thus far, though if they continue their ravages to the same extent that they have been working for the past two weeks they will ruin it all.

Oats.—Our oat crops before we cut them were damaged fully 50 per cent. The grasshoppers ate the blade and then cut off the head, leaving the ground perfectly white in places.

Millet.—The millet is literally alive with grasshoppers, but as it is very thick the damage does not seem to be so great, though if they continue their work they will doubtless ruin it.

Sorghum.—While the sorghum patches are filled with grasshoppers I can not see that they have done any great amount of damage; only here and there we found where the blades had been cut.

In the foregoing I have tried to give you a thoroughly correct idea from my own personal observation of the damage done on this property. As far as I have been able to ascertain the grasshoppers have not done much damage south of the town of Benoit, which is in Bolivar County, though in the northern part of the county I am advised that they have eaten up whole crops as they are now doing on Dahomy. Mr. Charles Scott, of Rosedale, informs me that they are devouring his crops as well as other crops in his neighborhood. They are also to be found along the ditch banks on the plantations throughout Washington County, though they have thus far done but little injury to the crops there.

I have written to the agricultural colleges in this State and Louisiana endeavoring to get them to send some one to look over the situation and devise some means for preventing further damage, if possible, as well as to put a stop to their ravages in future, but unfortunately the entomologists of both colleges are absent, one of them being in San Francisco and another at Cornell University.

I now write to ask that you send some one to investigate the matter with a view of applying a remedy immediately, or instructing me what to do in order to save a part of our crops this year.

Both colleges have sent me their formulæ for preparing a mixture of poison, consisting of paris green with bran and molasses or sweetened water, and distributing it through the fields. We have carried out the directions and find that the grasshoppers eat the mixture voraciously, but it does not seem to kill them. We find a very few dead grasshoppers, but practically the mixture does them no harm. We have dusted the grass and weeds in the ditches with the raw, unmixed paris green, where the grasshoppers were in great numbers, and upon examination next morning we would find a few dead ones at the bottom of the ditch, but just as many living ones feeding on the grass as before we sprinkled it with paris green; hence it seems that this poison is not efficacious.

I feel that the matter is one of great importance to the cotton planters of this section, and I sincerely trust that you will send out one of your best men to Vicksburg and I will take pleasure in going with him to this property and taking care of him while there, rendering every facility for destroying the pests.

I am advised that in 1897 the first was seen of the grasshoppers in this locality in any quantities, and that year they did but little damage, eating some cotton or corn at the ends of the rows along the ditch banks. In 1898 they did more damage along the ditch banks on this particular property, injuring probably one or two hundred acres of cotton. However, they did not destroy any of it outright, while this year they literally cover the larger part of the property, and in the foregoing letter I have endeavored to give a correct estimate of the damage done to date.

It is not the same species that we have had with us all along, and we are disposed to fear that perhaps the grasshopper of the West or some other similar species is now visiting us.

Very respectfully, P. M. Harding.

Hon. James Wilson,
Secretary of Agriculture, Washington, D. C.

Mr. Harding's letter was referred to the Division of Entomology, and Dr. L. O. Howard made the following reply:

July 11, 1899.

Dear Sir: Your letter of the 6th instant, addressed to the honorable Secretary of Agriculture, duly received and referred to this Division for attention. I wish to acknowledge also the receipt of two large packages, one of corn and one of cotton, sent from Benoit, Miss. An examination shows that the grasshopper which is depredating so seriously on cotton, corn, etc., in Mississippi proves to be what is known as the differential locust (*Melanoplus differentialis* Thos.). This is a common native species of grasshopper, occurring every year throughout the Mississippi Valley. It feeds normally on grasses, such as timothy, alfalfa, and clover, as well as the native grasses, and is not especially an enemy of cereal crops or cotton. In Mississippi, however, it has been known to multiply excessively in lowlands and waste grass patches along ditches, and so forth, and to migrate from such situations into cotton fields and neighboring cornfields. This habit, therefore, is unusual and peculiar, and dependent on very favorable conditions, which have led to the unusual multiplication of the grasshopper. The habits of this species have been detailed in three of our bulletins relating to grasshoppers or locusts. I am sending you a copy of each of the three, namely, Nos. 25, 27, and 28, old series, giving habits of different species of grasshoppers and the means of control. The differential locust is discussed in Bulletin No. 25 on page 30, in Bulletin No. 27 on pages 62 and 63, and in Bulletin No. 28 on pages 15 to 17. I refer you particularly to the advice as to remedies mentioned under this species in Bulletin No. 27. After the locusts have become winged, as many of them are at present, it is impracticable to attempt any of the ordinary means of control, such as collecting with hopperdozers or driving them into ditches, and so forth, and the only remedy is in the use of poisons. I do not believe the bran-arsenic mash to be practicable over the large areas infested, in view of the scattered condition of the locust. It will doubtless be of more or less avail, but I am inclined to think that very heavy poisoning of all grass along the ditches and elsewhere frequented in numbers by the grasshoppers, if accompanied with a dusting of the cotton plants by the poison, as practiced for the cotton-leaf worm, will be the more profitable and feasible course. It is difficult to advise in the absence of direct knowledge of conditions, and I am, therefore, in response to your request, which has been seconded by the Hon. T. C. Catchings, M. C., of Vicksburg, Miss., and the requests of several other correspondents, about to send one of my assistants, Mr. James S. Hine, to make a personal investigation of the case and give such directions in regard to remedial work as, in his judgment, will be deemed most worth while after a personal investigation. Mr. Hine will proceed to Vicksburg and call on you there.

Yours, truly,
L. O. Howard.

Mr. P. M. Harding,
President Delta Trust and Banking Company, Vicksburg, Miss.

As the differential locust matures as early as June 25 in the latitude of the section infested, nearly all of the grasshoppers had reached the adult condition by the time Mr. Hine arrived at Dahomy, and little if anything could be accomplished, save to carefully investigate the conditions likely to precipitate such an outbreak, and to recommend measures looking to the suppression of a similar or even more extensive occurrence of these locusts the following year.

In the fall of 1899, the writer, fearing the spread of this destructive

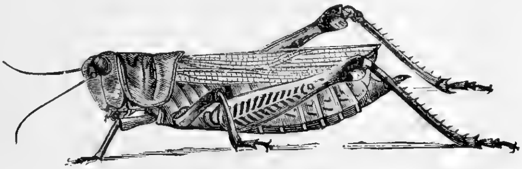


Fig. 1.—*Melanoplus differentialis*—natural size (after Riley).

locust into the Mississippi Valley of Louisiana, began, through the assistance of Mr. Harding, an investigation of the Mississippi situation. Specimens of eggs sent from Dahomy were placed in breeding cages and in the spring of 1900 some of the habits and the life history of the differential and other species were observed. During the winter, as the managers of Dahomy were following out the instructions given by Dr. Howard and Mr. Hine, to have the infested fields plowed and thoroughly cultivated, additional eggs were secured in sections of soil, thus augmenting our breeding-cage operations and making it possible to anticipate by cage data the development and habits of the grasshoppers in the field.

LIFE HISTORY AND HABITS OF MELANOPLUS DIFFERENTIALIS.

The following observations were made in the fall and winter of 1899 and during 1900 in breeding cages of the laboratory of the Louisiana State University, and in the fields upon and in the vicinity of Dahomy plantation, Bolivar County, Miss.

Eggs.—Eggs are deposited in masses (*oothecae*), see fig. 2, just below the surface of the ground. They are arranged irregularly in the egg sac, are small, light colored, and contrast strongly with the large, conspicuously red eggs of *Schistocerca obscura*, so often found associated with those of the differential. The period of egg-laying depends upon the time the females reach maturity; even those hatching at the same time may vary in maturing as much as twelve days or two weeks. It was found that eggs may be deposited from July 20 to October 1, and by stragglers even later. The bulk of oviposition, however, takes place between August 10 and September 15. Single females separated to determine the number of egg-pods deposited indicate in most cases that but a single batch of eggs is laid. The number of eggs in each sac ranged from 103 to 132. Mating was observed to generally take place twice at an interval of from ten to twelve days; the female ovipositing from three to five days after the second copulation.

Egg-laying areas.—Places selected for depositing eggs are more or less local, and a knowledge of them is interesting and important, as they offer most excellent means of effecting remedies.

FIG. 2.—Ootheca or egg case of *Melanoplus differentialis* (original).

The account, given above, of the basin of 300 acres which had become hard after flooding, and the spread of the grasshoppers from this region into cultivated fields suggests that any such territory is perhaps the most favorable egg-laying area; other places were found equally attractive during 1899. Ditch and bayou banks, plantation roads, the railroad right of way, upon levees, Indian mounds (common in the delta), around stumps and logs, and even in the logs, at the end of corn and cotton rows (the turn rows), in lanes, and Bermuda pastures were all found plugged with egg-pods. Just at the edges of sloughs and on the turn rows are thought by the managers to be the most common egg-laying places, but the opportunity for witnessing the females ovipositing eggs in these regions is much better than in the less-frequented waste and sodded areas, and thus we may account for the prevalence of this belief. Some females were seen depositing eggs far out in cultivated fields, but such cases were not common, and even then the harder spots near the basis of a cotton plant were selected. It was not unusual to find the egg-pods of three or even four species of grasshoppers side by side. In fact, it was due to the conspicuous colonizing of the eggs of *Schistocerca obscura* that many of the egg-laying areas of *differentialis* were discovered.

Young and adults.—Eggs remaining in the soil over winter begin hatching as early as April 15, but the majority of young emerge between May 1 and May 20. Eggs exposed upon the surface of the ground hatch during warm spells of early spring, but those normally placed seldom hatch until continuous warm weather prevails. Those in the upper portion of the pods or egg sacs hatch first, sometimes many days in advance of those in the lower part; the species is thus protected from complete annihilation should an unexpected severe cold spell intervene between the first and second hatching.

The average life cycle of the differential locust as determined in the breeding cages is as follows:

Grasshoppers emerging from eggs on April 20, 1900, molted five times before reaching the full-grown or adult condition. The first molt took place May 7, the second May 22, the third June 2, the fourth June 13, and the last June 27. The first mating was observed July 19, the second July 28; the females deposited eggs August 3, and were dead by August 17. The entire period, minus the time required for incubation, was one hundred and nineteen days. The young on first emerging from the eggs are sordid white and after an airing of an hour or two are darker, assuming a color not unlike the dark gray alluvial soil over which they feed. There are changes of color as the earlier transformations (stages) are assumed, but until the close of the third stage these changes are not readily perceptible in the field to the naked eye. At the close of stage four the greenish-yellow color becomes prominent on many forms, and in stage five the greenish-yellow and yellow ground colors predominate. The vigorous feeding and rapid growth of the young in stages four and five, and the prominence of the wing pads in stage five, cause the grasshoppers in these conditions to appear almost as conspicuous as adults.

The habits of the young are interesting, and a knowledge of some of them may be helpful in developing remedies. After hatching they remain for several hours in close proximity to the egg-pod from which they emerged. With this period of faint-heartedness over they may venture out for a few yards each day into the grass, weeds, or crop neighboring the egg area. Upon being disturbed they invariably make the effort to hop in the direction of their so-called nest. Nymphs emerging from eggs upon a ditch bank, if forced into the water will seldom make the effort to reach the other side but will turn in the water and swim back to the bank from which they were driven. As development takes place the extent of their peregrinations into the crop is easily traced by the shot-hole appearance of the leaves upon which they feed. The tender leaves of cocklebur are always preferred by the grasshoppers in the early stages. Young Bermuda grass is also a favorite food, and succulent grasses of all kinds are freely eaten. In the third, fourth, and fifth stages, as grass, weeds, and even young shrubs disappear along the ditch banks and bayous, the crops of corn and cotton adjacent begin to show signs of vigorous attack, and the march of destruction commences. The rather rare occurrence of more grasshoppers, even in the adult condition, upon and near the ditch banks seems to be explained in the commingled instinct of the young to hunt the retirement and seclusion of the nesting or egg-laying areas, and of the adult to seek, and survey beforehand, suitable places for oviposition. A few hours before molting the grasshoppers tend to congregate and become sluggish. Ecdysis (molting) varies as to time, and slightly as to manner, with different stages. In the early stadia less time is required, and the operation takes place upon the ground or upon low bunches of grass and weeds. Every effort of the grasshoppers at this time seems to be to avoid conspicuity, and in doing so spare themselves, in a manner, enmity of parasites. After molting of the first, second, and third stages it is not long before the young grasshoppers are sufficiently hardened to again begin feeding, but often the molt of the fourth and fifth stages, particularly the last molt, some time is required to extend the wings and dry and harden the body before feeding is resumed. The last molt usually occurs upon the upper and well-exposed leaves of corn and other plants upon which they may be feeding, though it is not uncommon for the grasshoppers to drop to the ground during the maneuvers of the process. The reason for the selection of the more exposed places for the last molt is obvious. The bodies are large, and rapid drying protects them from fungous diseases which lurk in the more shaded and moist sections during the months of June and July.

The last prominent habit to which we call attention is that of the fully grown grasshoppers to seek the shade offered by the growing plants during the hottest part of the day. Upon Dahomy plantation they appeared in such numbers a little before sunset as to change the entire coloring of the fields. Instead of the rich green, a disheartening glistening bronze prevailed.

MEANS USED TO DESTROY THE BROOD OF 1900.

The serious loss of 1899, and the alarming increase in the number of grasshoppers over 1898, together with the startling number of eggs in widely distributed egg areas, caused no little uneasiness as to the outlook for 1900. Preventives and remedial operations were begun early in the winter and were actively continued until it seemed that all danger of serious loss was past. These operations consisted in fall and winter cultivation, spraying the egg beds and young grasshoppers with coal oil and coal-oil emulsions, covering the ditch water with oil emulsions and driving the young into the trap thus prepared, of using improvised tarred sheets, and of different kinds of hopperdozers, and finally to disseminate among the developing grasshoppers a disease commonly known as "the South African fungus."

Cultivation.—Three methods were used to determine the efficacy of the method of destroying eggs. Conditions were produced in breeding cages as nearly as possible like those existing in the fields. Eggs were collected in the fields a few weeks after cultivation had occurred, and lastly careful observations were made in fields cultivated before planting and those that were not. While none of these methods, taken separately, would give exact experimental proof, yet when the results of all three are considered, the estimate may be regarded as approximate.

Breeding cages showed that after egg areas had been broken, as represented in fig. 3, and the eggs exposed to rain, frost, and sunshine for two months, that over 80 per cent failed to hatch. We failed to determine the influence of frost alone upon exposed eggs, but young

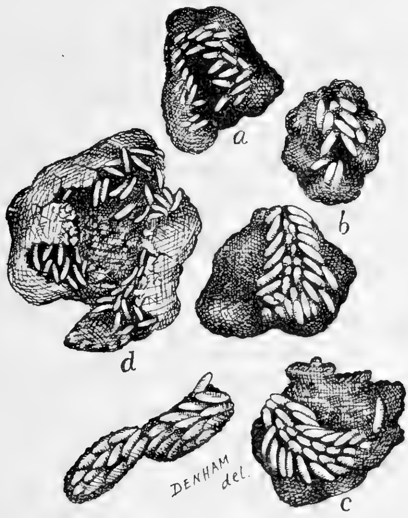


Fig. 3.—Grasshopper eggs exposed by cultivation (drawings from a photograph).

grasshoppers which had been hatched artifically, when subjected, March 15, 1900, to a temperature of 32° F., all died.

Of several hundred eggs collected on February 15 from fields which had been plowed in December, 1899, and the eggs kept from further exposure, only 30 per cent hatched and most of these came from egg pods which happened not to be thoroughly broken.

From field observations where favorable contrast could be made in egg areas cultivated and those left undisturbed the evidence in favor of cultivating is, to say the least, very conclusive. Mr. G. G. James, of Mound Landing, Miss., states, in a letter dated March 14, 1900: "While dragging a plow along a wagon road on March 12, the point dug up a few clusters of grasshopper eggs, and after finding these I had the entire road plowed up, and to my astonishment I found quantities of eggs its entire length. In a certain part, a space of about 20 feet long and 6 feet wide, there was almost a solid mat of nests." We were informed by Mr. James early in May that upon this roadbed, which had been thoroughly cultivated even as late as March 12, few of the eggs hatched, and this single experience convinced him of the value of winter cultivation. In the Delta, as far south as the State of Mississippi, warm, summer-like spells of weather often occur in winter, and fertile eggs exposed to such conditions invariably hatch, with the result that the young perish during subsequent winter weather, while eggs in pods just below the surface of the ground do not hatch until the latter part of April or early in May. It is therefore evident that the practice of fall, and even spring, cultivation is one of the most available means of destroying grasshopper eggs.

Unfortunately, upon plantations of many thousand acres, and especially upon those where a number of waste tracts occur, it is impossible to find all of the egg areas and to effect the remedy of winter cultivation.

The use of kerosene upon egg-beds at the time of hatching.—One or two seasons' experience with grasshoppers greatly quickens the powers of observation, and egg-beds not discovered in the fall and winter may be detected the first week in May by the presence of the young grasshoppers. Upon Dahomy spray pumps were kept actively at work upon egg areas, spraying each with 12 per cent coal-oil emulsion at least once a day. It often happened that as many young grasshoppers were in evidence the day following each application, but careful observation soon revealed the fact that only those hatching after the emulsion had been applied survived, and those were killed by the next spraying. While the emulsion spray was found expensive when compared with that of cultivation, yet in the face of such conditions as prevailed in the Mississippi Delta its effectiveness many times outweighed the expense. Applications of coal tar were not made to the egg-beds, but there is every reason to believe that this substance would also have proven useful. The use of coal tar in the hopperdozer and upon the drag sheets certainly warrant a trial of it upon egg areas.

Spraying ditches.—The experience in spraying ditch banks soon developed the cheaper and perhaps more effective method of destroying young grasshoppers, that of damming water in the ditches and covering the surface with coal oil or coal-oil emulsion. Before and after rains the ditches were dammed and the water covered with a 12 per cent coal-oil emulsion. The young grasshoppers were then driven into the ditches, with the result that very few, if any, escaped. In this way a single application of oil would last several days, as many millions may easily float upon the water of a ditch not more than 2 feet wide. Unless the grasshoppers are scattered too far from the ditch banks no difficulty is experienced in getting them to move in the direction of the oiled water on account of the "homing" instinct above mentioned. Young grasshoppers will not drive more than from 10 to 20 feet before taking what is commonly termed by the plantation managers "the sulks," when they cease hopping and show an aggravating indifference to the brush of the switches used in driving them. The necessity of early learning the location of the egg-beds and the time of hatching is obvious if the ditch method be practiced.

Upon river plantations many open ditches are indispensable, and when rains are sufficient to keep them filled or partly filled with water they serve a most excellent purpose in the destruction of young grasshoppers. During the grasshopper campaign of 1900 over 225 barrels of coal oil were used upon Dahomy and not a little of this quantity was placed upon the water of the ditches of the plantation in the form of emulsions. At the height of the season as many as 50 miles of ditches were oiled, and the number of young grasshoppers killed may be roughly estimated when we state that the surface of the water for this distance was completely covered. After the water evaporated the stench from decaying grasshoppers was very perceptible, and had it not been for the satisfaction of knowing that millions had been slain the stench, no doubt, would have been objectionable.

Mr. Robert Glenk, a member of the experiment station staff of Louisiana, spent two weeks in the field in charge of the grasshopper work, and in his report to Mr. Harding, dated May 31, 1900, says:

> Sunday afternoon brought up a heavy rain and filled many of the ditches with standing water. We had oiled the surface of the water and made a combined attack upon the insects, which has resulted in their wholesale destruction. We are using gangs of men and are making a systematic drive to the ditches.

One hitch occurred in the use of the emulsion. In driving the tank wagon over rough ground the emulsion became so thoroughly churned that the oil separated and floated to the top. This condition, however, was soon revealed by the effectiveness of the spray. The use of the pump, which mechanically mixes the oil and water, should obviate this difficulty.

Tarred sheets and hopperdozers.—The operation of the ordinary hopperdozer may be considered an easy matter in meadows, pastures, and over crops planted upon the level, but one has to experience once the trouble of working a hopperdozer in alluvial sections where the high ridging of the land prevails to realize that the ordinary use of the hopperdozer is impracticable. To construct one of these implements suitable to alluvial conditions will require further experience and trial. During the efforts with the hopperdozer Mr. C. D. Patterson, general manager of Dahomy, improvised a tarred sheet similar to that illustrated in fig. 4. It consists of six attached strips of osnaburg 6 feet long, with light poles attached to the ends. The sheet was kept moist with coal tar and was dragged by a mule along all the ditch banks and even down in the ditches where this was possible. Several of these sheets were made and kept actively at work while the grasshoppers were young, and great numbers of the insects were thus collected. While these sheets possess the merit of not breaking the young corn and cotton and of catching myriads of the grasshoppers, it is to be regretted that they soon wore out when dragged over cultivated areas.

The hopperdozer, which was finally constructed and which possessed

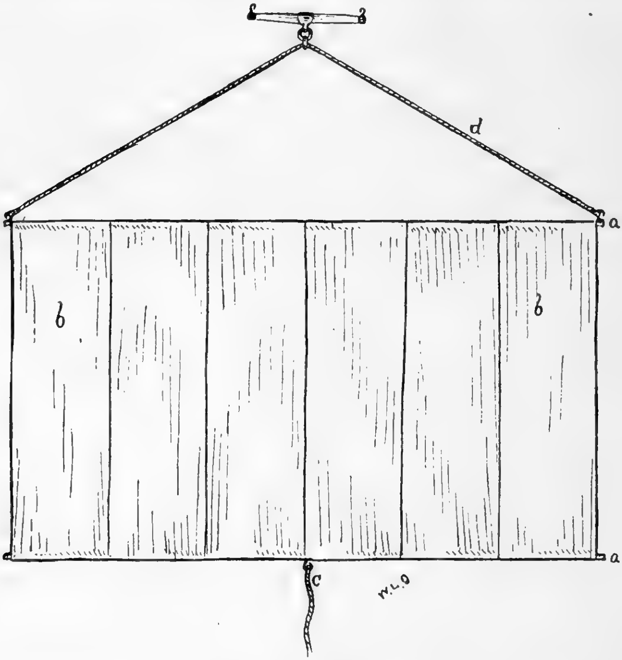


FIG. 4.—Patterson tarred sheet: *a*, strip of wood supporting sheet; *b*, strip of osnaburg; *c*, guide rope; *d*, hitch rope (original).

much merit when run diagonally over the rows of cotton and corn, consisted of three runners 3 inches high and 2 feet long, a pan of corrugated or sheet iron, and a back of osnaburg. (See fig. 5.)

Two more contrivances for catching young grasshoppers are to be recommended. These are of value during dry weather when it is impossible to hold the rain water in the ditches, or to fill them from the river or neighboring bayous by irrigating pumps. One is a hopperdozer sufficiently narrow to run in plantation ditches and light enough to be handled by a man upon the sloping ditch banks. They will prove serviceable, too, upon limited egg areas when the young are emerging. The other is a tarred strip of osnaburg just as long as can be conveniently handled in the bottoms of dry ditches. A strip 30 or 40 feet long will suffice. After this is stretched in the bottom of the ditch the grasshoppers are driven from the sheet just as they are driven into oiled ditches, and as soon as the distance of the length of the strip is cleared the canvas is hauled forward and the drive again made. This continued, the ditch banks may be as effectively cleaned in dry weather as when the ditches are filled with water.

The bran-arsenic mash.—The experience of Mr. Harding in 1899 (see his letter July, 1899) rather discouraged an extended effort with

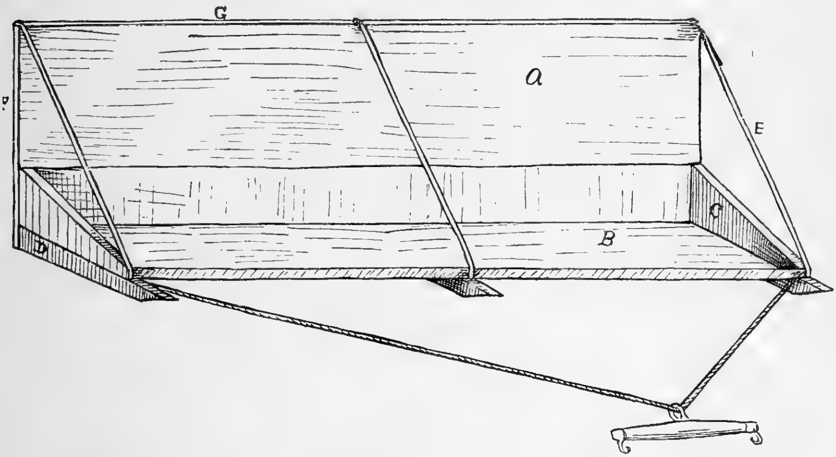


FIG. 5.—Hopperdozer: *A*, osnaburg back; *B*, pan; *C*, wooden ends of pan; *D*, runners; *E*, *F*, *G*, supports (original).

this bait. Mr. Glenk, however, ventured a number of trials with the mash and writes of it as follows:

> I placed the arsenic mash in many places with moderate success. Found a few dead grasshoppers on the leaves and around the mash. The rain, however, interrupted my experiments.

The mash can not be relied upon in severe outbreaks, such as occurred in the delta, but may be used in limited attacks where the area affected would not warrant the more aggressive methods.

The South African fungus.—On May 24 the following letter was received from Dr. L. O. Howard, inclosing Mr. Edington's directions for the culture and spread of the fungus, which are also herein given:

MAY 22, 1900.

DEAR PROFESSOR MORGAN: In response to your letter I am sending you six of the tubes of the South African locust fungus, together with a duplicate of a letter which I have just sent to Mr. Harding, at Benoit. I think it will be advisable for you to grow the fungus in the laboratory. Mr. Edington, director of the Bacteriological Institute, writes me that it is best grown on saccharinated agar-agar, which is very faintly acid in reaction. I hope you will report results. The South African circular of instructions is inclosed.

Yours, very truly,

L. O. HOWARD.

Prof. H. A. MORGAN, *Baton Rouge, La.*

[Inclosure.]

LOCUST DISEASE FUNGUS.

Small tubes containing this fungus are prepared at this institute and supplied to all applicants, who may also obtain them by application through the civil commissioner of their division.

The methods mentioned below should be followed, and the result carefully watched and reported to me.

Highly satisfactory results have hitherto been obtained, and it is particularly requested that all persons using the fungus will report the result of their experiments to this institute.

During dry weather it is difficult to get the disease to spread, and hence it is advisable to use it in moist or wet weather, and to make the infection of the swarms just before sunset.

DIRECTIONS FOR PREPARING THE FUNGUS PREVIOUS TO USE.

Open a tube and take out the contents entire; add to it two teaspoonfuls of sugar, and rub the whole together with a spoon or flat knife, so as to break up the material and mix it thoroughly. Then dissolve this in three-fourths of a tumblerful of water, which has previously been boiled and allowed to cool. Float in this a few pieces of cork, which have been previously steeped in boiling water and cooled.

Now cover the tumbler with a piece of paper, and let it stand during the day in a warm corner of the house or until the fungus is seen to be growing around the pieces of cork.

METHOD OF DISTRIBUTION.

(1) Catch some locusts, and, after dipping them into the fungus, let them go into the swarm again.

(2) Smear patches of damp ground, where the locusts alight to feed, with the fungus.

(3) Confine some locusts in a box which contains some favorite food moistened with the fungus, and, after the food has been eaten, return the locusts to the swarm.

(4) Collect a large number of locusts which have died from the fungus. Dig a hole in the ground about 18 inches deep and 1 foot wide.

Strew some locusts over the bottom, then sprinkle some water over them. Repeat with locusts and again sprinkle until the hole is full. Do not press the locusts into the hole, but leave them lightly packed. Then cover over with a piece of tin or board and keep the hole thus carefully covered for four or five days. If very warm weather, four days will be sufficient, but if colder a longer time will be required.

At the end of this time remove the locusts and spread them out in the sun for an hour or two, or until thoroughly dry. Now grind them into a meal.

Of this meal, which may be kept dry for a long time until wanted, take two tablespoonfuls and add it to a large tumblerful of water, into which some sugar has been placed. Leave this in a warm place for twelve to forty-eight hours, and then treat live locusts by dipping, etc., just as one does in using the fungus when supplied in tubes.

METHOD OF APPLICATION FOR VOETGANGERS.

Take about 1 pound of white bread; dry it, and then grate it down into coarse powder. Put a cupful into a bowl and add enough water to make a watery paste. Add to this the contents of one tube of fungus, and keep it in a warm place until the fungus is seen to be growing over it. Now place small portions where the voetgangers are appearing, and take care to see that where not eaten up the small portions are kept moist from day to day until they have been eaten.

ALEXANDER EDINGTON, M. B.,
Director Bacteriological Institute, Grahamstown.

FEBRUARY 19, 1899.

These tubes, together with six more sent directly to Mr. Harding at Benoit, Miss., were with instructions turned over to Mr. Glenk, and on May 31, 1900, Mr. Glenk made the following report to Mr. Harding:

The South African fungus came duly to hand. I immediately began its propagation in the manner directed, and steeped the grasshoppers and their favorite food (cocklebur) in the liquid and fed a large number of hoppers with it. Two infection boxes were started, with dampened soil covering the floor and cheese cloth the tops, and the insects were placed in contact with the spores of the fungus. The infected grasshoppers were liberated in various badly infested spots, and the results which should be noticed in a few weeks are looked forward to with much interest.

In a letter to the writer dated June 5, 1900, Mr. Glenk states:

I have had better success with the fungus than when you were here. I made an incubator out of some boxes and used my lamp for keeping an even temperature. The fungus grows well in a warm, moist atmosphere. I dissolved the nutrient agar-agar in two of the tubes, in hot water, mixed with it the sugar solution, added the fungus film, stirred well to distribute the spores, and poured the solution upon the leaves and moist earth. Dead grasshoppers were found in both of my infection boxes in a few days. I used up all the tubes received from Dr. Howard and made up enough liquid for all the managers. We put out a dilute solution of the fungus over several badly infested areas and spread it upon the grasshoppers, and the leaves of corn and cotton in many parts of Dahomy.

The month of June was very propitious for the spread of disease among grasshoppers. Rains began the latter part of May, and during June 9.29 inches fell at Greenville, Miss., 40 miles south of Dahomy, the nearest point where meteorological records are kept.

On July 18, 1900, the writer received the following from Mr. C. D. Patterson, general manager of Dahomy:

By request of Mr. P. M. Harding I am sending you by mail to-day some dead grasshoppers, which we find attached to weeds on ditches and bayou banks. We also find a few on cotton. Mr. Ike Edwards (manager of Matthews place) tells me that he has found as many as six dead grasshoppers upon one stalk of cotton. The dead grasshoppers I am sending you were gotten on Glass place.

Early in August a visit was made to Dahomy, with a view of making some observations upon the spread of this fungus, and it was found that over the areas where the liquid infection was spread by Mr. Glenk diseased hoppers were abundant. As many as a dozen dead grasshoppers could be found upon a single plant, and some upon nearly every weed on ditch banks where grasshoppers were numerous. From the centers of infection great areas had become inoculated, spreading even beyond the plantations first infected. While a local fungus (*Empusa grylli*) was in evidence throughout the delta, the general spread of the imported fungus upon Dahomy indicates a thorough infection of this property with the South African fungus. The spread of the disease is similar to that reported from Colorado, where, Dr. Howard informs me, the disease has also done effective work.

Associated with the differential locust in the same tracts of land were numbers of a much larger locust, the *Schistocerca obscura*, as well as many of the local species of grasshoppers found throughout the delta any season. Of all the specimens sent to the laboratory and of all those observed in the fields none were found to succumb to the fungus but the differential.

Miscellaneous experiments.—The habit of the differential to remain along sloughs, ditch banks, etc., suggested the scattering of lime, acid phosphate, kainit, and other substances to check the march of the grasshoppers out into the crops; but, as none of these materials proved of any value, a continuation of this line of work was early abandoned.

We found it advisable not to destroy cockleburs growing in the vicinity of the egg areas, as this plant is the favorite food of young grasshoppers and serves to congregate them, which not only renders more available effective remedies, but also preserves the stand of corn and cotton in these localities. Where it is possible, we also recommend delaying the cutting out of the crops to a stand until the young hoppers have been destroyed by some or all of the remedies stated above.

NATURAL ENEMIES.

Aside from the very timely rainfall during the latter part of May and in June, there were many predatory and parasitic enemies found common to the differential locust in the Mississippi Delta.

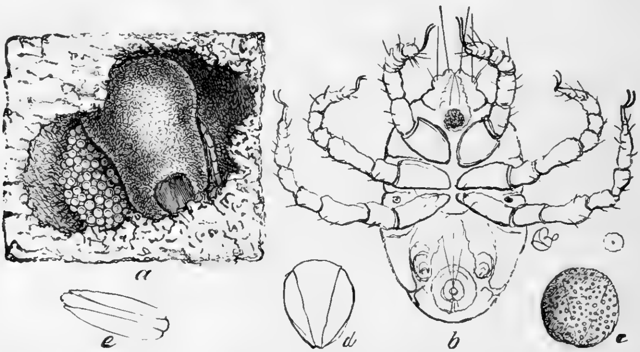


FIG. 6.—*Trombidium locustarum*: *a*, female with her batch of eggs (from Emerton); *b*, newly hatched larva—natural size indicated by the dot within the circle; *c*, egg; *d*, *e*, vacated eggshells (from Riley).

Upon the eggs.—Three predatory and two parasitic forms were found feeding to a greater or less extent upon the eggs.

The locust mite, *Trombidium locustarum* (see figs. 6 and 7), which occurs throughout the United States and Canada was in evidence in the Mississippi Delta. The full-grown mites, as well as bunches of the small red-colored eggs, were commonly seen during the cultivation of the land in April and May. While most abundant in the vicinity of the egg-beds, it was not uncommon to find them anywhere over the entire plantation. Many were placed in breeding cages where quantities of eggs of *differentialis* and of other species were kept, but we were disappointed somewhat in not finding them more ravenous feeders upon grasshopper eggs. From the statements of other observers of their beneficial attack upon eggs it may be that our cage conditions were not suitable for aggressive work of this mite. The numbers to be found were very assuring and this mite must be recognized as an important enemy to grasshoppers.

The larvæ of a species of Carabid beetle, which we were unable to

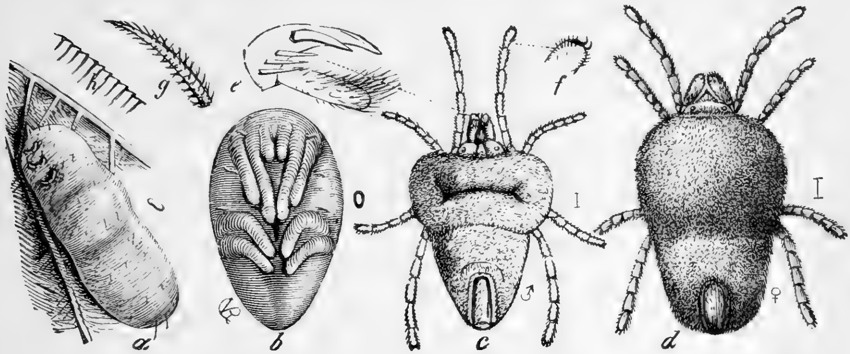


FIG. 7.—*Trombidium locustarum:* *a*, mature larva when about to leave the wing of a locust; *b*, pupa; *c*, male adult when just from the pupa; *d*, female—the natural size indicated to the right; *e*, palpal claw and thumb; *f*, pedal claws; *g*, one of the barbed hairs; *h*, the striations on the larval skin (from Riley).

rear to the adult condition, were also found to be an energetic feeder upon eggs. With their large mandibles they were observed breaking the egg sacs and devouring the contents.

During April, May, and June the ash and black colored blister beetle (*Macrobasis unicolor*) (see fig. 8) showed by its numbers and the manner of the attack of the young to be an important enemy of grasshopper eggs. In sweeping they were a common capture, and in following the plows and cultivators the pseudo pupæ (coarctate) were seen in great numbers. The young of the first and second stages were also found among the egg-pods.

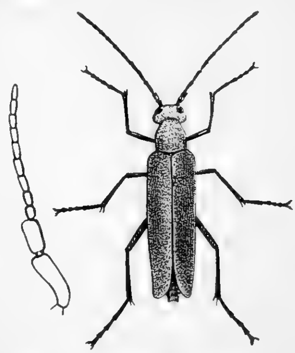


FIG. 8.—*Macrobasis unicolor:* Female beetle at right, twice natural size; male antenna at left, greatly enlarged (from Chittenden).

Of the true parasitic forms two species were bred, *Scelio hyalinipennis* Ashm. and *Scelio œdipodæ* Ashm. While the former species appeared earlier than the latter, both continued to emerge as adults irregularly from May 1 until the latter part of June. They were found to come in the majority of cases from the eggs of the lower end of the pod, and in a few instances this was found the case even where grasshoppers were coming from the upper ends. As a rule not all of the eggs of the pods are parasitized, and the inference is that the habit of the parasites to attack the deeper placed eggs is to so retard the development of the offspring as to guarantee food for the broods that follow. As the eggs of the differential are not deposited before August 15, the appearance of the parasites long after the young grasshoppers emerge suggests that, were they to appear earlier, the species would perish for lack of food. Those reaching the adult as early as June find food in the eggs of species of grasshoppers which deposit their eggs in the spring as *Schistocerca americana*, or in those of double brooded species, as *Chortophaga viridifasciata*.

Parasites of nymphs and adults.—As the fight against the grasshoppers progressed it was thought of interest to determine, as far as possible, all of the natural agencies at work, that with a fuller knowledge of these we might better know how to direct the expensive and time-consuming artificial measures, or knowing more accurately nature's rigid methods of establishing equilibration among the beings

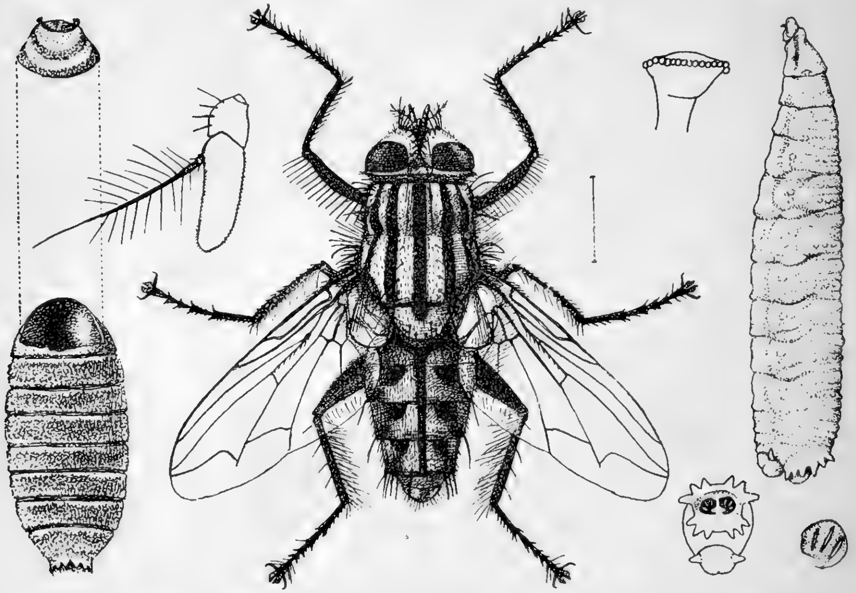


FIG. 9.—*Sarcophaga sarraceniæ:* Larva at right; adult in center; puparium at left—enlarged (from Howard).

in her charge we might assist and encourage her with less expense and more profit than carry out our own.

From time to time hundreds of grasshoppers were collected and confined to cages where each day quantities of fresh food were given them. As the later stages of the grasshoppers were reached maggots were noticed emerging from the conjunctivæ (sutures) of the abdomino-thorax and head. None, however, appeared until after the specimens had died, either from the conditions of confinement or from the attack of the parasites. As the collections were made after the "South African fungus" had been spread, many of the specimens were attacked by the parasitic flies and the fungus as well. Just to what extent the attack of the fungus encouraged the attack of the flies we were unable to determine.

Of the parasites bred most of them are peculiarly orthopterous enemies belonging to the genus Sarcophaga. Of the flies reared there were six Sarcophagids, two Tachinids, and one Muscid. The identifications were made by Mr. Coquillett and are as follows: *Sarcophaga sarraceneæ* Riley (fig. 9), *S. assidua* Walker (fig. 10), *S.* sp. near *incerta*

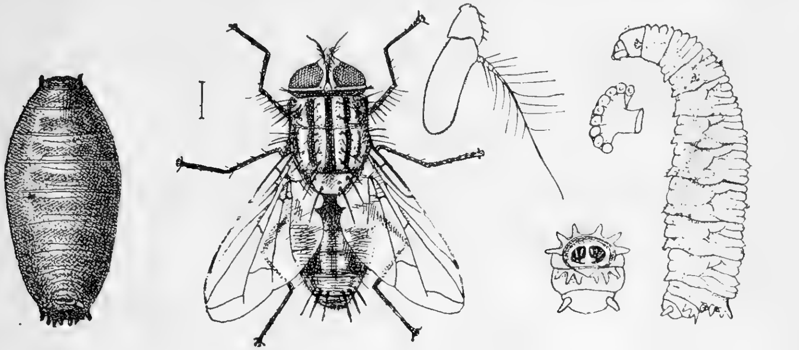


FIG. 10.—*Sarcophaga assidua:* Puparium at left; adult in middle, with enlarged antenna; larva with enlarged parts at right—enlarged (from Howard).

Walker, *S.* sp. near *cimbicis* Towns., *S. hunteri* Hough, *Helicobia helicis* Towns., *Euphorocera claripennis* Macq. (fig. 11), *Acemyia dentata* Coq., *Lucilia cæsar* Linn. (fig. 12).

Of the above species *Helicobia helicis* Towns. was the commonest fly bred. By isolating specimens of the differential locust, in order to derive information relative to its life history, a part of the life history of *Helicobia helicis* was incidentally reached. May 26, 1900, a specimen of grasshopper of the third stage was placed in cage. The last three molts were successfully accomplished and a few days after this female—for the specimen proved to be a female—had reached maturity a male was given her. Mating took place twice and a single pod of 132 eggs was deposited. August 16, 1900, the female died and was placed in a separate tube cage for further examination. During the period between August 28 and September 1 six maggots of *Helicobia helicis* emerged from the body of this grasshopper. Within forty-eight hours all had entered the puparia, and on September 17 the last of the flies appeared. From the above

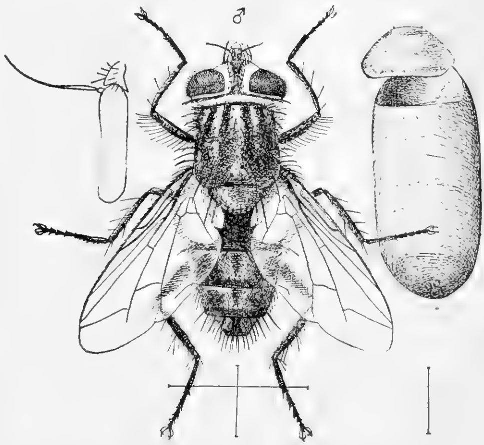


FIG. 11.—*Euphorocera claripennis:* Adult with enlarged antenna and with empty puparium at right—enlarged (from Howard).

observation it is evident that the eggs (or maggots) of the parasite were placed upon the host (this grasshopper) previous to the third molt, and that the larval life of the parasite is at least as long as from May 26 to August 28, or a period of ninety-five days. It is astonishing that all of the natural functions of grasshoppers went on during this remarkable period of parasitic attack.

Just to what extent the parasitic flies lessened the number of grasshoppers it is difficult to say owing to the prevalence of fungous diseases. Numbers of dying specimens were examined, and the viscera of those specimens infested with the fungus was much more disintegrated than those attacked by maggots, yet, as many of the grasshoppers were common hosts of disease and maggots, it was impossible to arrive at any very definite conclusion. Little information could be gotten from examination of the dead grasshoppers in the field as numerous ants soon deprived the hoppers of viscera or parts of viscera left by the maggots.

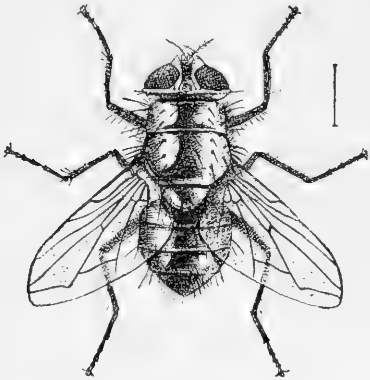


FIG. 12.—*Lucilia cæsar*—enlarged (from Howard).

From the puparia of *Helicobia helicis* two secondary parasites were reared. One of these, *Aphærreta pallipes* Say, was bred August 3, the other, *Perilampus cyaneus* Brullé.

The young of the locust mite was found to do effective work as parasites upon the wing pads and wings of grasshoppers. Upon the majority of those collected in the fifth and last stages young mites were common guests.

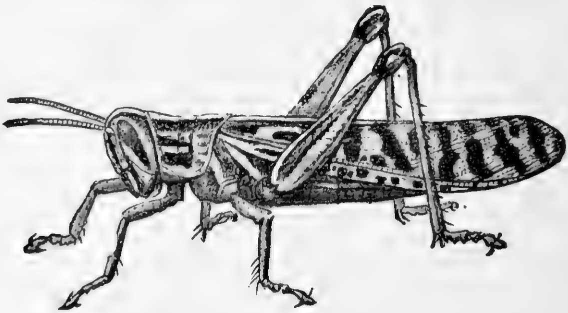


FIG. 13.—*Schistocerca americana:* Adult (from Howard).

Blackbirds and turkeys were observed to feed upon grasshoppers in all stages, and upon some plantations turkeys were purchased and liberated in infested fields. The exact information is not at hand as to the real merit of turkeys, but a common belief prevails that they may be made to serve a very practical purpose in grasshopper outbreaks.

OTHER GRASSHOPPERS MORE OR LESS INJURIOUS IN DELTA.

These belong to the families Acrididæ and Locustidæ. *Schistocerca americana* and *Schistocerca obscura* were the most common of the former family.

Schistocerca americana or bird grasshopper (see fig. 13).

This species is single brooded, deposits eggs in the spring, and hibernates in the adult condition. Specimens collected early in May deposited eggs May 15. In the field the egg-laying places are usually

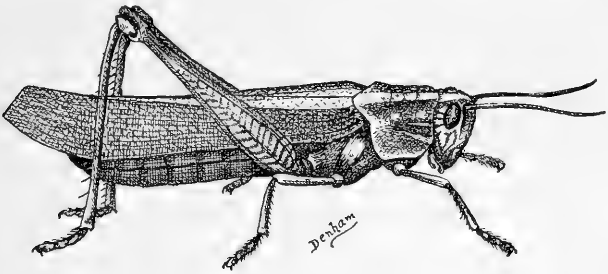


FIG. 14.—The full-grown *Schistocerca obscura* (original).

Bermuda-covered spots and waste areas. Eggs hatch about June 15, and the young molt six times (June 23, June 29, July 5, July 11, July 20, and August 5) before reaching the adult condition. In the delta the grasshopper attracts considerable attention owing to its size and bird-like appearance when in flight, yet it has never appeared in threatening numbers. Mr. C. D. Patterson, commenting upon the habits of this species, stated that during the clearing up of the waste lands in winter, as the flies ascended the tall trees, these large grasshoppers would fly out from the upper limbs in great numbers. Just how they found shelter among the higher branches of trees is unknown. We found it difficult to carry the bird grasshopper through the winter in captivity, and only succeeded in keeping specimens alive until February 2. In the fields, however, a few specimens have been collected from January until the last of May. No parasites were bred from those captured and no special remedial efforts were directed against this species. The egg areas were found, however, and cultivation and the use of coal oil will no doubt prove effective.

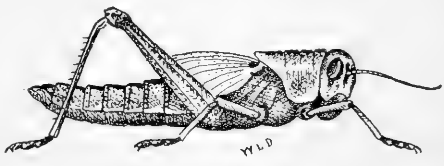


FIG. 15.—The fifth stage of *Schistocerca obscura* (original).

Schistocerca obscura.—(See figs. 14 and 15.) This species in size and shape is not unlike the bird grasshopper. Attention was first called to it in the egg condition. The large brick-red colored eggs are to be found associated with those of *Melanoplus differentialis.* A few egg sacs were isolated and during the latter part of May the young grasshoppers made their appearance. In the first and second stages they are pea green, but in the third stage changes in the ground color occur. Some remain green, while equally as many become brown. The body and appendicular markings of the two color varieties remain the same. This locust hibernates in the egg condition, though the eggs are deposited much later than are those of *differentialis*. Adults placed in the breeding cages on October 15 deposited eggs November 2. Five molts occur before maturity is reached. Young emerging from the eggs on May 28, 1900, molted June 10, June 19, June 29, July 8, and July 28. Adults in confinement are shy and soon die in captivity. In destructiveness to crops of the Mississippi Delta this species stands next to *differentialis*. It readily attracts attention by its size, color, and vigorous flight. Notwithstanding its prevalence, not a single specimen was found attacked by parasitic flies or by the South African fungus. *Scelio hyalinipennis* Ashm. was bred from the eggs, as was *Scelio œdipodæ* Ashm.

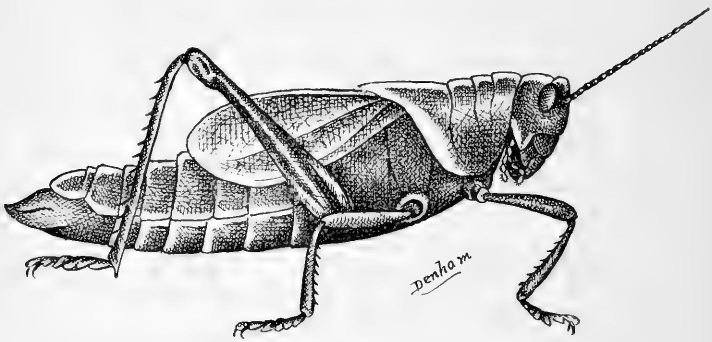


FIG. 16.—The large black grasshopper *Dictyophorus reticulatus* (original).

The egg beds of this species being similar in position to those of the *Melanoplus differentialis* the remedial measures recommended for *differentialis* will prove effectual for this.

Dictyophorus reticulatus.—(See fig. 16.) This large black species is a short-winged form, is only locally distributed and may occur only in spots, even upon a small plantation. It is a voracious feeder, preferring the coarser grasses and sedges of swamp areas. Its wandering into cultivated crops is only occasional, and hence this locust does not attract much attention.

The eggs are deposited in sodded areas all during the month of August (see fig. of egg pod; fig. 17).

By September 15 females are rare, not more than 10 per cent of hundreds collected at this time were females. This is just the opposite of the observations upon *differentialis*. Males usually die a few days in advance of females. Eggs of Dictyophorus hatch as early as April 20. As is usual with most Acridids five molts occur in the process of development, the last one occurring from June 25 to July 1. The mating season begins in from fifteen to twenty days after maturity, and in as many more the oviposition season begins.

From the local distribution of this locust, as well as its large size, conspicuous coloring, and lubberly movements, no trouble is experienced in destroying it. The bran arsenic mash had been used upon this locust with good effect. Locating the eggs and exposing them by winter tillage is the most practical remedy. In very local outbreaks the net has been used to collect both nymphs and adults. A species of Sarcophagidæ has been found a common parasite of this grasshopper.

Dissosteira carolina.—The Carolina locust eggs resemble very much in size and form those of the *Schistocerca obscura* after the coloring from the latter has been removed by alcohol. (This coloring of the eggs of *obscura* resembles in its reactions the color extract from the petals of red roses.) The eggs are laid in the same areas as *differentialis* and *obscura.* The preferred food of the young we were unable to determine, and hence were unsuccessful in the effort to determine the life history of this locust. Grasshoppers of all species are difficult to rear in cages, and this one we found no exception. The young would congregate upon the window side of the cage, and would there remain until starved to death. Cockle-burs, which were readily eaten by other species, were only occasionally nibbled. This locust did not appear in destructive numbers and is given consideration only because the eggs and young are frequently confounded with those of the differential. From field observations the period of development of the Carolina locust is about equal to that of the differential, though mating and egg-laying is later.

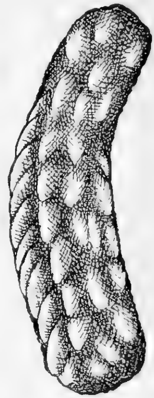


FIG. 17.—Egg sac of *Dictyophorus reticulatus* (original).

Chortophaga viridifasciata.—This species is widely distributed through the South, and though it appears in the Mississippi Delta in unusual numbers for this species, the damage done was not appreciable. It is here considered for two reasons: First, the young appear early in the spring and have been frequently mistaken by planters for the differential. The young of the first brood appears as early as the middle and last of March. It is double brooded, and receives a second consideration because the eggs act as food for differential egg parasites which appear earlier than August 15 and September 1. The first brood matures about May 15 and the last from October 1 to 18. As hibernation is passed in the egg condition, fall and early winter cultivation will prove destructive to the eggs.

Melanoplus atlanis and *Chloëaltis viridis* were also found upon Dahomy, but not in sufficient numbers to warrant any alarm. Specimens of *atlanis* were received from the alfalfa sections of the Red River

Valley in Louisiana, and were reported by Mr. George W. Arnold, of Vanceville, La., as injuring alfalfa. No opportunity was presented for a study of its life history and habits.

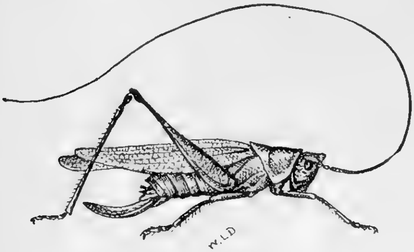


FIG. 18.—Field locust (*Orchelimum agile*) (original).

Field locusts.—In August, September, and October from among the coarse ditch grasses and those of swamp and waste places come the rasping sounds and almost continuous buzz of the field locusts. Not much attention has been paid to these long-horned grasshoppers or locusts. In ordinary seasons they are not prone to wander from the ditch banks, but when the differential prevails, they are forced into the crops in search of food. In 1898 and 1899 considerable damage was done. The prevalence of a species of Orchelimum may be imagined when in certain sections of the Delta, particularly near Mound Landing, Miss., hundreds of acres of dry cotton stalks were found to contain numbers of eggs in every branch and twig (see fig. 19 showing general appearance of punctured stalks and position of exposed eggs). These eggs were also found abundant in the tassel stalks of corn in widely distributed fields.

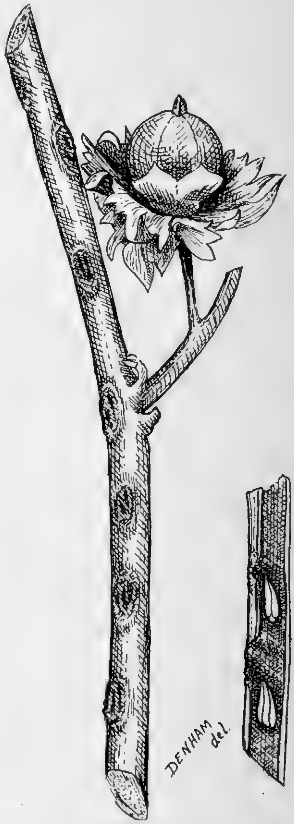


FIG. 19.—Portion of cotton stalk showing punctures and eggs of *Orchelimum agile* (original).

The eggs hatch during the latter part of May and continue until June 20. Moisture has much influence upon hastening incubation and hatching. In cages the stalks of cotton were moistened every few days, and after each dampening the young emerged more numerously. The exact number of molts was not determined. After molting the young devour the cast skin and frequently they have been found devouring one another. Maturity is reached very irregularly owing to the difference in the time of hatching and of the variations of development. The form most commonly found upon Dahomy was *Orchelimum agile* (see fig. 18). It matures from the middle of July until September 1, deposits eggs from fifteen to thirty days after reaching the adult, and winters in the egg condition. In 1899 *Orchelimum agile* was a real enemy to cotton, but the habit of depositing eggs in cotton branches and the tassel stalks of corn suggest the burning of all egg-infested cotton and corn stalks, which has been the common practice upon some plantations.

The field locust eggs are common hosts of two hymenopterous parasites, *Eupelmus xiphidii* Ashm. MS. and *Macroteleia* sp. near *floridana* Ashm. In breeding cages the latter appeared during the month of June, while the former appeared at intervals from July 21 until October 15; the majority, however, emerged between August 25 and September 18, and all were females. It is interesting to note that the parasite delays development and reaches the adult stage at a time when locust eggs are fresh and more or less abundant.

From adult locusts a number of Sarcophagid flies, *Helicobia helicis* Town. were bred. The maggots appeared on September 15, pupated September 17, and matured September 24.

THE RELATION OF CREVASSES AND RAINFALL TO THE APPEARANCE AND DISAPPEARANCE OF GRASSHOPPERS.

Planters operating behind the levees of the Mississippi River have, from experience, begun to expect insect outbreaks of one kind or another after overflows. In many sections the Southern grass or army worm (*Laphygma frugiperda*) makes its appearance in damaging numbers, while in other places grasshoppers and the army worm may both become destructive. It has been frequently observed that previous to crevasses predaceous beetles of many kinds are abundant on alluvial lands. They feed upon the army worm and easily keep them in check. During crevasses the beetles are either destroyed or are carried to other places by the flow and rush of the crevasse water. As soon as the water recedes and the land is put in cultivation the army-worm moths from neighboring sections fly in, and as this species is a rapid breeder, the crops of the overflowed area are soon infested with armies of caterpillars. It is usually a month or more before the predaceous beetles can migrate in numbers sufficient to check and overcome the march of the caterpillars.

In the case of the grasshopper the conditions are somewhat different. A part of the overflowed land may be thrown out of cultivation a season or more, and thus nesting places are provided. Should heavy rains prevail during May and June of the season immediately following the crevasse, nothing is heard of the ravages of grasshoppers; but should dry summers follow, the conditions for grasshopper propagation and development are much more favorable, and complaints are usually common. The relation of predaceous beetles to grasshoppers is not so intimate as in the case of the beetles and the army worms, though it must not be wholly disregarded, nor are the rains so destructive to the army worms as to grasshoppers.

The above statement of conditions is given in order to emphasize the importance of a study of the conditions of insect outbreaks. Were we better acquainted with accurate environments preventive measures would invariably take the place of the more expensive remedial ones.

Capt. Charles L. Potter, Corps of Engineers, Memphis, Tenn., has kindly furnished the following list of the breaks occuring in the Mississippi River (between Rolling Fork and Coahoma, the grasshopper infested territory) since 1887:

Name of crevasse.	Distance by river from Cairo.	Date.	Remarks.
	Miles.		
Offutts	444	Mar. 18, 1890	
Skipwith	530	Mar. 26, 1890	
Mound Landing	435	Mar. 28, 1890	
Huntington	438	Mar. 28, 1890	
Austim	288	Apr. 3, 1890	About 30 miles above Coahoma.
Catfish Point	432	Apr. 4, 1890	
Robertsonville	354	Mar. 11, 1891	
Stella	503	Apr. 3, 1891	
Deerfield	492	Mar. 28, 1897	
Sledge	380	Mar. 30, 1897	
Stop Landing	434	Mar. 30, 1897	
Flower Lake	300	Apr. 4, 1897	About 20 miles above Coahoma.
Shipland	548	Apr. 21, 1897	Latitude 8′=about 10 miles south of Rolling Fork.

There were no crevasses in the Mississippi levees from 1887 to 1890.

A small crevasse occurred at Greenville in 1891 that was closed before the discharge was appreciable.

All the breaks except those at Flower Lake, Austim, and Shipland are located between Coahoma and Rolling Fork.

Grasshopper outbreaks occurred in 1891 and 1892, and again in 1898, 1899, and 1900. It is a significant fact that the rainfall of May and June, 1893, and of the same months in 1900 had a decided effect in suppressing the injurious numbers of grasshoppers, and conversely, the dry summers immediately following the crevasses encouraged greatly their development.

The following table of rainfall for Greenville, Miss., the nearest meteorological station, furnished by Mr. W. S. Belden, acting station director, Vicksburg, Miss., supports the above conclusions.

Rainfall at Greenville, Miss., 1888–1900.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1888	6.11	2.41	9.88	1.65	4.54	3.95	2.28	10.39	2.69	1.61	3.89	3.89	53.29
1889	4.89	2.71	1.85	2.60	4.03	7.09	4.50	1.86	4.05	0.40	5.92	1.05	40.95
1890	4.98	6.30	6.63	11.01	4.67	2.31	2.23	2.09	4.94	2.79	1.48	3.94	53.37
1891	3.79	8.38	4.43	2.24	3.42	3.02	12.32	2.44	1.54	0.86	5.40	3.40	51.24
1892	5.59	3.60	3.91	9.74	2.93	2.54	9.25	3.50	6.96	0.80	2.44	6.54	57.80
1893	4.63	5.27	2.70	5.69	7.39	6.59	2.33	2.87	2.67	0.34	6.34	1.87	48.69
1894	7.37	3.19	9.48	4.48	0.61	0.30	5.09	......	1.17	1.53	0.35	4.25	37.81
1895	6.32	5.24	......	1.71	1.32	11.50	4.30	7.23	0.37	1.20	3.78	3.58	45.55
1896	3.29	5.24	7.98	2.48	1.09	0.71	0.85	1.84	0.74	3.20	4.73	0.17	32.32
1897	4.31	4.05	11.48	1.96	2.19	1.05	3.85	2.24	T.	2.20	2.96	8.37	44.66
1898	8.19	2.89	2.94	3.83	3.15	2.54	1.57	7.51	6.12	5.85	4.60	1.51	50.70
1899	5.30	4.57	5.21	2.19	4.67	1.51	2.10	0.87	1.18	1.15	0.94	4.23	33.92
1900	1.94	5.44	5.64	7.11	4.02	9.29	6.11	0.93	2.58	5.03	......	......	[1] 42.98

[1] For 10 months.

The habits of young grasshoppers to seek the soil crevices during a rain results in the burial of millions beyond the possibility of a resurrection. This, with the development and propagation of fungous diseases among the nymphs, are the most potent natural agencies which destroy grasshoppers during wet summers.

The fact that the differential locust will deposit eggs in logs has given some support to the idea that crevasse water introduces the grasshoppers. There are sections of the delta, however, which are almost annually overflowed by the high water of the Mississippi and its bayous and which would be common infesting grounds were this the case, but these do not seem to suffer except when dry summers prevail.

SOME INSECTICIDE EXPERIMENTS.

By C. L. Marlatt.

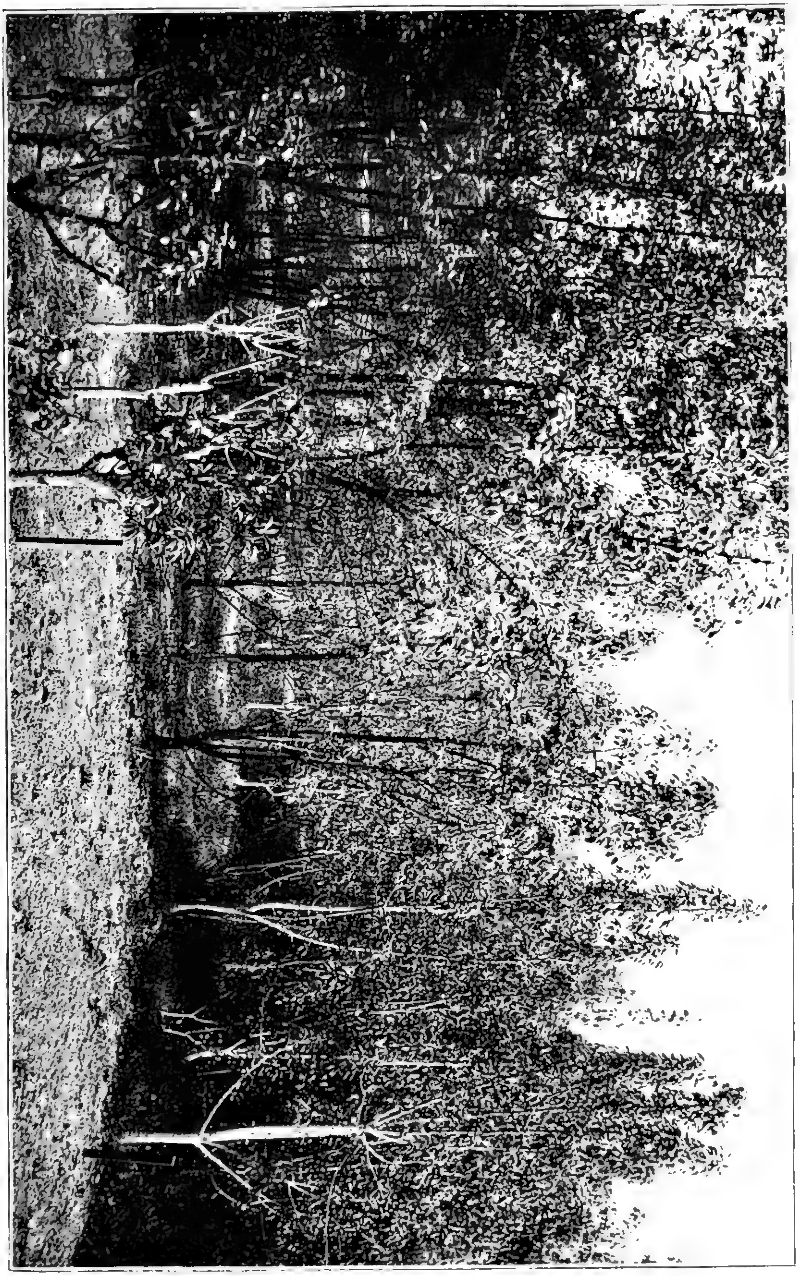
A series of experiments with certain insecticide substances was made in the spring and early summer of 1900 and are herewith recorded. The experiments were especially designed to test the effect of various substances which might be used against the San Jose scale, both as to their effect on trees and efficiency as destroyers of the scale. They included work with (1) crude petroleum; (2) refined kerosene; (3) lime, sulphur, and salt wash; (4) hot water; (5) Bordeaux wash and kerosene emulsion; and (6) a kerosene and lime emulsion. The experiments with the latter two substances were made at the suggestion and with mixtures furnished by Professor Galloway. An experiment was also made, at the suggestion of Dr. L. O. Howard, with a heavy lime wash or whitewash. For the washes containing lime the period immediately following the applications was unusually favorable, little rain falling for upwards of two or three weeks. In the use of crude petroleum and kerosene nothing especially new is to be noted except the fact that the treated trees were not in any way injured and the effect on the scale was all that could be desired. The lime and salt wash, rather unexpectedly for the East, proved to be a very efficient insecticide, doubtless owing to the fact, however, that the weather conditions were exceptionally favorable. The lime emulsion indicated good results. The Bordeaux and oil mixture was less favorable, and the whitewash spray, while most promising in appearance at the outset, was valueless as to results in the outcome.

Crude and refined petroleum.—A series of plum, apple, and pear trees were sprayed March 22 with crude petroleum (43° Baumé), the applications being made thoroughly enough to completely wet the bark. The plum trees were thickly infested with *Diaspis pentagona* and the pear trees with the San Jose scale. Some of these trees had been pruned back heavily, and others were straggling trees 10 or 12 feet in height. The application was made between 2 and 3 p. m. on a bright, dry day. At the same time a block of trees was sprayed with kerosene, or refined petroleum. The weather continued fair and dry for four days, and there was no rainfall of any amount prior to April 11. After the second day the kerosene had very largely evaporated, the treated trees showing only a very light discoloration. Trees treated with crude oil, on the other hand, were still very wet and oily looking. The full-grown female scales of *Diaspis pentagona* were thoroughly soaked and were permanently preserved, apparently, in the oil and had scarcely changed color and were not drying up. After six days a slight change in the coloration of the female scale insects began to be observed, the color slightly altering from light lemon to light orange. This change in coloration is a certain indication of the death and gradual drying up of scale insects, which usually change from lemon to orange and finally to brown or black in the different stages of drying after being killed by an insecticide. Three weeks after the application the trees treated with the crude oil were distinctly greasy in appearance and blackened by the oil. Trees sprayed with the pure kerosene gave no indication of having been treated at this time, the oil having entirely evaporated. Curiously enough, the grass growing about the trees treated with these oils seemed to be more affected by the refined than the crude oil, being somewhat yellowed. This grass had been sprayed pretty heavily with the oil to see what result would follow. Two weeks later—namely, five weeks after the application—the bark of the trees treated with the crude oil was still dark and distinctly oily. All the trees treated with oil were leafing out and blooming just as freely and fully as untreated trees. The grass, which had shown yellowing at the outset, had entirely recovered and was apparently uninjured, seeming to indicate, at any rate, that grass will stand a considerable application with both crude petroleum and the refined oil without being killed. This fact is interesting in connection with the use of this substance against white grubs on lawns. (See Pl. I.)

Lime, sulphur, and salt wash.—A mixture of this substance was prepared, differing slightly from the formula given in Farmers' Bulletin No. 19 in that the amount of lime was somewhat reduced, namely, from 40 to 30 pounds. This reduction in the amount of lime was made simply because in the ordinary formula the lime is very greatly in excess and remains as a pure lime sediment in the wash and has to be kept in suspension by agitation. Even as thus reduced there is still a considerable excess of lime. The formula followed was:

Lime	pounds	30
Sulphur	do	20
Salt	do	15
Water	gallons	60

The mixture was steam boiled altogether in barrels about four hours and applied March 23 and repeated March 24. The hot liquid was



DARK-COLORED TREES AT LEFT SPRAYED WITH CRUDE PETROLEUM; LIGHT-COLORED TREES IN MIDDLE FOREGROUND AND AT LEFT SPRAYED WITH LIME, SULPHUR, AND SALT WASH.

taken immediately from the barrels at almost a boiling temperature and sprayed at once on the trees. A series of experiments was also made with the preparation of this wash on a smaller scale, following practically the same formula. The products obtained were submitted to the Chemist of this Department for analysis, and the assistant chemist charged with the work was especially advised just what features were supposed to be desirable and what points the analysis should bring out. The result of this analysis, made by Mr. J. K. Haywood, of the Bureau of Chemistry, as reported by Dr. H. W. Wiley, Chief Chemist, is given in a footnote.[1] It is very interesting and valuable as showing the probable exact chemical nature of the wash in a dry climate and correspondingly also in a wet climate, in these respects practically substantiating the theory which the writer had announced several years ago. The practical application of this wash, as described above, was made to pear and plum trees, both infested with the San Jose scale, the plum trees being very thickly covered with the scale from top to bottom and the pear trees scaly from the butts upward three or four feet, scattering more or less over the whole tree. The plum trees had also more or less of *Diaspis pentagona*.

The question naturally arose, in view of the extreme heat at which the liquid was applied, whether any results gained might not be due to the high temperature of the liquid rather than from any insecticidal action. To test this matter some plum and peach trees covered with *Diaspis pentagona* were sprayed on March 27 with water at boiling temperature, or nearly so, the nozzle being held within 3 or 4

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[1] The lime, salt, and sulphur wash, as finally prepared, contains the following substances in solution: A large amount of (CaS) calcium sulphid, some of the higher sulphids of Ca (as CaS_3 and CaS_5), small amounts of ($CaSO_4$) calcium sulphate, and traces of ($CaSO_3$) calcium sulphite, and a large amount of (CaS_2O_3) calcium thiosulphate; also some of the excess of $Ca(OH)_2$ lime is in solution. The residue is composed of lime.

On evaporating down a portion of the wash, with blast and at a gentle heat, no decided change takes place. Calcium sulphid still remains, as does calcium thiosulphate. A small amount of sulphur is deposited (doubtless from the polysulphids of calcium), and the amount of calcium sulphate is increased to a small degree.

If such a wash were applied to trees in a dry climate, the various compounds formed would remain for a long time and only gradually decompose. Eventually, however, the calcium sulphid would decompose, most likely forming calcium sulphate and some hydrogen sulphid (H_2S), and the calcium thiosulphate would decompose, first setting free sulphur and calcium sulphite, which last would oxidize to calcium sulphate. The lime would change to calcium carbonate ($CaCO_3$) and the polysulphid would break down, yielding sulphur and calcium sulphid, which would in turn change as above.

In a wet climate the calcium sulphid and the calcium thiosulphate would soon leach out, leaving behind small amounts of calcium sulphate and a large amount of lime, which would in turn form insoluble calcium carbonate. In this latter case the tree would still remain white and appear to still have the wash upon it, but, in fact, very little other than the calcium carbonate would be left.

inches of the bark and the spraying being very thoroughly done. At a distance of 18 inches, as tested by spraying on one's hand, the mist or spray was barely warm; at a distance of 12 inches, fairly hot, and very hot at from 4 to 6 inches. The bark of the trees sprayed was cold to the hand as soon as spraying stopped. This hot-water spray brought to bear closely on the scale insects, it was thought, would kill them, although it would of course be impracticable to make such close-range application in general practice. On the contrary, however, the scales remained in a vigorous, healthy condition, and apparently did not suffer in the least from the warm douche.

The results, therefore, gained by the lime, sulphur, and salt wash may be properly ascribed, it is believed, to a true insecticidal value of the substance rather than to the temperature of the application. The trees treated with this wash remained nearly snow-white, little, if any, of the mixture being taken off by the light snow and rain of the 25th and 26th instant. Discoloration of the Diaspis began to be noticed on the 27th instant. On April 13 the Diaspis scale insects killed ranged between 20 and 50 per cent on the young, vigorous limbs. All were dead on the old trunk, where the wood was in a very unhealthy condition owing to the completeness of the infestation, both by the Diaspis and the Aspidiotus. The San Jose scale, so far as investigation could determine, seemed to be killed completely; no insects were found on the young, vigorous shoots or older wood. The trees were still whitened with the wash, which had not been carried off to any very great extent by the heavy rains of April 11 and 12. The infested trees, especially those that had been pruned back, made a very vigorous growth, and the fruiting and growth of the others were entirely satisfactory.

In this experiment, which differed so remarkably in results from other experiments made in the East with this substance, it must be noticed that the weather conditions were exceptionally favorable. The application was made on March 23, and no washing rains followed until April 11 or 12, the light rain and snow of the 25th and 26th of March being not enough to vitiate the wash particularly, as very little of the snow rested on the trees, and much that did gain lodgment fell or was blown off subsequently. A very light shower occurred on April 4, but the first heavy downpour and long rain occurred on the night of April 11.

This experiment would seem to indicate that if one could count on a week or two of good weather following an application, the lime, sulphur, and salt wash might be as beneficial in the East as on the Pacific coast. Its cost is inconsiderable compared with the other treatments for the San Jose scale.

During the summer of 1900 the writer spent considerable time in California and saw a great many deciduous orchards that had been treated with the lime, sulphur, and salt wash. This treatment had been made in the winter or early in the spring, before the trees had begun to leaf out, and at the end of August the trees were still distinctly whitened by the application, there having been no rains in the interim to remove it from the bark. Under such circumstances it is plainly to be seen that this wash has the maximum chance of effectiveness, and that it is thoroughly effective under these conditions is beyond question. Its effectiveness is undoubtedly, in the first instance, chiefly due to the direct insecticidal action of the mixture; and possibly, secondarily, in protecting the tree by the limy and sulphurous coating, which remains for months and is undoubtedly distasteful to the young scales coming from old individuals which may have escaped, and perhaps retains enough of its insecticidal value to destroy many of them.

Bordeaux mixture kerosene emulsion.—This mixture, suggested by Professor Galloway, is an attempt to emulsify a small amount of kerosene in a comparatively large amount of Bordeaux wash. The formula used was—

	Gallons.
Bordeaux mixture	5
Kerosene	1

The two are churned together until the oil is emulsified. Some peach trees infested with *Diaspis pentagona* were sprayed with this mixture on April 14. At the time of the application the trees were just coming out in leaf and bloom. The weather conditions immediately following the application were favorable, no rain falling on the 15th or 16th. There was a good deal of rain, however, between April 17 and 22. This mixture seemed to have little effect on the trees, and also little effect, if any, on the scale insect. It must be remembered that the Diaspis has an unusually thick scale, and is therefore more than ordinarily protected and correspondingly immune from the action of insecticides, as was illustrated in the preceding experiment with the lime, sulphur, and salt wash, where not above 50 per cent of this Diaspis was killed by a wash that completely exterminated the San Jose scale. The testing of this mixture has not, therefore, been wholly satisfactory, and it is probably worth while to do some more work with it in the future with other scale insects.

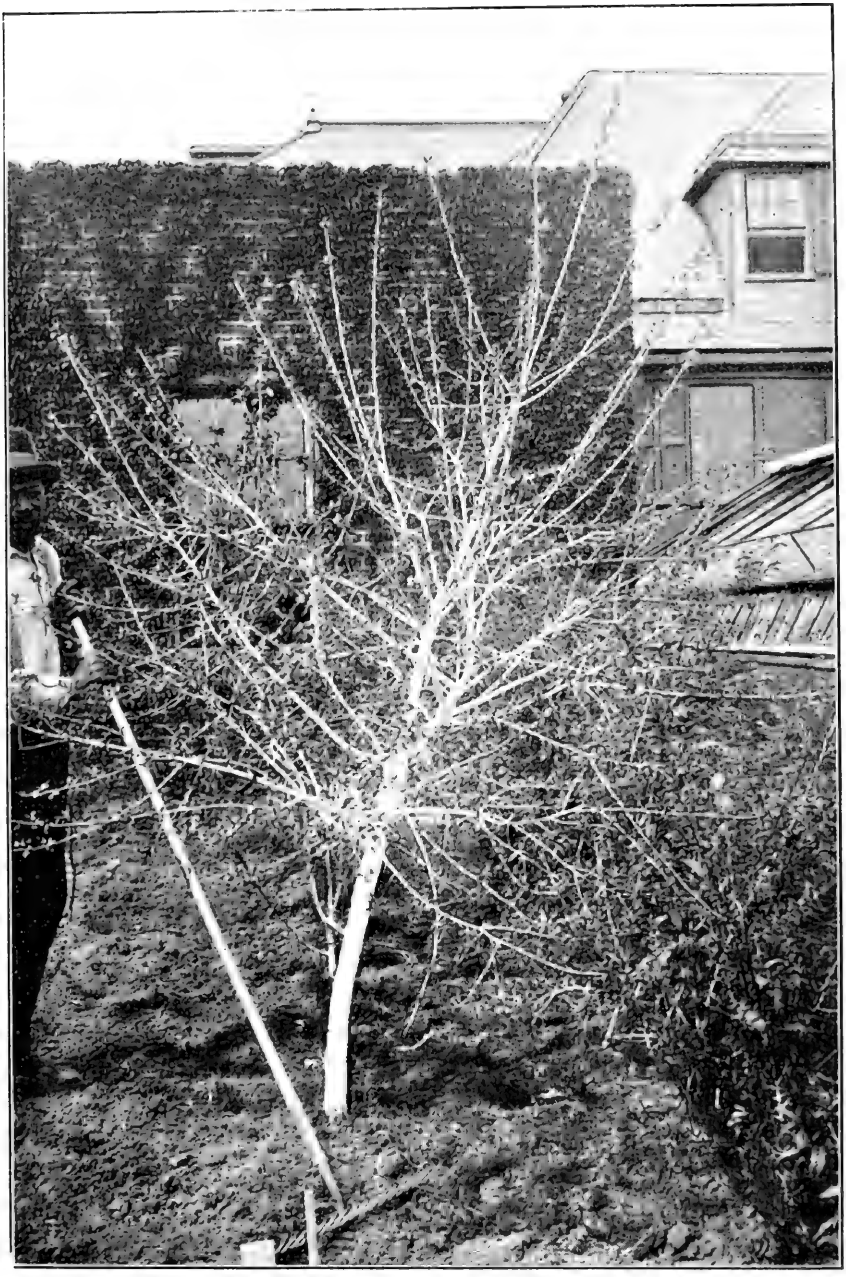
Kerosene-lime emulsion.—This mixture, recommended to the writer by Professor Galloway some years ago and experimented with in a limited way at the time, was again brought to his notice by Professor Galloway, who prepared for his use an emulsion after the following formula:

Fresh lime	pounds	4
Water	gallons	5
Kerosene	do	1

Slack the lime slowly with small quantities of water in order to get a creamy solution. When thoroughly slacked dilute to 5 gallons, add 1 gallon of kerosene, and churn until emulsified (one or two minutes). This mixture was applied April 14 to a peach tree badly infested with *Diaspis pentagona*, and to several pear, quince, apple, and peach trees not infested with scale insects, the application to the latter being made more particularly to determine the effect of the wash on different kinds of trees. The application whitened the trees, not entirely, however, obscuring the bark. The treatment was very heavy and thorough. It is possible that more lime would have been an advantage, making a better emulsion and a slightly heavier wash. This treatment was made at the same time as the Bordeaux wash, referred to above, and experienced the same weather conditions. The effect of this wash on trees was not unfavorable, no injury being noted.[1] The Diaspis on the one scaly tree subjected to the wash were, for the most part, dead or dying by the 17th of April, the wash holding well and still coating the trees uniformly. This lime emulsion is worthy of a more extended trial, and it is hoped that others who have opportunity to test its effect on various scale insects will undertake experiments with it.

Whitewash.—At the suggestion of Dr. Howard and with the idea of determining the effect of the lime in the several lime washes used, a good sized plum tree thickly infested with *Diaspis pentagona* was subjected on the same date as the last two experiments to a thorough spraying with a strong whitewash, prepared by slacking 2 pounds of stone lime in a gallon of water. The application left a thick coat of whitewash on the tree, entirely obscuring the bark and leaving the plant snow-white. At the time of treatment the buds had not started. This lime wash held very well except that it cracked and scaled off a little in spots, due to the action of the wind. In the main, however, the bark of the tree remained snow-white and thickly covered for three or four weeks, in fact, at the end of the summer the lime still adhered to some slight extent. The tree came into bloom and leaf later on without any checking from the application. The adult female scales were not affected, apparently, at all by this application, rather to our disappointment, but it was still hoped that the lime coating would remain and prevent the young scales from settling on the bark. The young of this species, however, appeared very late in the spring and, unfortunately, before that time the lime had so cracked and scaled off in spots that little benefit was gained from its presence, and the second brood at least of this species again completely covered the tree. A lighter coating of lime as indicated by the lime, sulphur, and salt wash and the Bordeaux wash, and also the lime emulsion, adhered

[1] The infested peach tree first mentioned subsequently died, not necessarily, however, as a result of the treatment, but more likely in part from this scale infestation. The other peach trees were nor injured, nor did any of the other trees suffer from the wash.



Plum Tree sprayed with a heavy Lime Wash.

better than the heavier coat experimented with in this instance and perhaps might have proven of some slight value in preventing the settling of the young scales. Further than this the pure lime wash appears to be of little value against scale insects, at least as indicated by this single test. (See Pl. II.)

The insecticide value of formaldehyde gas.—Some experiments were made in conjunction with Dr. E. A. de Schweinitz, of this Department, several years since to determine the insecticide value of formaldehyde gas. The results of these early trials indicate little, if any, value in this gas for the purpose named. This year opportunity was offered to test this gas in a much more satisfactory way. A patent generator having been devised by some local parties especially for germicide purposes, the owners were very anxious to have it tested, also to determine its value as a means of destroying insects. Under the writer's supervision, therefore, it was used in the first instance against insects affecting stored products. The gas was generated to three or four times the amount necessary for germicide purposes in the fumigating room of the Department which contained some grain badly infested with the Angoumois grain moth and some beans thickly stocked with the bean weevil. The gas killed some of the moths which were flying about thickly when the generator was put in operation, but the bean weevils were apparently not injured in the least by it and a good many of the moths were not killed. The generator was subsequently placed under a tented peach tree thickly infested with *Diaspis pentagona.* The generation of the gas in this instance was again in enormous quantity for the space inclosed, a quart of alcohol being converted. The effect on the tree was, however, most disastrous, the leaves showing almost complete withering as soon as the tent was removed and the tree dying shortly after. The scale insects were immediately killed by the application, and therefore not as a result of the death of the tree. The effect on the scale insects and the tree may have been, and was, very likely, due to the heat which the generation of the gas produces. This gas is generated by the imperfect combustion of wood alcohol in a burner or stove especially designed for the purpose. The insects in the fumigatorium and the scale insects on the tree were subjected to the influence of this gas between three and four hours.

A recent bulletin of the Hatch Experiment Station of the Massachusetts Agricultural College (No. 69) would seem to indicate that this gas has little or no value as a fungicide.

THE CARRIAGE OF DISEASE BY FLIES.

By L. O. Howard.

So much is said nowadays of the carriage of a certain class of diseases by mosquitoes that the agency of certain flies in the transmission of another class of diseases is apt, to a certain extent, to be overlooked. The malarial germ has to pass through the body of certain mosquitoes before attaining its highest development or its full life history. So far as we know as yet, certain mosquitoes are necessary secondary hosts in the development of this disease germ. The malarial germ is an animal organism. It belongs to the group of animals known as Protozoa, and from analogy it is altogether likely that the as yet undiscovered germ of yellow fever will also prove to belong to the same class of parasitic organisms. The parasite which causes Texas fever in cattle is also analogous to the minute spore which causes malaria in human beings. It inhabits the blood just as does the malarial parasite, and is conveyed by a biting insect; in this case the cattle tick, just as the former is conveyed by certain mosquitoes. With diseases caused by bacterial organisms (which belong to the plant kingdom and not to the animal kingdom), a biting insect is not necessary for their transfer from a sick individual to a healthy one in the majority of cases. Such diseases are notably typhoid fever, cholera, and pulmonary consumption. With these diseases, and more especially the first two, the agency of non-biting flies as transmitters becomes important, and for this country their agency in the transfer of typhoid fever is especially important. It has been known for some time that flies may carry bacilli and bacteria on their feet. That was experimentally proven by allowing flies to walk over cultures, and after allowing them to walk upon sterilized media the same bacteria developed. Moreover, as early as 1888 it was shown by an Italian investigator that flies fed upon pure cultures of typhoid bacillus were able to transmit virulent bacilli with their excrement. Further early observations showed that flies are important agents in the transmission of Asiatic cholera.

Typhoid fever was astonishingly prevalent in the concentration camps in this country at the outbreak of the war with Spain, and the disease received a thorough investigation at the hands of a special commission of army surgeons appointed for the purpose. It was shown that although excellent preventive measures had been recommended in circulars issued by the Surgeon-General of the Army, these instructions were not carried out in many camps and that the excrement of the troops had not been properly cared for. Flies were found to swarm over the infected fecal matter in the pits and then proceed to the mess tents and feed upon the food prepared for the soldiers. This was convincingly shown by the fact that where lime had been sprinkled over the pits flies with their legs whitened by the lime were found upon the mess tables. In the report published by one of the members of the commission a number of significant and interesting facts relating to typhoid fever were brought out. It was shown, for example, that the virulent germs may be excreted by a person for some time before he is known to have typhoid. It was also shown that such germs may be found in the excrement for a long time after apparently complete recovery of the patient. By the agency of flies which visit such excrement the bacilli may be carried far and wide to food supplies, and by their consumption may enter the digestive tract of many healthy individuals.

An investigation has been carried on in this office for the purpose of ascertaining just what flies breed in human excrement or are in the habit of visiting such substances, and, conversely, just what flies are found in dining rooms and kitchens where food is being served and prepared. These investigations have been conducted with the utmost care and in many different parts of the country. A very large amount of material was studied, and the detailed results were published in the proceedings of the Washington Academy of Sciences (Vol. II, pp. 451–604). Briefly summarized, it was found that the number of species of insects which breed in or frequent human excrement is very large. There are many beetles (44 species, and many hymenopterous parasites); none of these, however, are especially significant in this connection. Flies are the important creatures, and

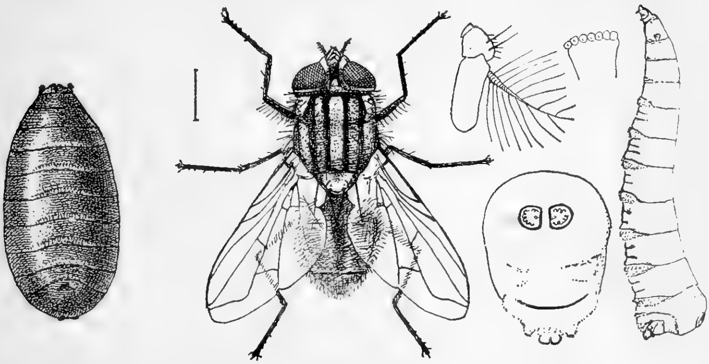


FIG. 20.—*Musca domestica:* Puparium at left; adult next, with enlarged antenna; larva and enlarged parts at right—enlarged (original).

of these 77 species were studied. Thirty-six of them were found to breed in human fæces, while 41 were simply captured while visiting this substance or feeding upon it. Some, of course, were scarce and others were very abundant.

Now, in order to ascertain exactly which ones of these are important in the disease-bearing function more than 2,300 flies were caught in kitchens and dining rooms in different parts of the country from Massachusetts to California and from New York to Louisiana, and were all carefully examined. It was proven that of the excrement flies six species are found in houses in sufficient numbers to constitute them dangerous species. The most abundant species found in or on excrement do not occur in kitchens and dining rooms, but, as just stated, these six species are sufficiently abundant in both relations to become very dangerous.

At the head of these six species must stand the common house fly, *Musca domestica* (fig. 20). This insect constituted over 98 per cent of the whole number of flies captured in kitchens and dining rooms, and while it was by no means one of the species most commonly captured upon excrement, it was shown conclusively that under certain conditions this insect may be a factor of the greatest importance in the spread of intestinal disease. In the most cleanly and best cared for portions of a large city these conditions do not exist. The admirable water supply and sewerage systems pertinent to such localities—the admirable water-closet facilities which sanitary plumbing has carried to such a degree of excellence—obviate in a large measure typhoid-transfer possibilities, yet, even in such places, where the vessels used in the sick room are not promptly disinfected and where by reason of neighboring stables house flies are especially abundant (since these creatures breed by preference in horse manure), the possibility may still exist, but in army camps where fæces are left exposed the house fly will and does breed in this substance in large numbers and in

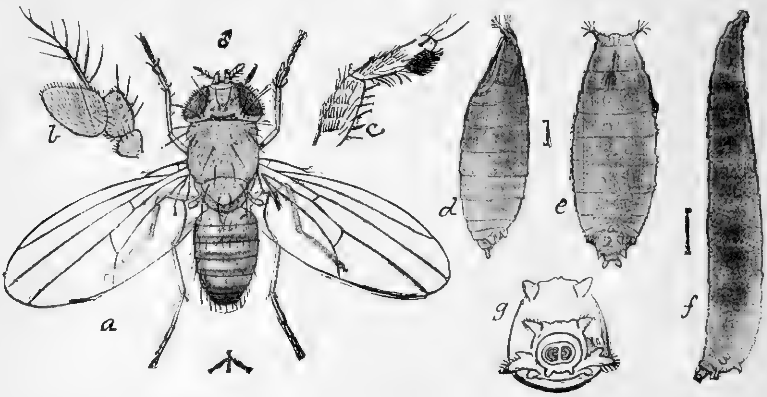


FIG. 21.—*Drosophila ampelophila:* *a*, adult; *b*, antenna of same; *c*, base of tibia and first tarsal joint of same; *d*, puparium, side view; *e*, puparium from above; *f*, full-grown larva; *g*, anal spiracles of same (author's illustration).

towns where the box-privy nuisance is still in existence (and this applies to very many farmers' houses in the country) the house fly is a constant source of danger. Moreover, in the low quarters of a large city where there is lax sanitary supervision, in the open lots surrounded by an ignorant population, fæces are frequently deposited in the open, sometimes in close proximity to kitchens, and thus may become very dangerous.

The other species of flies which are of especial importance are as follows: The little fruit flies of the genus Drosophila, and especially *Drosophila ampelophila* (fig. 21), which is so commonly found in houses in the autumn, attracted to overripe or partly decaying fruit, and which sometimes swarm in great numbers about the fruit stands in markets, is also an excrement breeder, and at certain times of the year becomes an important form in the disease-transfer relations. The species known as the little house fly (*Homalomyia canicularis* and *H.*

brevis (fig. 22), a small species sometimes with a light-colored abdomen, which is found commonly upon windows though not nearly so abundantly as the house fly, is also a dangerous species. The other most dangerous forms are the stable fly (*Stomoxys calcitrans*) (fig. 23)—a biting fly which looks so much like the house fly that it can hardly

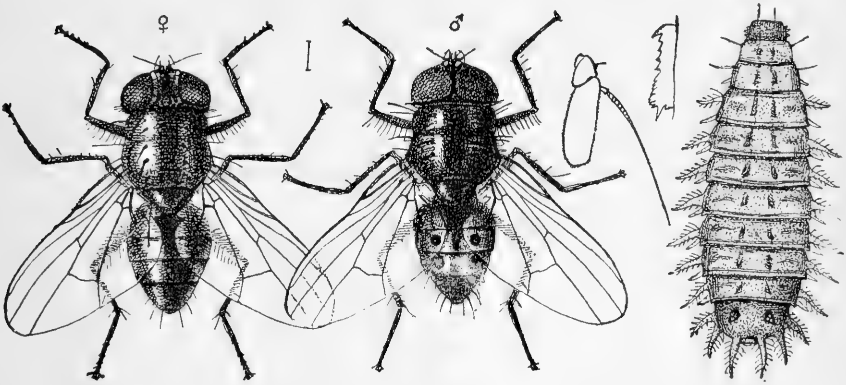


FIG. 22.—*Homalomyia brevis:* Female at left; male next, with enlarged antenna; larva at right—enlarged (original).

be distinguished from it, but which has a piercing proboscis and bites severely—and the forms known as *Phora femorata* and *Sarcophaga trivialis*.

In brief, the results of the observations indicate—

(1) That in the interests of health, and especially as obviating the

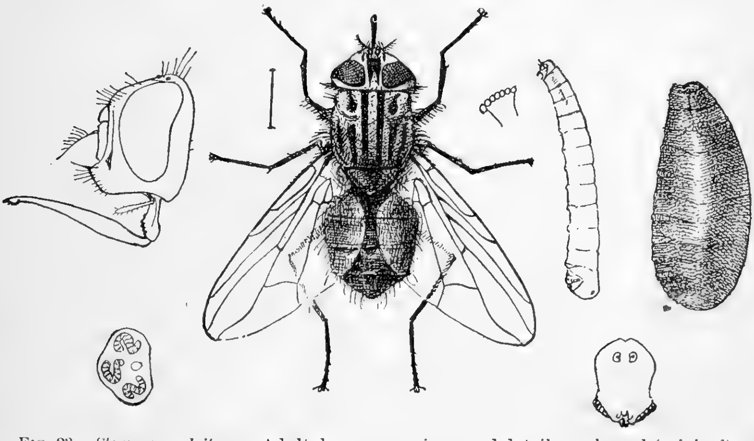


FIG. 23.—*Stomoxys calcitrans:* Adult, larva, puparium, and details—enlarged (original).

possibility of the transfer of typhoid fever by flies, the box-privy nuisance should be abolished wherever it exists, even with ordinary farmhouses, and some form of earth closet should be substituted, preferably one in which the contents can be removed and securely buried at very frequent intervals.

(2) Excrement should never be deposited in the open without being immediately covered with a thick layer of earth.

(3) In the low quarters of cities the especial attention of boards of health should be directed toward such open deposits, and such a deposition should be considered a punishable misdemeanor, and the regulation should be vigorously enforced. Of course, such offenses are generally committed after dark, and it is difficult to trace the offender, but the first responsible person who notices it should be required to report it to the police so that it may be removed or covered as soon as possible. Dead animals are so reported and cared for, but human excrement is much more dangerous than dead animals.

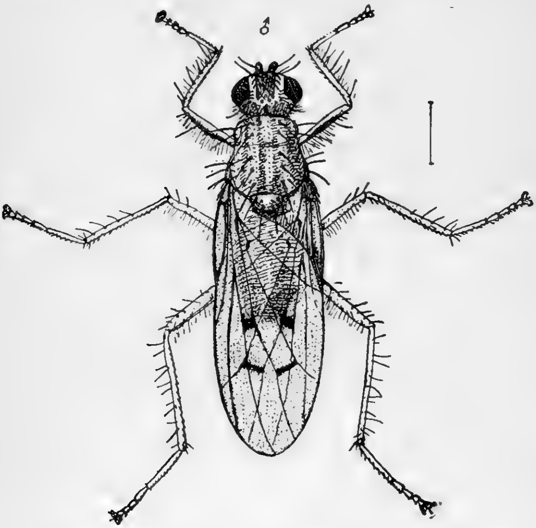


FIG. 24.—*Scatophaga furcata* (a common excrement fly): Male, with closed wings—enlarged (author's illustration).

(4) Every effort should be made by boards of health in cities and by private persons in the country to limit the breeding of the common house fly, and to accomplish this result a strict supervision of stables in which horses are kept should be carried on. As stated above, the great majority of house flies breed in horse manure. The breeding is rapid, and a small pile of horse manure may be responsible for an enormous number of flies. The writer has found by careful experimental work with many different insecticidal substances that chlorid of lime is the most efficient substance which can be applied to manure piles in order to destroy the maggots of house fly, but to treat an outdoor manure pile of large size with chlorid of lime would be an expensive matter. The writer has suggested, therefore, that some receptacle for the manure from each stable be

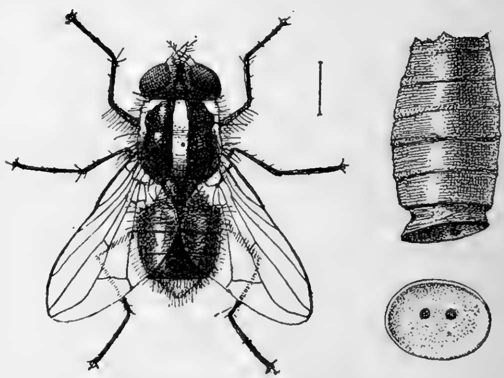


FIG. 25.—*Morellia micans* (a common excrement fly): Broken puparium at right—enlarged (original).

constructed, either in the form of a large closet with a door opening outside as well as one inside, or that a pit be made. The stable should be cleaned daily or every other day, and each time that a day's or two days' accumulation is added to the pile in the closet or pit a shovelful of the chlorid of lime should be thrown over it. When the manure is needed for the farm or garden it may just as conveniently be shoveled upon a wagon from the outside door of such a closet as described as from an outside pile. Thorough experiments were carried on some time since at the stable of the Department of Agriculture and it was found that by a little careful, inexpensive work of this kind the numbers of house flies of the whole neighborhood were rapidly and enormously lessened.

THE GREEN CLOVER WORM.

(*Plathypena scabra* Fab.)

By F. H. Chittenden.

One of the commonest insects about the District of Columbia is the Deltoid moth, *Plathypena scabra*, the larva of which, called the green clover worm, feeds on various leguminous plants, particularly clover. During the season of 1897, and again in 1899, this larva was frequently observed in connection with observations on insects attacking beans and peas in this vicinity.

RECENT OCCURRENCE.

Early in June, 1897, larvæ, mostly half grown, were observed on beans in the District of Columbia; also on soy beans August 18, and later nearly or quite mature on peas September 4. During autumn they were also observed on a species of tickweed (*Meibomia* sp.).

June 14, 1899, Mr. T. A. Keleher, of this office, brought specimens of the larvæ found on beans growing in the city of Washington. About the same time the writer observed this species of larva on vetch, a forage plant growing on experimental plats at this Department. Larvæ were still being found on vetch and bean until June 24. August 1 larvæ were found on Lima bean at Marshall Hall, Md., and August 10 on the same plant at Cabin John, Md., and during September larvæ were again obtained in great numbers on a species of Meibomia in the former locality.

Although it appears probable that this species feeds to all practical purposes exclusively upon the Leguminosæ, it is evidently capable of subsisting upon other plants, as was proved by the finding at different times by the writer of larvæ that agree with *Plathypena scabra* in every discernible particular on both strawberry and blackberry.

July 31 a moth of this species was reared from a larva obtained on strawberry in the District of Columbia. August 2 a second specimen was reared from a larva from the same strawberry patch. The pupal condition in this case was passed in eight days, and the chrysalis was concealed in a rolled-up leaf of strawberry. Taking into consideration a previous observation on the larva's occurrence on strawberry in 1899, it would seem that this is a true larval food plant.

The moth is typical of the Deltoid group of Noctuidæ, a group of genera which derives its English name from the triangular outline of the moths when at rest, which is suggestive of the Greek letter Delta (Δ).

DESCRIPTION OF THE SPECIES.

The moth, like many others of this group, is remarkable by reason of its palpi, which are long and prominent, projecting in front like a snout, hence the name snout-moth. The hind wings are unusually broad. The color is variable, dull, sometimes very dark brown, form-

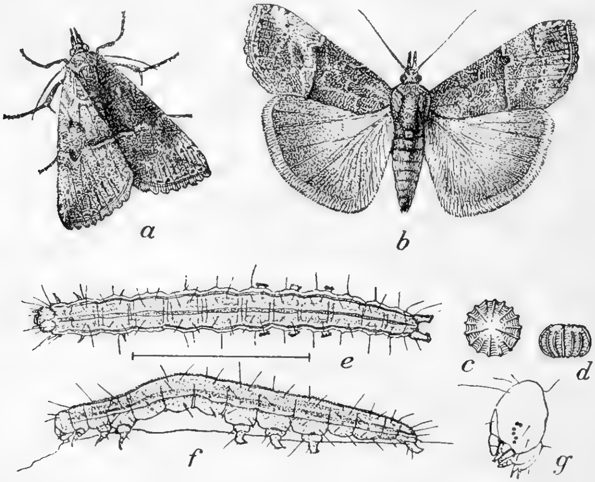


FIG. 26.—*Plathypena scabra*: *a*, moth in natural position with wings folded; *b*, same with wings expanded; *c*, egg from above; *d*, egg from side; *e*, penultimate stage of larva from above; *f*, same from side; *g*, head of larva—all enlarged; *c*, *d*, *g*, greatly enlarged (original).

ing the ground color varied with black and gray, arranged in the average specimen in a pattern similar to that figured in the illustration at *b*. A rather unusually light-colored individual was selected as the type for illustration in order to show the markings in full, since in dark specimens the pattern is often very obscure. A moth at rest is shown at *a*. The moth is also variable as regards size, the average expanse being about an inch and a quarter, although a series of specimens before the writer shows a still greater expanse, and one individual measures but five-eighths of an inch.

A technical diagnosis of the genus, detailed specific description, and bibliography is given by Dr. John B. Smith in his revision of the Deltoid moths (Bul. U. S. Nat. Museum, No. 48, 1895, pp. 110–112).

The distribution there accorded is "Nova Scotia to Texas, east of the Rocky Mountains." In the national collection is a series showing a distribution from Maine to Texas. The localities here represented and recorded include the following:

Maine; Williamstown, Mass. (Grote); Syracuse and New York, N. Y.; Boonton, N. J., "common everywhere" (Smith); Marshall Hall, Cabin John, Md.; Washington, D. C.; Virginia; St. Louis, Kirkwood, Mo.; Dayton, Ohio (Pilate); Hearne, Dallas, and elsewhere in Texas; Canton, Kirkwood, Miss.; Macon, Ga.; Alabama; Woodstock, Ill.; Volga, S. Dak., and St. Anthony Park, Minn. (Lugger). Also recorded from Winnipeg, Manitoba (Hanham).

About the city of Washington this moth is one of our latest as well as earliest species, individuals occurring commonly in the writer's experience about the Department buildings throughout the month of November, as late as the first week of December, and as early as March 10. An individual was observed flying on the last-mentioned date in a temperature of 51° F., which is about the lowest temperature in which any save exceptional species of insects are active.

This insect is a near relative of the hop-vine snout moth, *Hypena humuli* Harr., with which species it was, in fact, confused at an earlier date.

The green clover worm has not attracted much attention on account of its injuries, but good accounts of it have been given by Prof. J. H. Comstock in the Annual Report of this Department for 1879 (p. 252), and in the Canadian Entomologist for July, 1881 (Vol. XIII, pp. 137–138), the latter paper by Mr. Coquillett, of this Division.

THE EARLIER STAGES OF THE INSECT.

The egg.—Owing to an oversight, the eggs obtained hatched before a detailed description could be made. Dorsal and side views of the egg, however, were drawn, and are illustrated herewith (fig. 26, *c*, *d*), and from these a general idea of the egg as it looks under the microscope may be had. From memory the writer believes that the eggs were light gray in color and at least tinged with iridescence. Following are Mr. Coquillett's descriptions of the egg and of the first stage of the larva:

Globular, slightly flattened above, more decidedly so below; lower half smooth; upper half deeply grooved, the interspaces rounded and marked with fine transverse impressed lines; whitish, the upper half sometimes dotted with dark brown; transverse diameter, nearly 0.5 ^{mm}.

Measurements showed an average diameter of 0.5 ^{mm} and a height of 0.35 ^{mm}.

THE LARVA.

First stage.—"Body green; a dark-colored dorsal line, edged each side with a whitish line; a white subdorsal and stigmatal line; piliferous spots green, each bearing a short black hair; venter green; head polished green; body provided with only 14 legs."

In coloration this larva is somewhat suggestive of the common cabbage looper, *Plusia brassicæ*, but the form is entirely different, being much more slender, and although the species is a semi-looper, like Plusia, it is not at all likely to be mistaken for it. The colors are somewhat more constant in the several stages.

The penultimate stage.—The larva is green and white striped and is in its most characteristic colors when in the penultimate stage, as it loses its striation to a great extent when fully matured. The general color is clear, translucent green, a shade or two lighter than the bean or other leguminous leaves upon which it feeds. It is about ten times as long as wide and segmentation is well marked. The body is widest about the middle, tapering gradually toward each end, the last segments being narrowest. The head is of nearly the same color as the remainder of the body, a trifle lighter and less translucent. The entire surface of the body is sparsely covered with long, slender, and dark brown hairs. The piliferous warts project above the surface, but otherwise are not noticeable, being only a very little lighter in color than the body. The thoracic legs are nearly the same color as the head. There are only three abdominal prolegs. The anal prolegs are long and project well beyond the last segment. There are six white stripes on the body which alternate with the general green. The green dorsal line is a little darker than the general color of the body. There is a rather wide white stripe each side, a latero-dorsal narrow white stripe, and a broader irregular lateral stripe. The prothoracic folds are strongly pronounced, particularly in the region of the legs; abdominal folds also pronounced. Length in this stage, $20–24^{mm}$; width, $2.4–2.6^{mm}$.

Last larval stage.—After the final molt the larva usually loses to a great extent its striated appearance and becomes nearly uniform paler green in color as well as stouter. The head is sometimes somewhat yellowish, as is also the first thoracic segment. The ocelli are twelve in number, arranged at the sides of the head in three pairs, as shown in the figure at *g*.

In alcohol the larva loses its color, being apt to be turned black unless first boiled in water, when the color becomes milk white. Length at maturity, $25–29^{mm}$; width, $2.8–3.0^{mm}$.

The penultimate stage is figured because, as previously remarked, more characteristic of the species than the final stage before pupation.

THE PUPA AND COCOON.

The pupa.—The pupa is dark brown and presents rather good characters for description, but as this stage has previously been very fully characterized by Professor Comstock, in the report of this Department for 1879, his description is transcribed:

Rather stout, dark mahogany-brown. Wing sheaths and crural sheaths closely soldered; the former obtusely rounded and extending to the end of the fifth abdominal segment. Stigmatal tubercles quite prominent. Dorsum of thorax and wing sheaths coarsely shagreened. Dorsum of abdominal segments rather sparsely punctulate, the posterior border of each segment being smooth and shining. The anal segment at its end is furnished with several (a variable number) minute recurved hook-like spines. From the apex of the head to the end of the fourth abdominal segment the dorsum is elevated into a slight ridge, more marked upon the abdominal segments than upon the thorax.

The cocoon.—Pupation takes place in a somewhat loosely built but not fragile cocoon, those in our rearing jars having been formed just upon the surface of the earth. They were constructed of particles of sand joined together with silken web and sometimes attached to leaves or other vegetation. They are of elliptical form and somewhat depressed, and measure on the outside about 16–18^{mm} in length and 6–8^{mm} in width.

ON THE HABITS OF THE SPECIES.

In the report of this Department for 1879 (*loc. cit.*) attention was called to the abundance of the moth in the District of Columbia during the winter of 1878–79, when it was seen flying on warm, sunshiny days, while in the summer months larvæ were found so commonly upon clover "that in many places one could hardly make a swing of the beating net through the grass without capturing one or more of them."

The larvæ are quite active, and when disturbed either let themselves down to the ground by means of their webs or quickly throw themselves from their food plant after the manner of many Pyralids. The moth is a rapid flyer, and although normally keeping in concealment, is often found exposed on the walls of buildings and on windows in conspicuous places.

In Bulletin No. 3 of the United States Entomological Commission the late Professor Riley had a short note on this species, in which he stated that the larva fed also on locust (Robinia), and gives some notes on the hibernation of the species. He says that this insect hibernates in the imago state all over the country and that in Missouri the chrysalis may also be found under bark in winter, but the habit of hibernating in the pupa state is doubtless exceptional. The late and early appearance of the moth would alone indicate that hibernation takes place in the mature condition.

Mr. Coquillett traced the insect through its various stages at Woodstock, Ill. The periods were as follows: From the deposition of the eggs to hatching, four to six days; larval stage, twenty-five days, and from the spinning of the cocoon to the issuance of the imago, twelve to fourteen days. Only two larval molts were observed, the time from hatching to the first molt being seventeen days, from the first to the second molt, three days, and from the second molt to the time of spinning the cocoon, five days. Several individuals which were kept under observation at this office transformed from larva to pupa June 23, and the moths issued July 4, having passed eleven days as pupæ.

Of the number of generations of this insect Mr. Coquillett observed that there appeared to be only two broods in a season in the latitude of Woodstock, Ill., and Professor Comstock says there are certainly two and perhaps three broods in a season. The writer's observations tend to show at least three well-marked generations for the latitude of the District of Columbia, the first generation usually developing toward the middle of June, the second early in August, and the third sometime late in September or early in October. There is no indication, however, of any great regularity in the issuance of the moths, since they have been reared at this office at various other times than on the dates mentioned. The exact dates of issuance as recorded in our notes are: June 12, 15, 23, 28, 30; July 4, 8, 16; August 1; September 2, 5, 6, 25, 27. Moths, however, as has previously been observed, have been found much earlier than in June and as late as the first week of December, at the latter time on several occasions, once when the thermometer registered 54° F.

NATURAL ENEMIES.

A single parasite was reared from the pupa of this moth September 7, 1899, and on being referred to Mr. Coquillett was identified as the the Tachinid fly, *Exorista blanda* O.–S. This is the second natural enemy that has been observed for the green clover worm to the writer's knowledge, the other being a chalcis fly, *Euplectrus platyhypenæ* How. The latter was reared at this office July 11, 1882, from material from the District of Columbia. (Bul. 5, o. s., Div. Ent., p. 27.)

REMEDIAL TREATMENT.

Ordinarily the injuries effected by this clover worm are so inconsiderable as not to necessitate any special line of treatment. It is one of several common insects that live habitually on clover and which by their combined effort devour a certain proportion of the clover crop over considerable territory. Poisons are, of course, out of the question in pasture land and in clover fields, and on lawns there can be little doubt that frequent mowing with a lawn mower is all that is necessary, since the insects live freely exposed upon their food plants during the day and do not resort to the plans of concealment resorted to by cutworms.

REPORT UPON AN INVESTIGATION OF THE CODLING MOTH IN IDAHO IN 1900.

By C. B. Simpson, *Special Agent.*

The following report upon an investigation of the codling moth in the State of Idaho is made in accordance with the authorization of the Secretary of Agriculture and instructions of the Chief of the Division of Entomology:

Upon reaching Boise I commenced a rigid inspection of orchards in that vicinity and observed the methods used against the codling moth and the results of the same. Numerous cages were started for the study of the life history of the insect. Many articles upon the insect were published in the leading papers. These articles were copied by many of the other papers. I also had a long conference with Professor Aldrich, of the University of Idaho, in regard to the codling moth.

EXTENT OF INJURY.

Indications of damage caused by the codling moth were seen in every section of the State which I visited where apples are grown. By report the moth is present all over the State, except in a few limited localities in the mountains. From my observation I can say without hesitation that 50 per cent of the apple crop of Idaho was destroyed by the codling moth in 1900. According to Mr. McPherson the loss in South Idaho and about Lewiston for the districts was 75 per cent.

In untreated orchards I found a great difference in the percentage of apples infested. The injury ranged from 40 per cent to practically 100 per cent. In the small orchards and isolated trees in and about Boise I have been unable to find sound apples. In the larger untreated orchards which were more or less isolated I found in some cases the injury to be about 40 per cent. In orchards well cared for I estimated the injuries to vary from 50 to 0.05 per cent. In an orchard near Boise that was sprayed and banded 44 per cent of the crop was lost. In an orchard in the city of Boise that was sprayed with arsenites and banded the loss was only about 20 per cent. In more or less isolated orchards that were well cared for the loss was found to be 10 per cent or less. In another orchard near Boise which had been sprayed three times and not banded the injury was from 90 to 98 per cent. In an orchard that was only banded the injury was about 60 per cent.

About Lewiston the damage is somewhat less than in the southern part. Professor Aldrich tells me that in 1899 the damage about Moscow was 21 per cent, while in 1900 it was only about 10 per cent.

I have been informed that in small valleys in the mountains the codling moth does no damage. The apple is the fruit most infested. The injury to pears never exceeds 0.05 to 10 per cent.

INTRODUCTION AND SPREAD.

Previous to 1887 the codling moth was practically unknown in Idaho. It was probably present before that time, but did so little damage as not to be noticed.

The moth, without doubt, came into the northern part by way of the Snake River valley. Its spread was rapid, although checked to some extent by the long distance between orchards.

The sections which are shipping apples are now all infested. The newer orchards are more or less free, but can not remain so very long.

RESISTANCE OF VARIETIES OF APPLES.

Only scattered observations were made upon this point, and these do not harmonize. Some of the varieties in order of damage sustained are:

1. Pewaukee (always badly infested).
2. Spitzenberg.
3. Bell-flower.
4. King.
5. Gravenstein.
6. Wealthy (very variable).
7. Ben Davis (very variable).
8. Rome Beauty (very variable).
9. Winesap (but little infested).

This question is believed to be one of the most important to be worked out, as in general the apples given as least infested are the best varieties for Idaho.

LIFE HISTORY OF THE CODLING MOTH.

The life history, as usually given, applies to the insect in a climate far different from that of Idaho. On this account I spent much time in studying the variations in the life history.

THE EGG.

The eggs can be found at any time during the summer, either upon the fruit or upon the upper surface of the leaves. In certain orchards the eggs were almost entirely upon the fruits; in orchards near by they were nearly all upon the leaves. Where apples were in abundance there were but few eggs upon the leaves, and where apples were scarce but few eggs were upon them. Apparently the moth prefers to lay its eggs upon the fruits.

The eggs have been described as whitish, milk-like spots. They adhere closely to the fruit or leaf, and even after hatching the shells remain for a long time. When the egg is a few days old a brown horseshoe-shaped band appears indicating the embryonic larva.

THE LARVA.

In from about six to eight days the larva is fully formed and breaks its way out of the shell. Most of them come out through the top covers, but a few were observed in which the larvæ had evidently emerged through the lower surface of the egg next to the apple or leaf.

The young caterpillar is about one-fifteenth of an inch in length and is of a semitransparent color. Later dark spots appear around the hairs.

The young larva, after piercing the apple, makes a shallow mine just under the skin. Those mines can be easily recognized by the lighter color and by the excrement which is cast out. The larvæ which enter by the calyx also take their first few meals at the surface inside the calyx.

By counting infested apples on unsprayed trees I found that about 60 per cent of the larvæ of the first brood enter at the calyx end. In the later broods but few enter the calyx end. Many enter the apple at the stem end. The greater proportion, probably from 60 to 90 per cent, enter at any part of the apple. A favorite place of entrance is at the point where two apples touch.

At the end of four or five days the larva commences to tunnel toward the central portion of the fruit. Arriving at the center, it commences irregular excavations, which are filled with excrement, the pellets of which are bound together by silken threads. Surrounded by abundance of food, the insect grows rapidly, casting its skin many times. I have found many burrows, sometimes as large in diameter as a full-grown larva, in which no larva could be found; therefore, I believe that sometimes a larva feeds upon more than one fruit. In all cases where fruits touch they are both injured.

While one larva usually feeds upon but one apple, one apple may be eaten by many larvæ. A large apple was found with thirteen worm-holes in it, both entrance and exit, and three larvæ, of various sizes, were feeding inside. It is a very common occurrence to find from four to seven holes in an apple. These different holes are usually made by insects of different broods. In a badly infested orchard the earlier apples rarely had but one insect in each, A larval stage of from ten to fourteen days, as given by Professor Card, is, I think, nearly correct for Idaho.

On summer apples and most fall apples the effect of the insect is to cause the fruit to ripen prematurely. In the winter varieties, such as Winesap, there is no such ripening. In all cases the fruit is rendered unfit for use. When full grown the larva eats its way to the surface of the apple. The burrow is kept closed by frass, or sometimes an adjacent leaf is fastened over the hole with silk. Having eaten as much as it desires, the larva pushes out the plug or removes the leaf and leaves the fruit. In warm weather the worms, for the greater part, leave the apples in the early evening or night; but in colder weather, in the fall, they emerge during the heat of the day. If the fruit has fallen, the larva crawls along the ground to a suitable place to spin its cocoon. The worms have two modes of leaving the fruit left on the tree. In some cases they drop by a silken thread to the ground. I have observed a larva hanging by this thread, and many threads were noted hanging from the trees. The other, and by far the most common method, is for the larvæ to crawl from the apple to a branch and thence to the tree trunk.

Upon leaving the apple the worm immediately seeks a place to spin the cocoon. The place usually selected is under rough, loose bark, in cracks or holes of the tree trunk and larger branches, under bands or cloths on the trees—in fact, in almost any dark and tight crack or crevice. Many cocoons are placed in cracks in the ground about the trees. This is especially true when the tree trunk is smooth and offers no suitable place. Mr. McPherson says he has found many cocoons among the clods of earth in his orchard. Where apples are stored the worms spin the cocoons in the boxes. I have found as many as 30 cocoons in and on one box. Having found a satisfactory place, the larva spins a tough silken case. In the earlier broods the larvæ spin their cocoons quite thin and do not usually use other substances than silk in its construction. The last brood, however, build their cocoons thicker, and in nearly all cases hollow out a space for it and mix little pieces of wood, bark, or cloth with the silk. The larva is bent in a U shape in the cocoon. If the cocoon be destroyed the larva will set to work immediately to build another or to repair the old one if it be not completely destroyed.

THE PUPA.

In from three to five days in the summer the larva sheds its skin and becomes a pupa. In the last brood the larval stage lasts until the spring. The pupa is at first of a yellowish color, later becoming brown and then bronze in color. When the moth is ready to emerge, the pupa, aided by the spines on the abdominal segments, wriggles itself out of the cocoon. I have seen empty cases that had been thrust through heavy muslin which was used as a band.

These empty pupal skins are familiar objects upon infested trees. I once counted 50 of them protruding from under pieces of bark in a space of about a square foot. During the warmer season the time spent in the cocoon is from seven to eleven days. Many stay in a longer, but very few a shorter time. The last brood stay in the cocoon about eight months.

THE MOTH.

The moth is a beautiful insect whose front wings have the color of brown watered silk, and are crossed by lines of brown and gray scales. Near the tip of the wing is a large bronze-colored spot. The hind wings, which are concealed during repose, are of a grayish color. The moth varies in size, but never expands over an inch. The sexes may be distinguished readily by the fact that the male has a streak of black hairs upon the upper surface of each hind wing, and upon the under surface of each front wing there is a long blackish spot. The relative number of moths of each sex is about equal.

The adult insect is rarely seen. In my summer's experience I saw but five. These were either resting upon the upper surface of the leaves or were upon the trunk or larger branches. In warm evenings by aid of a light I saw a few flying about the trees.

It has long been known that the moth is not attracted to lights. I examined the contents of an electric (arc) light globe that was near an orchard without finding a single codling moth.

It has been observed that the moths feed upon apple juice, and I saw two moths feeding upon the juice of a crushed apple. Mr. Hitt tells me that it is common to find moths about cider mills. I have found that if a piece of ripe apple was placed in a cage of moths they would lay eggs in abundance, and if the apple was wanting no eggs or but few would be laid.

After laying eggs, the moths in cages die in about a week.

BROODS OF THE INSECT.

In view of the fact of the differences of altitude and temperature in Idaho there must exist a corresponding difference in the number of broods.

Upon arriving at Boise I immediately commenced work upon this question. I found the overlapping of broods to be something remarkable. From July 7 to about September 1, I could find in the field all stages of the insect except the adult, which I could breed in cages. From my band records I find that while I kept records there were larvæ going under bands every day.

From the records of Mr. Ayers, of Boise (as given later), we find that in 1897 there were larvæ under the bands every week from June 25 to October 19. To sum up, we have every day throughout the season moths emerging and laying eggs, eggs hatching, larvæ coming out of apples and spinning cocoons, and larvæ changing to pupæ.

This fact, together with the number of broods, certainly explains why the codling moth is more injurious in the West than in the East. The overlapping can be accounted for by the difference in rate of development of different individual insects.

Professor Aldrich says that in the section from Boise to Weiser and about Lewiston there are at least three broods, and part of a fourth was observed at Boise this year (1899). Mr. McPherson, Mr. Hitt, and others have arrived at the same conclusion. Without doubt the number of broods in Fremont and Bingham counties is less.

The following are the band records taken by Mr. Ayers, of Boise, on 140 trees:

Date.	Larvæ.	Date.	Larvæ.
1897.		1898.	
July 2	862	July 5	1,118
July 9	704	July 13	2,201
July 16	1,268	July 20	2,020
July 23	740	July 27	1,454
August 2	606	August 3	1,335
August 9	290	August 10	963
August 18	580	August 17	1,095
August 25	684	August 24	1,125
September 2	1,526	August 31	1,580
September 10	1,227	September 7	1,474
September 21	1,340	September 14	1,860
October 4	1,642	September 22	1,965
October 19	778	October 1	1,594
		October 10	1,125

From the preceding record, from that of Professor Aldrich taken at Juliaetta for 1899, and my own I have compiled the following table:

	1897.	1898.	1899.	1900.
First brood:				
Maximum	July 16	July 13	July 21	July 15
Minimum	Aug. 9	Aug. 10	Aug. 12	Aug. 4
Second brood:				
Maximum	Sept. 2	Aug. 31	Aug. 18	Aug. 25
Minimum	Sept. 10	Sept. 7	Sept. 4	Sept. 1
Third brood:				
Maximum	Oct. 4	Sept. 22	Sept. 25	Sept. 25
Minimum				

From these records, supplemented by observation, I can say definitely that there are three broods in the vicinity of Boise and the greater part of the Snake River Valley.

As to the fourth brood I have no definite information at hand. Several growers have told me that such a brood exists in part. At certain periods it is impossible to say to what brood an insect belongs. For instance, in 1900, if a half-grown larva was found October 4 it would be impossible to know whether it was the last of the third or the first of the fourth. When cold weather comes, there are many interesting things apparent. If young larvæ are left in the fruit on the ground, they evidently perish. However, if taken inside with the apples they complete their development, and if not destroyed insure a crop of moths for the following spring. About September 5 it was noticed that the larvæ that had spun cocoons were not transforming, but were still in the larval state, while those that had reached the pupa state were developing slowly and the moths were emerging. It is evident that it takes a higher temperature for the insect to change from larva to pupa than from pupa to adult.

MOISTURE AND HEAT.

There is great mortality among the eggs of this insect, the direct rays of the hot sun causing many to die.

In the larval state, especially when young, there are many agencies of destruction. I have found tips of branches upon which there was but one apple. On the leaves near by there were half a dozen or so hatched eggs, while the apple contained but one larva. In one case the larva would have to crawl 20 feet before finding another.

In many cases I have found from 2 to 5 per cent of the larvæ dead before they had commenced their burrow to the center of the apple from the mine under the skin. There are very few deaths due to fungus and bacteria in the dry regions. In many orchards, in which the water used for irrigation is allowed to stand around the trees, the number of infested apples is markedly less than in those orchards where irrigation is by ditches. Also one does not, as a general rule, find as many worms under bands on trees which have moist soil around them. The only explanation is that the moisture either causes the insects to die by fungus or bacteria or to seek other places. This method, however, has grave disadvantages, since water allowed to stand in an orchard will sooner or later kill the trees.

NATURAL ENEMIES.

I did not succeed in finding any egg parasites, but within a pupa I found a pupa of a Hymenopter, but the parasite did not emerge. It was probably a Pimpla. In another pupa I found many pupæ of a Hymenopterous parasite, which died before becoming adults. Under some neglected bands were many silk cocoons, probably of a Microgaster. Although they are not bred directly from the codling moth, there is little doubt but that they were from this insect.

While the larvæ are seeking a place to spin their cocoons in the daytime they are preyed upon by ants and birds. Chickens allowed in an orchard eat them readily. Often I have observed holes in the bark, and upon examination found empty cocoons. One evening several bats were noticed flying around apple trees and probably feeding upon the moths.

PREVENTIVE MEASURES.

One of the best preventive measures is following the best general horticultural practices, such as keeping the soil and trees in healthy and vigorous condition and keeping a close watch upon the orchard. If a fruit grower has no codling moths, what should he do to keep them out of his orchard? The answer to this question has many conditions, according to location, etc. To begin with, every grower should be familiar with this insect in all its stages and know how to fight it. An orchard may be at such an altitude that the insect will not be a very serious pest. In this case the small amount of damage should not be an excuse for letting it alone. It would be well for the grower to be careful in importing infested fruit and to exercise utmost vigilance in watching his orchard, and if the moth is found, even in small numbers, no expense should be spared to apply the proper remedies immediately.

One source of trouble that can be easily prevented is that when apples are stored the larvæ emerge from the fruit, spin their cocoons, and upon emerging as moths in the spring find easy access to the orchard. I studied two well-marked cases of this. At Mr. C. M. Kiggins's place apples were stored in boxes in a cellar in which there were open ventilators. I found many old cocoons in and about these boxes. When I examined the orchard, July 9, I found that in trees nearest the cellar practically all of the apples were infested. In going from the cellar a noticeable decrease was observed, and in the farthest part of the orchard the injury varied from 5 to 30 per cent.

In the well-kept orchard of Hon. Edgar Wilson a similar case was noted.

These examples show the futility of remedial measures when the moth has such a start. Both Mr. Wilson and Mr. Kiggins are fully aware of the above conditions, and will take care that the mistake is not repeated. Either of three courses may be followed: To fumigate with hydrocyanic-acid gas while the larvæ are in the cocoon, to put screens over the holes and crush the moths which will collect there, or not to store apples on the premises.

In some cases picking the apples early to escape a coming brood is practiced. If the stages of the insect are known, this method may be followed to much advantage.

REMEDIAL MEASURES.

In fighting this insect, the first question which presents itself is, In what stage can the insect be best attacked, and how?

As a result of the work that has been done on this subject, it is evident that any mixture strong enough to kill the egg will injure the tree. Further work may throw more light upon this subject.

At two periods in this stage the insect is vulnerable, and a larger portion of the remedies have been used at these periods.

After the young larvæ hatch, and before they have started for the center of the apple, has long been recognized as the most vulnerable point in the life of the insect. At this point spraying is a most effective remedial measure.

I found that in Idaho the fruit growers were using many kinds of spraying solutions, with varying results.

A patent mixture, composed largely of carbolic acid and coal tar, was used by some. This solution is supposed to have a smell about it that keeps the moth away from the tree. The best I have seen this solution do, with several excellent sprayings, in conjunction with bands, was to save 66 per cent. I believe that what good effects are derived from its use are due to the killing of the larvæ with which it comes in contact.

Many of the fruit growers add an arsenite, usually paris green, to the carbolic compound. The results with this mixture are varying.

Others have used kerosene in the arsenite, thereby combining both poisonous and contact insecticide. One grower used this combination, and writes me that "There are no wormy apples to be seen" (in his orchard), and that the apples injured by all sources amounted to only about 0.05 per cent.

One difficulty is to get these different ingredients to mix well. Whale-oil soap is used in combination with other sprays, but I could find no facts in regard to the results of its use.

By far the greater number of growers use the arsenites alone. Of these arsenites paris green is most used, in the proportion of 1 pound to 150 gallons of water, with from 1 to 2 pounds of freshly slacked lime.

Some are using London purple, and others are using a combination of London purple and Paris green. Many are using the lime arsenite with excellent results. In fact, wherever any of these arsenites are used intelligently good results are obtained. Some growers are prejudiced against certain of these arsenites on account of past experiences. In two cases I found that they had omitted the lime, and in both cases the foliage was badly burned.

My observations have led me to believe that it makes but little difference as to what arsenite is used if it is well applied.

The pumps used were of all kinds and conditions. Many were using nozzles which threw a coarse spray that was valueless. The time for spraying is as essential as the spraying itself, and I wish that this fact could be impressed strongly upon the Idaho growers. One can readily see that a spray would do but little good when the maximum of a brood are going under bands, compared with a spray when the maximum of a brood is hatching from the egg. To secure good results, there must be at least three sprayings, and in extremely bad cases it is advisable to spray six times.

If the injury for the previous season was large, I would advise two sprayings while the calyx remained open—one immediately after the blossoms have fallen and the other in about a week. If, however, the injury of the previous season was not large, one spraying from five days to a week after the blossoms have fallen may answer. In all cases I would advise the two sprayings, as it is well to be on the safe side.

It has become one of the best known principles of spraying that these first sprayings are the most efficient, and if it were not for the number of broods in Idaho these, I believe, would be sufficient. In short, the poison is put in the calyx cup, the calyx closes, and when the young larva enters the calyx for its first few meals it gets some of the poison. As about 60 per cent enter the apple at this point, it is very plain that this is the golden opportunity in this combat. Professor Aldrich finds that 41 per cent of the larvæ entering the calyx end are destroyed by this spraying. An insect killed at this time not only saves the apple, but reduces the number of the insects of the following broods. By a single spraying and by banding one prominent grower tells me that he can save 50 per cent of his apples. Many people spray only once a season, and consequently the effect of it is lost later in the season. If rains wash off these sprays, they should be repeated immediately.

The next spraying should be done when the second brood is entering the fruit. Find the maximum of the preceding brood going under the bands and spray about two weeks later. It would probably be better to spray a few days earlier than two weeks. A few growers watch the increase of spots on the apples. The later sprayings should be determined in the same way. Other sprayings can be done with profit on account of the overlapping of the broods, but they should be made as near the maximum of egg-hatching as possible. In fact, late in the season, when the maximum is poorly defined, a spray is more or less effective at any time. Last year (1900) the dates, according to band records, for most effective spraying were June 10–15, July 27, and September 5. No inflexible rule can be given for these dates, as each grower has different conditions to meet and seasons vary. Each grower must determine these dates for himself. The greater number of the growers simply space off the season and spray at empirical times, without regard to the stage of the insect, and obtain, as a consequence, poor results.

It has been clearly demonstrated that these few sprayings alone are not always sufficient to control the insect. If the sprayings were made every week, the insect could be controlled, but this is too expensive. The spray is effective only for a short time, and must be supplemented by something to take the insects which enter the fruit between the sprayings. Banding has been found to be the most efficient in this connection.

Many people object to the use of arsenites for later sprayings on account of the liability of poisoning those who eat the fruit. I believe this objection is not well taken, since one would have to eat an enormous quantity of apples to be affected. If a large amount of poison remained in the hollow around the stem of an apple, there might be some danger. I have eaten many apples upon which the spray still remained and experienced no evil effects.

During the growing period of the larvæ the infested apple may be picked from the trees and either destroyed or fed to stock. However, this method is so expensive in a large orchard that it is out of the question. If the people in the towns who have apple trees more for shade rather than for the fruit would destroy their apples, they would aid materially in reducing the number of the pest, and would also eradicate a constant source of infection.

In the "windfalls" there is another chance to attack this insect. In many orchards the fallen apples literally cover the ground. Careful experiments have shown that about 50 per cent of these fallen apples contain larvæ. Many methods may be used in the destruction of the windfalls. The best and easiest applied is to allow hogs or sheep to run in an orchard. These animals soon become very efficient and keep the ground well cleared. In doing this, the grower not only gets rid of the apples, but gets his stock fed upon food that would otherwise be wasted. Many growers collect the windfalls at stated intervals and make cider from them. At best, destruction of the windfalls is only partially effective, but is a useful ally to other methods.

When the larvæ are full grown, and after leaving the apples are seeking places to spin their cocoons, another point of attack is opened.

Banding is simply providing a suitable place for the insect larva to spin its cocoon. Temporary bands of hay or paper, which are afterwards burned with the larvæ, may be used. Many kinds of permanent bands, which are not destroyed, have been devised, but a piece of cloth from 4 to 8 inches wide, folded lengthwise once, and placed around the trees is the most efficient and economical. These bands can be made of any thick dark-colored cloth, such as pieces of old clothing or burlap. Professor Aldrich recommends brown canton flannel. I have seen many bands that were but strips of white muslin, which did not offer an attractive place for the insect, and thus the purpose for which they were put on was defeated.

It is highly essential that before a band is put on a tree all places where the larvæ could spin up be removed. The rough bark should be removed from the tree, and all holes should be filled with either mud or mortar. I have obtained twenty larvæ from a hole in a tree. If a large cavity is present in the tree trunk, bands should be placed above and below.

The bands should be placed around the trunk of the tree from about 1½ feet above the ground. If the tree is large it is best to put a band on each of the branches. Two bands on a tree trunk are better than one, but if the tree is well scraped and the holes filled I think one wide band is sufficient. A convenient and time-saving device for fastening the bands on, is to drive a small nail into the trunk and cut off the head diagonally so as to leave a sharp point. This nail is allowed to remain in the tree and the ends of the band are pushed over it.

Apparently banding is more efficient in Idaho than in any other

State where experiments have been made. The number of larvæ caught is sometimes very large. Professor Aldrich records that the highest number he found on one tree in a week was 110. Various persons have found from 50 to 190 on neglected trees. I once found 170 under a neglected band and a cloth in the crotch of a large tree. In 1898 Mr. Ayres obtained from 6 to 15 worms per tree throughout the season. In the maximum in September I have obtained on large trees as many as 20 to 30 daily for a few days, in a neglected orchard. Professor Aldrich records that in his banding experiments he obtained 215 worms per tree for the season of 1899.

The worms which have been collected under bands should be killed every seven days. Six days is recommended by some. I think six days too short as but few moths emerge before seven or eight days. However, the person who is killing the larvæ can easily tell whether the time is too long or too short. If old pupal skins are found the time is too long, and if no larvæ have changed to pupæ the time is too short.

Many ways of killing the larvæ have been used, such as burning temporary bands, plunging the permanent bands in hot water, or running them through a clothes wringer. I find that the majority of fruit growers in Idaho simply crush the worms, or cut them with a knife. Hon. Edgar Wilson suggested to me that, as the larvæ used parts of the band and bark with which to build its cocoon poisoning the band might be an easy way of getting rid of many. I tried soaking the cloth bands in strong solution of paris green, but the results do not warrant any definite statement. I believe that this may kill some of the last spinning up, but doubt its efficiency of the earliest broods. However, it is worthy of further investigation. In want of better knowledge many people apply bands and do not kill the worms that have collected. In this way the insect is positively aided. Professor Gillette records a fact that must be noted. He finds that in the spring the larvæ leave their old cocoons and migrate to other places and spin new ones. This, however, is not always the case, but it should be guarded against. Bands should be applied about two weeks after the blossoms have fallen and be kept on for a week or so after all the fruit has been picked in the orchard.

Banding should always be practiced in connection with spraying, and by this combination the best results are obtained.

By spraying with Paris green and London purple and by banding, Mr. Tiner, of Boise, saved about 80 per cent of his apples. This orchard is in the city of Boise and has neglected orchards all around it.

Hon. Edgar Wilson used arsenites and banding. In the part of the orchard not infested by the moths from the apple house the loss is estimated from 5 to 10 per cent. In Mr. Fremont Wood's orchard the results were about the same.

Dr. Ustick, of Boise, used lime arsenite and banding. I estimated his loss to be about 10 per cent. I visited these last three orchards September 24, and searching diligently under the bands for larvæ, found but 3 under 30 or 40 bands. Mr. C. Hinze, of Payette, used Paris green with either kerosene or coal tar. He writes me that his total loss from all causes amounted to only 0.05 per cent.

For contrast it might be mentioned that in Mr. Tiner's orchard I found only 8 larvæ under bands at 18 trees, while in a neglected orchard on the same date (September 21) I found 94 larvæ on 10 trees.

In all these cases cited the orchards were sprayed from four to six times.

The pupæ may be killed with the larvæ under the bands by crushing. They are so well protected that this is the only practicable way to reach them.

I have previously stated how the adults in a storehouse may be killed. A few fruit growers have told me that they caught numerous adult codling moths by trap lanterns. All accurate work upon this point has shown that the moth is not attracted to light, the noctuids and sphingids caught being mistaken for codling moths.

One grower says he catches many of the moths in buckets in which there is some cider or vinegar. This fruit grower is a man well informed upon the subject and I tried to experiment with his remedy, but was stopped by cold weather and sickness.

SUMMARY AND CONCLUSIONS.

1. The codling moth is more injurious in Idaho than in the East, on account of the number and the overlapping of broods.
2. There are three broods and probably a part of a fourth, which overlap.
3. The moth can not be controlled by natural means.
4. It has been allowed to get a firm foothold in the State.
5. By several sprayings with arsenites and by banding the injury may be reduced to from 5 to 20 per cent, depending upon locality.
6. I firmly believe that if the recommendations given here be followed by all fruit growers in a locality for one or two years that the moth would cease to be a serious pest in that locality.

I recommend that this work be carried on in Idaho and possibly Oregon and Washington another year, as I believe this last summer's work has simply outlined the problem and discovered the points to be worked upon.

INSECTS AND THE WEATHER DURING THE SEASON OF 1900.

By F. H. Chittenden.

Investigations begun during the season of 1899 upon the effects of atmospheric and other conditions, in causing an increase or decrease of injurious insects during that year, were continued during the season of 1900 with some interesting results.

The studies of this subject that have been made have not been as complete as could be desired, but as a result of observations conducted during the two seasons the writer feels justified in drawing some general conclusions. Some of these were given expression in an earlier article on pages 51–64 of Bulletin No. 22 of the present series.

It may be remembered that the writer hazarded an opinion as to the probabilities that certain Northern forms would continue in similar or increasing numbers as a result of protracted cool winter weather, that would tend to facilitate perfect hibernation, while certain Southern species, which were apparently nearly exterminated in and near the District of Columbia as a consequence of the cold winter of 1899–1900, would continue absent from this neighborhood, or at least that the crops habitually attacked by them would not be materially affected during the season of 1900. This prediction has been partially verified. Such Northern species as came under observation as a result of their injurious abundance in 1899 continued to be injurious, as it was judged they would, but certain of the Southern forms became quite numerous. True, only one of these was abundant early in the season, but the remainder, although extremely rare during the early part of the year, became sufficiently numerous to attract rather general attention late in the season. Prominent among these were the cabbage Pionea, the single species which occurred here in numbers from early in the year; the cabbage looper, which was universally troublesome to late cabbage and other cruciferous crops, and the boll worm, also destructive to late crops, such as corn and tomatoes.

As to the cause of the early reappearance of the first-mentioned pest after such extreme scarcity, the only conclusion that can be reached is that this was due mainly, if not entirely, to the flight of the parent moths from the South either late in the season of 1899 or early in 1900, or at both times. It is to be regretted, however, that the mature insects were not detected at lights or in the field either in autumn or spring. The cabbage looper and boll worm owe their increase probably to the same cause as the Pionea.

It is now a matter of almost annual occurrence—and the season of 1900 was no exception—for the cotton worm, *Aletia argillacea*, to fly from the cotton fields thousands of miles north of their natural habitat, a phenomenon well known to collectors, who frequently take this insect at electric lights in the Northern States, and even in Canada, although their larvæ have not been detected north of the cotton belt. This is only one of many species which have the same habit, and the writer believes that the invasion of the territory about the District of Columbia and northward by the three species above mentioned has been made in the same way, the moths having flown northward, at intervals perhaps, during the season with winds which favored this flight, from localities farther south not affected to the same extent by the atmospheric conditions of the winter of 1898–99.

A circumstance which lends color to the above expressed hypothesis, that the re-stocking of the District of Columbia and its vicinity with the apparently exhausted supply of Southern forms was due mainly to flights induced by favoring winds, consists in the observed fact that there was not a corresponding increase in the numbers of Southern insects of other orders, such as beetles and bugs, insects of feeble powers of flight as compared to moths. The harlequin cabbage bug is an example of the less active fliers, as this insect was only slightly more abundant than in the previous year, until very late in the season, when injury occurred in some few localities.

ATMOSPHERIC CONDITIONS DURING THE WINTER OF 1899 AND 1900 AND SUBSEQUENTLY.

The condition of the weather at different periods of the year was noted whenever it was thought that these conditions might affect insect life. Some of the more important phenomena should be mentioned as a preliminary to remarks that will be made upon the effects of these conditions in limiting the increase or decrease of the insects under observation.

No change worthy of mention which it was thought might affect insects injuriously was noted during the winter months of 1899.

December 24 the temperature reached a maximum of 53° F. during the afternoon, and at this time several species of insects were observed at work in addition to those which will later be mentioned as affecting crucifers. That night, however, there was a considerable fall in temperature, a little more than 10° lower than the average for the day before, the minimum reaching 24°.

During the next eleven days there was a considerable drop in the temperature, snow falling and the ground remaining frozen until January 6 or 7. At one time during this period the temperature descended to 9°. On the 5th the days began to become warmer, but the night temperatures continued quite low, as low as 15° on the date mentioned.

February 24, after a protracted rainy spell of several days' duration, the storm cleared, the sun came out, and the thermometer reached a maximum in the afternoon of 58° F. Search among grasses showed several forms of insects in activity near the surface, and it is probable that many other insects were brought to the surface from their hibernating quarters by these conditions. That night a severe windstorm with rain and snow came on, the temperature dropping by 6 a. m. of the following day to 9° F., remaining below the freezing point for three days, but again attaining a maximum on March 1, of 59°, similar to that experienced after the storm just specified. For the next twelve days the temperature was scarcely below the freezing point for more than a degree or two at any time until March 11, when another storm set in, the temperature falling to 11° F. the following day, but warming the day after that.

March 15 a storm set in about 6 a. m. with considerable snow fall, most of which remained upon the grass for five or six days, and in protected localities as late as the 24th. March 25 still another storm occurred, during the night, with a lighter fall of snow, followed by finer and clearer weather beginning on the 27th.

After the first of April winter weather had ceased and spring begun.

It would be a matter of some difficulty to define the exact significance to be attached to the terms Northern forms and Southern forms used in the present and also the earlier article of the writer on the subject under discussion. This matter can be best explained, perhaps, by repeating what has been said in the first article mentioned (p. 53), that the District of Columbia occupies a place, zoologically speaking, in the Carolinian faunal area nearly midway between its two extremes as at present defined; and the Northern forms are those which develop more freely north of this line; while the Southern attain their greatest increase south of this line. To be more explicit, however, it should be said that the injurious species which will be particularly mentioned as Southern are believed to be truly Austro-riparian, while the Northern species belong rightfully to the Alleghanian area of the Transition zone and the most northern portions of the Carolinian or upper Austral life zone. At least two species which it was found impossible to assign to either the Northern or Southern group, the writer believes, as a result of his study during the past season, have now been correctly placed. They are the fall army worm, which must be considered a Southern form, although it finds its way quite far northward, and the destructive green pea louse, which rightfully belongs in the Northern group.

OCCURRENCE OF SOUTHERN FORMS OF INJURIOUS SPECIES IN 1900.

Of the fifteen injurious forms of insects mentioned by the writer (loc. cit., pp. 55, 56) as unusually scarce in the neighborhood of Washington in 1899 several species showed marked increase. To mention these all in the same category, the list includes four species which were not seen at all the previous year. These are the pickle worm, *Margaronia nitidalis*, and the melon caterpillar, *M. hyalinata*, each of which was abundant in one locality only; the cabbage pionea, *Pionea rimosalis*, which was everywhere numerous and quite destructive throughout the season, and the garden webworm, *Loxostege similalis*, which was several times observed during September.

The Northern leaf-footed plant-bug, *Leptoglossus oppositus*, was generally abundant and was very troublesome, something never before noticed in this vicinity.

The horned squash bug, *Anasa armigera*, was similarly abundant, and so numerous in individuals on many plants examined that they often outnumbered the common squash bug, *A. tristis*, ten to one.

The corn-ear worm, *Heliothis armiger*, was moderately destructive early in the season, and appeared later in great numbers, and in some places did considerable injury to late corn, tomatoes, and similar crops which it is known to affect.

The cabbage looper, *Plusia brassicæ*, returned to this vicinity, and although rare early in the season, became quite troublesome to late cabbage. It seems probable that it is held in check, at least partially, in ordinary seasons by parasites and other natural agencies than weather.

It was not expected that the harlequin cabbage bug, *Murgantia histrionica*, would increase to any observable extent, and this was borne out by the season's observations, the species as a whole hardly ranking as an injurious one to crucifers other than horse-radish and very late cabbage. To horse-radish it was troublesome chiefly owing to the fact that drought also affected this plant, the crops suffering from the combined effects of the two factors.

One genius of Noctuidæ classed with the cutworms and of omnivorous tendencies, Prodenia, was noticeably rare in 1899, but the fact was not mentioned in the writer's consideration of the Southern forms affected by the severely cold weather of the preceding winter. Two species were very abundant during 1897 and 1898, the moths being commonly found at lights, but in 1899 they were extremely rare. In 1900, however, one form, *Prodenia ornithogalli* (*lineatella*) was frequently observed in the larval state in the field and more abundant on tomatoes than other crops, while the moths were not rare at lights. The other species, *P. commelinæ*, could not be found.

The Southern cabbage butterfly, *Pieris protodice*, which was scarcely seen at all, except in the mature condition in a few individuals during 1899, was found to have accumulated in great numbers at St. Elmo, Va., in the late fall. Mr. Pratt, who reported the occurrence, stated that next after the cabbage looper this was the most abundant enemy of crucifers in this region, occurring in about equal numbers on kale and turnips from the latter days of September throughout the month of October.

The Southern tobacco worm, *Protoparce carolina*, also increased in great numbers, particularly during the latter part of the season, and was destructive to late growing tomato plants. The Northern tobacco worm, or tomato worm, *P. celeus*, it should be remarked, was rare as in the previous year. The parasites of both of these, as usual, were very abundant.

The fall army worm, *Laphygma frugiperda*, although it extends its distribution quite far north at times must be included in the category of Southern species, as it is of comparatively recent Southern origin and appears to die out from year to year in its more northern range. It was destructive in a single locality, the District of Columbia, late in the season, but was not reported by any of our numerous correspondents in spite of our inquiry.

Of other Southern forms the green June beetle, *Allorhina nitida;* imbricated-snout beetle, *Epicærus imbricatus;* squash-vine borer, *Melittia satyriniformis*, and American locust, *Schistocerca americana*, showed a perceptible increase in numbers, while the tobacco flea-beetle, *Epitrix parvula* was not so abundant. The larger corn stalk-borer, *Diatræa saccharalis*, was not seen at all.

The opportunity is taken to observe that the eggplant flea-beetle, *Epitrix fuscula*, a Southern form, was extremely abundant during the year, but flea-beetles, as the writer has had occasion to observe in his earlier article, seem to be little affected by changes in weather.

In earlier mention of the weather in relation to the destructive green pea louse, *Nectarophora destructor*, and its abundance during 1899, the writer was unable to specify as to whether it belonged to the northern or southern group of injurious insects. It would now seem that it is a northern species, as it is recorded from several Transition localities, notably in Wisconsin and in Nova Scotia and other portions of Canada, where it is destructive, and, so far as reports go, it has not found its way farther south than a northern strip of the lower austral in southeastern Virginia, near the seacoast, and a single known locality in North Carolina. It therefore falls naturally into the list of species that have multiplied in the neighborhood of the District of Columbia as a result of the cold winters experienced during two years. Nothing else can explain its great abundance, as none of its natural enemies, if we except the fungous disease to which it is subject and which has not yet been made the subject of special study by anyone, either in its relation to the multiplication of this insect or otherwise, have had any appreciable effect in reducing the numbers of this pest.

Taking into consideration the occurrence of this species throughout the country, it would appear that it was at least as numerous in 1900 as in 1899, as during the latter season it was destructive over the same and additional area, although not in all cases to the same extent as in 1899. Its increase westward was noticeable.

ABUNDANT NORTHERN FORMS IN 1900.

Of the northern forms of insects which were present in great numbers in 1899 nearly all of the thirteen species mentioned (loc. cit., pp. 56, 57) occurred in the same numbers during 1900. There were severe outbreaks of the oblique-banded leaf-roller, *Cacœcia rosaceana*, not only about Washington, but in various other portions of the country and as far south as Norfolk, Va., and the strawberry leaf-roller, *Phoxopteris comptana*, was extremely abundant here, in Maryland, and elsewhere. Three of the species previously mentioned, however—the rhubarb curculio, zebra caterpillar, and plum moth—were not conspicuous by their numbers.

The raspberry sawfly, *Monophadnus rubi*, was more abundant than in the previous year.

The asparagus beetles, *Crioceris asparagi* and *C. 12-punctata*, were reported by Professor Johnson to have occasioned some injury in Maryland (Bul. 26, p. 81), but the hot spell of July and August practically put a stop to injury, as neither beetles nor larvæ of either species were to be found in late August and early September, when the plants in several localities were examined.

ON SPECIES COMMON TO NORTH AND SOUTH.

It may be well to state briefly that of the seven species previously noticed (loc. cit., pp. 57, 58) as having been particularly destructive about Washington in 1899, and which do not fall into either category of north or south as to origin, all were destructive during 1900, although in some instances in restricted localities.

The bean leaf-beetle, *Cerotoma trifurcata*, did more harm in the East than was ever before known. The same is true of the spinach flea-beetle, *Disonycha xanthomelæna*.

One of the most interesting of injurious occurrences of the year was that of the variegated cutworm *Peridroma saucia*, which was quite destructive over a wide extent of country, including the Pacific coast, where it was particularly troublesome in the State of Washington. The infested territory comprised portions of Texas, Missouri, Kansas, Maryland, West Virginia, Illinois, Washington, Oregon, and northern California, and the crops infested included nearly everything that grows in gardens, as well as the foliage and fruit of various orchard trees. According to testimony of some of our correspondents, this insect assumed the habit of traveling in armies, but was not noticed on the march in the daytime.

ON NATURAL ENEMIES AND THEIR INFLUENCE UPON INSECT REPRODUCTION.

The question of the effects of the abundance of natural enemies upon injurious insects is closely related to the effects of weather upon them, but the subject is much involved, and we know so little about it that it is difficult to generalize with much certainty. This much is certain, however, that conditions which would affect injuriously a parasite may not necessarily affect a host; predaceous insects are not necessarily affected by conditions which would be injurious to either parasitic or to injurious species, while fungous and bacterial diseases are probably affected by still different conditions.

Predaceous insects, as a rule, are more resistant to extremes of temperature, dryness, or humidity than all of the other insects and organisms which produce diseased conditions of insects.

Parasitic insects were more abundant during the season of 1900 than during 1899, but this does not apply to all of the common species. For example, our two common parasites of the imported cabbage butterfly, though numerous early in the season, were extremely rare toward the close of the year.

Some experiments were made to test the prevalence of parasitic insects and fungi and their effects upon the reproduction of some common pests.

The imported cabbage butterfly, *Pieris rapæ*, was one of the species with which experiments were made. Larvæ were obtained from all available sources from the District of Columbia, Virginia, and Maryland, and kept under the best possible conditions during September, 1900, with the result that not a single parasite was reared, nor did this species appear to be affected by any disease at this time. Practically all of the larvæ used in experiments which were approaching maturity when placed in our rearing jars produced pupæ and eventually butterflies.

While on the subject of the parasites and other natural enemies of this cabbage pest it should be stated that *Pteromalus puparum* and *Apanteles glomeratus* made their appearance with the development of the first generation of butterflies, the Chalcidid appearing at the same time and the Braconid only a few days later. The wheel bug, *Prionidus cristatus*, does not appear to have been recorded as an enemy of this cabbage worm. It was many times observed during the season of 1900 devouring the "worms." One was observed June 23 which had killed a larva twice its size.

Specimens of diseased larvæ referred to the Division of Vegetable Physiology and Pathology in the fall of 1899 were found to be affected by a fungus of the genus Sporotrichum, identified by Mrs. Flora W. Patterson as probably *S. globuliferum* Speg.

The cabbage looper, *Plusia brassicæ*.—Diseased and dead larvæ of this species taken in the fall of 1899 and referred to Mrs. Flora W. Patterson, Assistant Pathologist, were identified as suffering from a fungus of the genus Entomophthora, doubtfully referred to *sphærosperma* Fres., a species which occurs upon many insects of different orders.

During September, 1900, it was estimated that a little less than 20 per cent of the larvæ of this species present in the fields about the District of Columbia had yielded to the effects of disease usually just before attaining maturity. This disease was by no means general, and was found to be more prevalent in Maryland near the District line than on the grounds of the Department of Agriculture. In the latter place there was practically no infection worth mentioning.

A very large proportion of cabbage loopers was affected by the minute parasite *Copidosoma truncatella*, perhaps 15 per cent during September, but none in earlier and less in later months.

Observing that the larvæ were most extensively affected by the Copidosoma parasite in a region badly infected with rot, a number of healthy larvæ were placed on potted cabbage affected with both the bacterial and brown rots, while others were kept as a check lot on fresh cabbage, this experiment being made to ascertain if the rots were in any way responsible for the diseased condition of larvæ. Somewhat to the writer's surprise it could not be seen that the larvæ placed with the diseased plants were affected in any manner more than those kept under the same conditions with perfectly healthy plants.

The melon plant-louse, *Aphis gossypii* Glov., affords a striking example of the combined effects of weather and natural enemies in the control of an insect. Of all common plant-lice this species appears to be most susceptible to climatic variations. During moist or humid weather, particularly in the early portion of the summer, this species is capable of propagating in the greatest numbers, but during protracted heated and dry spells, such as happened in the season of 1900, its natural enemies, which are legion, are able to keep it almost completely under control. During the year it was not reported at this office as doing any damage save in one locality in Nebraska, a State in which it does as much if not more damage than any other in our country. In the year 1899 this species was very destructive in the States of Florida, Texas, Maryland, Virginia, Pennsylvania and Georgia, and District of Columbia, while the previous year it did damage over much the same territory, as well as in Kansas and Arkansas, injury being particularly pronounced in Texas.

SOME GENERALIZATIONS.

As a result of study of the subject of the effects of weather upon different species of injurious insects which occur in the neighborhood of the District of Columbia during the past year in connection with observations that were made the previous year the writer has deduced certain conclusions. One of these, not expressed in the earlier article on this subject, is that there is a tendency on the part of introduced forms to develop one or more generations in their adopted habitat than native northern species produce, a habit which conduces very largely to their destruction, resulting in a corresponding decrease in their numbers.

TENDENCY OF INTRODUCED FORMS TO PRODUCE EXTRA GENERATIONS IN ADOPTED NORTHERN HABITATS.

European introductions in the United States frequently produce one or more generations in excess of the number that has been observed and recorded in the northern countries of Europe where observations have been made, and even attempt generations late in the year, which are often apt to perish by being overtaken by frosts before transformation can be accomplished or suitable places sought out for hibernation.

Southern forms that migrate northward in time appear to become perfectly at home in northern localities; in fact, thoroughly acclimated, but this is apparent only, as there is every reason to believe that many species attempt the production of one or more generations more than similar northern species have; or, in other words, essay the normal generations which they had in the south, which are apt to be cut short by intervening cold weather before their completion.

Examples of both forms are apparently more frequent in leaf-feeding mandibulates, particularly the larvæ of Heterocera or moths and phytophagous Coleoptera, especially Chrysomelidæ or leaf-bettles. Several injurious forms of plant-lice are in the same category, although these have not been given special study. Many genera are known to feed in cold weather long after frosts, and may even be taken on their host plants under the snow.

An excellent illustration of polygneutism, or the production of several generations annually in a species recorded as normally monogneutic in its native home, is to be found in the imported elm leaf-beetle, *Galerucella luteola.* There can be little doubt that this species is monogneutic in Europe, but observations conducted at New Brunswick, N. J., and Connecticut cities in the Upper Austral life area have shown that there is an incomplete second generation. In the more southern portions of the same life area there are invariably two generations annually, and in exceptional seasons a third generation is attempted; at least, beetles of the second generation have been observed to lay eggs.[1]

An example of an extra generation being produced by a southern species is found in the squash-vine borer, *Melittia satyriniformis*, which is single-brooded on Long Island and northward, apparently single and partially double-brooded in New Jersey, while in the latitude of the District of Columbia the species is both single- and double-brooded, as shown by the writer in recent years (Bul. No. 19, n. s. Div. Ent., p. 39). This peculiarity in reproduction is evidently a survival of the time when this species lived in a tropical climate, where it was

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[1] Even some of our native species closely allied to the elm leaf-beetle, e. g., *Galerucella americana* Fab., have been observed by the writer to lay eggs for a second generation late in July (Proc. Ent. Soc. Wash., Vol. III, p. 275), but this is, with little doubt, exceptional.

possible for breeding to be more nearly continuous. The instinct of this and other insects of recent southern origin is still to remain late feeding in the open, provided appropriate plants are available for their subsistence, or, to put it otherwise, they have not learned to seek shelter at the same time as native or acclimated forms do.

Recent observations on this and other species of similar habits and origin suggest that the ancestors of those individuals which produce only a single generation were introduced in early times and are thoroughly established and acclimated, while those which produce a second generation are the offspring of ancestors which have spread from the south more recently and have not yet become accustomed to the differences in the weather in the North and in the South.

The development of two generations by Melittia and other southern introductions in the District of Columbia and places having a similar climate is a matter apparently not so much dependent on the weather as upon the inability of the insects to find the appropriate food for their larvæ; for example, were cucurbits to be planted earlier and later, there would be no trouble in the vine borer producing two well-marked generations in spite of the fact that the vines of cucurbits are readily killed by frosts, the insect being able to survive upon stems which are not of the freshest.

Certain species recently observed, e. g., *Plutella cruciferarum*, the diamond-back cabbage moth, there are the best of reasons for believing are able to produce an additional generation during the latter days of November and the first week of December, as many larvæ captured at this time were full grown and accompanied by numerous pupæ, most of the individuals captured changing to pupæ before the end of the first week of December, in which condition they would naturally be less exposed to frost and better able to survive the rigors of winter. Still another generation, however, was attempted, as one moth captured deposited its eggs at this time. This generation was, of course, doomed to failure.

The effort on the part of so many introduced Old World species of producing extra generations would naturally lead to the belief that these insects came originally and in comparatively recent times from southern Europe or southern Asia, became acclimated farther north in Europe in the same manner that native Southern forms become established by migration to our Northern States, whence they were introduced in the Upper Austral portions of the United States, for the most part about our principal seaports, Boston, New York, and in some cases Baltimore, and in other large cities, such as Philadelphia and perhaps Washington, and after becoming adapted, more or less imperfectly perhaps, to the environment of those cities, have made their way still farther south, where they have again resumed what was probably their original habit of producing two, three, or more annual generations.

RESIDENCE OF CERTAIN SOUTHERN FORMS IN LOCALITIES FAR NORTH OF THEIR NATURAL LIMITS IS TRANSIENT.

In the increase of the areas occupied by these insects they obey a natural impulse for migration, and are evidently largely influenced by the wind, and this is particularly the case with moths. There can be little doubt, also, that insects introduced into the North, and from there southward, are again brought northward by winds from the South; in fact, there is little stability in the localities occupied by many species, winds, frosts, prolonged heat and consequent drought, excessive rains inducing abnormal moisture of the insect's food plants, diseases, and natural enemies being among the elements which produce changes causing fluctuation in numbers in this or that locality, a decrease here this year and an increase there another year.[1]

SPECIES INTRODUCED IN THE NORTH FROM THE SOUTH AND FROM EUROPE REMAIN LATE IN THE FIELD.

Southern or Lower Austral species, particularly those which are injurious, which have come up to this region from the South in comparatively recent years, are rarely found early in the season, especially after severe winters, but increase toward the end of the season, and often, if not usually, occur in their larval stages, busily feeding through the months of October and November, even after frosts, as has been noticed for several years, and particularly during the two seasons just passed. The same is true, for some reason, of species which have widened their range in other directions, and particularly of insects which have been introduced from Europe.

Most of the introduced plant-lice, and those which have come up from the South, live on their food plants after frosts, long after nearly all other insects have disappeared in the field.

It is true that many native plant-lice also remain feeding late in the season.

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[1] The writer desires here to call attention to the absurdity of recording strong-flying species of insects, and especially moths, like those just mentioned, as residents of northern localities beyond their natural limits, where there is no proof whatever that the species could ever have bred there, particularly when we know that no food plant upon which the larva could have subsisted grows there. If such species are included in local lists at all, the circumstances attending capture should be added. A familiar example of an insect which lives normally in the South and is frequently found as far northward as Canada is the gigantic Noctuid, *Erebus odora*. It is native to the West Indies, and not known to breed in the United States. In spite of recent remarks that have been made that would appear to indicate that this moth might breed within the territory of the United States proper, the writer can not believe that it is at present established here, or even will be within the near future, as only isolated specimens are found northward, and these in late summer or autumn, as in the case of the cotton-worm moth, which it has been, I think, definitely proved does not breed in the Northern States.

Of southern species both the cotton worm and the boll worm moths are to be found very late in the season, and the writer has seen the cotton-worm moths in November in great numbers at Ithaca, N. Y., at light, after most other insects had been absent from lights, at least in any numbers, for weeks. Immense numbers of the moths were attracted to the electric lights on the principal streets of the city.[1]

Larvæ of two important species, the imported cabbage butterfly, *Pieris rapæ* and the diamond-back moth, *Plutella cruciferarum*, both of comparatively recent introduction, were found during the winter of 1899–1900 in the last week of November freely feeding after several frosts. They were accompanied by the harlequin cabbage bug, *Murgantia histrionica*, which we know to have recently spread northward from the Southern States, and by the cabbage looper, *Plusia brassicæ*, which has also spread from the south northward, though not in very recent times.

SUMMARY OF CONCLUSIONS.

The result of recent studies may be summarized briefly as follows:

(1) That there is a tendency on the part of forms introduced in the North from farther South to produce one or more generations in excess of the number developed by similar forms native to the region of this adopted habitat.

(2) That as a result these forms remain later in the field than do species native to the North.

(3) That, largely as a result of the above and other habits, in addition to greater susceptibility to low temperatures, these southern introductions are apt to be destroyed every year in large numbers, their residence in their northern homes being, therefore, not strictly permanent. Cold snaps following warm spells during the winter are, according to observation, the most important factors in their destruction.

ON THE HABITS OF ENTILIA SINUATA.

By L. O. Howard.

This interesting little leaf-hopper, certain of the habits of which have been described by Mrs. M. E. Rice, of Coryville, Pa., in Volume V of Insect Life (pp. 243–245), is common throughout the eastern United States, and may be found upon many different plants, such as potato, ragweed (Ambrosia), spikenard (Aralia), *Cnicus altissimus*, *Lactuca spicata*, *Rudbeckia laciniata*, cotton, sunflower, and other annual and herbaceous forms. Mrs. Rice studied the eggs, which were laid upon the midrib of a leaf of sunflower and began to hatch

[1] The exact date was not noted, but it is much colder in that locality than on the corresponding date in Washington, there being about a month's difference in that climate in ordinary seasons, and although the event happened many years ago, it is remembered that a heavy overcoat worn at the time was very comfortable.

out on September 1. Sunflower leaves infested by the larvæ die and the whole plant looks as if scorched. About two weeks after hatching the larvæ molt for the first time. During their entire life, Mrs. Rice noticed, almost every colony was guarded by one or more ants. When she raised the leaf to examine closer the ants gave battle and bit her finger. When she removed the ants the little leaf-hoppers, both larvæ and imagoes, scattered with astonishing celerity all over the plant. The ants returned and rounded them up exactly as the collie dog does sheep, placing one ant on guard if the colony were small and more if the colony were large. She noticed when one of the little leaf-hoppers strayed away an ant went after it and, with infinite patience, drove it home again. She noticed further that when

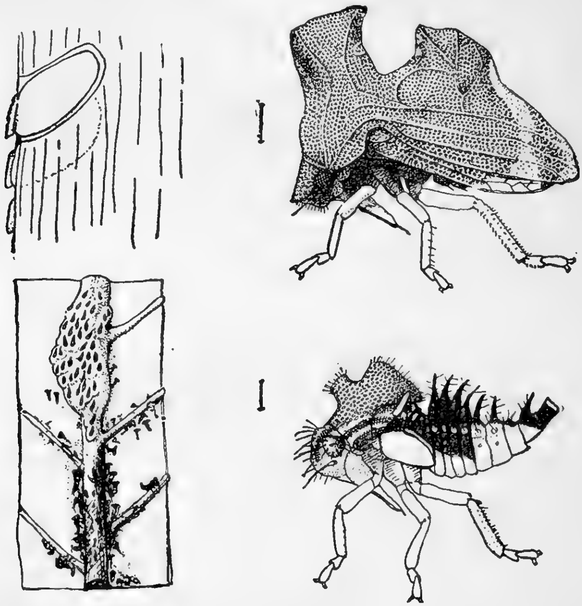

FIG. 27.—*Entilia sinuata;* Adult nymph; swelling of stem due to eggs; angle at which eggs are laid (original).

the larvæ were ready to molt and the skin began to split on the back the ants supervised the process, seeming to peel off the empty larval skin. When one considers the fact that the leaf-hoppers in perfect condition can both fly and jump, the control which the ants maintain over them is remarkable. The writer had an opportunity of studying this interesting little insect during the month of August near Tannersville, N. Y., also upon sunflower, and from the specimens collected at that time the accompanying illustrations have been drawn.

The swelling of the midrib, caused by the insertion of the eggs, was very pronounced, as shown at figure 27, while the exact angle at which the eggs are inserted is also shown at figure 27.

The young, when first hatched, were almost immediately attended by two species of ants, specimens of which were collected, and which are determined by Mr. Theodore Pergande as *Camponotus pictus* Forel. and *Formica subsericea* Say. It was noticed, however, that both species of ants were not found upon the same leaf. Specimens of one species would guard a colony upon one leaf, while on the next leaf on the same plant a colony of the leaf-hoppers might be guarded by several specimens of the other species of ant.

When so guarded the leaf-hoppers clustered at first near the midrib and in the vicinity of the eggs in the manner shown at fig. 27. The successive stages of development are shown at figs. 28 and 27. The second and third larval stages are very characteristic, and not until the final larval stage is reached does the young show any resemblance to the adult leaf-hopper.

A curious and interesting observation was made upon the first egg

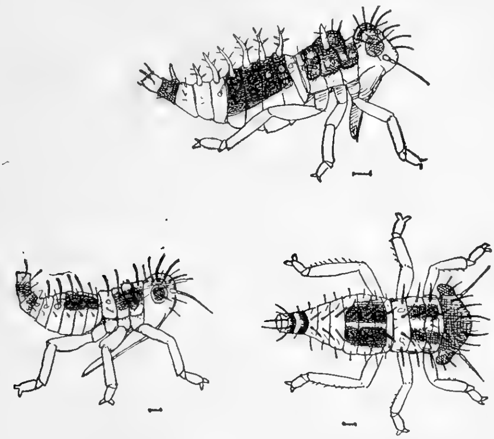

FIG. 28.—*Entilia sinuata:* Successive larval stages—enlarged (original).

mass seen, and which was verified again and again, and that is that the adult female seems to brood over hèr eggs until they are hatched. She assumes a position upon the swollen midrib parallel to the leaf surface, instead of perpendicular to it, and waits patiently and almost motionless for several days—in fact, until the young are hatched. The ants do not bother her while she is thus brooding. As soon as the young hatch out they put in an immediate appearance, and all of the observations made by Mrs. Rice mentioned above have been verified. Considerable honeydew is secreted by the larvæ, and this is undoubtedly the cause of the care taken by the ants. When allowed to stray the leaf-hoppers will run around to the upper side of the leaf, but are soon driven back by the ants and kept massed into clusters. The work of the insects causes the ultimate yellowing and dropping of the leaves, in which case the leaf-hoppers are carefully removed by the ants and placed upon fresh leaves. The Entilia may thus be considered an injurious species to cultivated sunflowers, and as the ants encourage them, take good care of them, and place them upon fresh leaves, the ants themselves become thus indirect enemies to the plant.

A kerosene emulsion spray is of course a perfectly efficient remedy.

FUMIGATION WITH CARBON BISULPHIDE.

By W. E. Hinds.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., July 15, 1901.

Sir: I submit herewith a report upon the use of carbon bisulphide in the fumigation of a large wholesale and retail tobacco establishment in Washington, D. C., together with some details of caution in its use and a few observations concerning the effects of this insecticide upon the user, which I have not found published hitherto.

Respectfully,

W. E. Hinds.

Dr. L. O. Howard,
Chief of Division of Entomology.

On the 13th of July, in accordance with your instructions, I visited this establishment and made a general investigation. The business is confined to what is practically one large room, having about 3,000 square feet on the ground floor and a cubical content of about 75,000 feet. At a height of about 12 feet a wide gallery runs around three sides of the room. This gallery, as well as the main floor, is filled with tobacco of various grades and styles of manufacture and in all kinds of packages. Altogether the stock consisted approximately of 800,000 cigars, 400,000 cigarettes, and 37,000 pounds of smoking and chewing tobacco. Only a very small portion of the stock showed any signs of infestation, and this was stored partly in the gallery and partly on the main floor. Several kinds of high-grade smoking mixtures (obtained mostly, as the proprietor informed me, from the same factory) were being seriously damaged by the cigarette beetle, *Lasioderma serricorne* Fab. It was stated that the beetles seldom appeared till the stock was about two years old, and the proprietors believed that the eggs were in the tobacco when it was packed, but that they remained dormant for a year or so more, developing abundantly toward the end of the second year. This, of course, is not the case. However, it may be possible that some stock was infested at the factory and the beetles subsequently passed through several generations in the package before their presence was discovered, and it seems very probable, since the beetles have been quite abundant in the store for at least the past two years, that stock originally clean may have become infested in the store during the two years in which it was more or less exposed to infestation.

A large number of the beetles were noticed in the store last year, and a small portion of the stock was at that time treated with CS_2; but the fact that some of the old stock is now badly infested makes it appear very probable either that the first treatment was not sufficiently extensive to include all the infested stock or that it was not thorough enough to destroy all the beetles in what was treated. This partial treatment was, however, sufficiently successful to satisfy the proprietors that if used in a sufficiently large quantity and so as to include the entire stock, carbon bisulphide would eradicate the pest. They had, therefore, made preparations to thoroughly fumigate the whole establishment, applying more than double the quantity of the insecticide that is usually recommended in such work. They desired to clean out the beetles at any cost and preferred to use an excessive amount of bisulphide rather than be obliged to repeat the treatment. Accordingly, they had provided 200 pounds of CS_2 and about 35 shallow tin pans about 3 feet long by 1 foot wide and 1 inch deep. At the writer's suggestion, an additional supply of evaporating pans was obtained. Over fifty of these large pans were distributed around the room in as high positions as possible, and a number were placed on top of the stock stored around the gallery. The stairway and elevator shaft leading to the basement were tightly closed and the worst infested stock was opened and the boxes spread around upon the lower floor. The cans of bisulphide were distributed and everything done to facilitate rapid work in the application of the liquid. Owing to the slight danger of generating a spark in turning off the incandescent lights which it would be necessary to have if the application were made at night, it was thought best to defer the exposure of the liquid till early on Sunday morning, July 14. (The dangers connected with the use of carbon bisulphide will be spoken of more fully at another place in this report.)

Soon after 6 o'clock on Sunday morning the work of pouring the bisulphide into the pans was begun simultaneously by the six persons (including the writer) present. Each pan received from 2 to 3 pounds of the liquid. The pans in a vault and the show window and in the wall show cases were filled first and the doors to those compartments were then closed to retard the fumes. Otherwise the doors to show cases and closets and the drawers were all left slightly ajar to allow the unhindered entrance of the fumes. The pans around the sides of the rooms under the gallery were placed so high that a 5 or 6 foot stepladder had to be used to reach most of them. As only one such ladder was at hand, the work was somewhat delayed at this point, and all lower pans on goods along the middle of the floor and on show cases were filled before the work on the higher pans could be completed. In the meantime the pans in the gallery were being filled and the fumes on the lower floor were becoming very dense. The air supply had become insufficient for the workers, and instructions were given to each man to go outdoors as soon as he began to feel dizzy. This most of them did, and after a few refreshing breaths they were able to return to the work; but one or two did not leave the room until the work was finished. (The effects of the gas upon the operator will be considered more in detail at another point.) After about 145 pounds of CS_2 had been exposed, occupying from fifteen to twenty minutes, the fumes had become so dense that we were forced to withdraw. The building was then carefully locked and left for twenty-two hours. People passing on the street at the time the exposure was being made and those having business in adjoining rooms complained of the exceedingly disagreeable odor, but at a visit to the premises later in the day the writer could detect but very slight traces of the odor on the street, even close to the door. No guard remained near the building during the day.

On Monday morning, at 4.45, the store was opened for ventilation. The density of the fumes had greatly diminished, but a watch was kept to see that no one passed close to the door with a lighted cigar until the fumes had mostly disappeared. In forty-five minutes the store was so well aired that but little of the disagreeable odor remained, though for several days slight traces of the odor lingered in the room.

An examination of many boxes of the infested stock on the lower floor disclosed many dead beetles, but no living ones. Unopened boxes of stock in the gallery were examined, and these showed only about one live beetle to every one hundred dead ones. So far as could be determined at the time, the treatment was very successful, and the proprietor expressed himself as very well pleased with the result.

The suggestion was made that future trouble with the cigarette beetle might probably be avoided by treating incoming stock with CS_2 in a quarantine chamber before placing it in the sales room. In the basement the writer was shown a large, zinc-lined, air-tight box, having 18 cubic feet capacity, which has been used as a moistening chamber. Upon being assured that this was an admirable thing for a quarantine box, the proprietor declared it his purpose to adopt the suggestion and treat all new or suspected old stock in this way.

DANGERS IN USE OF CARBON BISULPHIDE.

It is customary when anything is written concerning the use of this very volatile and highly inflammable liquid to emphasize the danger from fire in the presence of the fumes, and it is usually pointed out particularly that even a lighted cigar may cause a disastrous explosion. The writer has also seen printed mention of the danger of liberating the fumes in the presence of heated steam pipes. So it seems that a brief mention of a few other points of danger may not be out of place here.

No electric fan should be allowed to run in the presence of the fumes, as it is liable to give off occasional sparks. For the same reason there would be danger in turning on an incandescent light, and though the danger in turning out such a light is less than in turning it on, there is still too much chance of forming some connection which would produce a spark to run the risk of the explosion which would almost surely follow. The writer has personally experienced the formation of such a spark when turning off a light, and it very frequently occurs when turning it on. The danger from gas and arc lights is too apparent to need more than mention. It would be a matter of courtesy as well as a measure of safety to inform occupants of adjoining rooms of the nature of the work being done and the need for care in regard to fire should the fumes find entrance to their establishments. An additional safeguard would be to station a watchman on the premises till the treatment is ended. The danger to the operator making the exposure is but slight if he knows the nature and effects of the gas. As soon as he finds that he is being overcome and getting dizzy, he should at once get out into the open air.

EFFECTS OF THE GAS UPON THE OPERATOR.

The first appreciable effect is upon the sense of smell. At first the fumes have an extremely disagreeable odor; but the odor soon seems to gradually disappear, and in this treatment the men strongly doubted that they were using the same substance with which they began. This deadening of the smell continues until it is complete. The other senses seem to become benumbed simultaneously, so that the operator does not feel or realize that any change is taking place in him. But the heart beat becomes more and more rapid as the supply of oxygen in the lungs diminishes. The power of thought is very much weakened and the work is continued in a mechanical sort of way. Hearing and sight are also weakened; in fact, consciousness itself is being gradually lost. But before this weakening process has gone far enough to be really dangerous or injurious the operator feels rather "queer" in the head, with more or less dizziness. There is no pain or disagreeable sensation, no desire to escape out of it, and no sense of suffocation. But when a person reaches this condition it is high time to get out into the open air, where the ill effects will soon disappear. Should the operator persist in remaining longer in the room after this condition is reached there would be danger of a fall; and if no one happened to be near, his presence might not be missed and suffocation would soon follow. Even if he should get out safely the after effects would be more serious and a severe headache, at least, result. It should be clearly understood, however, that the action of the gas is somewhat poisoning as well as suffocating. These observations concerning the effects of the gas upon the men are gathered from personal experience and the statements of others engaged in making the treatment herein reported.

Owing to the effect of the gas upon the action of the heart, the writer believes that it would be wise to caution persons having any trouble or weakness about the heart against taking any part in the application of carbon bisulphide.

In view of the increasing use of CS_2 as an insecticide and the scattered condition of such observations as have been published in regard to it, the writer respectfully suggests the desirability of a more comprehensive report than has yet been made, published in some such form as to be readily available to all those desiring practical information upon this subject.

GENERAL NOTES.

ICHNEUMONID PARASITES OF THE SUGAR-CANE BORERS IN THE ISLAND OF REUNION.

Under this title M. Edmond Bordage, director of the Museum of Natural History of Reunion, has published a brief account of *Ophion mauritii* Saussure and of *O. antankarus* Saussure, which are parasitic in Reunion on the larvæ of *Diatræa striatalis* and *Sesamia albiciliata*, two destructive sugar-cane borers of that island and of Mauritius. He thinks that they are responsible for the marked reduction in the numbers of the borers.

The accompanying figures are from drawings by M. Bordage, and illustrate the wing venation of *O. antankarus*.

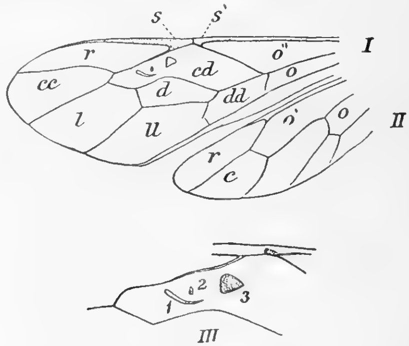

FIG. 29.—Wings of *Ophion antankarus*—I, upper wing; II, lower wing. The large cell (*cd*) of the upper wing has three spots of reddish or yellowish color, which are given in detail much enlarged in Fig. III; they take the form of a crescent, a mere speck, and a triangle. (With *O. mauritii* there is found in the interior of the large cell (*cd*) only one spot which is formed like a triangle.)

INSECTS FROM BRITISH HONDURAS.

The Rev. W. A. Stanton, S. J., of St. Louis University, St. Louis, Mo., sent February 12, 1900, for identification certain insects collected at Belize, British Honduras. The notes which accompanied them are of interest.

An insect known locally as the "doctor fly" was identified as *Diachlorus ferrugatus* Fabr. Mr. Stanton writes:

> The fearful local swelling which follows the bite of these insects causes them to be regarded with dread by the inhabitants. The effect, however, varies in different individuals.

Some small flies, very troublesome in some quarters, and called by the natives "botlass" flies, were determined as a species of Simulium; unfortunately, the specimens were too badly injured for study. The bite of this insect is quite painful and leaves a black spot on the skin, surrounded by a reddish circle which lasts for a week or more.

A species of tick taken from the body of one of the deadly "tommygoff" snakes, a species of Lachesis or "bushmaster," quite common in Belize, was identified as belonging to a species of Ophiodes.

Three spiders were sent and identified as *Argyroepeira argyra* Walck., *Argiope argentata* Fab., and *Gasteracantha cancriformis* Linn. The dorsal surface of the abdomen of the last named when alive is brick red in color, though many individuals are found, seeming to an ordinary observer to be of the same species, in which the color is pure white, or sometimes lemon yellow.

The sending also included specimens of the white ant, *Termes* sp. (probably *morio*), and a small black ant, very common in Belize, known scientifically as *Cryptocerus alfaroi* Em. ♀

NOTES FROM THE PHILIPPINES.

Lieut. Alfred T. Clifton wrote this office April 20, 1900, from military station No. 5, Bacolod, Negros, Philippine Islands, transmitting some specimens, with interesting notes. A giant wasp which he sends he states is called in the Philippines "avisar," or take notice, a sufficiently suggestive name for an insect of its class.

At the time of writing grasshoppers were very destructive, ruining the sugar crop in a few hours wherever they stopped. Our correspondent had seen great clouds of these creatures, so numerous that they obscured the sun, passing over the town. The natives on haciendos on such occasions turn out and beat on bamboo and make a racket to frighten them off.

The grasshoppers are very ravenous—always hungry. In the morning you can pass a field of young sugar cane a foot high, and when you return that way at noon it will sometimes look as if nothing had ever been planted. Notwithstanding this, these langosta, as they are termed by the inhabitants, are considered a great delicacy, but our correspondent had never had the courage to test this personally.

It is customary to place obstructions of sections of banana trees on top of the furrows of growing cane, and the locust eats the canes furrow by furrow, and when he reaches the obstruction, instead of going over it, he hops to the end where a hole has previously been dug, into which he falls. Here the locusts are collected and are then boiled, after removing the legs, heads, and wings. Thus prepared they make a black-looking mess. One haciendero stated to our correspondent that he had shipped a load of locusts to Iloilo, where they were worth $4 a bag.

The natives believe that the locusts come every seventh year.

MISCELLANEOUS NOTES FROM KANSAS.

Mr. F. F. Crevecœur, Onaga, Kans., an entomologist of considerable experience and a valued correspondent of this office, has reported the results of some interesting observations made by him during the past season (1900). Some of these are, in brief, as follows:

Notonecta undulata, one of the common, so-called back-swimmers, was observed feeding upon a related species, *Anisops platycnemis*, on one of our largest species of Corisa, and on the Dytiscid water beetle, *Coptotomus interrogatus*.

March 19 a species of spider, *Xysticus gulosus*, was noticed feeding on the dung beetle, *Aphodius inquietus*, under a board on the ground.

Crepidodera rufipes, the red-legged flea beetle, a long account of which was published some years ago in Volume V of Insect Life (pp. 341), was stated to be very abundant in the State of Kansas. It is a destructive enemy of young peach, cherry, and other fruit trees.

May 30 a wasp, *Odynerus tigris*, was observed bearing a larva and flying about a post in a barn looking for a hole in which to deposit it. The next day some of the same kind of larvæ, as well as pupæ, were found on the willow, *Salix amygdaloides*, which were reared and proved to be *Lina scripta*, the streaked cottonwood leaf-beetle.

June 6, *Anomœa laticlavia*, an interesting Chrysomelid, was reared from its pupal case found under a log about a month before. This case, which was made of dirt, was described as about five-eighths of an inch long by half that width, convex laterally, and somewhat concave longitudinally on the under side, with a fringe along the sides and crimped on the under side only, giving the case the appearance of being of organic origin instead of being of dirt.

June 18 *Plusia brassicæ*, the cabbage looper, was reared from larvæ on cottonwood, which pupated June 9. June 21 the same species issued from the larva taken on cottonwood, which pupated June 12. It will be noted that the pupal stage in both cases lasted nine days.

On two occasions during the latter days of June *Dasyllis tergissa*, a large robber fly, was noticed feeding upon *Macrobasis unicolor*, the ash-gray blister-beetle, *Onthophagus hecate*, a dung-beetle, and *Euschistus tristigmus*, a plant-bug.

June 10 *Atomosia puella* was noticed feeding upon *Lonchæa rufitarsus*, both Diptera.

June 14 *Macrobasis unicolor* was observed feeding on the bloom of hollyhock. It had ragged three or four flowers on this plant when observed.

While picking strawberries our correspondent happened to touch a specimen of the plant-bug *Euschistus variolarius*, which is often found feeding on the fruit of berries, and noticed that a small quantity of the fluid which this species exudes when disturbed caused a very painful sensation on a sore spot on his finger, almost like that produced by a burn.

During the last week of September two species of ants were noticed devouring apples on trees, some of the fruit having been almost completely devoured and badly honeycombed at the time.

October 6 *Euphoria inda*, the brown fruit-chafer, was observed feeding upon some apples that had been injured by ants.

UNUSUAL INJURY BY CUTTING ANTS IN TEXAS.

One of our correspondents, Mr. H. Booton, of Richmond, Tex., writes, under date of September 2, of very unusual injury by cutting ants in that State. As his letter is of unusual interest, we copy it entire:

Replying to yours of the 20th of August, in regard to the night ants, as you designate them, it is the same ant I refer to. We call them the cutting ants. In the lot next to me here in Richmond these ants undermined the wall to the city schoolhouse, causing the wall to fall. This same nest of ants destroyed 1½ acres of my orchard. I have gone down 10 feet after these ants. The school and county authorities sent to Galveston, Tex., for an architect to examine this house and give the cause of these walls falling, for which they paid this man $50. I was present when this man examined these walls. He pronounced them good walls—a sound foundation—the second best that can be made. He could not find the cause of the north wall falling. I offered him my assistance, which he accepted, and in five minutes I satisfied him that these ants had undermined this wall and were the cause of its falling. He so reported it and said it was the first wall in all his experience he had known to be destroyed by these cutting ants. I dug six holes, from 8 to 10 feet deep, in my yard for these ants. I smoked them with sulphur, which ran them under this brick house. The results I have stated. This nest of ants was destroyed or run away by the water running from the gutters off this house onto this nest after the wall had fallen. I use a buffalo blower to force the fumes of the sulphur into the holes of the ants. Bisulphide of carbon will not kill the cutting ants. It will kill the hill ants. These cutting ants will carry London purple and Paris green from 100 to 200 yards. I know of a well in this county which these ants destroyed by depositing London purple in it, and this well was nearly 200 yards from where these ants were fed on the London purple. I am the only man in this county who can kill these cutting ants.

INJURIOUS MOTHS ATTRACTED TO LIGHTS IN AUTUMN.

On the morning of September 23 the writer's attention was attracted to numerous individuals of the cotton moth (*Aletia argillacea* Hbn.) in the vicinity of electric-light globes in the business streets of Washington. The same species, together with the boll worm moth and other Noctuidae, were noticed at lights during the same evening, and the injurious forms predominated to such a degree that a tour was made of all available electric-light globes of the vicinity. From the captures an estimate was made and it was found that of the different species of moths attracted to the lights up to 11.30 p. m. about 85 per cent were injurious and the remainder innoxious. Other orders were conspicuous by their scarcity. A few common species of beetles, such as *Silpha* *surinamensis* and Carabidæ, were found here and there occasionally, as also numerous gnats of no known importance, economically or otherwise. Outside of the Lepidoptera the only insect commonly seen was a chrysopa fly (*Chrysopa oculata*), a well-known beneficial species. The temperature at the time of collecting was about 65° on the streets, but the official reported temperature was 60°.

The list which follows of the species captured, and the percentage of their occurrence, both on the date of capture and an estimate of their occurrence during the week ending September 23, may be found of interest, not only as showing the value of lights in attracting injurious forms in autumn, but also for comparison with the list of insects captured in a cotton field near Victoria, Tex., October 1, 1897, which was published in Bulletin No. 18 (n. s., pages 85–88). Fully half of the species listed are Southern, *i. e.*, forms more frequently found in the South than in the Northern States. Anyone who has paid any attention to the species of insects attracted to lights in spring and summer can not have failed to have been struck with the fact that beneficial forms are frequently so abundant as to show in many cases that the lights are of practically no value whatever in reducing the numbers of destructive insects. Although the noxious forms outnumber the others, it must always be remembered that each individual of a predaceous or parasitic species during a lifetime is capable of destroying many individuals of the injurious species.

The following is the list of captures:

Latin name.	Common name.	September 23.	Week's average.
		Per cent.	*Per cent.*
Aletia argillacea	Cotton worm	26	5
Heliothis armiger	Corn ear worm, boll worm	9	16
Leucania unipuncta	Army worm	6	6
Laphygma frugiperda	Fall army worm	5	3
Crambus vulvivagellus	Vagabond crambus	12	12
Hypena scabra	Green clover worm	4	3
Plusia brassicæ	Cabbage looper	5	8
Feltia subgothica	Dingy cutworm	9	20
Agrotis ypsilon	Black cutworm	1	
Protoparce carolina	Tomato worm	1	2
Protoparce celeus	Tobacco worm	1	
Pyralis costalis	Clover hay worm	1	
Thyridopteryx ephemeræformis	Bagworm	1	
Plusia precationis	A cabbage looper	1	
Loxostege similalis	Garden webworm	2	4
Prodenia ornithogalli	Cotton cutworm	1	5
Miscellaneous injurious species			6
Innoxious species of moths		15	10

—F. H. C.

THE ANGOUMOIS GRAIN MOTH IN PENNSYLVANIA.

It might be remembered by some of our correspondents that we made mention of the fact that the Angoumois grain moth (*Sitotroga cerealella* Ol.) is known to occur in the field as far north as Philadelphia, Pa. From accounts which have reached us this fall (1900), it is evident that the extreme heat of the past summer induced numerous individuals of this species to fly northward, and it is also evident, from the numerous reports of injury, that the species is established outdoors, at least temporarily, in other localities than Philadelphia. Writing November 30, 1900, Mr. J. E. Walker states that this insect was ruining the wheat crop in the vicinity of Media, Pa. He writes that it can not be fanned out, as the hull or injured kernel and the insect are apparently so nearly of the same weight. In one instance men at work upon wheat were obliged to leave the barn at various intervals during the process of threshing to clear their throats and relieve their noses from the flying insects, which came in clouds, both dead and alive, from the machine. The presence of the insect in the grain was not discovered until threshing commenced, in November. Most of the wheat in that vicinity was threshed in July and sold, or complaints of injury would probably have been general.

Writing again January 23, our correspondent stated that after inquiry among persons residing in the neighboring towns he ascertained the extent of injury by this species to comprise a district radiating from Media and extending from Philadelphia to Newtown Square, to Westchester, to Kennett Square, to Ashland, Del., and up the Delaware River to Philadelphia, which completed the circuit. He expatiated on the difficulty of obtaining the information desired, owing to a general suspicion on the part of persons interviewed that the information which they might give would interfere with the sale of their farms; also that it was simply out of the question to endeavor to persuade farmers to apply remedies to grain that had been threshed. They were all willing to sell for what the grain might bring, and it was left to the middleman to do the "doctoring." Some interesting instances of infestation by this species were cited. One person owning a farm at Newtown Square threshed his grain from the mow, shipped 600 bushels to Philadelphia, and when the car was opened the next day the grain was so badly heated that a man walked on the top of it without making an impression with his shoe soles. Those who threshed immediately after harvest succeeded in effecting a sale of their wheat. A milling company at Kennett Square was refusing to take wheat for grinding, as several thousand bushels in stock was badly damaged before the presence of the moth was discovered. Another mill at Ashland, Del., was caught like the preceding. Six thousand bushels was damaged. Injury was general about Westchester, especially to wheat which was stored in the sheaf and permitted to remain some length of time before threshing.

February 6, 1901, we received information from a milling company of New York City that this species, specimens of which were sent, was very generally destructive throughout New Jersey and eastern Pennsylvania.

USE OF SULPHUR AS A REMEDY FOR THE INDIAN-MEAL MOTH.

Mr. A. Martin, Lamont, S. Dak., writes, under date of November 3, 1900, that during the summer of 1899 the Indian-meal moth (*Plodia interpunctella* Hbn.) became so numerous that he was obliged to have recourse to remedies. Having a hard-coal heater in the building in which the infested grain was stored, he decided to make an experiment. The first was to ascertain if coal gas and heat would have any effect on his unwelcome guests. Neither produced the desired result. On the contrary, the heat enabled the insects to multiply more rapidly, and the grain for a foot or so nearest the heater became quite hot—as high as 110° F.

Sulphur was tried, 3 pounds being burned in a couple of days, with result that it killed some of the moths, the fumes not being strong enough to effect the destruction of the larvæ. He next tried 3 pounds of sulphur, repeating with 3 pounds more. This killed all the moths not protected by being under boards or in similar localities. It did not affect the larvæ as far as could be seen. Our correspondent estimates that the moths could all be killed at an expense of about, say, 5 pounds of sulphur to 10,000 cubic feet.

Bisulphide of carbon cost, in this case, 25 cents a pound, and was therefore too expensive.

FULLER'S ROSE BEETLE IN THE HAWAIIAN ISLANDS.

Since writing on the so-called "olinda bug" (*Pandamorus olinda* Perk.), in "Notes on insects affecting the koa trees at Haiku Forest, Maui," specimens were given to me at San Francisco by Mr. Charles Fuchs, who claims that they were common in gardens of that city. Mr. E. A. Schwarz, to whom we showed specimens, pronounced them the well-known "Fuller's rose beetle" (*Aramigus fulleri* Horn). The insect has been figured in the Report of the Entomologist of the Department of Agriculture for 1879.[1] Dr. Riley states that as early as 1875 specimens were sent to him by Mr. A. S. Fuller, who found it in greenhouses somewhat injurious to camellias. In his report, Dr. Riley stated that "it seems to be quite widespread, occurring from the Atlantic at least as far west as Montana, and its habit of injuriously affecting roses and other greenhouse plants must be looked upon as a comparatively recent acquirement."

The so-called "Olinda bug" is found on Oahu, and lately occurred in destructive numbers at Kohala and Kau, on Hawaii. The injury of this beetle to trees is in reality not as serious as it would appear, and its presence upon older trees is barely noticed, while upon the young trees growing among the Hilo grass its presence is more apparent.

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[1] More recently Mr. Chittenden has given an account of this species in Bul. 27, n. s., pp. 88–96.

We have seen many trees of the Java plum, recently planted, with every leaf eaten off, and some have died from the effects of the beetle and Hilo grass combined, while others again barely showed any sign of the beetle. Reports from Kohala state that the beetle also devours the bark of young trees. This we have never observed, but have no doubt of its accuracy where food is scarce. Most any plant or tree, and even the grass, is attacked by the beetle. The insect appears to be most numerous along the border of the forest, and it is found from the seashore up as high as 5,000 feet. Seven years ago we were shown the beetle at Paia, destructive to roses and garden plants in general. Mr. Perkins reports having some years since seen remains of the same at the base of koa trees near Olinda to a depth of several inches. It must have been present on the islands long before it became prominent, and it is likely an introduction from Mexico, and probably came from Acapulco.

The life history of the beetle is as yet but imperfectly known. Four years ago we found its larvæ under stones at Olinda, and collected large numbers of the same in all stages on this trip feeding on the roots of Hilo grass. We have obtained its eggs in confinement, deposited in clusters of some 75, of a light-yellow color, from three-fourths to 1^{mm}. long and half as wide. At the office we find that large numbers of young larvæ issue from galls produced by the Tortricid larvæ. Here the eggs are inserted anywhere where a hole is convenient, and are embedded in irregular masses partly covered by excremental remains. We should think that they are also found under the bark of trees on which the beetles feed. It was found that the large number of gall-like swellings on the terminal branches of the koa trees brought down for observation produced hundreds of young larvæ of the "Rose beetle." Whenever the galls showed any holes, or if partly split, they had been thrust full of eggs, often an inch or more in length. Doubtless this is done by several individuals when present in such enormous numbers as at Haiku. In gardens and small areas of land the beetles are easily dealt with, since they are wingless and can only crawl. They can readily be shaken off smaller trees into a bucket of water with a little kerosene and destroyed. This can be done at any time during the day or night while the beetles remain stationary upon the plants, where, if numerous, they will congregate in clusters.

Aramigus fulleri has not many enemies. The indigenous Carabid beetles on higher elevations must destroy many of their larvæ.

Insectivorous birds evidently feed largely upon the beetles. We found excrements of the mina or mynah bird consisting entirely of remains of these beetles. Quails are considered as excellent birds to destroy such insects; fowls should keep the surroundings of houses free of them. Probably some 90 per cent of the food of the mongoose consists of insects, roaches, crickets, grasshoppers, and centipedes, and, from examination made, he also feeds upon the "Olinda bug."—ALBERT KOEBELE.

SINGULAR INSTANCES OF ATTACK ON HUMAN BEINGS BY INSECTS.

From time to time we are in receipt of specimens of insects from nearly every quarter of the globe with report that the species sent had caused annoyance by attacking men. In previous publications of this Department we have had occasion to mention more or less in detail the attacks and alleged attacks of the so-called "kissing bug," mosquitoes, fleas, bedbugs, and various other insects which are known to attack man habitually. Extreme cases, however, are constantly being reported, and some of these may be of interest. During December, 1900, we received a communication from Mr. F. D. Granger, of the United States Coast and Geodetic Survey, this city, with accompanying specimens of the ground beetle (*Harpalus erraticus*), a common species in the West, which had been taken in September of that year on the farm of Mr. William Lord, at Page, Nebr. Mr. Lord said he had never noticed the insects before that year, but remarked that they were "savage biters." Mr. Granger stated that personal experience proved the correctness of this assertion, and that not only he but other members of the party camped in that vicinity were bitten by these beetles.

EFFICIENCY OF THE TWO-SPOTTED LADYBIRD AS A PLANT-LOUSE DESTROYER.

During the latter part of June Mr. J. J. Newbaker, Steelton, Pa., and Mr. M. P. Jones, Morristown, N. J., sent specimens of the cherry aphis (*Myzus cerasi*) and of the apple louse (*Aphis mali*) on peach and apple, respectively, in both cases with accompanying specimens of the two-spotted ladybird (*Adalia bipunctata*) in the pupal condition when received. The pupæ were found in groups of half a dozen and more within the curled-up leaves, and in neither case were any plant lice remaining, the larvæ having devoured them all before transforming. It seems probable that a similar condition of affairs existed in both localities upon the trees.

THE "OVERFLOW BUG" AGAIN.

October 15, 1900, Mr. J. Hardy, Milton, Cal., sent specimens of the ground beetle *Platynus maculicollis*, known in California as the "overflow bug" or "grease bug," with report that the species was a very annoying pest in that vicinity at that time of the year. Our correspondent writes:

> They make their appearance about dusk, within three or four days after the rain, and remain from ten days to three weeks. They enter the houses in great numbers and get into everything. If disturbed they emit a strong fetid stifling odor.

They enter the best built houses, which other pests never enter, nor does cleanliness about the premises or location on high or low ground seem to make any difference. * * * They will walk off of sticky paper, and "buhach" does not affect them. To give you some idea of how they run over us, I will say that I can at this time (8 p. m.) count over 50 crawling over a small table, about 1½ by 3 feet, in front of me.

A letter from the pen of Mrs. A. E. Bush, one of our California correspondents, was published concerning this insect in the American Naturalist of August, 1882 (pp. 681, 682), and we published a brief note from correspondence with Mr. A. A. Eaton, Riverside, Cal., in Insect Life, Volume V, page 342. This beetle is a Carabid, and, like most species of this family, may be predaceous. A number of the beetles were confined in a small box and sent to us by Mr. Hardy, and nearly all reached this city in good condition, a very unusual state of affairs when it is considered that they were in such close confinement and had nothing to feed upon. Even one beetle that died did not appear to have been attacked by its fellow prisoners. Possibly the disagreeable odor emitted by the beetles may have an effect in deterring others from attack.

A REMEDY FOR FLEA-BEETLES IN CALIFORNIA VINEYARDS.

We are in receipt of a communication from Mr. E. H. Twight, San Francisco, Cal., dated May 15, 1901, in which he states that flea-beetles do great damage in California at times, and that if the pests are not too numerous they can be fought with a flat with a slot to fit around the trunk of the vine, ending in a bag. When this is used early in the day, before it becomes too warm, the insects drop in with a slight shake of the vine. A man is supposed to treat 200 vines in an hour. When the bag is full it is dipped in hot water and the insects fed to chickens.

When the flea-beetles appear regularly every season, our correspondent states, it is desirable to keep the vineyard free of weeds, bushes, dirt, and other accumulations, and in fall place some artificial shelters, such as stray covers, about the vineyard on the ground, so that these can be burned in winter when the pest seeks them as a shelter in which to hibernate.

INJURY TO RUSTIC CEDAR FENCES AND SUMMERHOUSES BY BORERS.

May 24, 1900, Mr. J. Harold Austin, Lansdowne, Pa., complained of injury by *Callidium janthinum* Lec., judging by his description, to a small rustic cabin, built of red cedar, at that place. During the past five years injury by *C. janthinum* and some few other borers has been noticed by the writer to fences and summerhouses and other rustic buildings in many suburban homes and public resorts in the vicinity of Washington, D. C. This borer, with *Hylotrupes ligneus*

Fab., was by far the most numerous, but other insects assist somewhat in the injury, among them *Atimia confusa* Say. The first or second year after the borers have begun work the woodwork is greatly marred by the exit holes which are left in the bark.

May 13, 1901, we received information from Dr. R. H. Lawton, together with accompanying specimens, that *Hylotrupes ligneus* was the cause of considerable trouble in the cedars in his vicinity. March 30 the beetles made their appearance in an office in that town and were very plentiful until the middle of April, when they disappeared. Dr. Lawton found in a basement a pile of cedar sticks from which the insects had emerged. The sticks were badly damaged and fully accounted for the number of the beetles.

There seems to be no practical remedy when cedar wood is used for outdoor ornamental purposes. If it were kept indoors for a season or more and saturated in April and May with gasoline, or some similar preparation, it might be kept free from infestation and in time the wood would be so dry that the borers would not attack it.—F. H. C.

INEFFECTIVENESS OF KEROSENE EMULSION AGAINST WHITE GRUBS.

One of the remedies which has been frequently suggested as of value against white grubs is the kerosene emulsion. Its use has been advised in various publications and in the correspondence of this Division.

Kerosene emulsion diluted with 15 parts of water, applied to celery by Mr. Lull, formerly of this Division, in 1893, did not injure the plants, but killed the larvæ of *Allorhina nitida* which were at or near the surface of the ground, but apparently failed entirely to reach such larvæ as were at a depth of two inches or more beneath the surface. This matter was brought to the attention of the public in Bulletin No. 10, in an article by Dr. Howard (p. 25).

Mr. W. K. Shaw, acting upon our suggestion, tried kerosene emulsion against larvæ of Lachnosterna, presumably *Lachnosterna fusca*, the common white grub of Massachusetts, in the vicinity of Boston. He was at first of the opinion that it killed the small grubs but did not affect the larger ones. Later he could not see that the most careful use of this emulsion was effective against these white grubs.

There is no doubt about the strength of the emulsion, as Mr. Shaw is a graduate of the Massachusetts Institute of Technology, and directions for the preparation and application of this insecticide were followed implicitly, the ground having been thoroughly soaked, and in each case followed by an effective rain to wash the kerosene more thoroughly into the ground.

A NEW ENEMY TO FIGS IN MEXICO.

Dr. Edward Palmer, when visiting Parras, in the State of Coahuila, Mexico, in the midsummer of 1898, was surprised to notice the destruction of the fig crop by an insect he had not known before to be injurious to that fruit. He saw in the different gardens trees loaded with figs in the various stages of ripening. Under the trees were many which had fallen, and which were dry and hard. Little plant bugs were noticed attacking the fruit as soon as it began to be soft and sweet. They inserted their beaks and sucked until all of the sweet moisture was extracted. The trees were covered with fruit in all stages of destruction, and the dried fruit on the ground showed the end of the whole crop.

The fig was of the blue-black kind, a very prolific bearer, and quite sweet. There were no figs in the market, and the crop in that vicinity was practically destroyed.

Dr. Palmer brought home specimens of the insect, but all were, unfortunately, immature. Mr. O. Heidemann examined them and found that they belonged to a species of Pyrrhocoridæ, coming nearest to *Stenomacra marginella* H. S.

ON THE FOOD HABITS OF THE PAPABOTTE.

Mr. G. H. Ellwanger, Rochester, N. Y., writes us under date of November 25 concerning food habits of the papabotte, which is Creole French for Bartram's sandpiper, a bird somewhat more commonly known as the field, grass, or upland plover, which frequents our pastures and feeds on grasshoppers, crickets, and other insects. According to our correspondent, this bird appears in Louisiana and Texas in large numbers about the middle of July, remaining until the latter part of September. Simultaneously with the advent of a species of "Spanish fly," which also appears in great numbers, and which eats ravenously of various growing things. The papabotte feeds upon this insect and becomes very fat, acquiring a peculiar and very high flavor. But the flesh of the bird as a result of this diet is said to be sometimes poisonous, and also to be highly aphrodisiacal in its effects. A steward of one of the New Orleans clubs is quoted as stating that he found twenty-six of these Spanish flies in the stomach of a dozen birds examined.

As there are upward of a score of common species of Meloidæ, or Spanish flies, better known as blister beetles in portions of Texas, and nearly all of these become periodically very numerous and destructive, it is impossible to specify the insect or insects preferred as a food by this bird.

ON THE INSECTIVOROUS HABITS OF SQUIRRELS.

In writing of the natural enemies of *Catocala mæstosa*, the larvæ of which were observed to be injuring the foliage of pecan at Biloxi, Miss., Mr. James Brodie makes statement under date of June 19 that squirrels destroy these insects. June 28, he says his attention was called by his little girl to squirrels eating these caterpillars. At first he doubted, but watched and saw that it was as the child reported. One of the squirrels was partially tame and took nuts from his hand. A caterpillar was handed to this squirrel and it was eaten. In devouring a caterpillar the squirrel would take it in its paws, pull off the head and throw it away, while the viscera were expelled or drawn out and rejected, only the skin being eaten. Mr. Brodie also stated that the squirrels were fond of fungi. The squirrels observed eating insects were the common gray squirrel and the flying squirrel. One was observed devouring a large longicorn beetle, which was placed near it for the purpose.

INSECT INJURY TO BINDING TWINE.

We have received several complaints of injury by crickets and grasshoppers to binding or binder twine, which we are informed is used for stacking small grain in the field, a remedy or preventive being desired. During May, 1901, Mr. I. D. Sheaffer, Russell, Kans., and Miss Annette Bowman, Moscow, Idaho, wrote in regard to such injury. These are only two of several complaints. In no cases have we received specimens of the insects, nor have we been able to suggest any substance that would kill the insects or deter them from attacking the twine that would not at the same time be dangerous to those handling it. Poisons, of course, could not be used, and sticky substances would also be objectionable, although, of course, they would prevent injury by the insects.

TO RID CATS OF FLEAS.

The following from a New York paper adds something new to our knowledge of the means of ridding domestic animals of fleas. This method would probably be equally effective in ridding small dogs and puppies of fleas.

An excellent way to get rid of fleas is used by a lady in Chicago, who owns some of the best cats in America. She has ready a square of cotton batting and a square of cotton cloth, placing the cat in the center of the batting, which has been laid over the cloth; she rubs strong spirits of camphor quickly into the fur and then gathers the corners of the batting and cloth tight around the neck of the animal. She has a ine comb ready and a dish of hot water, for the pests, who detest the camphor, will n to the head of the cat, and must be combed out and plunged into the scalding water. Hundreds of them, however, will jump from the cat and lodge in the cotton batting, where their scaly feet stick in the cotton so that they can not get away.

When the fleas cease to run out onto the head of the cat she judges that they have deserted the cat. The animal is then let out of the batting bag, and the latter carefully carried to the kitchen and deposited in the stove. The scent of the camphor clings to the cat for some time and acts as a preventive. A whole cattery may be cleaned out in this way.

A NEW REMEDY AGAINST PHYLLOXERA.

Professor Vassiliere, in the Gironde, France, has for several years past met with good success in using calcium carbide against phylloxera.

It is said to be superior for this purpose to bisulphide of carbon, both as to efficiency and absence of danger in handling. The cost also is less and it can be used in any season. It is sufficient to use the residue resulting from the manufacture of carbide of calcium, which is of little value otherwise and which is sold at about $2 for 220 pounds.

For 1 hectare of vineyard land (1 hectare equivalent to 2.471 acres) about 1,100 pounds of carbide are required. The carbide pieces are put into holes in the ground, about 8 inches deep; water is poured in and the hole filled up again. The resulting vapors kill the phylloxera, while the ammonia generated manures the ground. Carbide is at present extensively used in the vineyards of southern France, and experts claim that it is the best remedy against phylloxera.—Richard Guenther, consul-general, Frankfort, Germany, May 28, 1901.

A NOTE ON THE GLASSY-WINGED SHARPSHOOTER.

(*Homalodisca coagulata* Say.)

Mr. W. D. Hunter, special agent of this Division, while at Victoria, Tex., during May, 1901, wrote us on the 29th as follows concerning this insect, specimens of which he sent, and which he stated were feeding upon planted banana trees in great numbers:

These insects feed upon the upper surface of the leaves and seem to prefer the cavity of the midrib, or that immediate vicinity, for their operations. I notice what was to me an interesting habit of these insects. While feeding during the portion of the day when the sun falls hottest upon the leaves of the plant, each one is continually, at intervals of only a few seconds, ejecting drops of liquid apparently from the anal aperture. These drops are large enough to be seen plainly at a distance of 15 feet and are forced out with such vigor that they go often as much as 12 inches in a straight line before beginning to fall. Where there are many of the insects upon a leaf a miniature rainfall is produced. Such a forcible ejection of honeydew, and in the case of insects outside of the Aphididæ or Ceropidæ, seems remarkable to me and may be of interest to you.

ON THE ALLEGED IMMUNITY OF REDWOOD TO ATTACK BY TERMITES.

December 13, 1900, we received a communication through a firm of lumber merchants of San Francisco, Cal., which appears to indicate that the California redwood lumber is immune to the attack of white ants, or termites. Through the firm in question we received a letter from Mr. J. E. Norton, dated December 4, relating to the resistance of this wood to the so-called Manila white ant or Annia. His letter is in substance as follows:

In the latter part of 1898 I secured from a transport a piece of redwood board about 12 inches in length, which was placed beneath a pile of lumber in a yard at Manila. The spot was damp, and various pieces of timber all around showed evidence of the existence of the ant in abundance. This piece lay undisturbed for a period of five or six months, and when examined was found as sound as when put there, not having been attacked by any insects. The Chinaman, owner of the lumber yard, was still doubtful, and undertook to get it eaten by putting it in different places under different conditions, such as on top of pieces already inhabited, between boards, and underneath piles, and finally, after three months, put the sample on exhibition in his office with the following placard: "Madera Colorado de California, no se comen Annai."

The quartermaster's lumber yard had piled for some four or five months a quantity of redwood, which upon my departure in October was still free from ants.

John MacLeod, of Manila, has a room in one of his houses finished in redwood, constructed over fifteen years ago, and to this day three-fourths of the original amount remains still in good condition, one-fourth having been worn out and replaced by other lumber.

THE BRAN-ARSENIC MASH AGAINST GRASSHOPPERS IN TEXAS.

One of our correspondents, Mr. S. D. Harwell, Putnam, Callahan County, Tex., writes as follows in regard to the successful use of bran-arsenic mash as a remedy for grasshoppers in Texas:

We are successfully using arsenic (for grasshoppers) at the following rates: 10 pounds wheat bran, 1½ gallons sorghum molasses, 1 pound arsenic. Make a thick mash, sow broadcast on infected ground, and it will surely kill them. I used 40 pounds last year and made 49 bales cotton. My neighbors did not do anything and entirely lost their crop.

TERMITES IN MEXICO.

We received during August, 1900, from Prof. A. L. Herrera, chief of the commission of parasitology, Condensa 4½, Mexico, D. F., Mexico, specimens of *Calotermes castaneus* Burm., a species widespread and commonly known in Mexico as "Palomilla de San Juan" (St. John's Dove). It is so named from the belief that it puts in its first appearance on St. John's day (June 24). It attacks wood and causes serious injury. Two hundred were collected in one room, attracted by a light placed in a vessel containing water. The insects fell into the latter and were drowned.

AN ENTOMOLOGICAL SERVICE IN MEXICO.

The Mexican Government proposes to start work in economic entomology under official auspices at an early date. Prof. A. L. Herrera, at present zoologist in the Museo Nacional, is to be "jefe efectivo," and Mr. O. W. Barrett is to be first assistant. The first work will be an investigation of the distribution of the Mexican orange worm (*Trypeta ludens*) and the best measures to be used against it.

NOTES FROM CORRESPONDENCE.

Remedies against ants.—Mr. J. B. Blandy, of Funchal, Madeira, writes that the following remedy is used in houses in Funchal against ants: Tartar emetic, 10 grams; white sugar, 100 grams; water, 1,000 grams. Mix the sugar and water well and put on the fire until it boils, then let it cool, add the tartar emetic and dissolve it equally. Set about in tins or other receptacles covered with wire netting for fear of injuring cats or dogs.

Mrs. Conklin, Perris, Cal., writes under date of October 27, 1900, that in her experience an application of corrosive sublimate applied with a brush to the edges, back, sides, and crevices of shelves in what is known as an adobe cool room, vanished ants for an entire season. Nests in gardens were destroyed with bisulphide of carbon, as recommended by this Division in Bulletin No. 4, on household insects, and Circular No. 34.

A troublesome ant.—Mr. John F. Wielandy, a fruit grower of Santa Fe, N. Mex., and an old correspondent of this Division, wrote under date of June 14, 1900, that a red ant, known as *Pogonomyrmex barbatus*, specimens of which were inclosed, was a most pugnacious and ill-natured insect; that its bite was far more painful to many persons than the sting of a bee or hornet. It is locally known as fire ant, and has never been known to foster aphids, as is the case with so many other species of ants.

Migration of the Western willow flea-beetle.—Concerning the flea-beetle, *Disonycha quinquevittata*, of which Mr. Herbert Brown, Yuma, Ariz., wrote some months ago (see Bulletin No. 18, n. s., p. 100), our correspondent writes under date of December 21, 1899, that these beetles were again observed migrating in that year, this time coming down the Gila River and going in the direction of the Colorado. They moved November 3 and 4 in a belt apparently not more than 100 yards wide, and continued doing so during the two days mentioned. When observed they were usually flying about 4 feet above the earth and never more than about 20 feet high.

The grapevine Fidia in Illinois.—Writing May 11, 1900, Mr. J. L. Lampe, jr., Bloomington, McLean County, Ill., states that the grapevine Fidia (*Fidia viticida* Walsh.) in his part of the State had done serious injury to vineyards. Damage was attributed by many growers to the severe winter of 1898 to 1899, which they thought killed the vines, but our correspondent was certain that this was a mistaken idea and that the vineyards were in reality ruined by this beetle, as he had observed conditions closely and had been in correspondence with Mr. F. M. Webster, of the Ohio experiment station. What was left of his once fine vineyard he stated he would experiment on with arsenate of lead, other insecticides seeming to have no effect.

Beetles occurring about smelting works.—October 18, 1900, Mr. Carroll Fowler, of the agricultural experiment station at Berkeley, Cal., sent specimens of the Buprestid beetles, *Melanophila longipes* Say and *M. consputa* Lec., with the accompanying information that they were reported to him to have been collected at Calaveras, Cal., September 2 of that year, in the immediate neighborhood of smelting works. These beetles were said to rest frequently on the hot slag and appeared to delight in the fumes of the smelting works.

A snout-beetle injuring guava in Porto Rico.—Writing July 30, 1900, Mr. J. W. Van Leenhoff sent specimens of the snout beetle *Diaprepes abbreviatus* with the information that they were met with in considerable numbers attacking the young plants of guava grown for shade, and according to report were attacking also young coffee plants. The young plants of guava were eaten bare of their leaves. They were kept in subjection by hand picking, the beetles as fast as caught being placed in a wide-mouthed bottle and afterwards burned.

This beetle is a rather striking species and plainly exotic from its appearance, not being known to occur in the United States. It measures, with the short snout, upward of half an inch in length, is black in color, with pale yellow elytra striped with black, and a yellow spot on each side of the thorax.

Reported injury by the oil beetle, Meloë impressus Kirby.—January 12, 1900, Miss Mary E. Murtfeldt, Kirkwood, Mo., sent a specimen of this species with the statement that it had been received from a correspondent in Missouri, with report that it was "eating wheat and rye to the ground in patches from the size of a dinner plate to that of a table, right through frost and sleet, as though nothing was wrong." The determination of the species is by comparison with specimens in the national collection. When this genus Meloë is given further study it may possibly prove to be a distinct form. Various species of Meloë are known to appear above ground during mild days in winter and early spring, and whenever they appear they usually occur in numbers.

Injury to apple leaves by the caterpillar of Euclea pænulata Clem.—August 15 Mr. H. G. Mitchell sent the beautiful larvæ of this limacodid moth with report that they were destroying the leaves of apple trees at Tuscaloosa, Ala. This insect is a well-known enemy of willow and its occurrence on apple is noteworthy.

Injury by Lygus invitus Say.—June 19, 1901, we received through Mr. E. S. Goff from Mr. W. T. Innis, Ripon, Wis., specimens of *Lygus invitus* Say, a near relative of the tarnished plant-bug (*Lygus pratensis*), with report that this bug was destructive to peaches last season in that vicinity. The bug evidently sucked the juices from the young fruits, causing them to shrivel and perish. This is the first instance of injury by this species with which we are at present acquainted.

The box-elder plant-bug (Leptocoris trivittatus Say) in Iowa.—April 8, 1901, Mr. J. H. Hill, Elkader, Iowa, sent specimens of this bug, with accompanying information that it made its appearance in that vicinity about four years ago, and although apparently harmless it had so increased in numbers as to have become an intolerable nuisance indoors. During warm weather the bugs inhabited the trees, but on the approach of winter they would creep into houses or wherever they could find shelter. At the time of writing, the county court-house resembled a beehive, inside and out.

A European plant-louse introduced in Massachusetts.—June 22, 1900, Mr. Samuel R. Thompson, Globe Village, Worcester County, Mass., wrote from Sturbridge, of the same State, transmitting specimens of twigs of peach infested with *Aphis persicæ* Koch.

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U. S DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY—BULLETIN NO. 31, NEW SERIES.

L. O. HOWARD, Chief of Division.

PROCEEDINGS

OF THE

THIRTEENTH ANNUAL MEETING

OF THE

ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

DIVISION OF ENTOMOLOGY.

Entomologist: L. O. Howard.
First Assistant Entomologist: C. L. Marlatt.
Assistant Entomologists: Th. Pergande, F. H. Chittenden, Nathan Banks.
Investigators: E. A. Schwarz, D. W. Coquillett, W. D. Hunter, C. B. Simpson.
Apiarian: Frank Benton.
Assistants: R. S. Clifton, F. C. Pratt, Aug. Busck, Otto Heidemann, A. N. Caudell, J. Kotinsky.
Artist: Miss L. Sullivan.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., December 3, 1901.

Sir: I have the honor to transmit herewith the manuscript of the Proceedings of the Thirteenth Annual Meeting of the Association of Economic Entomologists, which was held at Denver, Colo., August 23 and 24, 1901. From the fact that the papers presented at the meetings of the Association are always of great economic importance, the Department has hitherto published the secretary's reports as bulletins of this Division; I therefore recommend the publication of the present report as Bulletin No. 31, new series.

Respectfully,

L. O. Howard, *Entomologist.*

Hon. James Wilson,
Secretary of Agriculture.

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THIRTEENTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

MORNING SESSION, FRIDAY, AUGUST 23, 1901.

The Association met in room No. 3, Denver High School Building, Denver, Colo., at 10 a. m. August 23, 1901.

The following members were in attendance at the sessions:

William H. Ashmead, Washington, D. C.; Lawrence Bruner, Lincoln, Nebr.; E. D. Ball, Fort Collins, Colo.; A. N. Caudell, Washington, D. C.; Richard S. Clifton, Washington, D. C.; T. D. A. Cockerell, Mesilla Park, N. Mex.; E. M. Ehrhorn, Mountainview, Cal.; E. P. Felt, Albany, N. Y.; C. P. Gillette, Fort Collins, Colo.; A. D. Hopkins, Morgantown, W. Va.; W. J. Holland, Pittsburg, Pa.; L. O. Howard, Washington, D. C.; W. D. Hunter, Washington, D. C.; Vernon L. Kellogg, Stanford University, Cal.; W. M. Scott, Atlanta, Ga.

The meeting was called to order by President C. P. Gillette, who announced that the absence of Secretary A. L. Quaintance necessitated the election of a temporary secretary. Upon motion of Dr. Howard, W. M. Scott was elected.

After calling Mr. Hopkins to the chair, President Gillette delivered the annual address, which follows:

LIFE HISTORY STUDIES ON THE CODLING MOTH.

By C. P. GILLETTE, *Fort Collins, Colo.*

FELLOW-WORKERS: It is no small honor that you confer upon Colorado in coming for the first time to the Queen City of the West at the beginning of the new century—the Utopian century for all true scientific thought and the highest human development. Never before have you met so far away from the time-honored centers of learning in the East. To-day we are met at the very feet of the Rocky Mountains and in plain view of their eternal snows, which give freshness to our mountain air and unite the waters that feed the two oceans that wash our shores. You have not come in search of health or pleasure, as many do, but in the interest of science, whose one object is to search out the abiding truths of the Creator; and that branch of science which has for its object to make "two spears of grass grow where one grew before." The object is a most worthy one. May our sessions in this place be marked with an unusual degree of harmony and enthusiasm, which shall cause each to return to his field of labor with a new and deeper interest in his work.

In the address which it became my duty to deliver before this association one year ago I took occasion to emphasize the importance of more life-history study and a greater degree of cooperation in our work. As I exhausted my store of good advice at that meeting, and wish to seem to practice what I preach, I have concluded to offer at this time the results of some life-history studies on one of our longest, if not best, known insects—the codling moth. In this work I have received much kindly assistance from members of this Association and others who have answered my questions, and in some cases have put themselves to considerable trouble to collect data and make observations for me in their several localities.

Probably every member of this Association has been disappointed and surprised many times at finding the lack of positive knowledge in regard to certain portions of the life habits of our longest known insect pests. It is not necessary to discover a new insect, friend or enemy, in order to do good original work of the highest value.

The codling moth undoubtedly causes greater annual loss in Colorado than any other insect, unless it be the two-lined locust (*Melanoplus bivittatus*). Our topographical and climatic conditions, with the plains in the east and the mountains in the west, are extremely varied, and there is a popular opinion among many of our orchardists that the habits of the codling moth in Colorado are not to be compared with the habits of the same insect in the Eastern portion of the country. For these reasons, chiefly, my studies of this insect began, one of the main objects being to determine whether or not there are more broods in the warmer portions of the State, where the tenderer fruits are grown, than in the northern parts and in the East. In some ways this report will be one of progress only, as the work is not completed.

A few years ago we were telling orchardists that the codling moth lays its eggs in the calyces of the apples, and we might have been doing so yet had not Washburn corrected us. We were in error, and the fruit growers know it, and have lost confidence to some extent in the correctness of our statements. They do not know but what we are equally liable to be in error in regard to any other matter regarding the life habits of an insect where our statements seem to them doubtful or mysterious. I can not help wondering if some, yes, many of us, have not been equally careless in our statements as to the number of broods of the codling moth in our several States. It is often easier to accept the opinion of another than to verify its correctness. To be a thorough scientist one must be a good doubter, or at least questioner and thinker. Not always gainsaying the statements of others, but always ready to inquire into the basis of belief even of the most stereotyped ideas.

Riley,[1] knowing there existed a difference of opinion as to the number of broods of the codling moth in different portions of the country, made a special study of the insect in Missouri, and announced,

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[1] Third Missouri Rep., p. 103.

in 1872, that "At all events this insect is invariably double-brooded in the latitude of St. Louis," and expressed his doubts of its being single-brooded in New England. The year following Le Baron,[1] in speaking of the codling moth, says, "It is universally double brooded at the West; at least, in all parts of the State of Illinois and farther south." In recent years we have had the number of broods estimated by different entomologists, in various parts of our country, all the way from one to four, with variations in the form of "partial broods" thrown in. In fact it has almost become the custom to announce that in one's locality the codling moth is one-brooded with a partial second, or two-brooded with a partial third, and even three-brooded with a partial fourth. So far as my experience has gone, the insects with which I have had to deal have been very uniform in the number of life cycles through which a species passes during a year, and I recall no instance in my experience where an insect normally possessed an annual or otherwise regular fractional brood, and I am unable to find any published data giving strong evidence of such a brood of the codling moth in this country, except that from Dr. Smith, published in Entomological News (Vol. V, p. 284). Dr. Smith was unable for several years in succession to obtain any moths of the second brood in his breeding cages, though wormy apples continued to appear in the orchards in September and October.

In a recent letter from Dr. Smith he states that there is a partial second brood of the codling moth at New Brunswick, N. J., the larvæ of which attack, chiefly, pears of two varieties—Kieffer and Japan Golden Russet. The fact that at least a partial second brood occurs at New Brunswick makes me wonder if two full broods do not regularly occur under normal conditions in the orchard. It is a point upon which we should have more data both at New Brunswick and in other northern apple-growing districts where it has been supposed less than two annual broods occur. Larimer County, Colorado, is at the northern limit of successful apple-growing within the State, yet the codling moth appears to have been regularly two-brooded there during our studies upon its life history for the past three years at least, and I have been able to find no adequate evidence of even a partial additional brood in the warmer valleys in the mountainous districts, where peaches, apricots, nectarines, and the tender varieties of California grapes are grown to perfection. In breeding large numbers of insects of any species it is not surprising to obtain an occasional individual out of season. We have had a very few such instances in rearing many hundreds of the codling moth, but not enough to designate them as a partial brood. For example, three larvæ appeared in our cages before July 15, that remained larvæ over winter. I considered these mere stragglers that in some manner had been prevented from undergoing their life cycle in a normal manner.

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[1] Third Rep. State Entomologist of Ill., p. 172.

That there is probable error in some of the announcements as to the number of broods of this insect is further evidenced in the fact that I have received opinions of entomologists of equally good standing in which they estimate the number of life cycles differently by two broods in the same locality. Both can not be correct.

Again, if the codling moth is partial-brooded in a locality, it seems improbable that we should find it uniformly passing the winter in the larval state, yet all authorities seem to agree that such is the case.

HOW TO DETERMINE THE NUMBER OF BROODS.

It is not a simple problem to determine the number of broods of the codling moth where there are more than one. As the insect always winters as a larva, it must be double brooded, at least, if all the larvæ of the first brood of worms feeding in the fruit change to the pupa state soon after leaving the apples. Care should be taken to obtain first-brood larvæ, however, and if they do not change in breeding cages, bands should be left upon the trees for two weeks at least, and then the cocoons opened to see if any contain pupæ. If a good number of larvæ are obtained and none transform under natural conditions, it is fair to conclude that the insect is single brooded in that place. According to my experience the first-brood larvæ will continue to appear for fully one month before those of the second brood will begin to arrive.

The time occupied by the codling moth in passing through its complete round of development during the summer will average about seven weeks. Then if we know when the first larvæ appear in the spring and when the latest ones cease to appear in the fall in a given locality, it will be a very simple mathematical computation to determine a theoretical number of broods for the season, but it will be no evidence whatever that such a number exists, unless we know that all the eggs of a brood are deposited at one time and that all the individuals of the brood run their course at the same rate. We know these conditions never occur in case of the codling moth. The problem we have to solve is one in which many runners are to cover a circular course one or more times; they run at widely varying speeds, and some of the earliest to start will go around once before the late individuals make their start. We suppose all are to cover the course the same number of times, and we are to find that number and also learn whether the number is the same for all. Then what must we know in order to determine our unknown quantities? We must know the beginning and the end of the period during which the insect starts upon its various rounds of development, and we must know the range of time in completing that cycle; then we must know whether those that complete one circuit start upon the next. If one starts upon the course, it goes completely around—at least we know no exceptions to the rule. Then if the data gathered is sufficient to explain the entire occurrence of the insect for the year, we have no occasion to introduce partial broods. In fact I think their existence should only be announced upon the most positive evidence.

While the data that I have to offer in this address bear chiefly upon the matter of broods of the codling moth, I have not confined myself to that feature of its life history, and shall give such records and observations as I think may be of interest from our studies of this insect.

SPRING BROOD OF LARVÆ AND PUPÆ.

In our early spring studies of this insect we have always found it as a larva in all portions of Colorado. It begins to pupate freely just prior to the blooming of the apple trees, at which time, also, the earliest moths may be taken. The date of pupation varies greatly. Those upon the south side of trees pupate earlier than those upon the north, while others going into the earth about the base of the tree (which many do) or deep into some checked trunk or rotten stump change still later. The time spent in the pupa state by this brood has varied with us from 13 to 68 days, and the time has been as long in the Grand Valley as at Fort Collins.

April 23 of the present year the writer took 285 larvæ and 7 pupæ of the codling moth under bands in an orchard at Fort Collins. May 10, when the early trees were in bloom, he took 33 larvæ and 4 pupæ. From the latter date pupation took place much more rapidly.

SPRING MIGRATIONS OF THE LARVÆ.

I think it was in the spring of 1899 that I was told that a man living near Grand Junction had put bands upon his apple trees in February, and taken many larvæ of the codling moth under them. The following spring I requested parties in Rockyford, Grand Junction, Canon City, Edgewater, and Fort Collins to place at least 10 bands upon trees early in spring, to be examined weekly and report results. From all these bands but 6 larvæ were taken. The past spring I was in Grand Junction when Mr. Silmon Smith was removing bands to catch the migrating larvæ (May 8), and he reported 53 worms from 295 bands remaining on two weeks. I also addressed a letter to Mr. W. H. Barber, of Grand Junction, who it was said had been very successful in taking the larvæ, and he reported taking 307 larvæ April 2 and 409 April 17 from 2,500 bands. So there is a small percentage of the larvæ that seek a new place for pupation in the spring, but the number is usually so small that it seems doubtful if it will often be a matter of economy to attempt to capture them under bands. I can not vouch for the identification of larvæ in the last instance, but if they were all of the codling moth, working the bands must have paid well.

SPRING BROOD OF MOTHS.

At Fort Collins moths have been captured out of doors as early as April 26, long before apple trees were in bloom. Our earliest records for other portions of the State are as follows: Grand Junction, May 7; Canon City, May 5; Rockyford, May 10.

Moths from larvæ brought into the laboratory during April and May have continued to appear in good numbers to June 23 at Fort Collins, and moths have continued to appear in cellar breeding cages to July 24. The early larvæ and pupæ taken at Grand Junction by Mr. Silmon Smith continued to give moths till June 1, those taken at Canon City by Dr. Peare gave moths till June 24, and those taken at Rockyford by Mr. H. H. Griffin emerged till June 8. In none of these cases was any special attempt made to get the latest appearing moths for the locality. The extreme range in time of appearance of the first brood moths in our cages at Fort Collins in 1900 was 69 days.

The following table, giving the dates at which the codling moth appears in its different stages in different parts of Colorado and in some other States, may be of interest for comparison, although there are many blanks that can not be filled at present:

TABLE I.—*Dates of transformations of the codling moth in different places.*

Locality.	Moths of first brood, date of emergence.	Eggs of first brood.		Larvæ of first brood.	
		First.	Most common.	First.	Most common.
Mesilla Park, N. Mex	Apr. 24	May 4		May 31	
Grand Junction, Colo	May 7	May 18		June 5	July 5
Rockyford, Colo	May 10			June 15	do
Canon City, Colo	May 5			do	
Corvallis, Oreg	May 16	June 20			
New Brunswick, N. J				July 20	
Morgantown, W. Va				June 27	
Ithaca, N. Y	May 3	June 26		July 1	
Lincoln, Nebr	May —	June 3		June 20	
Denver, Colo				July 3	July 21
Fort Collins, Colo	May 5	June 9	July 3	June 28	July 25
St. Louis, Mo	May 7			June 23	July 8
Northern Illinois	May 12				

Locality.	Moths of second brood.		Eggs of second brood most abundant.	Larvæ of second brood.		Authority.
	First.	Last.		First.	Most common.	
Mesilla Park, N. Mex	June 26					T. D. A. Cockerell.
Grand Junction, Colo	June 28	Sept. 12		July 23	Aug. 15	Silmon Smith.
Rockyford, Colo	July 5	Sept. 15		Aug. 6	Aug. 20	H. H. Griffin.
Canon City, Colo	[1] July 15	Sept. 10		Aug. 1		R. J. Peare.
Corvallis, Oreg	Aug. 1	Sept. 15				F. L. Washburn and A. B. Cordley.
New Brunswick, N. J						J. B. Smith.
Morgantown, W. Va						A. D. Hopkins.
Ithaca, N. Y						M. V. Slingerland.
Lincoln, Nebr	July 2					F. W. Card.
Denver, Colo					Sept. 5	David Brothers.
Fort Collins, Colo	July 13	Sept. 13	Aug. 12	Aug. 3	Sept. 12	C. P. Gillette.
St. Louis, Mo	[2] July 8			Aug. —		C. V. Riley.[3]
Northern Illinois	July 15					W. Le Baron.

[1] On or before. [2] Estimated by writer. [3] First Missouri report.

DURATION OF SPRING BROOD OF MOTHS.

Of the 12 males kept in breeding cages 2 died on the second day, 3 upon the third, 1 on the fourth, 2 on the fifth, 3 on the sixth, and 1 on the seventh; an average of a trifle over 4 days. Of 7 females 1 died on the sixth day, 3 on the seventh, 2 on the ninth, and 1 on the thirteenth; an average of a little over 8 days. Fully half of the females in breeding cages did not lay eggs at all.

SPRING BROOD OF EGGS.

The starting point of the first brood can better be taken at egg laying than from the appearance of the moths. The moths that appear very early are compelled to wait for oviposition until apples are ready to receive their eggs. The earliest that eggs have been observed at Fort Collins was June 9, 1900. This year they were not found until June 19. They became increasingly abundant until they reached their maximum about July 3, and by July 21 it was almost impossible to find an unhatched egg. By July 27 a noticeable increase had started again, marking the beginning of the second brood.

Professor Cockerell records eggs as early as May 4 at Mesilla Park, N. Mex. At Grand Junction, Colo., I found them in small numbers May 25, 1900, and estimated that they might have occurred as early as the 18th of the month. Slingerland records them on May 26 at Ithaca, N. Y., and Card gives June 3 as the earliest date known to him for the appearance of the eggs in Nebraska. One is not liable to discover the first eggs laid by the codling moth, so it is likely that any of the above dates may be too late for the earliest eggs, and the dates in a given locality will vary in different seasons with the date of the blooming of the apple trees. This is so important a date to have from which to work in studying the life history of the codling moth that I offer the following table, giving the dates at which apple trees bloom in different portions of the country. It is chiefly compiled from answers to letters which I have sent out.

TABLE II.—*Dates at which apple trees bloom in different localities.*

Locality.	Date of bloom.	Informant.
Reno, Nev	Mar. 20–Apr. 10	R. Lewers.
Corvallis, Oreg	Mar. 25–Apr. 5	A. B. Cordley.
Urbana, Ill	Apr. 10	J. C. Blair.
Grand Junction, Colo	Apr. 15–27	C. P. Gillette.
Southern New Jersey	Apr. 20	J. B. Smith.
Columbia, Mo	Apr. 20–May 5	J. M. Stedman.
Blacksburg, Va	Apr. 20–30	J. L. Phillips.
Lafayette, Ind	Apr. 20	J. Troop.
Lincoln, Nebr	Apr. 27–May 2	Lawrence Bruner.
Rockyford, Colo	Apr. 28	H. H. Griffin.
College Park, Md	Apr. 30	W. G. Johnson.
Bozeman, Mont	May 1–5	R. A. Cooley.
Morgantown, W. Va	May 1–10	A. D. Hopkins.
Cornell, N. Y	May 1–10	M. V. Slingerland.
Geneva, N. Y	May 4–17	V. H. Lowe.
Fort Collins, Colo	May 5–15	C. P. Gillette.
Wooster, Ohio	May 8–10	F. M. Webster.
Canon City, Colo.[1]	May 10	R. J. Peare.
Lansing, Mich	May 10–12	L. R. Taft.
Ottawa, Canada	May 10–15	J. Fletcher.
Moscow, Idaho	May 10–15	J. M. Aldrich.
Burlington, Vt	May 15	G. H. Perkins.
Madison, Wis	May 15	E. S. Goff.
Orono, Me	May 20	W. M. Munson.

[1] Evidently a late season.

The time elapsing between the emergence of the moth and the deposition of eggs in the cages has varied between 1 and 9 days, with an average of 6.7 days.

The number of eggs laid in confinement has varied between 2 and 50, and nearly every one has hatched except where males were not confined with the female. Of 65 eggs inclosed in paper sacks upon the trees only 2 failed to hatch. Nearly all the eggs seem to be fertile at Fort Collins, but at the same time there are many more eggshells to be found upon the apples than worm holes in them, which would indicate a large mortality among the small worms. In our counts we have found nearly 90 per cent of these eggs upon the free surface of the apples and the remainder upon the leaves.

CHANGES IN THE EGG DURING INCUBATION.

When the egg is first laid it is of a pearly white color. Later there appears upon it a faint red ring, marking the position of the forming embryo. A day later this ring becomes more distinct and later disappears, and in its stead there is a dark central spot, produced by the black head and cervical shield of the embryo. When the larva leaves the egg the remaining shell appears like a fresh egg, except that it is very flat and along one side the slit from which the larva made its exit can usually be seen. Notes by an assistant, Mr. E. P. Taylor, upon 57 freshly laid eggs show that the red ring appears upon the second or third day after the egg is laid, the disappearance of the ring and the appearance of the dark spot 2 to 3 days later, and the hatching of the egg on the first or second day after the appearance of the dark spot. These eggs were deposited in the breeding cages. Eggs observed in the orchard required about 1 day more to hatch, probably on account of the lower temperature during night, making the average incubation period 7 and a fraction days. Riley gave this period as from 4 to 10 days, Washburn as 5 to 10 days, and Slingerland as about a week. We have found the time to vary between 6 and 8 days in the laboratory where the temperature ranged between 68° during the night and 75° during the middle of the day. For eggs kept in a greenhouse where the temperature ran to 110° during the middle of the day, the hatching period was 6 days. The records of the hatching of eggs in these two rooms is as follows:

TABLE III.—*Comparison of egg-hatching records in a cool and a hot room.*

	Cool room; temperature, between 68° and 75° F.	Hot room in greenhouse; temperature, 110° at midday.
Number of eggs	15	15.
Eggs laid	Aug. 11 (night)	Aug. 11 (night).
Distinct red ring	Aug. 14	Aug. 14.
Dark center	Aug. 17	Aug. 16.
Hatched	Aug. 18 (morning)	Aug. 17 (evening).

Eleven eggs hatched in each of the above lots, the difference in time being from evening one day to morning of the next. The time in the greenhouse was 6 days and in the cool room 6½ days. The eggs were all laid in a breeding cage upon one apple on the night of August 11.

It would seem from this test that if the temperature of the egg is kept above 68° an increase of temperature will not greatly hasten development.

SUMMER BROOD OF LARVÆ.

Our observations upon the very early larval habits have not differed materially from those made by Card and Slingerland, except that we have not found any indications of their feeding upon the surface of the leaves. The earliest that we have ever taken larvæ of this brood at Fort Collins has been June 28. This year the first capture under bands was July 1. The earliest record at Grand Junction is June 5, and at Rockyford and Canon City June 15; the earliest at Denver July 3. Professor Card's record for earliest larvæ of summer brood at Lincoln, Nebr., was June 20, and Professor Slingerland's for Ithaca, N. Y., was July 1. Dr. Smith wrote me July 20 of this year that the codling moth larvæ were just beginning to descend for pupation at New Brunswick, N. J., and Dr. Hopkins, of Morgantown, W. Va., recently wrote that the larvæ were just beginning to descend there on June 20. Professor Cockerell, in 1897, at Mesilla Park, N. Mex., found larvæ of this brood descending May 31. This is the earliest record known to me. If there are four broods of this insect anywhere in the United States, I am sure it should be at Mesilla Park.

The earliest that we have taken larvæ of the second brood at Fort Collins is August 3. In each of these localities the number of larvæ which will live over winter as such increases rapidly in a few days after the above dates. At Grand Junction pupation practically ceases by August 10, at Rockyford by August 20, at Canon City by August 21, and at Fort Collins by August 30 (see Table IV).

TABLE IV.—*Table showing proportions of larvæ, taken at different dates, that live over winter before pupating.*

Locality.	Dates larvæ were taken.	Number taken.	Number hibernating.	Record by—
Grand Junction, Colo	July 16–23, 1900	33	1	Silmon Smith.
	July 24–30, 1900	53	3	
	July 31–Aug. 6, 1900	60	8	
	Aug. 6–13, 1900	------	------	
	Aug. 13–20, 1900	79	78	
	Aug. 21–29, 1900	130	130	
	Aug. 30–Sept. 4, 1900	192	192	
Rockyford, Colo	Aug. 1–6, 1900	22	5	H. H. Griffin.
	Aug. 7–11, 1900	14	4	
	Aug. 12–14, 1900	51	14	
	Aug. 15–21, 1900	66	56	
	Aug. 22–28, 1900	115	115	
	Aug. 29–Sept. 6, 1900	80	80	
Canon City, Colo	July 30, 1899	25	0	Dr. R. J. Peare.
	Aug. 1–13, 1899	70	30	
	Aug. 14–20, 1899	50	44	
	Aug. 21–28, 1899	100	99	

Mr. David Brothers, of Edgewater, near Denver, published the record of his captures of codling moth larvæ in his orchard during the summer of 1900 in a Denver daily about January 15, 1901. I have a clipping only, and do not know the exact date that it was published, nor the paper in which it appeared. The record is as follows:

TABLE V.—*Larvæ taken under bands by David Brothers, Edgewater, Colo.*

Bands removed.	Worms taken.	Average per day.
July 4-6	200	
July 15-17	997	90
August 2-3	747	42
August 12-14	213	21
August 22-24	602	60
September 4-6	2,225	171
September, last week	2,315	*a* 88

a Approximately.

The following record, kept by an assistant, Mr. Titus, at Fort Collins last year, gives approximately the same dates at which the two broods of larvæ reach their maximum and minimum numbers. The dates run a little later at Fort Collins, which is the more northern point. The larvæ were taken twice a week by Mr. Titus, so some of the periods are 3 and some 4 days.

TABLE VI.—*Records of codling moth larvæ taken under bands.*

[Eleven trees in Harris orchard, Fort Collins, Colo., 1900.]

Tree.	July.			August.								September.									October.		
	25	28	31	4	7	11	15	18	22	25	28	1	5	8	12	15	18	22	29	4	7	13
10	1	1	0	1	0	0	1	0	0	1	1	0	3	9	17	4	4	4	5	4	1	6
13	0	0	0	0	7	0	1	0	0	0	0	0	5	12	20	2	6	4	9	5	1	4
14	16	0	1	0	0	1	0	0	0	0	0	3	5	5	19	10	6	4	8	4	0	3
17	9	11	0	8	0	0	0	0	0	1	1	6	15	8	28	8	9	6	9	7	1	0
18	2	0	0	4	0	0	0	0	0	0	0	0	10	20	19	6	12	8	9	5	1	0
19	3	0	0	1	0	0	0	0	0	0	0	8	9	9	21	14	12	6	2	9	0	2
20	1	0	0	8	6	0	0	0	0	0	1	0	6	5	10	4	4	2	12	3	1	0
21	1	3	0	4	0	0	0	1	0	0	0	4	13	11	4	0	4	6	4	1	4	6
22	0	1	0	0	0	0	0	0	0	0	7	9	24	14	28	5	8	4	14	12	3	5
23	6	0	0	9	0	0	0	0	0	0	0	0	2	1	3	0	5	5	9	9	2	6
24	0	0	0	4	0	0	0	0	0	1	0	0	6	8	7	5	5	4	13	0	2	0
	38	16	1	39	13	1	2	1	0	3	10	30	98	102	176	58	75	53	94	59	16	26

The first brood had reached its maximum when the bands were removed the first time, July 25. The great number of ciphers between August 11 and 22 indicate the division between the broods. The second maximum came September 12, and then the numbers diminished rather slowly for the next two weeks.

Another record kept the same year on a tree growing in the college lawn at Fort Collins gave a similar record, though the first maximum came a few days later. The record is as follows:

TABLE VII.—*Codling moth larvæ from bands on tree in college lawn.*

	June.	July.				August.				September.				
	29	7	14	21	28	4	11	18	25	1	8	15	22	29
Larvæ	2	1	10	8	14	24	18	115	84	87	216	464	390	38

The total number of larvæ taken under the one burlap band upon the above tree growing in closely cut grass ground was 1,481. We did not take so large a proportion of the larvæ from any tree growing upon well cultivated ground.

WHEN THE LARVÆ COME DOWN.

To determine what proportion of the larvæ leave the fruit during the bright daylight and what proportion at night to go in search of a place to spin up, I bandaged a tree that I passed each morning and evening and removed the larvæ at about 7.30 a. m. and 6 p. m. from August 15 to 26. There were 414 larvæ taken, 353, or 85 per cent, of which came to the band during the night, and 61, or 15 per cent, during the day, between the hours mentioned.

DURATION OF LARVAL PERIOD.

Dr. Riley[1] gave this period as 25 to 30 days outside the cocoon, Washburn[2] as about 4 weeks, Card[3] as apparently 10 to 14 days, and Slingerland[4] estimated the time at 20 to 30 days. In our records the time has varied between 12 and 24 days, with an average of 19, at Fort Collins.

WHERE THE LARVA ENTERS THE APPLE.

Unsprayed trees should be chosen to determine this point. There is also danger of error if the examination of the apple is superficial, as I have found that the larva often enters at the calyx, leaving no castings in sight, and then burrows out at the side some distance away, the latter burrow being kept open, but not the former. An examination of 526 apples wormy by the first brood gave the following results: Two hundred and sixty-seven apples were wormy at the blossom only, 18 at the stem only, 84 at the side only, and 157 had wormholes at the blossom and also at some other place. Adding this last number to the first, we have 424 out of 526 apples, or 80 per cent, with wormholes at the blossom end. The apples counted were of three varieties of crabs.

DURATION OF COCOON STAGE OF FIRST SUMMER BROOD.

The period elapsing from the time the larva leaves the apple or appears under a band to the time the moth emerges I have designated as the cocoon stage. The time elapsing before changing to the chrysalis Riley[5] found to be 3 days. During the present summer (1901) Mr. Taylor has carried through observations for me upon 76 larvæ which transformed to moths, for the purpose of determining the average time

[1] Fourth Mo. Rep., p. 22.
[2] Bul. 25, Or. Exp. Sta., p. 5.
[3] Bul. 51, Nebr. Exp. Sta., p. 22.
[4] Bul. 142, Cornell Exp. Sta., p. 23.
[5] Fourth Mo. Rep., p. 22.

of the entire cocoon stage, and he obtained the following results: The shortest time was 13 days, the longest time 23 days, and the average time 16.75 days.

Observations made for me by Mr. Titus in 1900 for the purpose of determining the entire cocoon stage and also the duration of its two periods—as larva and as pupa—gave results which I have tabulated below. His averages for the entire period are somewhat larger than those obtained by Mr. Taylor. It may be partially due to the fact that he was compelled to open the cocoons daily before pupation to determine their condition. This, however, should not affect the pupa stage.

TABLE VIII.—*Time spent by codling moth from beginning of spinning stage to appearance of moth, Fort Collins, Colo., 1900.*

Larvæ taken.	Larvæ pupated.	Moth appeared.	Number.	Total time.	Larvæ taken.	Larvæ pupated.	Moth appeared.	Number.	Total time.
				Days.					*Days.*
July 2	Aug. 3	July 16	1	14	July 8	July 14	July 31	1	23
Do	July 4	July 18	1	16	July 9	July 15	do	1	22
Do	July 6	July 16	2	14	Do	July 16	do	1	22
Do	do	July 22	1	20	July 10	July 14	do	1	21
Do	July 9	July 24	1	22	July 11	July 18	July 30	4	19
July 3	July 6	July 18	4	15	Do	do	July 31	3	20
Do	do	July 20	4	17	Do	do	Aug. 2	3	22
Do	do	July 21	1	18	Do	do	Aug. 1	4	21
Do	July 8	July 22	2	19	Do	July 19	Aug. 2	2	22
Do	do	July 23	1	20	Do	do	Aug. 3	2	23
Do	July 9	July 24	1	21	Do	do	Aug. 4	4	24
July 4	do	July 20	2	16	July 12	July 16	July 30	1	18
Do	do	July 21	5	17	Do	do	July 31	1	19
Do	July 8	July 23	1	19	Do	July 17	Aug. 3	2	22
July 5	do	July 21	1	16	Do	July 19	Aug. 4	1	23
Do	July 9	July 22	1	17	Do	do	Aug. 6	1	25
Do	July 10	July 23	1	18	Do	July 20	Aug. 4	1	23
Do	July 9	do	1	18	Do	do	Aug. 10	1	29
Do	July 10	July 22	1	17	Do	do	do	1	29
July 6	do	July 24	5	18	Aug. 11	Aug. 13	Aug. 30	3	19
Do	July 12	do	3	18	Aug. 13	Aug. 18	Aug. 31	1	18
Do	July 13	July 25	6	19	Do	Aug. 17	Sept. 5	2	23
Do	do	July 26	2	20	Do	do	Sept. 6	1	24
Do	do	July 27	4	21	Aug. 18	Aug. 24	do	1	19
Do	July 14	July 30	3	24	Do	Sept. 6	Sept. 16	1	29
Do	July 18	July 31	2	25	Sept. 4	do	do	1	12
July 8	July 12	July 30	2	22					

The time required for pupation, according to the above record, after the larva comes down from the tree, was, for 1 larva, 1 day; for 6 larvæ, 2 days; for 10 larvæ, 3 days; for 18 larvæ, 4 days; for 15 larvæ, 5 days; for 7 larvæ, 6 days; for 31 larvæ, 7 days; for 14 larvæ, 8 days; for 1 larva, 12 days; for 1 larva, 19 days. The average time was 5.6 days and the range in time from 1 to 19 days. Number of larvæ in the record, 104.

The time spent in the pupa state by the same larvæ was as follows: Four were pupæ 10 days; 2 were pupæ 11 days; 23 were pupæ 12 days; 13 were pupæ 13 days; 24 were pupæ 14 days; 13 were pupæ 15 days; 10 were pupæ 16 days; 7 were pupæ 17 days; 3 were pupæ 18 days; 2 were pupæ 19 days; 1 was pupa 20 days, and 2 were pupæ 21 days. The shortest time in the pupa state was 10 days and the longest time 21 days. The average time was 14 days.

If we combine the stages above given and call the two the cocoon stage, we shall have a record as follows: One moth appeared in 12 days; 3 in 14 days; 4 in 15 days; 4 in 16 days; 11 in 17 days; 13 in 18 days; 18 in 19 days; 7 in 20 days; 10 in 21 days; 12 in 22 days; 7 in 23 days; 8 in 24 days; 3 in 25 days, and 3 in 29 days. This makes the shortest time in the cocoon stage 12 days and the longest time 29 days, and the average 20 days.

Hatching records kept for me by Mr. H. H. Griffin, at Rockyford, and at Grand Junction by Silmon Smith, indicate that the duration of the cocoon stage in those localities is practically the same as at Fort Collins. Riley[1] gives the entire cocoon stage as 15 to 21 days, Washburn[2] as three weeks, and Slingerland[3] as two or three weeks. Aldrich[4] gives the time as a week or more, but greatly dependent upon temperature.

THE SECOND BROOD OF MOTHS.

The time of appearance of the earliest of the second-brood moths is easily determined by hatching them from the earliest wormy apples of the summer. Riley gave this date for the latitude of St. Louis, Mo., as July 8; Le Baron gave it for northern Illinois as July 15; Card, for Lincoln, Nebr., as July 2; Cockerell, for Mesilla Park, N. Mex., as June 26, and Professor Cordley has written me that for Corvallis, Oreg., he finds it to be about August 1. At Fort Collins the earliest bred moth of this brood appeared July 13; at Canyon City, Dr. Peare reports to me that he bred a moth July 15; at Rockyford, Colo., Mr. Griffin obtained the first moth July 5, and at Grand Junction, Mr. Smith obtained a moth on June 28.

The following records for the very latest moths appearing of this brood (or some later brood, as the case may be) are of interest in this connection. The latest moth to appear in breeding cages at Fort Collins came out September 16; the latest at Canyon City, September 10; at Rockyford, September 15, and at Grand Junction, September 12. These are all belated individuals, and all appeared after the general disappearance of the brood. (See Table IV, giving proportions of larvæ that live over winter from different dates.)

THE SECOND BROOD OF EGGS.

I know of no definite published records upon the second brood of eggs. At Fort Collins, this year, this brood seemed to begin its appearance about July 24, and they were most abundant about August 12. The two broods doubtless overlap, but at Fort Collins this year it was almost impossible to find eggs at all from the 20th to the 23d of July,

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[1] Fourth Mo. Rep., p. 22.

[2] Bul. 25, Or. Exp. Sta., p. 5.

[3] Bul. 142, Cornell Exp. Sta., p. 27.

[4] Bul. 21, Id. Exp. Sta., p. 101.

and then they began slowly to increase in numbers again. As the first eggs of this year were found June 19, this makes the time between broods about 54 days. On August 20 it was difficult again to find many unhatched eggs.

SECOND BROOD OF LARVÆ.

The earliest that we have taken mature larvæ of this brood at Fort Collins is August 3; at Canon City, August 1; at Rockyford, August 6, and at Grand Junction, July 23, as determined by the dates at which we have first obtained larvæ that did not pupate till spring. (See Table I.) Immediately following these dates the number of such larvæ rapidly increases until none are found except those which remain in the larval state till spring. These last dates, in all our observations, have been taken to mark the close of the appearance of the first larval brood. The dates we have are, for Grand Junction, August 13; for Rockyford, August 20; for Canon City, August 21, and for Fort Collins, August 30. (See Table IV.)

According to our observations this brood passes the winter entirely as larvæ, and begin active pupation at about the time the apple trees begin to bloom.

The pupa stage of this brood usually lasts much longer than that of the summer brood. We have often had pupæ remain 30 or 40 days before the moths emerged, and a considerable longer period has not been very unusual. The longest spring pupal stage that we have recorded is 68 days, March 7 to May 14, at Grand Junction.

THE NUMBER OF BROODS.

While the above data may be weak at some points, I believe it is fairly safe to announce that the codling moth is definitely two-brooded throughout Colorado, with no adequate reasons for postulating a partial brood to account for the belated larvæ that have fallen behind the majority in the race. Let us see if the data we have presented bear out the conclusions.

According to our records the entire life history of the summer brood is divided into periods about as follows: From egg to larva, 7 days; from larva to cocoon stage, 19 days; cocoon stage to emergence of moth, 18 days; emerging of moth to middle of egg-laying stage, 5 days (estimated)—a total of 49 days, or just 7 weeks.

The first larvæ matured in the apples last year at Fort Collins July 3, and we began taking larvæ that lived over winter August 12—just 40 days after. At Canon City Dr. Peare took the first larva June 15, and the first larva that did not pupate was taken 47 days later—August 1. Mr. Griffin, at Rockyford, took the first larva of the summer brood June 15, and the first that lived over winter without changing, 52 days afterwards, August 6. Mr. Smith, at Grand Junction, took the first mature larva last year June 10, and the first to live over winter without pupating, 43 days afterwards, July 23. As the time in each of these localities approximates the time required for the entire life cycle, according to our records, and as the number of larvæ not transforming until spring rapidly increased from the dates given for the first captured, so that within 20 days thereafter all were of this winter brood, it seems certain that there could not be a third brood in any of the localities mentioned, as there is not room for them. A partial brood from the early maturing second brood could be granted if necessary. Now, if we could find the first brood of larvæ extending late enough to account for the last larvæ that pupate, we should have no need whatever to suppose a partial third brood. This we can not quite accomplish from the data at hand, but we can so nearly cover the period that the few days remaining, in which only scattering specimens are taken that pupate, would, in my estimation, easily be covered by the few individuals that have taken a longer time for development than our breeding records will show, as it is practically impossible in a few breeding experiments to include the extremes of a brood.

In our records larvæ taken from the orchard late in April and transferred to a moderately cool cellar continued to give moths to July 24. This would easily account for eggs to August 4. As the first eggs were found at Fort Collins the same year, June 9, we have the egg-laying period extended over 56 days.

As the first larvæ were taken under bands at Grand Junction in 1900, on June 10, and the last larvæ pupating were taken August 12, these two dates mark the extremes of the brood, provided there is no partial brood. It exceeds the time our records indicate for it by 7 days. The time is so nearly provided for that it seems that a partial brood can only be allowed when proven to exist by actually carrying the insect through the three generations in breeding cages. So while we can not say positively that there is not a partial third brood at Grand Junction, or even Rockyford or Canon City, our records do not prove it, and the writer is strongly inclined to the opinion that it does not exist. A complete third brood can not be accounted for at all. When Mr. Brothers, near Denver, last year collected 2,223 larvæ and only 2 pupæ under bands that had been on the trees since August 24—13 days—he proved very conclusively that only stragglers of the first brood were remaining at that date.

I have not yet received sufficient data to state what the conditions may be in other States. Professor Cordley has recently written me that at Corvallis, Oreg., he has not been able in four years to rear a codling moth later than September 15, and he gives June 20 as the date of the first eggs upon apples that he has been able to find. This makes the period for the broods at Corvallis even shorter than at Fort Collins. He also states that his records "indicate two broods, and two only," at Corvallis. Prof. W. M. Munson, of Orono, Me., also writes under date of August 17, that "some wormy apples placed in boxes August 1 are now yielding pupæ." So there is at least a partial second brood in Maine.

I might deduce further evidence to support the opinions expressed as to the number of broods, but I have already tired you with a long address and many records and deductions drawn from them. The data referred to are included in the present paper. You may study them at your leisure and draw your own conclusions. I only hope that at no distant time we may be able to make definite statements without much guesswork as to the number of broods of this important orchard pest wherever it occurs in this country, and that the observations here reported may assist to that end.

On motion of Dr. Howard, Professor Gillette was voted the thanks of the Association for his excellent address.

A general discussion of the address followed.

Mr. Ball thought that much could be gained from this paper as a lesson upon the magnitude of a complete life-history study, and made a general suggestion that the life history of a closely allied species, living under natural conditions, could often be used as a check to the work on that of an economic species. As an illustration, he cited the case of the chinch bug and the false chinch bug, which have been variously reported as from one to four-brooded, while closely allied species occurring under natural conditions can be easily determined to be definitely two-brooded.

Mr. Howard said the paper was an education upon life-history work, but suggested that the statement that the insect was only double-brooded in the South as well as the North was somewhat startling, and that he was not at all disposed to accept it without further evidence.

Mr. Scott stated that he had done very little work on this insect, but from his general notes it appeared to be three-brooded in Georgia.

Mr. Cockerell thought that the greatest damage was done to September apples, while fruit maturing in June was not materially damaged. It was almost impossible to grow apples in southern Mexico, while the insect did not occur in Arizona.

Mr. Hopkins thought that the moth would be governed by the same phenological law as that which governed the periodical phenomena of plants and other insects—that is (as determined by him in West Virginia), an average difference of about 1 day for each one-fourth degree of latitude and about the same difference for each 100 feet in altitude.

The results of observations made by him in June and July, 1901, is compared with the calculated normals for first appearance of larvæ from apples in West Virginia, as follows:

Locality.	Date of observation and result.	Latitude.		Altitude.	Calculated normal dates.
		°	′	*Feet.*	
Morgantown	July 3, a few had emerged	39	45	1,000	July 1 (estimated base).
Gerrardstown	June 27, a few had emerged	39	30	400	June 24.
Elkins	July 9, a few had emerged	38	45	2,000	July 7.
Leebell	July 10, first emerging	38	40	2,200	July 9.
Huttonsville	July 11, a few had emerged	38	45	2,100	July 8.
Near Huttonsville.	July 11, none had emerged	38	45	2,600	July 13.

Matured larvæ collected at Morgantown on July 3 produced moths on July 16–17. Matured larvæ collected at Elkins July 9 produced one moth on August 9. Therefore he thought that at low southern sections in his State the moth might be two-brooded, while at high northern sections (Canadian zone) a second brood would rarely, if ever, occur. He also was inclined to believe in the three-brooded theory for the South.

Mr. Gillette suggested that it would be interesting for Dr. Hopkins to determine the number of broods of the codling moth in high altitudes as compared with low altitudes in his State.

Mr. Gillette had found it impossible to determine the number of broods with certainty without actually breeding the moths.

Mr. Ball stated that it took an apple a definite length of time to reach maturity and, in his opinion, this would determine the number of broods. The period of development of the fruit being the same North and South, it follows, in his opinion, that the number of broods would be the same.

Mr. Felt, in speaking of the variability of broods, cited the elm-leaf beetle, which has one large brood, with a second brood when the foliage is sufficiently fresh and tender to support it. He asserted that the second generation was produced from the adults of the first brood of larvæ. Trees infested with the second brood of larvæ would furnish adults which may fly to neighboring trees and develop a third generation. There may be, therefore, three well-defined generations under proper conditions.

Mr. Gillette stated that the appearance of late foliage upon the trees could hardly account for the appearance of a third brood of the insects to feed upon them. He did not believe that an abundant food supply would cause the insect to pass through another generation.

Mr. Hopkins stated that it is possible for the number of broods of an insect to vary according to conditions.

Mr. Felt agreed that favorable conditions would produce additional broods. The Hessian fly, for example, according to his notes, produced an additional brood when weather conditions were favorable in late-sown barley.

Mr. Gillette observed that if the codling moth is three-brooded anywhere it seemed as though it should be at Grand Junction, Colo., where the season is long and where there are both early and late apples for the insects to feed upon. Extensive observations in that locality, however, indicate that the insect is definitely two-brooded there.

The following new members were enlisted: James A. Southwick, Providence, R. I., proposed by A. H. Kirkland; A. N. Caudell, Washington, D. C., proposed by W. H. Ashmead.

Mr. E. P. Felt proposed the name of J. J. Burden, Stanley, N. Y., and Dr. James Fletcher proposed the name of Percy B. Gregson, Waghorn, Alberta.

These new names were objected to by Messrs. Ashmead and Hopkins on the ground that the applicants had done no original work in economic entomology, and upon motion of Professor Bruner they were placed on file. In this connection the by-laws touching the credentials necessary for membership were read by the secretary.

President Gillette then announced the following committees:

Program committee: W. M. Scott, E. P. Felt, T. D. A. Cockerell.

Committee on resolutions: A. D. Hopkins, William H. Ashmead, E. D. Ball.

Committee on nominations: E. P. Felt, Lawrence Bruner, William H. Ashmead.

The report of the secretary and treasurer for 1900 and 1901 was read and adopted.

Mr. Felt suggested an annual assessment of 50 cents per member to defray the expenses of the Association. Mr. Ashmead moved that an annual assessment of 25 cents be placed upon all members of the Association. The president ruled both motions out of order, they being contrary to the constitution.

Upon motion of Dr. Hopkins, it was voted that each member present should be assessed 75 cents.

The meeting then adjourned to meet at 2 p. m.

AFTERNOON SESSION, AUGUST 23, 1901.

The meeting was called to order by President Gillette, who announced a paper by Mr. E. P. Felt to be the first on the programme.

THE HESSIAN FLY IN NEW YORK STATE IN 1901.

By E. P. Felt, *Albany, N. Y.*

This pest caused considerable injury in New York State in 1899 and 1900, but the damage inflicted this spring appears, from all accounts, to have been very much greater than in recent years. Wheat passed the winter in excellent condition, and the remark was made in my presence that farmers would hardly have thanked anyone for a guaranty of a full crop, so promising was the situation early in the spring. The season was exceptional, and rains followed each other in quick succession, producing a vigorous growth of all grasses, so that the hay crop was an enormous one. So far as could be learned, there was little indication of the work of this pest last fall, but as the spring advanced the grain suffered more and more, till the latter part of June or early July, when reports of the true conditions of affairs began to come in. Some allowance was made in the case of the earlier reports, because in 1900 the injury was overestimated in some cases, and this may be true in part for 1901, but in some cases it is not. A personal investigation of some of the infested localities has convinced me that many of the reports made to me were literally true. I was shown a number of fields which to me looked like a rather rough pasture or poorly sown grass, and yet these were pieces which had been seeded with grass and sown to wheat last fall. There was no doubt of the total failure of the grain crop in such cases. These, however, were the worst; all grades of injury could be seen. Fields that escaped without injury were quite few in the regions visited.

This outbreak was utilized to secure some data which may be helpful in understanding the situation. Special reports were received from about 45 fields, located mostly in Erie, Niagara, Genesee, Wyoming, and Onondaga counties, and representing about 760 acres. Of these areas, 90 per cent or more of the grain on 134 acres was estimated as lost, 85 per cent on 58 acres, 75 per cent on 83 acres, 50 per cent on 176 acres, 25 per cent on 63 acres, and 6 to 12 per cent on 248 acres; or, 50 to 90 per cent or more of the grain on 451 out of the total of 762 acres was estimated as destroyed. These reports were not made on badly injured fields alone, but on others as well, and they were made in reply to a series of questions formulated for the purpose of ascertaining so far as possible the cause for this extensive damage. The inquiry developed the fact that a white beardless wheat, known as No. 6, was seriously injured almost without exception, while the bearded red wheat, known as No. 8, escaped with comparatively little harm. None of the above-mentioned reports attributes more than a 25 per cent injury to red wheat, while the white variety ranges from that figure to 99 or 100 per cent destroyed. The white wheat is a much heavier yielder, and is therefore greatly preferred by farmers. This inquiry was started primarily in the hopes of securing data on the date after which winter wheat could be sown with comparative safety. So much grain is grown in western New York, and the fields are so near each other, that it was impossible to secure anything very definite, except that white wheat sown the latter part of September or later was in all probability infested in the spring by flies from overwintered puparia or "flaxseeds."

Some climatic effects were also observed. The continued rains in the spring stimulated the transformation of the flies, and on July 10 a number of fields were seen where the spring brood of the fly had completed its transformation and departed. This was further confirmed by finding several large fields of barley, sown about May 15, badly infested with larvæ and young puparia of this pest. The attacks on the barley were confined largely to the upper, softer nodes, and in at least one field the infestation was very thorough. Every stalk was infested with a few of the pests, and 8 plants taken at random contained from 19 to 54 individuals, most of them being in the larval stage. Curiosity induced me to bring together Weather Bureau records showing the total precipitation and the number of rainy days in the growing months of the fall of 1900 and the spring of 1901. The two localities selected were Alden, Erie County, and Elba, Genesee

County, both in the immediate vicinity of the localities from which my reports were received. The table is as follows:

Month.	Alden, Erie County.		Elba, Genesee County.	
	Total precipitation.	Number of rainy days.	Total precipitation.	Number of rainy days.
	Inches.		*Inches.*	
1900—August	2.48	7	2.39	11
September	3.26	7	2.69	7
October	3.18	7	3.59	8
November	8.42	16	3.99	21
1901—March	3.09	12		
April	4.34	11	4.25	10
May	4.49	18	5.13	19
June	1.49	7	3.38	10

It will be seen that last May was very wet, rain falling 18 and 19 days, respectively, in the two localities, and it is no wonder that the spring generation of the fly thrived, completed its transformations, and was ready to infest late-sown barley. The contrast between a rank, succulent growth of the grain and grain injured by the Hessian fly was further shown on one hilly patch of wheat in which there was considerable grain on the gravelly, comparatively dry knolls, while in the more moist gullies the stalks of wheat were very scattering.

In the discussions of this paper, Mr. Ashmead asked what remedy Mr. Felt would recommend.

Mr. Felt replied that late sowing and trap crops plowed under were the most effective remedies.

Mr. Howard suggested the possibility of varieties resistant to the Hessian fly.

Mr. Felt said that No. 8 was said to be resistant.

Mr. Scott then presented the following paper:

JARRING FOR THE CURCULIO ON AN EXTENSIVE SCALE IN GEORGIA, WITH A LIST OF THE INSECTS CAUGHT.

Conotrachelus-nenuphar

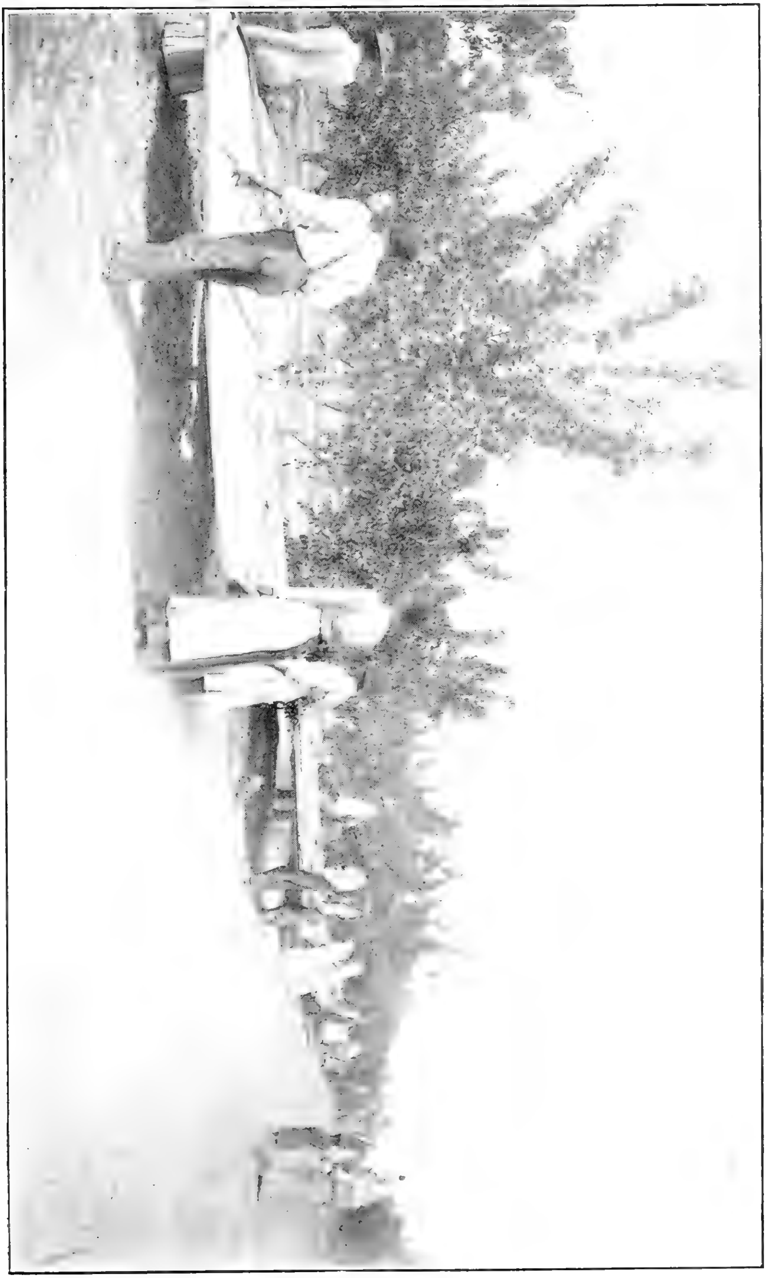
By W. M. Scott and W. F. Fiske, *Atlanta, Ga.*

CURCULIO DAMAGE TO PEACHES AND PLUMS.

In Georgia, where peaches and plums are extensively grown for market, perhaps the most perplexing problem that confronts the grower is how to combat the curculio. The San Jose scale, so prevalent in south Georgia, is thoroughly controlled by the kerosene-water treatment, the peach-tree borer is held in abeyance by the cutting-out method, and the brown rot is fairly well controlled with the Bordeaux treatment; but the curculio has succeeded in baffling all contrivances for its destruction, except, perhaps, the tedious and expensive method of jarring the trees and catching the beetles on sheets stretched on frames made for that purpose.

CURCULIO GANG AT WORK WITH SHEETS AND BUMPERS IN ORCHARD AT FORT VALLEY, GA.

From photograph furnished by Scott & Fiske.



CURCULIO GANG AT WORK IN THE HALE ORCHARD, FORT VALLEY, GA.

From photograph furnished by Scott & Fiske.

A conservative estimate would place the annual damage to peaches and plums done by the curculio in Georgia at 25 per cent of the entire crop. Aside from the work of the larvæ in the fruit, the adult beetles are active agents in disseminating the brown-rot fungus, as evidenced by our observations during the past season. In a number of orchards that were sprayed with Bordeaux mixture it was observed that brown rot developed almost exclusively on fruit that had been punctured or eaten into by the curculio, and the point of brown-rot attack was usually at wounds made by the beetles. It is evident, then, that this insect is responsible for considerable brown-rot damage either by actually conveying the spores or by merely breaking the skin of the fruit for their admission.

THE JARRING METHOD IN THE HALE ORCHARD.

Perhaps the most extensive work against the curculio that has ever been undertaken in the history of peach and plum culture was conducted by the Hale Georgia Orchard Company, at Fort Valley, Ga., during the past season. About 200,000 bearing peach trees and 50,000 bearing plum trees were jarred several times between April 18 and June 1. The entire orchard was gone over about six times, while some blocks of trees, particularly those adjacent to woods and other curculio-harboring places, received the jarring every day (except Sundays) between the dates named. The operations were carried on by 11 gangs of 5 hands each. Each gang was supplied with an outfit consisting of two sheets stretched on the underside of light wooden frames, 6 by 12 feet in dimensions, a pole 8 feet long padded with rubber on one end which served as a "bumper," and a supply of baking-powder cans in which to confine the insects captured. Each pair of sheets was carried by 4 women or children, accompanied by a man, who, by forcibly striking the trunk of the tree, effected the jarring.

The several gangs moved through the blocks of trees together, each taking a row, as shown in the accompanying illustrations. About every half hour the sheets were placed on the ground, and all hands engaged in picking off curculio and other insects that looked suspicious. In most cases the lady-bird beetles were allowed to escape.

The jarring was done from 3 a. m. to 9 a. m. and from 2 p. m. until dark. The best results, however, were obtained from the early morning work. With the 11 pairs of sheets about 40,000 trees were thus gone over in a day. (See Plates I and II.)

COST.

It required 60 hands (men, women, and children) to operate the 11 pairs of sheets, and the cost for labor amounted to $25 per day. These gangs of curculio catchers were employed for 37 days, making the total cost for labor $925. Mr. Hale estimated the cost for keeping the outfits in repair at $75, making the total cost for the work of the season $1,000.

RESULTS.

We furnished Mr. J. H. Baird, superintendent of the orchard, with cyanide jars for killing the insects in bulk once a week. As the lots came in they were gone over quite carefully and a collection of the different species occurring therein mounted. These were afterwards determined, so far as practicable, through the kindness of Dr. L. O. Howard, by Messrs. F. C. Pratt and O. Heidemann. Portions of several lots were separated and the curculio counted in order to get at the relative percentage at different times during the season, and at the end of the whole was thoroughly mixed. By counting a definite portion and carefully measuring the remainder a tolerably exact estimate of the total number and percentage was obtained.

The proportions of curculio in the catchings as thus determined varied from 56 to 94 per cent, the average for the entire season being about 67 per cent. The gross number of curculio was in the neighborhood of 137,000.

No attempt was made to determine the percentage of females, but if it be granted that the sexes were equally divided and that each female was capable of depositing 200 eggs an idea can be had of the immense damage that was prevented by the jarring work.

The most important results, however, showed up in the small percentage of curculio-damaged fruit from the jarred orchard as compared with the adjacent orchards that were not jarred. It was quite impossible, of course, to arrive at definite figures, but a fair estimate of the comparative results was obtained by examining both the immature fruit on the trees and the ripe fruit as it came into the packing houses.

In the midst of the shipping season, July 23, we made final notes on the work. The system of sorting the fruit in Mr. Hale's packing house is about as perfect as it can be made on a large scale. One hand sorts for two packers, and all fruit showing curculio damage, rot, or other defect is discarded. Out of one day's shipping of 5 cars, or 2,062½ bushels, there were only 20 bushels of culls, or about 1 per cent. Some damaged fruit is always overlooked and allowed to go on the market. For this we allowed another 20 bushels. In this orchard there was very little premature dropping due to curculio damage, and from our notes we would place this amount of damage about equal with the amount that came into the packing house. A fair estimate, then, would place the amount of curculio damage to the entire crop at 4 per cent.

An adjacent orchard of 130,000 trees was taken as a check. Careful notes made in this orchard and its packing house places the amount of damaged fruit at 40 per cent of the entire crop. The surroundings attending the two orchards are about the same, but it should be explained that the untreated orchard has never received the same clean cultivation that Mr. Hale's orchard is always given.

This would certainly account for a small part of the difference in the percentages of damage in the two orchards.

There seems to be no question as to the successful outcome of the experiment, and Mr. Hale, who shipped 143 cars of fruit from the orchard, considers the money required for the jarring well spent.

A study of the collections of insects made by thus jarring the trees has revealed many interesting features as regards the species present and their comparative abundance. About 325 species were mounted and determined; the larger part were found in insignificant numbers, but many were abundant. Outside of the Coleoptera and Hemiptera, very few of any order were taken, and of these no record has been kept. The presence in considerable numbers of the peach borer, *Sannina exitiosa*, during the early half of May is, however, worthy of note.

LIST OF FAMILIES REPRESENTED.

COLEOPTERA.

The Coleoptera easily outnumbered the Hemiptera, even without considering the immense numbers of curculio, and many of the species were of economic interest. The list of families represented is as follows:

CARABIDÆ.—Very few specimens early in the season, but many at later dates. Lebia, as might be expected, was common; *Calosoma sayi*, *wilcoxi*, and *scrutator* were scarce, but conspicuous from their size and color; Platynus was the most common genus, and represented by several species, of which *limbatus* was present in the largest numbers.

PHALACRIDÆ.—Scarce.

COCCINELLIDÆ.—These beetles, of such great economic importance in reducing the numbers of such widely distributed scales as *Aspidiotus forbesi*, etc., were sorted from the jarrings as made and set at liberty. Thus no good idea could be obtained as to their actual abundance; but, judging from the large numbers that escaped the mercy of the sorters, very large numbers must have been originally present. Thirteen species were identified (counting Scymnus as one), the most of them known as scale feeders. The most common was, however, *Anatis 15-punctata*, with a close second in *Hippodamia convergens*. Among those that have been especially noted as feeding on the scales infesting peach in Georgia were *Coccinella sanguinea*, common; *Chilcorus bivulnerus*, common; *Exochomus tripustulatus*, scarce; *Hyperaspis signata*, scarce. Scymnus was common, but the species are as yet undetermined. Strangely enough, *Adalia bipunctata*, which occurs about plant-lice in swarms, was wholly lacking.

ENDOMYCHIDÆ.—Very rare.

EROTYLIDÆ.—Scarce.

DERMESTIDÆ, NITIDULIDÆ, TROGOSITIDÆ, and DASCYLLIDÆ.—All rare.

ELATERIDÆ.—Abundant. The species, however, largely such as breed in rotten wood, such as the old stumps often occurring in orchards, or in its environs. For instance, *Alaus myops* was common and conspicuous; *Perothops mucida* was very common in some lots, and in general the species were of little economic interest.

THROSCIDÆ.—Rare.

BUPRESTIDÆ.—Abundant. The collections in this family were interesting, principally on account of the abundance of the genus Chrysobothris. *C. femorata* was very common toward the end of the season; *C. azurea* was equally common throughout, and the same is true of *C. harrisii*. *C. sex-signata* was less so, and a small form that may possibly be a much dwarfed *femorata* was scarce. It seems probable that all of these feed on peach, *femorata* unquestionably so, while *azurea* has been noted from March to July as being a common frequenter of peach trees, especially when old and diseased. About a dozen other species of the family were taken.

LAMPYRIDÆ.—Also a very common family, certain small species of Telephorus being very abundant, arranged according to abundance. Chauliognathus was also extremely common later in the season.

MALACHIIDÆ.—Fairly common.

CLERIDÆ.—Made fairly common by the presence of *Clerus thoracicus* in some numbers.

PTINIDÆ.—Several species, the "twig borer" *Amphicerus bicaudatus* in some numbers.

SCARABÆIDÆ.—The presence of *Anomala undulata* in numbers gave this family considerable prominence that it would not otherwise have possessed. *Lachnosterna* was unexpectedly scarce, though in some variety: *L. tristis* was the only common species.

CERAMBYCIDÆ.—Rivaled only by the Chrysomelidæ for variety, though few species were abundant. *Elaphidion villosum* was common through the season. In all about 40 species were found, and of them a few of the smaller ones were common.

CHRYSOMELIDÆ.—Over 50 species in this family were determined, though many of them were of but occasional occurrence. The flea-beetles were represented by some very prettily colored forms. Perhaps the most interesting economically was *Diabrotica 12-punctata*. This was one of the most common of all the beetles, and is quite injurious to the peach in early spring, eating out the center of the blossoms and opening buds. The potato and sweet-potato beetles found their way in considerable numbers to the slaughter.

BRUCHIDÆ.—Rare.

TENEBRIONIDÆ.—Abundant, represented by some of the more common wood-eating forms.

CISTELIDÆ.—Common.

LAGRIIDÆ.—Quite common.

MELANDRYIDÆ.—Rare.

PYTHIDÆ.—Rare.

MORDELLIDÆ.—Rare until nearly the end of the season.

ANTHICIDÆ.—Species of Notoxus were fairly common, and later in the season these insects are among the most commonly seen on the trees, crawling continually over the leaves for some obscure purpose.

MELOIDÆ.—Rare.

OTIORHYNCHIDÆ.—Rare, except for one species, *Aramigus fulleri*, which in some lots of the catchings was very common, but was far from being uniformly so throughout the season. What its habits may be in this connection is a question.

CURCULIONIDÆ.—*Conotrachelus nenuphar* of course formed a large proportion of the total number of insects caught, but a proportion that lessened as the season advanced, varying from 94 per cent under certain conditions to as low as 56 per cent toward the end of the season. This is in part due, we think, to the fact that much fewer curculio were caught and partly, also, to the increased numbers and activity of other insects. In addition to *nenuphar*, the following species of Conotrachelus were taken: *C. anaglypticus* was common, *C. seniculus*, scarce, and *C. cribricollis*, scarce. All these were noted as being more common during the latter part of the season. Others of this family were conspicuously numerous, as *Chalcodermus æneus*, *Anthonomus scutellatus*, and species of Cryptorhynchus and Baris.

BRENTHIDÆ.—Rare.

CALANDRIDÆ.—*Calandra oryza* was quite common.

SCOLYTIDÆ.—*Scolytus rugulosus* was abundant throughout the season and formed a considerable percentage of the insects outside of curculio.

ANTHRIBIDÆ.—Common, and represented by several species. The rare *Cratoparis lugubris* was not uncommon in one catching, but the individuals received were in a state of decomposition that spoiled them for specimens.

HEMIPTERA—HETEROPTERA.

The Hemiptera were very interesting, embracing as they did insects of quite varying economic status. The number of families at all common were limited, and, strangely enough, the Capsidæ were wholly without representatives. Any one of a dozen species could be selected from the Capsidæ or Pentatomidæ that would outnumber in individuals all the other species of bugs together, saving, perhaps, the Pyrrochoridæ.

CORIMELÆNIDÆ.—Scarce.

CYDNIDÆ.—Rare.

SCUTELLERIDÆ.—Scarce.

PENTATOMIDÆ.—Abundant, including both predaceous and phytophagous forms. *Stiretrus anchorago* was common, with both white and orange ground color and much variety as to detail of markings. Podisus was abundant, but the material has not yet been thoroughly worked over for species. Four or five species of the large flat Brochymena were more or less abundant, especially toward close of season. *Œbalus pugnax* was abundant. Euschistus, the most common genus of all, was represented by *servus*, *tristigmus*, and *crassus* in order of abundance. About 25 species in all were taken in this family.

COREIDÆ.—This family was also abundantly represented and by species of the highest economic importance, foremost among them being large quantities of the leaf-footed plant bugs. Falling in this group were: *Acanthocephala declivis*, common and conspicuous from its gigantic size; *Metapodius femoratus*, to which the same remarks apply; *M. instabilis*, rare; *Leptoglossus oppositus*, abundant; *L. phyllopus*, still more abundant (these two latter species formed 10 per cent of the total catchings in some cases); *L. corculus*, rare; *L.* n. sp., rare. The injury which these insects do in an orchard must be considerable. They sometimes occur in swarms on the trees, flying freely about from one to another, and piercing and sucking green, ripe, and rotten fruit promiscuously. There can be little question but that they thus act as agents in the dissemination of brown rot, and very effectively in a climate so conducive to the development of this disease as Georgia. *Euthocha galeator*, a species that is oftentimes a serious pest to nursery stock, piercing and sucking the terminal shoot, thus causing it to wither and the stock to branch, was caught in some numbers. *Chariesterus antennator* was abundant, and in all 17 species referable to the family were taken.

BERYTIDÆ.—Rare.

LYGÆIDÆ.—Scarce, on the whole. Several species of Lygæus; one, *turcicus*, fairly common.

PYRRHOCORIDÆ.—Common; represented by *Largus succinctus*.

ARADIDÆ.—Rare.

NABIDÆ.—Rare.

REDUVIIDÆ.—Represented by half a dozen species, all scarce or rare.

HEMIPTERA—HOMOPTERA.

Poorly represented by a few Fulgorids, Jassids, and Membracids, none of them common.

LIST OF INSECTS CAUGHT FROM PEACH AND PLUM TREES IN JARRING FOR THE CURCULIO.

COLEOPTERA.

CARABIDÆ.

Calosoma scrutator Fab. Less rare than *wilcoxi* or *sayi*.
Calosoma wilcoxi Lec. Rare.
Calosoma sayi Dej. Rare.
Pasimachus marginatus Fab. One.
Amara spp. Fairly common.
Calathus opaculus Lec. Common toward end of season.
Platynus limbatus Say. Not found in catchings until end of season, but then abundantly.
Platynus sp. Scarce.
Nemotarsus elegans Lec. Rare.
Lebia viridis Say. Common.
Lebia analis Say. Rare.
Lebia scapularis Dej. Rare.
Philophuga viridicollis Lec. Fairly common.
Chlœnius tomentosus Say. Rare.
Harpalus spp. Fairly common toward end of season.
Anisodactylus rusticus Say. Fairly common toward end of season.
Anisodactylus terminatus Say. Rare.

PHALACRIDÆ.

Olibrus spp. Common.

COCCINELLIDÆ.

Megilla maculata DeG. Abundant.
Hippodamia glacialis Fab. One only.
Hippodamia convergens Guer. Common.
Coccinella affinis Rand. Rare.
Coccinella affinis var. *venusta* Melsh. One specimen only.
Coccinella sanguinea Linn. Common.
Anatis 15-punctata Oliv. Abundant.
Mysia pullata Say. Common.
Psyllobora 20-maculata Say. One specimen only.
Chilcorus bivulnerus Muls. Common.
Exochomus tripustulata DeG. Scarce.
Exochomus pilatii Muls. Scarce.
Hyperaspis signata Oliv. Rare.
Scymnus spp. Common.

ENDOMYCHIDÆ.

Aphorista vittata Fab. Rare.

EROTYLIDÆ.

Languria mozardi Lec. Fairly common.
Languria gracilis Newn. One specimen only.
Tritoma festiva Lec. Rare.
Tritoma thoracica Say. Less rare than *festiva*.

DERMESTIDÆ.

Trogoderma ornatum Say. Rare.

NITIDULIDÆ.

Epurœa labilis Er. Rare.

TROGOSITIDÆ.

Trogosita virescens Fab. Rare.

DASCYLLIDÆ.

Prionocyphon discoideus Say. One specimen only.
Helodes pulchella Guer. Rare.

ELATERIDÆ.

Adelocera discoidea Web. Fairly common.
Lacon rectangularis Say. Common at end of season.
Alaus ocellatus Linn. Rare.
Alaus myops Fab. Common.
Cardiophorus sp.
Elater linteus Say. One only.
Ludius texanus Lec. Common.
Melanotus leonardi Lec. Rare.
Melanotus communis Gyll. Common.
Melanotus sp. I. Common.
Melanotus sp. II. Common.
Limonius griseus Beauv. Common.
Limonius sp. I. One specimen only.
Limonius sp. II. Common.
Sericosomus silaceus Say. Common.
Melanactes morio Fab. Common late in the season.
Perothops mucida Gyll. Common early in the season.

THROSCIDÆ.

Drapetes geminatus Say. One specimen only.

COLEOPTERA—Continued.

BUPRESTIDÆ.

Chalcophora virginiensis Dru. Fairly common.
Chalocophora georgiana Lec. Fairly common.
Dicerca obscura Fab. Common.
Buprestis lineata Say. Several specimens.
Buprestis striata Fab. One specimen only.
Buprestis decora Fab. Several specimens.
Melanophila notata Lap. & Gory. Several specimens.
Anthaxia viridifrons Lap. Rare.
Anthaxia cyanella Gory. Rare.
Anthaxia flavimana Gory. Rare.
Chrysobothris femorata Fab. Common.
Chrysobothris 6-signata Say. Fairly common.
Chrysobothris chrysoela DaCosta. Common.
Chrysobothris harrisii Hentz. Common.
Chrysobothris sp. Several specimens.
Acmœodera culta Web. Rare.
Agrilus sp. Several specimens.
Brachys œrosa Mels. Fairly common.

LAMPYRIDÆ.

Eros humeralis Rand. Fairly common.
Photuris pennsylvanica DeG. Scarce.
Chauliognathus marginatus Fab. Abundant toward the end of the season.
Calochromus perfaceta Say. Common.
Podabrus frater Lec. Common.
Telephorus lineola Fab. Common toward the end of the season.
Telephorus sp. Common.
Telephorus bilineatus Say. Scarce.
Polemius laticornis Say. Fairly common.

MALACHIIDÆ.

Collops eximius Er. Common.
Collops 4-maculatus Fab. Less common than *eximius*.
Tanaops longipes Lec. Scarce.

CLERIDÆ.

Elasmocerus terminatus Say. Fairly common.

CLERIDÆ—continued.

Clerus thoracicus Oliv. Fairly common.
Chariessa pilosa Forst. Rare.
Orthopleura damicornis Fab. One specimen only.

PTINIDÆ.

Ernobius mollis Linn. Common.
Sinoxylon basilare Say. Rare.
Amphicerus bicaudatus Say. Common.

SCARABÆIDÆ.

Canthon probus Germ. Rare.
Canthon praticola Lec. Rare.
Aphodius sp. Rare.
Serica sericea Ill. Rare.
Diplotaxis puberula Lec. Scarce.
Diplotaxis sp. Rare.
Lachnosterna arcuata Smith. Rare.
Lachnosterna fusca Froehl. Rare.
Lachnosterna crenulata Froehl. Rare.
Lachnosterna cognata Burm. Fairly common.
Lachnosterna luctuosa Horn. Fairly common.
Lachnosterna tristis Fab. Common.
Anomala minuta Burm. Rare.
Anomala undulata Mels. Abundant, especially early in the season.
Euphoria sepulchralis Fab. Fairly common toward end of season.
Euphoria fulgida Fab. Scarce.
Trichius piger Fab. Several.
Valgus squamiger Beauv. Rare.
Valgus canaliculatus Fab. Rare.

CERAMBYCIDÆ.

Asemum moestum Hald. Rare.
Phymatodes amœnus Say. Fairly common.
Phymatodes varius Fab. Rare.
Chion cinctus Dru. Rare.
Elaphidion mucronatum Fab. Several specimens in the last catching.
Elaphidion villosum Fab. Abundant. The most common Cerambycid, except possibly *Hyperplatys maculatus*.
Elaphidion unicolor Rand. One specimen only.
Heterachthes ebenus Newn. One of the more common Cerambycids.

CERAMBYCIDÆ—continued.

Ancylocera bicolor Oliv. Rare.
Elytroleptus floridanus Lec. One specimen only.
Batyle suturalis Say. Rare.
Stenosphenus dolosus Horn. Common.
Clytus marginicollis Lap. Only one specimen.
Xylotrechus colonus Fab. Rare.
Neoclytus erythrocephalus Fab. Rare.
Euderces picipes Fab. Rare.
Euderces pini Oliv. Rare.
Rhagium lineatum Oliv. One specimen only.
Acmæops bivittata Say. Rare.
Acmæops discoidea Hald. Rare.
Typocerus zebratus Fab. Not an uncommon species.
Leptura cruentata Hald. Rare.
Monohammus titillator Fab. Fairly common.
Acanthoderes decipiens Hald. Common in the last catching.
Liopus crassulus Lec. One specimen only.
Liopus variegatus Hald. Rare.
Hyperplatys aspersus Say. Almost as common as *maculatus*.
Hyperplatys maculatus Hald. One of the most common Cerambycids.
Acanthocinus obsoletus Oliv. Rare.
Acanthocinus nodosus Fab. One specimen only.
Ecyrus dasycerus Lec. Several specimens.
Eupogonius tomentosus Hald. Quite common toward the end of the season.
Hippopsis lemniscata Fab. Rare.
Ataxia crypta Say. Rare at first, but more common than *Elaphidion villosum* in the last catchings.
Saperda lateralis Fab. One specimen only.
Tetrops jucunda Lec. One specimen only.

CHRYSOMELIDÆ.

Donacia aequalis Say. One specimen only.
Donacia sp. One specimen only.

CHRYSOMELIDÆ—continued.

Lema cornuta Fab. Rare.
Lema sayi Cr. Rare.
Babia 4-guttata Oliv. Fairly common in the last catchings.
Chlamys plicata Fab. Rare.
Cryptocephalus 4-maculatus Say. Common.
Cryptocephalus 4-maculatus var. *notatus* Fab. Common.
Cryptocephalus sp. One specimen only.
Pachybrachys morosus Hald. Common.
Pachybrachys carbonarius Hald. Rare.
Pachybrachys luridus Fab. Common.
Pachybrachys subfasciatus Hald. Several specimens.
Pachybrachys striatus Lec. Rare.
Xanthonia 10-notata Say. Common.
Glyptoscelis pubescens Fab. Rare.
Myochrous denticollis Say. Rare.
Typophorus canellus Fab. Not common.
Metachroma quercata Fab. Rare.
Metachroma luridum Ol. Rare.
Colaspis brunnea var. *costipennis* Cr. Common toward the end of the season.
Doryphora 10-lineata Say. Rare.
Doryphora juncta Germ. Common at times.
Chrysomela similis Rog. Several specimens.
Chrysomela bigsbyana Kirby. Only one specimen.
Lina lapponica Linn. Rare.
Lina scripta Fab. Common.
Diabrotica 12-punctata Fab. Abundant.
Diabrotica vittata Fab. A few specimens only.
Cerotoma trifurcata Forst. Common.
Blepharida rhois Forst. One specimen only.
Œdionychis thoracica Fab. Common.
Œdionychis vians Ill. Rare.
Œdionychis petaurista Fab. One specimen only.
Œdionychis miniata Fab. Common.
Œdionychis scalaris Mels. Rare.
Disonycha pennsylvanica Ill. Fairly common.

COLEOPTERA—Contined.

CHRYSOMELIDÆ—continued.

Disonycha caroliniana Fab. Fairly common.
Disonycha discoidea Fab. Several specimens.
Disonycha abbreviata Mels. Fewer specimens than of *discoidea*.
Disonycha 5-vittata Say. One specimen only.
Haltica chalybea Ill. Common.
Haltica ignita Ill. Not nearly so common as *chalybea*.
Haltica rufa Ill. One specimen only.
Crepidodera helxines Linn. Common.
Systena elongata Fab. Several specimens.
Odontota scapularis Oliv. One specimen only.
Odontota dorsalis Thunb. One specimen only.
Odontota rubra Web. One specimen only.
Cassida bivittata Say. Common in the later catchings.
Coptocycla aurichalcea Fab. Fairly common.
Coptocycla guttata Oliv. Fairly common.
Coptocycla purpurata Boh. Rare.
Chelymorpha argus Licht. Rare.

BRUCHIDÆ.

Spermophagus robiniæ Sch. One specimen only.

TENEBRIONIDÆ.

Opatrinus aciculatus Lec. Rare.
Arrhenoplita viridipennis Fab. Rare.
Platydema ruficornis Sturm. Scarce.
Helops americanus Beauv. Common.
Helops cisteloides Germ. Abundant.
Polypleurus geminatus Sol. Rare.

CISTELIDÆ.

Hymenorus obscurus Say. Common.
Hymenorus dorsalis Sz. Common.
Hymenorus sp. I. Common.

CISTELIDÆ—continued.

Hymenorus sp. II. Common toward the end of the season.
Isomera sericea Say. Common.
Capnochroa femoralis Mels. Fairly common in the last catchings.
Chromatia amœna Say. Rare.

LAGRIIDÆ.

Statira gagatina Mels. Fairly common late in the season.

MONOMMIDÆ.

Hyporhagus punctulatus Thom. Rare

MELANDRYIDÆ.

Hypulus (*liturata*). One specimen only.
Eustrophus tomentosus Say. Scarce.

PYTHIDÆ.

Boros unicolor Say. Rare.

MORDELIDÆ.

Mordella 8-punctata Fab. Common in the last catching.
Mordella sp. Several in the last catching.
Glypodes helva Lec. Scarce.
Mordellistena sp. Scarce.

ANTHICIDÆ.

Eurygenius wildii Lec. Fairly common.
Notoxus nuperus Horn. Fairly common.
Notoxus bicolor Say. Rare.

MELOIDÆ.

Macrobasis unicolor Kirby. Rare.
Epicauta vittata Fab. Rare.

RHINOMACERIDÆ.

Rhinomacer elongatus Lec. Rare.

RHYNCHITIDÆ.

Pterocolus ovatus Fab. Fairly common.

COLEOPTERA—Continued.

OTIORHYNCHIDÆ.

Pandeletejus hilaris Hbst. Rare.
Aramigus fulleri Horn. Abundant, especially in the early catchings.

CURCULIONIDÆ.

Apion spp. Common.
Pachylobius picivorus Germ. Abundant.
Hylobius pales Hbst. A few specimens only.
Lixus concavus Say. Rare.
Lixus musculus Say. Rare.
Otidocephalus chevrolatii Horn. Rare.
Coccotorus scutellaris Lec. Rare.
Anthonomus scutellatus Gyll. Abundant.
Anthonomus suturalis Lec. Rare.
Læmosaccus plagiatus Fab. Rare.
Conotrachelus nenuphar Hbst. Extremely abundant.
Conotrachelus seniculus Lec. Fairly common.
Conotrachelus cribricollis Say. Not common.
Conotrachelus anaglypticus Say. Common.
Chalcodermus æneus Boh. Common.

CURCULIONIDÆ—continued.

Phyrdenus undatus Lec. Fairly common.
Cryptorhynchus sp. I. Common.
Cryptorhynchus sp. II. Rare.
Baris umbilicata Lec. Rare.
Baris transversa Say.
Baris spp. Abundant.
Trichobaris trinotata Say. Rare.
Madarus undulatus Say. Rare.
Centrinus picumnus Hbst. Rare.

BRENTHIDÆ.

Eupsalis minuta Dru. Several specimens.

CALANDRIDÆ.

Calandra oryza Linn. Quite common.

SCOLYTIDÆ.

Scolytus rugulosus Ratz. Abundant.

ANTHRIBIDÆ.

Toxotropis pusillus Lec. Common.
Anthribus cornutus Say. Common.
Cratoparis lunatus Fab. Common.
Cratoparis lugubris Oliv. Several specimens in one catching.

HEMIPTERA—HETEROPTERA.

CORIMELÆNIDÆ.

Corimelæna unicolor Pal. Beauv. Fairly common.
Corimelæna nitiduloides Wolff. Fairly common.

SCUTELLERIDÆ.

Aulacostethus marmoratus Say. Fairly common.
Aulacostethus simulans Uhl. Fairly common.
Camirus porosus Germ. Rare.
Orsilochus guttatus H. Schf. One specimen only.

CYDNIDÆ.

Pangæus uhleri Sign. Fairly common.
Sehirus cinctus Pal. Beauv. Rare.

PENTATOMIDÆ.

Stiretrus anchorago Fab. Fairly common.
Podisus spinosus Dall. Common.
Podisus modestus Dall. Common.
Proxys punctulatus Pal Beauv. One specimen only.
Podops cinctipes Say. Rare.
Brochymena carolinensis Westw. Rare.
Brochymena arborea Say. Rare.
Brochymena 4-pustulata Fab. Fairly common.
Brochymena annulata Fab. Common.
Neottiglossa cavifrons Stal. One specimen only.
Œbalus pugnax Fab. Common.
Mormidea lugens Fab. Common.
Euschistus servus Say. Abundant.
Euschistus tristigmus Say. Common.

HEMIPTERA—HETEROPTERA—Continued.

PENTATOMIDÆ—continued.

Euschistus crassus Dall. Rare.
Lioderma uhleri Stal. Rare.
Trichopepla semivittata Say. Rare.
Peribalus limbolaris Stal. Common.
Thyantha custator Fab. Common.
Murgantia histrionica Hahn. One specimen only.
Nezara pennsylvanica DeG. Rare.
Nezara hilaris Say. Common.
Banasa dimidiata Say. Common.
Banasa packardii Stal. Less common than *dimidiata*.
Dendrocoris humeralis Uhl. Fairly common.
Dendrocoris fruticicola Bergr. One specimen only.

COREIDÆ.

Chariesterus antennator Fab. Common.
Chelinidea vittigera Uhl. One specimen only.
Corynocoris distinctus Dall. Fairly common.
Archimerus calcarator Fab. Rare.
Euthoctha galeator Fab. Common.
Acanthocephala declivis Say. Quite common.
Metapodius femoratus Fab. Common.
Metapodius instabilis Uhl. Several specimens.
Leptoglossus phyllopus Linn. Abundant.
Leptoglossus corculus Say. Rare.
Leptoglossus oppositus Say. Abundant.
Leptoglossus n. sp. Several specimens.
Anasa tristis DeG. Rare.
Anasa armigera Say. Rare.

COREIDÆ—continued.

Alydus eurinus Say. Rare.
Harmostes reflexulus Stal. Rare.
Corizus punctiventris Dall. Fairly common.

BERYTIDÆ.

Jalysus spinosus Say. Rare.

LYGÆIDÆ.

Nysius angustatus Uhl. Rare.
Ischnorynchus didymus Zett. Rare.
Geocoris borealis Dall. Rare.
Oedancala dorsalis Say. Rare.
Pamera vincta Say. Fairly common.
Dorachosa illuminatus var. *umbrosus* Dist. Rare.
Lygæus turcicus var. *kalmii* Stal. Fairly common.
Lygæus bicrucis Say. Scarce.
Lygæus facetus Say. Rare.
Oncopeltus fasciatus Dall. Scarce.

PYRRHOCORIDÆ.

Largus succinctus Linn. Common.

ARADIDÆ.

Brachyrhynchus granulatus Say. Rare.

NABIDÆ.

Coriscus sordidus Reut. Rare.

REDUVIIDÆ.

Sinea spinipes H. S. Fairly common.
Milyas cinctus Fab. One specimen only.
Zelus luridus Stal. Rare.
Zelus socius Uhl. Rare.
Apiomerus crassipes Fab. Several specimens.
Myodocha serripes Oliv. Several specimens.

HEMIPTERA—HOMOPTERA.

JASSIDÆ.

Homalodisca coagulata Say. Several specimens.
Oncometopia undata Fab. Fairly common.
Oncometopia costalis Fab. Fairly common.
Aulacizes irroratus Fab. Common.

MEMBRACIDÆ.

Tylopelta gibbera Stal. Rare.
Stictocephala festina Say. Fairly common.
Archasia auriculata Fitch. Rare.

FULGORIDÆ.

A single specimen of a large species.

Mr. Ashmead said that it was very gratifying that something was being done with the curculio problem, and he recounted some of the difficulties which attended the attempt toward its control. He mentioned its parasite (*Sigalphus curculionis*, Fitch) and suggested that if it did not already occur in Georgia it be introduced.

Mr. Bruner spoke of the great variety of insects caught, and expressed a desire to see the complete list.

Mr. Hopkins suggested that many of the insects would fly away in the process of jarring, and for that reason all the insects that might occur on the trees would not be taken. He thought that most of the Lachnosterna might thus escape, but that a better explanation of the scarcity of these insects in the catchings was probably in the fact that for some reason they were not generally abundant this season. He also spoke of the interesting relations existing between insects and fungi, as referred to in the paper comparing the curculio and the leaf-footed bugs in their relation to the brown-rot fungus with the mutual dependence between certain Scolytids and the fungus with which they are closely associated, in causing the death and rapid decay of forest trees.

Mr. Scott said that the operation was conducted during the early morning hours when the insects of nearly all sorts were in a semi-dormant condition, and on this account many species were taken which would not have been later in the day. The leaf-footed bugs might be cited as examples, for, though captured in numbers, they are among the most active insects. It would have been possible to have listed many species of Hymenoptera, Diptera, Lepidoptera, etc., but it was not thought advisable because the specimens were in a badly mutilated condition.

Mr. Galloway said that the agency of insects in disseminating brown rot was a point that should be taken into account in the treatment of this disease.

Mr. Howard thought that while cheap labor made the jarring method practicable in Georgia, in the North the higher price for labor might make it too expensive.

Mr. Ehrhorn said that this pest did not exist in California and that the fruit growers there were in great fear of its introduction.

Mr. Gillette said that so far as he knew it did not occur in Colorado, and that they also entertained fears of its introduction.

Mr. Bruner, Mr. Howard, and others, thought it would add much to the value of this paper if it were accompanied by a complete list of the insects taken in the jarring operation, and the writers were requested to furnish the list for publication.

Mr. Ball then presented the following paper:

A SIMPLE FORM OF ACCESSIONS CATALOGUE.

By E. D. Ball, *Fort Collins, Colo.*

This Association has listened in the past to three excellent papers on organization methods in economic entomology, and any State worker at the present time who has not a thoroughly satisfactory system of recording his observations can not do better than carefully study the papers presented on this subject by Dr. Forbes, Dr. Hopkins, and Professor Webster; and if his department has an abundance of clerical help he probably can not do better than to adopt one of these systems. On the other hand, if his working force is somewhat limited the modification hereafter suggested is submitted for his consideration. The author has, however, no intention of offering a system in competition with either of these, but simply of suggesting one or two modifications that can be used in connection with any of these systems or a modified system to be used when it is impossible to carry out a more elaborate one in detail.

The average working force of our stations in economic entomology does not exceed two men, and if the division of salary be any criterion then not over one-third to one-half of their time is devoted to the economic work. Now, under such conditions it would be impracticable to maintain a system of recording requiring the expenditure of any considerable amount of time in the clerical part and at the same time carry on any very extended experimentation, hampered as they are by the ordinary routine of the college work.

Another important factor that may well be considered here is that in this combination of college and station not all collecting is along economic lines, but that one of the duties as a college officer is to build up a systematic collection, an obligation requiring almost endless years of careful and thorough work. Naturally enough this work and that of the station is carried on at the same time, and it would seem that the best system of recording for the smaller stations, and, in fact, for the great majority of our stations, would be that in which the two different objects could be combined, and that with a minimum amount of clerical work, label writing, bookkeeping, etc.

The following system which was experimented with by the author and finally adopted at the Iowa station, and which has been used in the Colorado station for three years, seems to meet these requirements and at the same time furnish a broad enough basis on which to build up any one of the complete systems, if one chooses to do so.

In this system, which may be conveniently called the date system from its fundamental principle, the accession catalogue contains one entry for each trip or special collection, this entry being in the form of a date, giving the year, month, and day; then every specimen as it is labeled up, in place of an accessions catalogue number, as in ordinary way, bears the place of capture and the date on a single small label.

When a collection is made, the first thing to do is to write up the accessions catalogue. To do this, write the date in the left-hand column in figures, the month first, as 6–12, the year being written only once—at the top of each page. In the second column write the locality just as it appears on the label, and in the third column the special locality where these insects were taken. In the next column write the name or simply the initials of the collector. Then for the rest of the width of the page any notes of value on anything taken, as in any other system. I usually here outline the exact trip taken, the stops made, the particular plants collected from, etc., noting as I go along any facts that will add to existing knowledge. In this way if there is anything to record it is written out, and if there is nothing special to note or only facts that have been noted many times before, the simple date and trip note will be sufficient. Oftentimes in this way when the life history or food plant of a species has been made out, a great deal of additional information or confirmation can be gained from these short notes; while any deductions made at that time would probably have been erroneous. A sample form follows:

1901.

6-12	Fort Collins..	R. R. south.......	E. D. B.	*Nysius minutus* found abdt. in strawberry bed sucking the juice from the berries as fast as they ripen. They were clustered on a tumble weed (*Monolepis*), which appeared to be their breeding place. On south to alfalfa field found *Melanoplus bivittatus* larvæ, small to half-grown, abdt. on margins and ditch banks. Swept Jassidæ and Cercopidæ from *Agropyrum glaucum*. On over to dry pond took Laccocera abdt., both sexes, from dry ground, by fence; also several Lygæids. Coleopt. from willow.
8-3	Durango, Colo.	Up hill east......	E. D. B.	Swept *Artemisia 3-dentata;* took short-winged grasshopper, common everywhere, one *Phlepsius* sp. like one from Rifle, three white Anabrus from clumps on hillside. Swept oak; took *Euttettix* sp. near *jucundus* (red) Scaphoideus, Melinna. Swept cedar; took Scaphoideus (white tip), red Platymetopius, a green Eutettix and the pretty n. sp.
8-15	Fort Collins..	North 6 miles....	C. P. G.	Swept dry ground; took two species of Scolops and Driotura. Small bees from Cleome, Bombus from Helianthus. Typhlocybinæ abdt. on apple.

The labels we print ourselves on a hand press. They are all printed out except the day of the month, and where large collections are made on a given date the entire label is set up. The regular Fort Collins labels are all printed in advance for the season; the others are printed at odd times and as they are needed.

The labels are never over 10 mm. long and 3 mm. wide; the card points are cut with a razor to a uniform length of 9 mm., and the labels are pinned at one end and extend under the card point. On insects that are pinned through the body the labels are pinned so as to extend parallel with the long axis of the insect. In this way it is very rare that a label extends beyond an insect, and never beyond a card point, thus insuring a neat collection.

In referring to the notes the date is used the same as an ordinary catalogue number by looking on top of the page for the year and then down the column for the month and day, which will follow each other in serial order the same as in a series of numbers, and will be found as readily. Having found the date one will always find the exact location and conditions of capture and any other notes thought worth recording at the time.

ADVANTAGES OF THIS SYSTEM.

The main advantage of this system over the others is in the fact that one can collect and record any number of specimens of a species, or any number of species, without materially increasing the labor beyond the mere labor of mounting and labeling any specimen, while in the other systems each individual specimen must have its accessions-catalogue number written out and placed on it, a special entry made in the accessions catalogue for every species, with all of its accompanying records, cross-references, etc., and consequently but few specimens can be mounted in a given time.

Another important factor of utility is in the fact that it is not at all necessary to separate or mount up any of the specimens at the time of capture. All that is necessary is to write up the record, place the locality and date on the package containing the specimens, and it serves the double purpose of an accessions number and the future label. In practice we usually mount the specimens at the time of making the record and then put them away to dry, labeling them up at any convenient time thereafter.

The greatest gain comes from the fact that there is nothing placed on the insect that is not necessary to any well-mounted specimen, i. e., a place and date label, and that nearly all of this label is or can be printed, thus requiring a minimum of hand work.

The fact that this system requires that every specimen be correctly labeled with both place and date will commend it to many persons who have received material for determination from half a dozen different experiment stations bearing nothing more distinctive than a lead-pencil number.

An animated discussion followed the reading of this paper.

Mr. Felt suggested that numerals should not be used to represent months. He thought that less confusion would come from the use of such abreviations as Jr. for January and Mr. for March. His system of note taking required cards, a field book, and an accessions book, each being employed for special conditions and rarely duplicating. He thought he could not adopt Mr. Ball's system to advantage.

Mr. Cockerell said that he used no numbers, and thought that cards were more convenient than record books. In his experience insects were frequently recorded from localities in which they never occurred, but were so labeled because the owner or collector happened to be there.

Mr. Hopkins said that his system had been modified and improved since it was first announced at the Madison meeting; that he was more than ever convinced of the importance of some well-planned and convenient system, varied according to the special needs and requirements of the individual collector or investigator, by which the necessary collecting notes and original observations may be permanently recorded, so that they will be available and intelligible as long as the specimens and notes may exist.

The records which he considers as absolutely necessary to accompany all specimens are, exact locality, date, collector's name, and if any further notes are made on food habits, life history, descriptions, etc., an unduplicated number (for the species of any given accession catalogue or set of notes) should always accompany the specimens. He said that locality and date labels with collector's name are all right and all that are necessary simply for collected material, but all biological material, and that on which special observations are noted in a book or on a card, should, in order to be of permanent value, bear a number referring directly to a corresponding number of the entry in the book or on the card. To avoid the large numbers which would result from many years of active work, he has adopted a subcharacter or subnumber, or both, to distinguish the many species which may come under the head of one general note; as, for example, the insects collected from a dead pine tree, accession No. 7775 would refer to the general note, while the separate species and their relation to each other and to the trees may be designated by the addition of a letter to the number (7775*a*), which may be extended, as required, from *a* to *z*, and still further extended by double letters, or better by $\frac{a}{1}$, $\frac{a}{2}$, $\frac{a}{3}$, $\frac{b}{1}$, $\frac{b}{2}$, $\frac{b}{3}$, etc., to designate several species found on different parts of the tree, or also the parasites and other natural enemies associated with a given enemy of the plant.

With this system it is not necessary to identify the species in the field, since the individual number will enable it to be identified at any future time or by a specialist, and the name subsequently entered with colored ink in the original note.

He stated that it seemed to him that the permanent usefulness and advancement of economic entomology depended, to a great extent, on accurate and full field notes systematically recorded, so that they will be most available for the individual worker, his assistants, and successors.

Mr. Caudell said that a system almost exactly like that here proposed by Mr. Ball was introduced some two years ago by a writer in the Journal of Applied Microscopy and Laboratory Methods, Volume II, page 449 (1899). The scheme was recommended for all kinds of objects, and the individual number is prefixed to the regular numbers, instead of added, and the day of the month comes first. Thus, the example quoted, a specimen collected on August 12, 1899, would be 1–12–8–99, 2–12–8–99, and so on.

Mr. Ball replied that the system referred to by Mr. Caudell related to keeping slides of embryological and histological material, and while the date system part of it was the same, the application was quite different. He had been using the system five years before that one was published. He also said that every collector ought to be able to give the genus of the specimens taken, but that if he could not, a few descriptive words would serve to identify the species when the material was worked over. He suggested that it be borne in mind in the discussion that the present system was not offered as an improvement upon the systems of Messrs. Felt, Hopkins, and Forbes, nor for any laboratory where they had help enough to carry out one of these systems, but that he thought that it was an improvement upon the system in use in the majority of economic laboratories and that the date system feature might be incorporated into any system to advantage.

Mr. Ashmead indorsed Mr. Hopkins's system and said that he always put the name of the collector on the specimens received at the museum. He ordinarily used two labels, but three were used when the original label of the collector was retained. He thought it of primary importance to accompany the specimen with the name of the collector.

Mr. Bruner agreed that the name of the collector should always appear and said that he used printed labels.

The session then adjourned to meet at the capitol at 9 o'clock the next morning for the purpose of looking over the State museum, returning to the high-school building at 10 a. m. for the morning session.

MORNING SESSION, AUGUST 24, 1901.

Mr. Howard read a paper entitled:

A PRELIMINARY REPORT ON THE SAN JOSE SCALE IN JAPAN.

By C. L. Marlatt, *Washington, D. C.*

The investigation of the San Jose scale in Japan by the writer has reached the stage when it is possible to give a definite conclusion on the question of original home so far as Japan is concerned. The report is provisional only in the sense that some work remains to be done in the northern provinces, which can hardly alter the conclusions, and that time and facilities are lacking to make it full and complete.

In the three months already spent in Japan the writer has explored the main islands pretty thoroughly from Tokio southward to the lower extremity of Kiushu—the large island completing the chain on the south. In all some 35 provinces or districts have been visited and carefully examined, the points being selected where orchard and nursery interests were oldest and most important. There remains to be explored the north half of the main island (Hurdo) and the northern island of Hokaido, the whole of Japan covering a stretch of latitude about the equivalent of from Newfoundland to Florida.

The Japanese Government has taken and is taking the greatest interest in the investigation, and has sent out with the writer one of the officials of the Central Agricultural Experiment Station of Tokio, Mr. S. K. Hori, a capable entomologist of Cornell training, and, furthermore, has interested the agricultural experiment stations and schools and governing authorities in the provinces throughout the Empire in the investigation, and extended a multitude of courtesies which it would be impossible here to list.

All scale insects have been studied and collected, and especially those of fruit trees and economic plants, and—as far as possible without interfering with the main object—other injurious insects also.

This report, however, relates to the San Jose scale exclusively, except as it seems desirable to include some facts discovered relating to the peach, plum, cherry, and mulberry scale (*Diaspis pentagona*), the very general occurrence of which in Japan has a very marked influence on the rôle played by the San Jose species.

To give a correct picture of conditions, some knowledge of Japanese fruit-growing must be had. In the first place, this industry as known to America is unknown in Japan, except in a few small districts.

The great mass of the Japanese fruit trees are grown as yard ornaments, or in little garden patches attached to the dwelling houses. Every little thatched cottage has its flowering cherry tree and plum tree, and very possibly a pear, a peach, a persimmon, and very often an orange tree. Sometimes two or three of each sort will be grown, and the more pretentious gardens of the wealthier townsmen amount to miniature orchards—the different fruit trees and ornamental plants being jumbled together in rank confusion. In other words, the popular fruit and flowering trees, while universally grown, are in very small numbers.

There are a few orchard districts where numerous patches of from one-fourth acre to 3 or 4 acres of fruit trees occur. These are chiefly of the old native pear tree, more or less invaded by replantings of American trees or new orchards of the same, some small apple orchards, (more extensive in the north, where I have not been) very rarely a small peach orchard (only two seen), and in the south small orchards (not common) of orange.

The walnut orchards of the island of Kiushu are the only ones that truly compare with orchards in the American sense.

Growing fruit, and especially the deciduous varieties, amounts to little in Japan, but is increasing with the introduction of American varieties. Her enormous population of 46,000,000 has compelled the growth of cereals and other necessities of life wherever possible, and among these necessities tea and mulberries must be included, but these are grown as hedge plants, or where rice can not be grown very often.

A people too poor to enjoy more than the most meager living, the Japanese have not indulged very much in such luxuries as fruits.

Their love of the beautiful, manifested in a thousand ways, finds its most common exemplification in the presence everywhere of flowering trees (cherries, plums, etc.) where fruit trees might be grown, and the conditions briefly described have been characteristic of the country for two thousand years—her agriculture being scarcely altered from the time of Alexander.

The distinctively native Diaspine scale of Japan is the *Diaspis pentagona* already referred to. It is what we know in America as the white peach scale, and which in Italy is the enemy of the mulberry. In Japan this scale is found on the flowering cherry and plum, grown in every dooryard, in all the parks and temple yards, along roadways and along the little strips of soil dividing one rice patch from another, and is almost worshiped in the season of bloom. These trees, cherished as nowhere else in the world, attain a great age, and when protected by dryness or almost immovable supports, inclosed with fences and marked and labeled with imposing stone monuments, become to the entomologist valuable records of insect work or the absence of it, of one or two hundred years' standing. The peach—a rough-barked scraggy tree in Japan—it infests as a rule but slightly. The mulberry is often badly attacked, as are also other plants, and notably the Kaido a green-barked ornamental tree very commonly grown.

The reason for believing this scale insect to be undoubtedly native or introduced so long ago as to practically amount to this is that it occurs everywhere, not only on the main islands, but on the little islands also; and, furthermore, in every dooryard and on absolutely every cherry and plum tree within the limits of the Japanese Empire. Such universal and invariable occurrence I have never witnessed anywhere else, nor in the case of any other scale insect.

Very rarely does it occur more than scatteringly, so that great damage is not often suffered. Chalcidid parasitism does not play so important a rôle in keeping it thus in check. The chief agent in this direction is a little twice-stabbed ladybird, which I identify from the named collection at the hands of Mr. Nawa, at Gifu, as *Chilocorus similis* Rossi. This little beetle, looking almost exactly like our *C. bivulnerus*, though possibly smaller, is everywhere with the Diaspis, feeding as larva or adult on it, and keeping it from often developing in large numbers.

The San Jose scale, on the other hand, presents a very different picture, and is undoubtedly of comparatively recent origin in Japan.

While occurring rarely on many plants, it is economically limited to its attacks on the pear and apple, having spread (rarely, as the conditions show) to the others from these two.

The pear in Japan is represented by the old orchards of native trees and dooryard or garden trees, usually also native for the most part. These orchards and trees are usually of considerable age, fifty to one hundred years, except the replants. During the last thirty years a good deal of American pear stock has come into Japan chiefly from California without any fumigation, and very often undoubtedly infested with the San Jose scale.

The nursery business in Japan is very largely limited to three principal nursery districts or communities, and these were early thus infested, and the new stock from America and the native varieties grown in the nursery alongside of the former, and infested therefrom, have been sent out all over the Empire in small lots and used to replace trees in old native orchards or planted here and there in yards and gardens, scattering the San Jose scale exactly as it was in eastern America a few years ago, and the San Jose scale conditions in Japan to-day are the exact counterpart of what they are in our Eastern States.

In many instances I was able to see the beginning of scale infestation on American or other stock obtained but a few months before from one or other of these nurseries, two of which I have examined. In two instances, at least, the San Jose scale was on the young stock of experiment stations—American varieties, which the stations were experimenting with and about to introduce in their respective provinces.

In most of the orchards of native trees only, the scale had acquired but a very slight foothold. Newly set trees (which were traced in nearly every instance to one of these nurseries) were the centers of contagion, or in some instances new orchards alongside of old ones had carried the scale to the bordering trees of the old orchard.

Old native pear trees in yards and gardens are usually still exempt from this scale, and when infested, easily accounted for by the near-by presence of new stock. It very naturally suggested itself that the native pear of Japan is resistant to the San Jose scale, and this is the more plausible because it is a rather scraggy, rough-barked plant, much more so certainly than the American varieties.

A very little examination demonstrated, however, that the San Jose scale once carried to one of these native pear trees affects it just as severely as it does the American variety. In other words, it is not scattering or rare, but when it once gains lodgment, multiplies rapidly in the temporary absence of its ladybird enemy, and occasionally kills a tree. Were it a native species we should certainly find it widely scattered, though probably sparingly, in these old orchards and yardtrees, as is the Diaspis on the cherry and plum, etc.

The apple is scarcely grown at all in the south two-thirds of the Empire, save as exemplified by a few orchards near Tokyo. Furthermore, this fruit as economically cultivated is of recent and purely American origin. The native apple of Japan is a crab, grown more for ornament than fruit, and a very rare tree, unknown to most Japanese.

The improved varieties of apples now grown here came from America (California), and the industry is not 30 years old. Much of the stock was undoubtedly infested when received, and I am informed that the orchards of north Japan have suffered much from this insect from the start, although the nature of the trouble has not been long recognized. Its very general non-occurrence in the one or two-hundred-year-old plum and cherry trees, or those of lesser age grown in thousands throughout the Empire, is very significant, especially as it attacks both of these trees when carried to them. It should be remembered also that Koebele did not find it in Japan at all some ten years since.

It is perfectly patent, therefore, that the San Jose scale came from America to Japan on American fruit trees which have been regularly imported during the past thirty years, and chiefly from California, where the San Jose scale has been longest and worst. Its wide distribution in Japan has been by the leading nurseries, just as in America.

It is here that the Diaspis has benefited Japan. The little ladybird enemy of this native scale insect has taken readily to the introduced species, and has very materially checked its injuries. As already shown, there is not a corner in all Japan where this ladybird does not occur with the Diaspis, and wherever the San Jose scale has been carried it has found this active and fecund predaceous insect ready to devour it, and very rarely does a tree at all badly infested long escape discovery and measurable protection. Isolated trees may become covered with scale before the beetles find them, or new orchards and replanted trees infested with scale will be injured, but it does not last long, as a rule.

The San Jose scale is attacked also by one or two Chalcidid parasites, presumably the ones we have in America and brought to Japan with the scales or cosmopolites. (Sent to Dr. Howard for identification.)

Further, the San Jose scale, together with other Diaspine scales in Japan, is badly attacked very often with what appears to be the same orange-colored fungus which we find in our Southern States. The climate here is especially favorable for the fungus—moist and sultry heat characterizing much of the year.

So much for the origin and present status of the San Jose scale in Japan. It may be of interest to add some notes on one or two allied subjects.

For a long time the Japanese entomologists and some foreign ones, notably in Germany, have held that the scale in Japan represented a different species, or at least variety, from the American insect. I am now able to confirm an older belief of mine that this is not the case. The Japanese insect is the typical San Jose scale. All the features and characters noted in the so-called varieties may be found in a single colony together with the typical scale as we know it in America.

I merely mention this misconception here to report a false security felt by German importers and officials in letting Japanese plants come into Germany and other European countries without check until within the last twelve months, when Germany included Japan with the United States as dangerous sources of plants.

The dwarf pear and apples, etc., in the chief nursery of Japan are, as I have found, all infested with San Jose scale. (The dwarf trees are ordinary nursery trees from the nursery rows, starved and cut back, and not special varieties.) These have been exported, the proprietors inform me, to America, to two or three ports in Germany (up to twelve months since), and are still sent to England. When sent to America they are now fumigated, because Mr. Craw has sent some lots scale-infested to limbo. Most of the export plants are ornamental plants, pines, maples, etc., but a good many of the quaint dwarf fruit trees in flower pots and bearing fruit are also sold and shipped abroad. I do not think this need alarm Europeans, for I much doubt whether, with the climatic conditions of Europe and with the conditions of fruit growing there, the San Jose scale ever will amount to much on that continent.

In connection with the identification of the San Jose scale in Japan, I wish to add that Professor Sasaki, the entomologist of the Agricultural College of the Imperial University, following Professor Cockerell, has held that the Japanese scale was distinct from the form occurring in America. He also expressed to me the alternative belief—not at all compatible with the first, however—that if the same species it came to Japan from America on imported stock.

In the last view he is undoubtedly correct, and I have no doubt but that he will give up the former view, which he has hitherto urged very strongly.

His chief anxiety, evidently, was to free Japan from the onus of the San Jose scale of America one way or another, and both of his theories attained this end. He is therefore well pleased with this report.

As an economic problem the San Jose scale is not so important for Japan. It is widely distributed already, and extermination is out of the question, but the natural conditions of climate, character of fruit growing, fungous disease, and parasites will probably always keep the scale in check.

Most orchards of pear and apple, etc., are grown as we do grapes, on trellises, and the trees are cut back to mere dwarfs, all the branches being within easy reach.

Labor is so cheap that the trees can be given a very thorough hand scrubbing every winter, and now in places it is the practice to do this with a salt-water wash, just on general principles of cleanliness. I have felt it merely necessary to recommend soap instead of salt as more valuable where scales are concerned.

The important feature for America is the Japanese ladybird (*Chilocorus similis*). With the literature available here I can not determine whether this beetle has already been carried to America by Koebele or Compere, but I am expecting daily information on this point from Washington, so that if necessary I can send, or at least make the attempt to send, living beetles to California and the East.

A general discussion followed the reading of Mr. Marlatt's paper.

Mr. Cockerell said that he was very glad to hear Mr. Marlatt's paper, as it threw a great deal of interesting light on the conditions existing in Japan. Hitherto we had greatly lacked information of this sort. He wished to correct one statement in the paper, that he (the speaker) considered the Japanese insect distinct from the true San Jose scale. This was the exact reverse of the truth, but he did consider that the scale presented some varieties in Japan, as, for example, the one feeding on orange trees, a thing the insect in California never did. Mr. Marlatt's statement about the Chilocorus was very interesting. The speaker had noticed a similar case in Arizona when the *Chilocorus cacti*, feeding normally on the native *Diaspis toumeyi*, came to prey upon the introduced date palm scale (Parlatoria). As regards the main proposition advanced by Mr. Marlatt, that the San Jose scale was certainly not a native of Japan, Mr. Cockerell could not see that any proof had been offered. The fact that the insect occurred mainly upon imported American varieties was just what might be expected if it were native to Japan, as the American varieties would be less resistant than the Japanese. It has been observed by Dr. John B. Smith that the Keiffer pear was, to a considerable degree, resistant to the scale. Now, this pear was a hybrid with the Chinese sand pear, and it seemed to show that trees having Chinese or Japanese blood, or one should say sap, were more or less resistant to the scale. The fact that the scale was not found on wild plants in Japan proved nothing. Mr. Cockerell had found many Coccids in New Mexico on wild plants, and though the plants were abundant the Coccids were usually confined to very limited localities, and even after years of residence in the immediate vicinity were very likely to be overlooked. He also knew of cases such as those of *Toumeyella mirabilis* and *Dactylopius prosopidis* in which these isolated colonies were entirely destroyed by parasites or predaceous enemies.

The San Jose scale belonged to a Palæarctic or at least a Holarctic group, and must surely have originated in the northern temperate zone. It certainly could not be supposed to come from Europe, and it did not seem likely that it was American. Hence, on general principles, one would look for its home in eastern Asia. However, the speaker thought it might just as well have come from China as Japan.

In concluding, Mr. Cockerell said he did not accept the view that *Diaspis pentagona* was certainly a native of Japan. On some such grounds as those mentioned by Mr. Marlatt it might be referred to Jamaica and various other places. He did not consider we yet knew certainly where this scale originated.

Mr. Jordan said that a very large proportion of the flora of Japan came from China, more especially the fruits, and it was therefore possible that the San Jose scale might have been introduced into Japan from China. Upon his trip to Japan he was impressed with the utter neglect of the orchards in that country and the wholesale destruction of birds.

Mr. Kellogg said that Mr. S. I. Kuwana, assistant in entomology at Stanford University, spent all of last summer collecting and studying the Japanese scale insects, giving special attention to the San Jose scale. Eighty species were taken, twenty of which were new. Mr. Kuwana visited three of the four principal islands of the Empire, and found the San Jose scale generally distributed throughout these islands in native orchards as well as on imported trees. The San Jose scale has been known to the natives of Japan for more than thirty years under the name of ki-abura. He could not agree with Mr. Marlatt that the weight of evidence was in favor of America as its native home. He was of the opinion that there were not yet sufficient facts at hand to determine this point definitely, but that the present indications were that the insect came from Japan to California. He stated that Mr. Kuwana had found the scale attacked by parasites and predaceous insects, which would have some weight in favor of Japan as its home. He thought that both Mr. Marlatt and Mr. Kuwana had made a mistake by confining their investigations to the lines of the railroad instead of giving the wild plants more particular attention.

Mr. Howard said that in his opinion Mr. Kellogg's statement as to parasites did not affect the point in question, that native parasites might attack an introduced species of scale. He thought also that old native trees were quite as liable to the attacks of scale as introduced plants. He said that Mr. Marlatt's wide experience in the study of the Diaspine group of scales in the eastern United States admirably equipped him for the investigation now in progress in Japan and that his expressed opinion should have the greatest weight. He held to the opinion that the weight of evidence indicates that Japan is not the original home of the San Jose scale, but that it was introduced into Japan from America; but stated that Mr. Marlatt would be instructed to extend his investigations into the wild country, in the hope of securing further facts bearing upon the question at hand.

The next paper on the programme was presented by Mr. Hopkins:

NOTES ON (1) THE PERIODICAL CICADA IN WEST VIRGINIA; (2) THE HESSIAN FLY; (3) THE GRAPE CURCULIO.

By A. D. Hopkins, *Morgantown, W. Va.*

[Withdrawn for publication elsewhere.]

Mr. Ehrhorn wanted to know if the parasite of the Hessian fly was abundant in West Virginia, and stated that these parasites did not exist in California, and that he desired to obtain some material in the hope of establishing it in his section.

Mr. Hopkins replied that these parasites were very abundant last year, but not effective.

Then Mr. Felt presented the following paper:

FURTHER NOTES ON CRUDE PETROLEUM AND OTHER INSECTICIDES.

By E. P. Felt, *Albany, N. Y.*

A preliminary paper on some work along these lines was read by the writer at our last meeting and a full account of the experiments in 1900 has been presented in his report for that year, and the results there set forth need no repetition at this time. No very apparent differences among the trees experimented upon, aside from those recorded during 1900, were observable in the spring of 1901. All the trees passed the winter about equally well, after making due allowance for their condition, and though several trees died, it was only those which were in a desperate condition the preceding autumn. It is rather significant that of the three trees sprayed with undiluted kerosene in the spring of 1900, but one was alive a year later, and of the four treated with undiluted petroleum, but two were alive, and both of these came through the winter with a large proportion (25 to 50 per cent) of their branches dead. It is but just to add that most of these trees, as previously recorded, were at the outset very badly infested with San Jose scale.

The poor results obtained with spring applications of kerosene and mechanical emulsions of the same led to the concentration of the work on the more promising insecticides, namely, crude petroleum and whale-oil soap in various combinations.

Another test was made with undiluted crude petroleum. Some oil was sent me direct from the Frank Oil Company, Titusville, Pa. It was a light amber-colored oil, said to test from 44° to 45° on the Beaumé oil scale, and in the field, just before spraying and at a temperature of about 65° F., it gave a reading of 43.3° Beaumé. Two trees were sprayed April 11, 1901, with this oil. The day was bright and there was a gentle breeze. Tree 116, a badly infested Lombard plum, showed serious injury July 3, at which time several limbs were dying and the remainder did not present a normal, vigorous appearance. August 9 the tree was dead and all the leaves thrown out in the spring had shriveled. Tree 117, a very badly infested Crawford peach, was also sprayed at the same time, and July 3 it was dead.

It might be added that the oil was used liberally, and that in the case of tree 117 the infestation was so very bad that it was hardly expected that the tree would survive.

Some comparative experiments with mechanical crude petroleum emulsions were made. The above-described oil from Titusville and an oil used in the experiments last year were tried. The latter was purchased in the Albany market as crude petroleum sold by the Standard Oil Company. It is a quite fluid greenish oil, and that used in 1901 gave a reading in the field of 41.8° Beaumé. Neither the 20 nor 25 per cent emulsions of either oil injured the trees, so far as could be seen, this agreeing with the results obtained with the emulsions of Standard oil in 1900. The Standard oil, that is the heavier one, appeared to be a little more effective as an insecticide, but as the lighter Titusville oil has been used in 25 to 50 per cent emulsions without injuring the trees and with very satisfactory results as an insecticide, it would appear that the heavier the oil the less can be used with safety and the more effective it is as an insecticide. There is evidently a very narrow margin between the amount of this substance necessary for satisfactory work against scale insects and that which will seriously injure or kill trees, especially peach and plum trees, and in the case of those very badly infested, particularly if the bark is quite rough, it is doubtful if enough oil can be applied to kill practically all the insects and at the same time not injure the tree seriously.

The experiments tried last year with a combination of 1 pound of whale-oil soap to 4 gallons of water, to which was added 10 per cent crude petroleum, were not quite satisfactory, as it was hoped that the combination would prove more effective as an insecticide and less injurious to the trees than either substance separately in the usual proportions. This year both 10 and 15 per cent of the crude petroleum obtained from the Standard Oil Company were used in combination with the pound to 4 gallons solution of whale-oil soap. There was no perceptible injury to the trees in either case, and the San Jose scale was pretty thoroughly checked with both mixtures, the one with the higher per cent of oil giving on the whole the best satisfaction.

The results obtained with whale-oil soap solutions, both 1½ and 2 pounds to the gallon, were up to date practically the same as those of last year. The scale was severely checked, but in no instance was it so thorough as where crude petroleum in some form was used. Two pounds to the gallon gave a little better result than the weaker solution.

Mr. Scott said that he had made similar experiments in Georgia looking to the control of the San Jose scale and had obtained gratifying results. He had used a 25 per cent strength of crude oil with water on peach and plum trees, spraying in the winter time, with the results that the scale had been effectually destroyed and the trees not damaged. He had found, however, that the undiluted crude oil killed peach trees outright, as did also refined kerosene. He had used the Pennsylvania crude oil registering 43° on the Baumé oil scale. The high price of the crude oil, as purchased from the Standard Oil Company, made it more expensive than refined kerosene, and for that reason, and because of its variable character, he did not recommend it for general use. For three years he had used a 20 per cent strength of kerosene with water as a remedy for San Jose scale, and the results were all that could be expected from the application of any spray whatever. He said that at the recent meeting of the Georgia State Horticultural Society the general expression from the fruit growers was to the effect that the San Jose scale was no longer feared since the kerosene treatment had proved so effective. He said that infested orchards of more than 100,000 trees each were being successfully treated.

Mr. Felt suggested that perhaps the San Jose scale did not become so dormant in Georgia as it did farther north, which would explain the successful use of comparatively weak applications of insecticides.

Mr. Scott replied that this was true, as he had frequently found the scale breeding on warm days in midwinter.

Mr. Kellogg expressed a surprise that the price of crude petroleum should be so high, and suggested that it might be obtained at a reasonable price direct from the oil wells.

Mr. Gillette then presented the following paper:

NOTES ON SOME COLORADO INSECTS.

By C. P. Gillette, *Fort Collins, Colo.*

Nysius minutus has been unusually abundant in portions of Colorado this summer, and numerous inquiries have been received concerning it.

My attention was first called to it by being told that it was destroying the strawberries upon the experiment station grounds. A visit to the strawberry patch was made at once and the bugs found in large numbers upon leaves, fruit, and blossoms, but most numerous upon fruit, both green and ripe. They were not giving special attention to strawberries, however, as they were much more abundant on some of the weeds growing between the rows, and particularly were they abundant upon wild mustard and *Monolepis nuttallii*, wilting the plants to the ground. Plants of yellow dock, and even Helianthus, were literally covered with them. In fact, hardly any species of plant in the vicinity entirely escaped the accumulations of these bugs; but that all served as food plants I am not certain. It is a common insect in the State upon beets, and has been reported to me as injuring cabbage and cauliflower.

The usual contact poisons—kerosene emulsion, whale-oil soap, and buhach—were used upon the bugs in the ordinary strengths without satisfactory results. In fact the most thorough applications would hardly kill any of these insects.

Aspidiotus howardi was first found by the writer some years ago at Canon City, Colo., where it was present in injurious numbers upon European and American varieties of plum, attacking both twigs and fruit. Scattering specimens were also noticed at that time upon pears. While the scale has remained in considerable numbers in the small plum orchard where it was first found, I have not known of its occurrence in any other locality until the present summer, when I was called by the horticultural inspector of Delta County, Mr. H. E. Mathews, to go with him to determine what scale was infesting a pear orchard in the vicinity of Delta. The scales could be found upon nearly all the pear trees in the orchard, attacking both bark and fruit, chiefly the latter. There were but few trees upon which the scale could be said to be abundant. We visited the orchard June 12, at which time young lice were hatching in small numbers. These were of the usual yellow color, but the little scale that first forms over them is pure white. From that date to August 20, at least, these young lice have continued to appear. On raising the scales from the females I nearly always found two or three young lice beneath them, and for some time thought the scale must be viviparous, but a new lot of the scales sent by Mr. Mathews August 17 contained females beneath which eggs were found. The eggs apparently hatch very soon after they are deposited, as it is usual to find two or three young lice and but one or two eggs under a female. Possibly the females are both oviparous and viviparous.

The scales cluster, for the most part, about the blossom end of the pears, and where they rest upon the cheek of the fruit they usually cause a depression and sometimes a red ring, which is considered to be characteristic of *perniciosus*. In this orchard occasional scales were found upon plums also. I have fruit with me with these scales upon it that you are at liberty to examine.

Chermes abietis.—This louse is abundant upon silver spruce in Colorado, especially in high altitudes, causing the cone-like galls at the tips of the new growth. The galls are always present in considerable numbers in trees of silver spruce upon the college campus at Fort Collins.

Chermes sp.—Two species (possibly one) of Chermes, one infesting Douglass spruce and one pine (*Pinus ponderosa*), are abundant nearly every year in the northern portion of the State, at least about Fort

Collins and Denver. Like *C. abietis*, these also deposit their eggs in clusters, each egg being anchored by means of one or more waxy threads, and covered with a white waxy secretion from the abdomen of the female. These lice are very small, not exceeding a millimeter in length. They are dark in color and are all wingless early in the season. Early in June winged individuals appear. These winged females have less of the waxy secretion with which to cover the clusters of eggs that they lay upon the leaves, and so they cover them with their enormously large wings. Both species seem to be entirely oviparous. The newly hatched lice arrange themselves in rows along the leaves, and when the white secretion is well formed they are completely covered by it. The species infesting the pine is specially numerous at the new growth at the tips of the twigs, and the little lice winter very largely between the pairs of needles that grow together and near their base.

Both lice and eggs are readily killed by the use of kerosene emulsion or whale-oil soap. (Photographs were shown illustrating these lice.)

PLANT-LICE.

The grain louse (*Nectarophora granaria*) did considerable damage in eastern Colorado last year. I know no previous record of its occurrence in this State. This year it has occasioned no complaint, and I have no knowledge of its occurrence.

Last year Mr. Ball investigated the injuries of this louse along the line of the Santa Fe Railroad in the State and found wheat, oats, and barley attacked, but the chief injury was to wheat.

The snowball plant-louse (*Aphis vibernum*) is a comparative recent acquisition in the northern portion of the State. For the past two years it has been rather abundant upon snowball bushes upon the campus of the State Agricultural College at Fort Collins.

The ash gall louse (*Pemphigus fraxinifolia*) continues to be one of the worst pests that our ash shade trees have to contend with on the plains of the eastern slope in the State. It is not destructive to the trees, but seriously mars their beauty, and the secretions that fall from the lice are annoying, to say the least, to those who would enjoy the shade of one of our best lawn trees.

The apple louse (*Aphis mali*) has become one of the most common of our plant lice within the State, occurring upon both slopes. The eggs blacken the twigs of apple trees in the fall so that they are noticed during winter by the owners of orchards, who send them to the Entomologist for identification. The strange thing about these eggs is that we have not been able to find any lice hatching from them upon trees where they are deposited, and twigs have been brought into the laboratory bearing thousands of eggs of this louse; but we have not succeeded in getting any to hatch. It does not seem that it could be due to lack of fertilization, as the little wingless brown males occur in large numbers and freely copulate with the females during the fall.

The cabbage louse (*Aphis brassicæ*) seems to be a worse pest upon cabbages and cauliflowers than the cabbage butterflies, *P. rapæ* and *P. protodice.*

The beet army worm (*Laphygma flavimaculata*), which ravaged the sugar-beet fields to such an alarming extent in the Grand Valley in the summer and fall of 1899, was almost entirely absent over the same area in 1900, in spite of the fact that the moths emerged in enormous numbers late in September for hibernation. They did occur in considerable numbers last year, however, in the vicinity of Rockyford, Colo., where sugar beets were being grown for the first time in large numbers for commercial purposes. The past summer the first brood of this insect appeared in considerable numbers, both at Palisade, in the Grand Valley, and in the Arkansas Valley in the vicinity of Lamar. It is now time for the second brood to be on in full force, but I have heard nothing of it yet. It looks as though another native insect, formerly unknown as a destructive species, had come to stay as an enemy to beet culture.

The cabbage Plutella (*P. cruciferarum*).—A curious instance in the food habits of this insect was called to my attention the present summer. Mr. H. E. Mathews, horticultural inspector for Delta County, sent me a quantity of leaves from small peach trees, with hundreds of small white cocoons upon them, with the statement that some new peach defoliator had appeared in an orchard in Delta County and he wished me to tell him what to do about it. I could not tell what the insect would turn out to be, but in a few days moths of the cabbage Plutella appeared in large numbers, and I was almost as much puzzled as before. I told Mr. Mathews the ordinary food habits of the insect, and then he explained that the year previous the ground in this orchard had been allowed to grow up to a wild mustard, and that the weeds had been thoroughly kept down this summer. The moths, doubtless, hatched there in large numbers and, not finding their natural food plants, deposited eggs upon peach leaves, upon which the larvæ developed. (Photographs of the cocoons of this insect upon peach leaves were exhibited.)

The thistle butterfly (*Pyrameis cardui*) was unusually abundant throughout the State while fruit trees were in bloom, so that many inquiries were made as to the significance of this insect in such numbers.

The bean ladybird (*Epilachna corrupta*) does considerable damage to the foliage of beans, particularly wax beans, near the foothills of the east slope of the mountains every year, but the degree of destructiveness varies much. The present season the injuries have been more severe than for several years past. It is also difficult to combat on account of the beans being very susceptible to injury from the application of arsenical mixtures and the further fact that nearly all feeding is done upon the under side of the leaves. The arsenicals, however, seem to be our best means of destroying the beetles by means of insecticides.

Phytoptus sp.—There is a Phytoptus mite that seems to be steadily on the increase in Colorado, which attacks the cottonwoods. As the leaves open in the spring, reddish excrescences begin to form about the buds and upon twigs and limbs, of a more or less reddish color, that continue to enlarge in size during the summer. The year following, additional growth may appear about the old gall and new ones form. In early spring the mites within the chambers of the galls are of a deep red color, while those that appear during the summer are lighter in color. In the northern portion of the State these galls are so abundant as to be very noticeable to passers-by when the foliage is off. Some trees are literally filled with them, so that scarcely a twig can be found without one or more of the galls upon it.

Another peculiar development, as the result of Phytoptus attack in the cottonwoods, takes place in the same trees, and may be due to the same species, so far as I know. It is the transformation of the flower catkins into large pendant masses, often 6 or 8 inches in length, reminding one of a long slender cluster of grapes. An interesting thing in connection with this abnormal growth is that the attack of the mites causes the flower parts to revert into leafy growths, pointing to the origin of the development of the parts of the flower.

LEAF-CUTTER BEES.

Until the present summer I have never heard of leaf-cutter bees being abundant enough to seriously defoliate plants, but am told by an intelligent lady residing near Fort Collins, some 10 miles from the foothills, that her rosebushes were so badly defoliated by them the past summer that it was necessary to cover them during the day to save any leaves at all.

Mr. Caudell said that in the garden of W. M. Rysler, of Delta, Colo., this season he saw a number of mature radishes, every plant of which was completely killed by the minute false chinch bug (*Nysius minutus* Uhler), myriads of which at that time covered the entire plants. In some gardens he saw a patch of potatoes much injured by the larvæ of *Plusia brassicæ*. The injury was so striking as to be noticeable from a distance, resembling the ravages of the potato beetle. These same larvæ were infesting cabbage, cauliflower, lettuce, sugar beets, and garden beets.

Mr. Hopkins said that he had collected the galls of a *Chermes* sp. (which Mr. Pergande thinks may be *Chermes sibiricus*) from the Sitka spruce at Newport, Oreg., and from the Engelmann spruce at Sand Point, Idaho.

President Gillette then announced that the proposal of new members was again in order, whereupon the following names were offered and received:

W. D. Hunter, Washington, D. C., proposed by Mr. Bruner; Vernon L. Kellogg, Stanford University, Cal., proposed by Mr. Bruner; Dr. W. J. Holland, Pittsburg, Pa., proposed by Mr. Hopkins.

The meeting then adjourned for lunch, to reassemble at 2.30 p. m.

AFTERNOON SESSION, AUGUST 24, 1901.

Mr. Scott presented the first paper of the afternoon programme, viz:

A PRELIMINARY NOTE ON A NEW SPECIES OF APHIS INJURIOUS TO PLUMS AND PEACHES IN GEORGIA.

By W. M. Scott, *Atlanta, Ga.*

Early in April, 1898, I observed a chestnut-brown Aphid in great numbers attacking plum trees in an orchard at Fort Valley, Ga. The insects were crowded thick on the growing tips and leaves of several thousand plum trees, and their injurious effects were then evidenced by the curled and twisted condition of the leaves and stunted appearance of the young shoots.

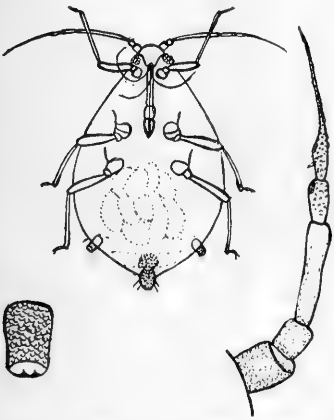


Fig. 1.—*Aphis* n. sp: stem mother on peach and plum in Georgia, much enlarged (from drawing furnished by Scott).

Thinking it was probably only one of the well-known species of plant-lice common to the plum, I took no special notice of it more than to have the infested trees treated with 10 per cent kerosene in mechanical mixture with water, which proved to be an efficient remedy.

Several days later the same conditions were found in plum orchards at Marshallville, and during the course of the season the insect was located at a number of places in middle and south Georgia. The following year, 1899, this insect again showed up in numbers even more injurious than when first observed. Investigations during that year showed it to be generally distributed over the State, equally prevalent in the northern, middle, and southern portions. It was then found to infest the peach as well as the plum. Its natural food plant would appear to be the wild plums, as these were found badly infested in every section of the State. Among the cultivated plums the Wild Goose, Robinson, and Mariana appear to be favorites of this insect, but the Japanese varieties also suffer serious damage from its attacks.

In July of the same year specimens of this Aphid began to be sent to the office as being injurious to the nursery stock, and the fall nursery inspection showed it to be a serious pest in the nurseries, particularly on June-budded peach trees. The terminals are attacked early in the season and further growth is seriously checked.

It soon became evident that this plant-louse was not one of the species commonly known to infest stone-fruit trees, as I had first supposed.

Accordingly, on November 4, 1899, specimens of this insect were submitted through Dr. Howard to Mr. Pergande, who identified it as apparently a new species of the genus Aphis. (This information was accompanied by the statement, "I think it well worth your while to make a careful study of this insect.")

San Jose scale overshadowed every other pest, and all of my time was occupied in dealing with it. At that time, therefore, it was out of the question to start any breeding work whatever, and nothing

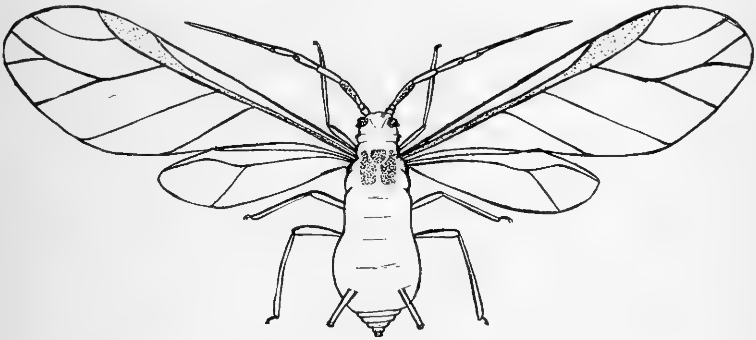


FIG. 2.—*Aphis* n. sp: winged form on peach and plum in Georgia, much enlarged (from drawing furnished by Scott).

could be done on the Aphis more than to make general field notes. At the last session of the State legislature, however, I was given an additional appropriation, which made possible the employment of an assistant and an extension of the work.

While the nursery and orchard police work still demands most of the time of both my assistant, Mr. W. F. Fiske, and myself, it was decided that between us we might trace out the life history of this new Aphid. Accordingly, on March 25, 1901, a plum tree in Atlanta, which I had noted the previous year as being badly infested with the lice, was examined just in time to find the newly issued to nearly full-grown larvæ present. These had apparently hatched from over-wintering eggs, as evidenced by the presence near them of the dark-brown shells, and the five antennal joints that developed in the adult as against six joints in the adults of succeeding generations.

From these stem mothers, colonies were established both in the laboratories and in the open air on young plum trees grown from

Mariana cuttings and also on peach seedlings. Isolated colonies on the original plum tree were also watched.

In some colonies when members of the fifth generation reached maturity, on May 8, winged individuals developed, while in other colonies the winged form did not appear until the sixth and seventh generations were reached. Our field notes show that the winged form appeared in south Georgia as early as April 18, and, indeed, winged individuals were found in great numbers in Atlanta on a plum tree that was not at first under observation as early as May 1.

All forms that have been observed to the present date are parthenogenetic. Only a small percentage of a colony would become winged, but winged individuals have continued to develop in every generation until the present date (August 14).

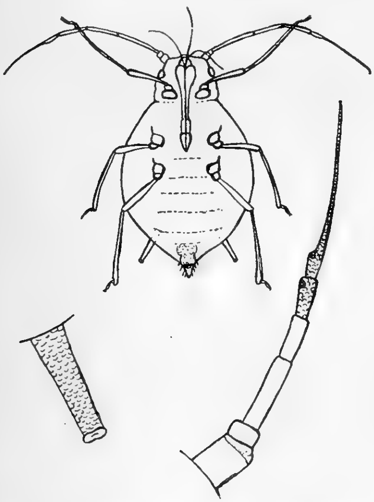


FIG. 3.—*Aphis* n. sp: adult from winged form, much enlarged (from drawing furnished by Scott).

After about twenty-four hours from maturity the winged individuals leave the colony and establish themselves, either singly or in groups of two or three, upon neighboring trees, where they feed for several hours before giving birth to young. The terminals of succulent shoots were invariably selected, and the peach seemed to be preferred to the plum; in fact, the winged were never observed to locate on the plum, although several plum trees were growing on the grounds.

It was never observed that the direct offspring of the winged form developed wings, but some individuals of the second and succeeding generations usually do so.

It was also observed that when a colony was kept reduced to a small number of individuals no winged individuals would develop, but when allowed to increase to considerable numbers some such would always appear.

On August 14 some of the colonies had been carried to the tenth generation from the winged.

In order to get further assurance that an old species was not under observation, specimens were taken from one of the breeding numbers and submitted to Mr. Pergande, who again identified the insect as a new species of the genus Aphis.

It is desired to carry this breeding work on until the true males and females are secured before describing the species.

Adalia bipunctata frequented our breeding colonies in great numbers, and it was a continual fight between us and the beetles as to which should have the lice.

The larvæ of Scymnus, as well as certain Syrphid flies and Chrysopidæ, also preyed upon this Aphis.

In the discussions of this paper Mr. Ashmead said that the record of this new Aphis attacking the stone fruits was very interesting, inasmuch as this group of plants already suffered from the attacks of half a dozen well-known species of plant-lice. He suggested that the Aphididæ afforded a splendid field for investigation, and that there was pressing need for such work. He said that Mr. Pergande was authority on this group and had in his possession the types of both Riley and Buckton.

Mr. Bruner said that his former assistant, the late Mr. Williams, did extensive work upon the aphides, describing 35 species, but that his work had not yet been published.

Mr. Gillette called attention to the great danger of the black peach Aphis being disseminated on nursery stock, and said that it had been thus communicated to Colorado from Missouri.

Next in order was a talk upon "Fighting insects with fungous diseases," by L. Bruner, Lincoln, Nebr.

Mr. Bruner said in part that the successful control of the chinch bug in some sections by means of a fungous disease had been a great calamity to working entomologists, because this success had created a false belief that injurious insects in general could be controlled by fungous diseases. As examples of insects destroyed by fungi he mentioned the chinch bug, locusts, and house flies. He said that the disease among grasshoppers would act only when conditions were favorable; that a grasshopper might eat a diseased one and be immune if conditions were not just right.

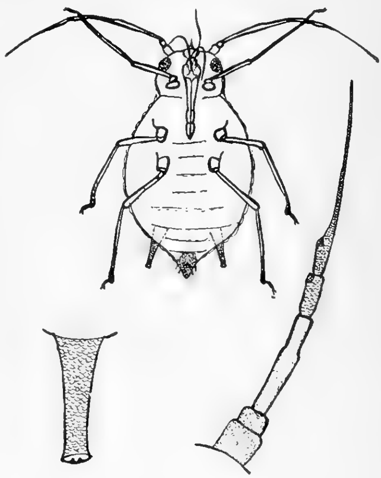


FIG. 4.—*Aphis* n. sp: wingless form fourth generation, fourth stage, much enlarged (from drawing furnished by Scott).

He had received from the Department of Agriculture what was supposed to be the South American locust disease, which proved to be only a Mucor. The material was distributed over Nebraska, and while some who received it reported good results, others "cussed." In his experiments he had found that none of the locust diseases were successful.

In the discussion of this subject Mr. Gillette said that he often recommended the farmers of his State to grind the diseased and dead grasshoppers as finely as possible in plenty of water and then sprinkle the water upon plants where the grasshoppers were feeding. In his opinion the disease germs are usually present, and the disease will make its appearance when the climatic conditions are favorable. He believes the only object in scattering the germs is to make more certain the spread of the disease when other conditions are favorable.

Mr. Cockerell was of the opinion that the diseases of insects would not be effective in the destruction of scattered individuals, but that where insects were crowded together the introduction of disease would meet with success. He thought much good would result from the dissemination of the diseases of insects.

Mr. Hopkins then read the following paper:

INSECTS DETRIMENTAL AND DESTRUCTIVE TO FOREST PRODUCTS USED FOR CONSTRUCTING MATERIAL.

By A. D. Hopkins, *Morgantown, W. Va.*

There is constantly increasing complaint among the manufacturers and consumers of construction timbers relating to the difficulty of securing material that is free from defects caused by wood-boring insects. This trouble appears to be due to two conditions—one a diminished supply of the best timber, the other that of increased injury to forest trees by insects.

The increase of insects is largely due, it is believed, to prevailing crude and wasteful methods of lumbering and general forest management. The old, defective, and undesirable trees are allowed to stand, which, with the stumps, refuse logs, and tops in the cuttings, serve as breeding places for vast numbers of the kinds of insects which are to blame for the injuries complained of, as well as for increased damage to the standing timber in the remaining uncut forests.

THE PRINCIPAL INSECTS.

The principal insects which are injurious to the wood of forest trees and their timber products may be briefly referred to as follows:

The oak timber worm (*Eupsalis minuta*) is without doubt the worst enemy of oak wood throughout the eastern, middle, and southern United States. It breeds in old stumps and logs, dead and defective standing trees, as well as in living trees, which it is ever ready to enter through the slightest wound in the outer wood, and in a few years the larvæ of successive broods penetrate the heart wood and extend their mines for a long distance above and below the original entrance. Under favorable conditions the larvæ will continue to work in the heavy lumber and square timbers cut from trees thus infested for many years after it is taken from the woods and placed in the structure. Especially is this true with reference to oak timber used in railroad construction, such as ties and culvert, bridge, and trestling timbers. This insect will breed in old oak logs as long as there is sufficient amount of sound wood for it to work in, and under favorable conditions it will doubtless do the same in railroad ties and other similar material which comes in connection with the ground.

The chestnut timber worm (*Lymexylon sericeum*) is another exceedingly destructive insect to the wood of living, dying, and dead oak trees, stumps, logs, and heavy construction timbers as long as the conditions are suitable for it to do so. The destruction of the wood of old chestnut trees throughout the Appalachian region, so far as its value for construction material is concerned, is well-nigh complete. Otherwise this durable and valuable timber would be a good substitute for the rapidly diminishing oak, and on account of its rapid growth from a young sprout to a tree of commercial size would be a most profitable forest tree to grow for future supplies.

The giant root borer (*Prionus laticollis*) is another enemy of wood which not only breeds in the roots and stems of living oak and other timber trees, but in old stumps and logs, railroad and other timbers which, owing to their connection with the ground, retain a sufficient amount of moisture. Some years ago I observed a large number of larvæ, apparently of this species, in some old oak railroad ties which were being removed from the roadbed in front of the Baltimore and Ohio station in Morgantown. It is therefore evident that this class of large wood borers contribute not a little to the rapid deterioration of oak ties and other timbers.

There is another class of Cerambycid, or round-headed borers, of the Centrodera, Leptura, and other allied genera, which breed in the wood of dead trees and logs, hence are capable of breeding in railroad ties and similar construction material. There are also many species in the family Buprestidæ with similar habit. In the Scolytidæ there are large numbers of species which bore in the wood of living, dying, and dead trees and cause serious defects. Indeed, there is a long list of species of Coleoptera which bore in the wood of trees and construction timbers and contribute to rapid deterioration and decay.

In Lepidoptera there are some very destructive enemies of the wood of living trees, notably the carpenter worms, which infest the oak and locust and bore large holes through the best part of the wood.

In Hymenoptera there are certain wood-boring bees and ants which do great harm to the timber and other woodwork of buildings, bridges, and railroads.

In Neuroptera the termites are among the most destructive enemies of wood and of wooden structures, working both in the moist and sound wood. Recently the writer has determined that these so-called white ants are very injurious to railroad ties and other railroad timbers.

Thus a great variety of insects are to blame for defective timber. They attack the dead, living, and felled trees, the rough manufactured product in the mill yards before it is used, after it is used in the structure, and until it is so badly damaged that it must be replaced by new material.

When we take into consideration the enormous amount of timber used in railroad construction alone, and the damage to such material by insects, from the time it is taken from the forest until it is replaced by new material in the structure, it is plain that we have in this an economic problem worthy of special attention. It involves not only the determination of methods of preventing losses to vast commercial interests, but the conservation of our forest resources, and the economy of present and future supplies of that which is in greatest demand.

When there was an abundant supply of timber it was possible to select only the best and to discard the defective, but at present it has become necessary, on account of the growing scarcity, to use much timber that is defective. This is evident from the character of the railroad ties and other construction material observed in the lumber yards, and piled along the road ready for use. Therefore, the problem of treating defective timber to promote its durability is becoming an important one. The need of investigations to determine the true character of the various kinds of defects caused by insects and their relations to the entrance of wood-decaying fungi, as a preliminary to the discovery and adoption of practical methods of checking or preventing premature decay, is apparent.

In the accumulation of data relating to the kinds of insects to blame for the commoner injuries, and to some important features in their habits, life history, and distribution, considerable progress has been made within recent years. While this technical knowledge of the insects, the characteristics of their habits, and the character of their work is of prime importance in suggesting methods of preventing losses, there is a feature relating to experiments with such methods to determine and demonstrate their practical application, which requires a considerably greater expenditure of money and time than has yet been available. Indeed, the funds available from public appropriations for original investigations of this character are not sufficient to warrant the undertaking of the elaborate experiments necessary. If, however, private individuals, or companies whose immediate interests are involved, would cooperate with departments of scientific research in this work, as is being done in some other lines of investigation relating to forestry problems, it is believed that results of the greatest value could be attained.

Mr. Cockerell asked whether a moderate number of forest pests might not in a way be beneficial by killing out the old trees and leaving room for the young ones to grow. He also mentioned the curious habits of the sugar cane Xyleborus in the West Indies, which, from attacking dead wood, had come to attack the living sugar cane.

Mr. Scott suggested that Georgia afforded a splendid field for investigations of this nature, as valuable timber in that State was being rapidly destroyed by the work of insects. He made particular reference to the wholesale destruction of chestnut and oak.

Mr. Bruner said that he had been connected with growing trees upon forest reserves and that he had seen the destructive work of these forest insects. He said that species of Dendroctonus kill thousands of trees in the forests of the Black Hills. He thought the Bureau of Forestry should take up the matter of insects in connection with other work, and he thought the time ripe for the publication of a manual on forest insects.

Mr. Hopkins said that the species of Dendroctonus referred to was evidently the one he had determined as a new species, from specimens sent to the United States Department of Agriculture from the Black Hills, to which he had given the manuscript name *Dendroctonus ponderosa*. He also said that it belonged to the division of the genus which includes the most destructive enemies of the pine and was, therefore, doubtless the one to blame for the serious troubles which from time to time during the past three years has been reported from the Black Hills region.

Mr. Felt followed with his paper entitled:

OBSERVATIONS ON FOREST AND SHADE TREE INSECTS IN NEW YORK STATE.

By E. P. Felt, *Albany, N. Y.*

The season of 1901 has not been specially notable on account of insects depredating on either forest or shade trees. The senatorial oak worm (*Anisota senatoria* Sm. & Abb.) is more or less abundant every year at Karner, only 7 miles from Albany. This summer there was a very large deposition of eggs, and by July 27 it was easy to find entire shoots defoliated, and none of the larvæ were more than one-third grown. The scrub oaks (*Quercus prinoides* and *Q. ilicifolia*) are likely to suffer severely before the end of the summer, as is not infrequently the case. The web nests of *Cacœia argyrospila* Walk. were not uncommon on the same oaks, the moths emerging at intervals during the greater part of July and in early August.

Systematic collecting at intervals of ten to fifteen days throughout the season has been practiced at Karner, where there is an admirable growth of scrub oaks and small hard pines (*Pinus rigida*). A portion of the results are given at this time.

The two large Buprestids, *Chalcophora virginiensis* Drury and *C. liberta* Germ., were taken throughout June and in early July, and two of the former species were captured August 9, though not met with on two previous trips. Large numbers of smaller Buprestids were also taken on pine, but they are not included in this account, as they have not been determined. *Anomala lucicola* Fabr. was present in considerable numbers, mostly on pine, though not uncommon on oak, from June 26 to July 19, and a few were taken as late as the 27th. One or more species of Dichelonycha occurred rather abundantly during the latter half of June and the first week of July. *Monohammus scutellatus* Say and *M. titillator* Fabr. were taken in very small numbers, though larvæ which must belong to these species and to *M. confusor* Kirby appeared to be common enough in this locality. *Glyptoscelis hirtus* Oliv. was captured on hard pine in rather small numbers from June 4 to 26. The common pine weevil (*Pissodes strobi* Peck.) was obtained in large numbers on hard pine, it being specially abundant in June, but occurring in small numbers throughout July and in early August. Two other weevils (*Magdalis lecontei* Horn and *M. alutacea* Lec.) were also taken throughout June and during the first week in July in association with the white pine weevil. The former of these two was even more abundant than the Pissodes.

Bark-borers.—The hard pines at Manor, Long Island, the white pines in the vicinity of Albany, and the balsam or fir trees of the Adirondacks have all suffered more or less from the attacks of various species of bark-borers. Investigations in all of these localities failed to reveal adequate cause for the great mortality among these trees unless it be due to the work of species of Tomicus. I am well aware that Dr. Hopkins, who has made a special study of bark-borers and is a well recognized authority on the group, inclines to lay blame on forms belonging in some other genus. The work of *Dendroctonus terebrans* Oliv. was very common at the bases of the hard pines on Long Island, and I found it in smaller numbers in white pines about Albany, but never in large enough numbers to cause very serious injury. In both of these localities, however, *Tomicus calligraphus* Germ. and *T. cacographus* Lec. and, in some instances, other species were uniformly present and many of the trees bore many pitch tubes, the work in most instances of the first-named form. *Tomicus calligraphus* was found by me last fall working in enormous numbers in dying white pines, the beetles not hesitating to run galleries into living, apparently healthy tissues, and so abundant was the insect that I could not help thinking it responsible in part, at least, for the death of the tree. This month I have found undoubted evidence of *Tomicus calligraphus*' entering what to every appearance were healthy trees. It is true there were not quite so many branches at the top of the tree closely inspected as there frequently is, but the needles were all green and gave no evidence of injury, and the bark from the base of the trees to the top was nice and green so far as the eye could discern, and yet such a one had been entered in large numbers by *Tomicus calligraphus*, and the beetles are even now running primary galleries and depositing eggs. The trunk of this tree was well spotted with pitch tubes, and small masses of pitch had dropped on the leaves of the surrounding shrubs. The tree above described is only one of a number which show an attack of this character in one stage or another. The condition about Albany is rather serious because many of the nicest trees in the rather small groves of white pine are dying from the effects of the work of this insect and of its allies. At Manor, Long Island, the hard pines covering an area of approximately 60 square miles were largely killed through the agency of bark-borers, and I am inclined to believe that species of Tomicus have considerable to do with the matter. *Tomicus cacographus* Lec. and *T. pini* Say were frequently associated with their larger relatives and in some instances may be the first to attack a tree. This opinion is further strengthened by the fact that *Tomicus balsameus* Lec. undoubtedly kills many balsam trees in the Adirondacks. I have found this species working in immense numbers in the entire length of the trunk of large balsams. The top of one tree examined had browned some, but the lower limbs were apparently unaffected at the time it was cut and inspected. Adults of this beetle were found throughout the tree running transverse galleries in green tissues, eggs had been deposited in many instances and larvæ of various sizes and even pupæ were found. A very interesting case of complete girdling was discovered. Two beetles, starting from the point of entrance on a green limb about an inch in diameter, worked in opposite directions around the limb, and when the specimen was cut, their burrows had overlapped each other by half an inch.

Monohammus displays in New York State a great readiness to attack diseased or dying trees, and I have noted a number of cases where grubs belonging to this genus and also Buprestid larvæ were working in pines which appeared to have suffered no greater injury from other causes than a slight lowering of vitality incident to drought or other unfavorable conditions. These larvæ, though working in considerable numbers in living tissues, did not as a rule cause much exudation of sap. Dr. Packard records in Bulletin 7 of the United States Entomological Commission, page 220, his belief that members of this genus may kill balsam or fir trees, and from what I have seen in the vicinity of Albany, it would appear that this may also be true of pines. Adults of *Monohammus confusor* Kirby were taken in considerable numbers on one white pine, and it is presumable that most of the larvæ found in infested trees belong to this species. One example of *Monohammus titillator* Fabr., one of *M. scutellatus* Say, and one of *Xylotrechus sagittatus* Germ. were also taken on the same tree.

Elm leaf-beetle (*Galerucella luteola* Müll).—This imported species continues to be a serious enemy of European elms in Albany, Troy, and vicinity. The depredations of this pest have been so severe as to lead to the maintenance and operation of two power-spraying outfits by the municipality of Albany. Two are also in operation by a private party in Troy, where they are kept busy throughout the spraying season, each individual paying for the treatment of his own trees. The general condition of the shade trees in both cities is much improved by this work, and considering all the trees in the streets of both cities, the results are decidedly in favor of Albany. This is probably due almost entirely to the fact that it is much more economical to take a street at a time and spray all the trees than to go hither and thither as desired by private parties. The former is possible only where the city undertakes to spray all the trees on the streets, while the latter must obtain where spraying depends upon the will and financial ability of the owner of the abutting property. It might be well to add, that as a rule Albanians neglect the trees on their own premises, while Trojans, who have spraying done, invariably include the trees on the premises as well as those in front of the property. The elm leaf-beetle has almost undisputed sway in the poorer portions of Troy, because the residents can not afford to have their trees sprayed, while in Albany these as well as those inhabited by the wealthier class are treated and the results are most beneficent, because it is in these poorer quarters that shade is most urgently needed. It therefore seems to me most advisable to urge the prosecution of such work, when necessary, upon municipalities rather than to allow it to depend upon the enterprise of private individuals, solely because it means the greatest good to the greatest number at a minimum of expenditure. This imported pest is slowly extending its range northward of Albany and Troy and in some localities where no spraying is done it is this season proving a scourge to both European and American elms.

Forest tent caterpillar (*Clisiocampa disstria* Hübn.).—This insect has been a most serious pest in New York State for the last four or five years, and in localities here and there it has proved exceedingly destructive this season. The outbreak of 1901, so far as I can learn, was much more limited in area than in the previous years and confined largely to sections adjacent to where the insect had been specially abundant previously. The caterpillar appears, as a rule, to be unable to exist in large numbers in one locality for more than four or five years in succession. This is probably to be explained by the local activity of natural enemies. Another marked feature has been the increasing predominance of the pest in orchards. It is perhaps hardly necessary to add that most of the injuries in orchards could have been prevented by timely and thorough spraying.

Carpenter moth (*Prionoxystus robiniæ* Peck).—This is a serious enemy to maple, oak, and ash trees in certain sections of New York State. Its destructive work at Ogsdenburg was brought to my attention by Miss Mary B. Sherman, of that place, and through her some interesting examples of the borers' work in sugar-maple trees were secured. One-third of a section or a tree about 15 inches in diameter was fairly riddled with the large burrows of the caterpillar of this insect. It was so abundant as to ruin a number of fine trees in that locality and necessitate their removal. The work of this pest at Buffalo was brought to my notice by Mr. M. F. Adams, of that city, and through his kindness I have been able to secure good examples of the insects' work in ash and to observe its operations in oaks. This species also occurs on Long Island. All the examples of its work seen by me show that the full grown caterpillars prefer to run their burrows at some depth in the wood, and that as a rule they run so close to and communicate so freely with each other as to destroy the value of infested trees for timber. This insect also causes large unsightly wounds wherever its burrows come near the surface. Caterpillars about to pupate frequently take refuge in these channeled wounds, from which the pupæ work themselves partly out before the disclosure of the imago. The eggs are probably deposited in any available crevice, where they adhere to the bark rather firmly. A piece of root which had been bored by the willow curculio (*Cryptorhynchus lapathi* Linn.) was lying in a breeding cage and a female Prionoxystus embraced the opportunity to deposit six or seven eggs well within the burrow.

Apparently the females do not hesitate to oviposit before the appearance of males. Some eggs which were found in the office hatched, possibly without being fertilized, but it was impossible to prove this latter point. Dissection of a well-distended female, which probably had deposited no eggs, showed that she contained 269 well-formed ova and 133 which were partly developed, making a total of 402.

The small *Lecanium nigrofasciatum* Perg. has proved a rather serious enemy to soft maples in Albany. This scale insect has been so abundant on some small trees as to nearly cover the under surface of the limbs, and so much honeydew was exuded that the walks beneath were kept moist. The severe drain on the trees prevented much growth and resulted in the killing of a number of the smaller limbs. Badly infested twigs have a marked sour-semiputrid odor, due in all probability to the decomposition of the honeydew. Young began to appear in Albany about June 14, and by July 15 they were about 0.5 mm. long and were thickly set on the smaller twigs.

Pseudococcus aceris Geoff.—This comparatively rare species was observed in immense numbers on the bark of a hard maple at Albany, N. Y., August 6. The male cocoons were present in thousands, and in places formed large white masses on the trunk, giving a tree the appearance of being affected by a fungus. Some immature individuals were wandering over the masses of the male cocoons. The leaves were also badly affected. The cottony remains of adults were abundant, and here and there old females were still producing young, as a number of very small individuals were observed, and partly grown ones were assembled on the under surface of the leaf in long rows on both sides of the principal veins. There is a marked subacid, not unpleasant, odor about this species when present in large numbers. It is not nearly so offensive as in the case of *Lecanium nigrofasciatum* Perg.

Chermes pinicorticis Fitch is always more or less injurious to white pines in Washington Park, Albany, but this year it has been exceptionally abundant, not only giving considerable portions of the trunks a whitewashed appearance, but literally plastering the under surface of many limbs. A number of these pines, as a consequence, have a thin foliage and are sickly.

Mr. Hopkins congratulated the author on the large number of species recorded, but he doubted that the tent caterpillar had so changed its habits as to attack pine. He was of the opinion that the occurrence of this insect upon pine was merely accidental.

Mr. Ashmead said that he also was skeptical about the occurrence of the tent caterpillar on pine, and he advised Mr. Felt to withhold that statement from publication until further investigation could be made.

Mr. Cockerell mentioned that in New Mexico the larvæ of *Clisiocampa fragilis* sometimes crawled up the pine trees and pupated among the needles, but he did not find any proof that they ate the leaves. With regard to the insect called *Pseudococcus aceris* in the Eastern States, it could not be placed in Westwood's genus *Pseudococcus*, but belonged to *Phenacoccus*. The species was almost certainly not the European *P. aceris*, but was probably American, and without a name.

The secretary read the titles of the following papers by absent members, and, upon motion of Mr. Bruner, they were accepted for publication in the Proceedings: Review of the White-Fly Investigation with Incidental Problems, by H. A. Gossard, Lake City, Fla. Hydrocyanic Acid Gas Notes, by Charles P. Lounsbury and C. W. Mally, Cape Town, South Africa. The Use of Hydrocyanic Acid Gas for Exterminating Household Insects, by W. R. Beattie, Washington, D. C. Insects of the Year in Ohio, by F. M. Webster and Wilmon Newell, Wooster, Ohio. Fruit Seriously Injured by Moths, by C. W. Mally, Cape Town, South Africa. Notes on Four Imported Pests, by A. H. Kirkland, Boston, Mass. Drought, Heat, and Insect Life, by Miss Mary E. Murtfeldt, Kirkwood, Mo.

REVIEW OF THE WHITE-FLY INVESTIGATION, WITH INCIDENTAL PROBLEMS.

By H. A. Gossard, *Lake City, Fla.*

The white fly (*Aleurodes citri*) reached its maximum of destructiveness last year, and called forth much apprehension both within the bounds of its present distribution and outside of them. About 75 per cent of the orange groves in Manatee County are infested, and as this county puts out something like 200,000 boxes of oranges per year, worth on an average $3 per box, and since infested groves usually turn out one good crop not oftener than once in two years, and sometimes only once in three years, it is only reasonable to believe that with the insect absent the present annual yield of fruit in this county would be more than doubled. The damage to this single county alone can be hardly less than one quarter of a million dollars per year. The direct and indirect consequences of the insect's presence in the State could have amounted to but little less than one half million dollars the past year.

I believe the orange industry will flourish in spite of the fly and, barring freezes, that the restoration of our groves over middle and northern Florida will continue at a rate exceeding that of white fly dissemination, but if present conditions continue it appears that within a half dozen years our State will receive almost a million dollars less than it would with clean groves, though we do not doubt that the total income from the crop will have multiplied as many or more times than the loss during the interval. I am very sure the insect will not become worse anywhere than it was in Manatee County last year, and if groves are excellent property there at present they will remain paying holdings in said county and elsewhere, notwithstanding the presence of the fly.

Signs of alleviation from the pest have been noted for some years, but not until last year did the value of its fungous enemies become emphasized to the most casual observer as a more than decimating factor in its extraordinary numbers. By autumn disease had so reduced it that the worst infested districts are this year cleaner than they have been during any of the three seasons since coming under my observation. A visit paid to the infested territory in early July led me to recommend that the trees be left to themselves until the appearance of the September brood of larvæ, when resin wash might be applied if the fruit was becoming smutty with mold.

The fungous diseases of the insect seem well distributed throughout the State where the fly occurs, but may have been introduced by the hand of man following the coming of the fly. I have observed both the red fungus (*Aschersonia aleurodis*) and the brown fungus over all the Manatee River section, at Myers, and at Orlando. The growers usually make an effort to introduce these fungi whenever the Aleurodes appears in a new locality. The brown fungus seems more effective than the red.

Notwithstanding the mischief the white fly actually does and the dread it inspires, it is noteworthy that the earliest infested grove in south Florida on the west coast, that of C. H. Foster, of Manatee, the one mentioned in some of the very earliest literature of white fly (Insect Life, vol. 5, p. 219), and hence infested for at least ten years, is still living and vigorous, with the exception of a few trees, and looks as if it will be able to live right on indefinitely. The interior and shaded branches, instead of dying out, as they often do, have a color, thrift, and vigor often absent in groves never found by a white fly. These trees gave a fairly good crop of oranges last year, this year promising to just about pay for the cost of maintenance. No spraying has been done or other measures of suppression taken against the insect for some years in this grove. Considering its unquestionable vitality under such circumstances and the vulnerability of white fly to parasitic and predaceous attack, it seems impossible to doubt that natural agencies other than fungi will come to the relief of the trees before their life is spent. However, I have seen trees unmistakably killed by the insect, and the interior branches very often die from its attacks.

UNRECORDED POINTS IN ITS LIFE HISTORY.

Some adult flies of the fall brood may be observed, by reliable report, in early December, all eggs hatching before the middle of that month. Nearly all the insects are in the third or fourth stage before January 1, the eggs of a few stragglers alone furnishing specimens in the first or second stage. I recall no instance at all of having observed the first stage as late as Christmas. The earliest imagos were observed upon some lemon bushes in a few very sunny and sheltered spots at Ellenton, Fla., on the 11th of February. Egg laying had already commenced at this date. The body of the spring brood, however, does not appear until in April and May. This irregularity of appearance, with the late and early dates for imagos, suggests that the late November and early December representatives belong to a straggling fourth or winter brood. Further confirmation of such a guess may be found in the marked overlapping of broods, especially noticeable in the spring. This overlapping, every possible stage of the insect being represented at the same date, may be observed in one spot, but its value as evidence of a fourth brood is somewhat diminished by the fact that the appearance of corresponding broods may vary two or three weeks in places not 20 miles apart.

A leaf of young orange, 5 inches long and $2\frac{1}{2}$ inches wide in the middle, collected at Myers June 22, 1901, by careful mathematical computation had upon it upward of 20,000 eggs. While so many eggs upon so small a space is rather unusual it can not be said to be rare, for I have observed them as thickly placed many times.

SPRAYS.

Resin wash is the spray most commonly used to destroy the insect. In the hands of one who understands its use satisfactory results are almost certain to follow. If no attention at all is given the insect, the smutted fruit must be cleaned with a dampened cloth and sawdust or by some form of brush machine, the carrying qualities of the fruit being much impaired by either method. Kerosene sprays are as effective as the resin wash.

TREATMENT BY FUMIGATION.

The assistance of Prof. C. W. Woodworth, of the California Experiment Station, was secured for a month last winter, and his suggestions and experience were utilized during this period. Various styles of tents—hoop, sheet, and bell—were made ready, from 8-ounce duck or 6-ounce drilling, the cloth being mildew proofed at the tent factory. When upon the ground where they were to be used they were painted with linseed oil, into which enough lampblack was stirred to give body and color to the preparation.

Some trouble with burning of cloth was experienced, it being found to be almost impossible to paint a large bell tent without serious damage, necessitating extensive patching, unless the derrick upon which it was swung was in perfect working order and repair, so as to avoid the risk of leaving a fold in the canvas for even a short time while drying out. The weight of oiled tents is also a great objection to them. Cactus juice is not available in Florida in sufficient quantity for tent treatment and some new application must be found. A preparation used by sailors in semitropical waters has come to my attention, and I hope it is not without value. Mr. Arthur Weaver, who superintended the fumigation of Mr. A. G. Liles's grove, used the preparation and reported it lighter, tighter, cheaper, and more satisfactory in every respect than oil, with which he had had equal experience. It is said not to burn cloth and to be mildew proof. Cloth so treated and in use upon boats in Gulf waters is said to last five or six years. Such enduring quality is a very great consideration in our moist climate; and if continued experience with the recipe proves it to be as satisfactory as reported, I shall feel that one long step forward has been taken. As the recipe came to me but recently, I have not yet given it a personal test. The formula for this paint, as used by Mr. Weaver, is given in the Annual Report of Florida Experiment Station, now in the hands of the printer. The remainder of this paper, as well as much of that already given, consists in the main of almost verbatim extracts from said report.

For trees not over 12 feet high hoop tents were found to be most satisfactory. Above that to 20 feet in height I think sheet tents will prove best. Above 20 feet the bell or sheet will be most satisfactory. As one result of the work, a new pattern of derrick was devised for swinging large bell tents, which seems more flexible to varying requirements than the California patterns, or perhaps I should designate tents handled thus as box tents, for they are swung in pairs with the derrick upon the same general principle as the box tent, *i. e.*, the type of box tent described in Bulletin 122 of the California station, a derrick being substituted for the lifter. The idea that a bell tent might be handled like a box tent was due to Professor Woodworth, who mentioned it upon the day of his departure, and the practical working out of the idea was achieved by the writer's combination of ideas derived from various sources.

The main mast of the derrick is of spruce pine, about 35 feet high for trees 30 feet in height, and stands between the rows to be treated. To each side of it is attached a gaff 22 feet long, also of spruce pine. The foot of the gaff clasps the mast with arms of oak, being raised and lowered with double blocks and pulleys exactly after the manner of a ship gaff. The top of the gaff is double blocked and pulleyed to the top of the mast, so by means of its top and bottom attachments the gaff can be raised to any height, its top many feet above the top of the mast, if necessary, or it can be lowered to reach the ground. Since it can take any angle of direction also it may be quickly adjusted to trees of any height and at variable distances from the mast. The top of the bell is attached by pulley near to the end of the gaff. Three trail poles of hickory, each about 10 feet in length, are fastened to one side of the lower border of the tent, their ends being securely lashed to each other with rope, so that when they pull against each other the rope and not the cloth will catch the strain. The cloth is caught up and bagged slightly at these points of union of the trail poles, as additional protection against tearing. The center of each of these trail poles is connected with the top of the gaff by pulley, and thus the border of the tent to which they are attached may be elevated to any height, the opposite border swinging free within reach near the ground. A trail rope is attached to each of the trail poles. All pulley ropes belonging to the apparatus are secured to cleats on the mast.

In operation, when the mainmast, on rollers or wheels, has been placed in position, the height of the tree to be fumigated and its distance from the mast are noted, and the foot of the gaff is raised or lowered to the point of greatest advantage, as learned from experience. If the trees of a grove are of nearly uniform height and at regular distances apart one correct adjustment will serve for the whole grove. A similar adjustment is made of the top of the gaff, this operation by necessity being repeated with every tree. The top of the tent is next drawn fully up and then the three trail poles; the hanging free edge near the ground and as much of the border as possible is now brought into position and the top of the gaff lowered some if necessary. Slack is now given to the trail poles, and a man at each trail rope so pulls the pole to which his line is attached that the whole tent drops into position over the tree. The lower border of the tent must be extra strong to avoid tearing. It is best bound with rope. To remove the tent from the tree the procedure is almost exactly reversed. With men trained to work together the tent may be lowered over a tree in seven or eight minutes and removed in about five. Since the operation of removing the tent from one tree raises it almost in position to drop upon the next, the time required for changing will not be the sum of eight and five minutes, but the last five minutes is divided between the two trees, removing from the one and at the same time getting almost in position to lower upon another by a quick adjustment of the angle of the gaff, it requiring less than eight minutes to cover a tree from this position. The apparatus requires four men, one of whom may be the fumigator if his chemicals have been weighed out beforehand. A gang of four can operate about four tents or two derricks. This gives forty minutes to the tree and allows ten minutes for shifting of each tent. In order to realize this expeditiousness in practice all apparatus must be in perfect working order and repair and the men trained to handling it. The results secured in my practice satisfied me that this would be a reasonable estimate, for it was done often enough in this time with our then imperfected apparatus to justify such a conclusion.

Some determinations made by Professor Miller, of the chemical department, are of interest and importance. He found that 1 ounce of sulphuric acid and 1 ounce of water, mixed and cold, when added to 1 ounce potassium cyanide yielded 428.4 cubic inches of gas; that 1 ounce of sulphuric acid and 1 ounce of water, mixed and added immediately while warm to 1 ounce of potassium cyanide, yielded 467.9 cubic inches of gas, greater by a little more than 9 per cent than with a cold mixture of water and acid. Mixing the acid and water, therefore, only as used means a saving of 6 or 7 cents per tree on large trees requiring 2 pounds of cyanide. He further determined that a greater proportion of acid did not materially alter the result, and that ammonia seems not to be formed immediately after the reaction under laboratory conditions.

A number of experiments were made with citrus twigs, orange, lemon, pomelo, etc., infested with white fly, to determine the susceptibility of the insect to the gas, dose of chemicals to use, length of time necessary, and most favorable temperature for treatment, influence of moisture present upon the leaves when fumigated, etc.

It was found that in its larval and pupal stages the insect was very readily killed by much lighter doses of gas than are commonly used against the black scale in California; in fact, the field practice with tents demonstrated that the dose could be reduced about one-half; that the time should be about forty minutes; the variation in temperature ordinarily encountered in Florida seems to be a neglectable factor; moisture did not seem to interfere greatly with the efficiency of the work unless the leaves were almost dripping, when it became a factor of much disturbance, though not so great as I had thought probable.

Trees were fumigated in the field in warm sunshine at all hours of the day, in cloudy weather, and at night. But little injury to trees or foliage was observed if fumigated at night, during cloudy weather, early in the morning, or late in the evening. Trees fumigated after 9 a. m. and before 4 p. m. in sunshine were invariably somewhat injured, some of the younger limbs dying back and all the leaves usually shedding. The fallen leaves were all replaced by new growth in a few weeks and no permanent injury was done, but the crop upon such trees was noticeably reduced. The dropping of leaves from a tree in Florida has comparatively little significance, the trees instead of dying, as they sometimes do in California, putting on new foliage and going along as if nothing special had happened. However, the burning of limbs and injury to bloom is another matter, and therefore midday fumigation can hardly be practiced. While some defoliation occurred with trees fumigated at other times than midday, even after night, it was not strikingly noticeable nor was damage to limbs or crop of sufficient amount to be detected after a few months. Some of this work was done as late as February 18, when the blossoms were beginning to open, some of them being well expanded. The bloom seemed unaffected by the treatment unless the work was done with the sun at high meridian.

The white fly seemed practically exterminated upon the treated trees. In examining hundreds of leaves from dozens of trees about ten days after they were fumigated, and covering thousands of insects, I was able to find but a single living specimen. If a grove was segregated from all others, I have no doubt that one fumigation would render it so nearly clean that it would need no additional attention for two or three years. The great hindrance to its becoming a practicable remedy is that few groves are so isolated that the fly will not come to them from neighboring groves, and since the insect seeks young and tender growth for egg-laying purposes there is, perhaps, some tendency for it to go to trees that have been fumigated and are therefore putting out new growth. Under ordinary circumstances the insect is not a great traveler, though winged, and will often take a whole season, extending over three full broods, to spread over a 10-acre grove. Its progress will be marked by the trees showing sooty mold.

Special observations were made to determine the effect of the gas upon ladybugs. On the afternoon of January 22, 72 ladybugs, almost all *Chilocorus bivulnerus*, which had fallen to the ground under fumigation treatment, were placed in a shallow tin box and left until January 23; at 9.30 a. m. of the latter date 70 beetles were in the box, a few of them active; at 4 p. m. 66 remained in the box, about a dozen of them showing signs of activity. At 8.45 a. m. January 24 62 ladybugs were in the box, and 60 at 12.40 p. m. The 60 never exhibited signs of animation, all being observed to be dead several days afterwards. January 24, by 1 p. m., another lot of 176 fallen bugs, nearly all of the same species as before, was collected and kept in the same manner as the first ones. January 25, at 4.30 p. m., 160 of these were dead, 16 out of the lot having recovered. In the first lot 16 per cent of the whole revived; in the second lot about 9 per cent.

HYDROCYANIC ACID GAS NOTES.

By Charles P. Lounsbury and C. W. Mally, *Capetown, South Africa.*

The submittal of these notes is prompted by the increasing employment of hydrocyanic acid gas as an insecticidal agent in closed buildings other than for the destruction of insects accompanying nursery stock. Of late we note recommendations in American rural papers for its use in dwellings to destroy bedbugs, the strengths mentioned being those ordinarily employed for scale insects. Scale insects, we have found, are exceptionally easy to destroy by the gas, and therefore our experiences in the treatment of more resistant insects and some miscellaneous tests we have made may have interest to American workers.

The gas has been regularly used during the past two and a half years to effect the destruction of vermin in the sleeping coaches on the various systems of the Cape government railways. With the adoption of this treatment, complaints from bug-bitten passengers, before very frequent, abruptly ceased. On recent inquiry it was ascertained that the railway management remains perfectly satisfied with the measure. Bugs are no longer found, but the coaches are treated once in about four months. Two 1-pound charges of 98 per cent of cyanide are used to a coach and the exposure continued from two to four hours according to the length of time available for the work. Two pounds to a coach is about equivalent to an ounce to every 80 cubic feet.

Many of the colonial jails swarm with vermin despite many methods employed to mitigate the pest. Carbolic preparations, the use of corrosive sublimate in whitewash and as a spray, the burning of sulphur, and the liberation of sulphurous acid fumes are all reported inefficient. Hydrocyanic acid gas is now coming into use as a last resort. Under our direction several jails have been treated with success, and it is understood that the government will soon have arrangements complete for a regular and systematic fumigation of all the infested premises. The personal condition of the lower-class prisoner on entering is often so indescribably filthy that continual reinfestation must be contended with; hence the expediency of regular applications of the remedy. From 1 pound of cyanide for 1,600 cubic feet to 1 pound for 1,000 cubic feet is used for jail work, the relative amount being governed to some degree by the extent of unavoidable leakage, the nature of the contents that may be harboring the pest, and the season of the year. No trouble is spared to make a space tight; particular attention is paid to the roof and in case this be of corrugated iron, as is common in the colony, the corrugations over the sills and along the ridge are stopped with plugs of burlap or plugged with clay. The higher the roof the greater is the care exercised in making it tight, thus to offset the greater upward draft of air.

Blankets and as far as possible all else that comes in contact with the prisoners are so disposed as to be most freely exposed to the action of the gas; suspension of sleeping blankets by one corner from gratings forming the floors of galleries is sometimes practicable. The exposure is continued as long as circumstances allow, with a minimum of two hours.

The procedure of the work is kept as simple as possible, and no especial difficulty is experienced in treating comparatively large spaces. A number of cells sometimes have to be treated as a unit. In one case a corridor 90 feet long, extending in cupolas to a height of 50 feet, and inclosing with its connecting cells an aggregate of 140,000 cubic feet, was treated as one space. Forty-three charges, each weighing 3 pounds, were used, and 20 of these were generated in cells off a gallery above the main floor. Five-gallon tins, in which kerosene oil has been imported, and from which the tops have been cut, are generally used for large charges. These are found safely to take 3 pounds of cyanide, and to be serviceable for two or three usages. Their recommendation is their ubiquity in this country and their inexpensiveness. As in orchard fumigation, 2 ounces by measure of water and 1 ounce by measure of sulphuric acid are used to an ounce by weight of cyanide; thus for a 3-pound charge of the latter, 3 pints (United States measure) of acid are added to 6 pints of water. When a space necessitating the employment of many generating vessels is to be treated, as was the case in doing the corridor above mentioned, the water only is measured directly into the vessels, these being then, if not before, placed in the positions desired. The acid is measured into small receptacles, as tin basins, placed within an arm's length of the vessels, and the required weight of cyanide for each, for convenience in handling laid on a square of cheese cloth, mosquito netting, or even newspaper, is also laid within reach. Squares of cheese cloth, made bag-like by tying the alternate corners, are preferred for holding the cyanide, particularly when the series of discharges to be made is a long one. When the time comes to "fire," an assistant, beginning at the farthest corner from the exit, pours the respective measure of acid into vessel after vessel, and when he has a start of half a dozen vessels the operator follows, and, with the greatest dispatch compatible with certainty in action and care to avoid splashing, drops the bags of cyanide into the steaming acid-water mixtures. Familiarity with the work, quickness of movement, and a cool head are essential to safety, and no person not possessing these qualifications should attempt multiple discharges. When the series is short the operator himself may attend to the addition of both the acid and the cyanide, and even measure the acid directly into the water. The objection to following this procedure in long series is that the acid-water mixtures may have time to cool, and therefore fail to fully react upon the cyanide, particularly the larger lumps.

We consider this hand dropping of the cyanide into vessel after vessel far safer and much more expeditious than methods of dropping which involve the use of strings manipulated from without the space. The cloth bag facilitates the dropping act, and retards but for a brief space the evolution of the gas. Curiously the cloth is sometimes practically uninjured by the chemicals.

Great care is always needed when the spaces are opened for ventilation to keep out inquisitive parties, and it is then that the responsibility of the operator is greatest. On still days the generation of heat by fires and the burning of large lamps is useful to expedite renewal of the air. The gas soon dissipates from empty rooms, but clings to bedding somewhat tenaciously; hence several hours' airing is desirable if severe headaches are to be avoided. It has been noticed that persons with weak lungs, of which there are many in some prisons among long-term convicts, suffer painful inconvenience from traces of gas unnoticed by their healthier fellow-prisoners.

The public department in charge of plague work administration has begun to make limited use of the gas for dwelling fumigation to effect the riddance of bugs, fleas, and lice. The procedure followed is the same as in jail work and the same strength of gas is used; as prolonged control over the premises can be had, the exposure is made longer, as overnight.

These various governmental uses of the gas have not been inaugurated without experimental demonstration of its efficiency. Our tests, conducted in tight spaces, have shown that much stronger gas is required to destroy bedbugs than to destroy armored scale insects. For convenience we express the strength of gas as the ratio of the number of ounces of cyanide used to the number of cubic feet in the space inclosed. Gas at a strength of 1 ounce to 450 cubic feet appears to be uniformly fatal to scale insects (*Aspidiotus aurantii*, *A. nerii*, *A. rapax*, and *Diaspis pentagona*) exposed to it for an hour, but to have little, if any, effect on bedbugs. A portion of a given number of bugs is destroyed by an hour's exposure to 1 ounce to 250 cubic feet gas; and the proportion destroyed increased with increase in the strength of the gas and the period of the exposure. Our main series of tests with bugs was made in a photographic dark room approximating 235 cubic feet in capacity. The temperature of this space varied in the different tests from 56° to 64° F. Care was taken to have nothing present that might absorb and thus weaken the gas, and only active, healthy-looking specimens of the insect were exposed. Fifteen specimens were used for each test, and these inclosed in bags of gauze suspended at mid height on the side of the room opposite where the generating vessel stood. Eight specimens survived 1 ounce to 190 cubic feet for an hour, and three, 1 to 155 for the same period, but none 1 to 155 for two hours; these effects were determined by observation extending over a week. Only three specimens were recorded to survive the strength of 1 to 235 for one hour and three for 1 to 235 for two hours, but in these instances the specimens were all destroyed at the end of twenty-four hours, it not at the time being known that any might subsequently recover. In every case all of the bugs were stupefied by the gas, and none were noticed to again become active until at least two hours had elapsed. With the 1 to 150 strength for an hour, none showed signs of life at the end of five hours, but twenty hours later one could crawl and another feebly move its legs, and on the following day a third responded when probed lightly; at the end of a week the one seemed fully recovered while the others were still too weak to move about. It is evident from these tests that 1 to 155 gas for an hour is too weak for room fumigation since not all fully exposed bugs may be destroyed. It is only fair to mention, however, that in practice we have known 1 to 150 gas give seemingly perfect results in a number of instances. At other times while greatly decreasing the pest its use has not been satisfactory.

The eggs of bedbugs seem to be devitalized with the use of about the same strength of gas as is fatal to the active stages, but we have had little opportunity to make observations on this phase of the problem and therefore speak with reserve. Seven eggs laid within thirty hours of their exposure failed to hatch after treatment for two hours in 1 to 125 gas, the space in this case being a fairly tight room in a plague house and the eggs being fully exposed; nineteen eggs six days old failed to hatch after exposure for one hour in 1 to 150 gas in the dark room referred to above. Check eggs were not preserved. No eggs hatched in numbers of seemingly sound ones taken from treated railway coaches at the beginning of that work. It may seem strange that eggs should be devitalized by the gas, but in experiments conducted here three years ago it was determined that scale insect eggs (*Diaspis pentagona* and other species) succumbed to 1 to 300 gas; in fact, it was observed that eggs of a species of Dactylopius lost their vitality from an hour's exposure in the strength of gas mentioned when adults escaped death. Check lots of eggs of the different kinds exposed hatched.

The common roach (*Ectobia germanica*) succumbs to overnight treatment with 1 to 100 gas. The kitchen and scullery of one of the Cape Town clubs swarmed to an almost incredible extent with this insect. The spaces were treated with the strength intimated, and in the morning not less than a half bushel of dead roaches were swept up. About fifty that bore ootheca were boxed and brought to the office and no eggs hatched from them; there was no check test, however, to determine if such eggs would hatch were the females otherwise destroyed.

The fleas on a dog confined in a room, treated for an hour with 1 to 180 gas, were all destroyed; one hundred were removed and kept under observation for a week to make certain that the result was as it appeared to be. Lice (*Hæmatopinus spp.*) on rats confined in the same space were also destroyed. So were several kinds of ants and the common house fly; but not one of several hundred specimens of various kinds of ticks, and only 40 out of 57 bedbugs. Ticks are the least susceptible to the gas of all the creatures we have exposed. Adult *Argas persicus*, *Amblyomma hebræum*, and *Rhipicephalus evertsi* have been exposed in large numbers to 1 to 150 gas for two hours without a single specimen manifesting injury. A score of *A. hebræum* thus treated were a month later, along with as many more fresh specimens, exposed for an hour in 1 to 80 gas, and every specimen came through this severe test seemingly more active than before. Eight long-starved *R. evertsi* exposed to this strength were much affected, 4 of them being killed and the other 4 greatly enfeebled. It may be of interest to mention that cultures of *Bacillus pestis*, the plague organism, exposed by replacing the customary cotton plug with a covering of gauze, were unaffected at this strength and in weaker strengths. This bacterium is accounted easy of destruction by ordinary disinfectants.

In the practical application of the gas we consider it advisable to remove all water and all moist substances that might absorb the gas and thus affect its efficiency by decreasing its strength. Water and meat that have been exposed to the gas should be regarded as dangerous for consumption. We purposely exposed meat and water to extremely strong gas to see if they were really rendered poisonous. Both proved quickly fatal to dogs which began to partake of them. Meat exposed and then allowed to air for a few days proved harmless. Flour exposed and afterwards made into bread was eaten by one of us with impunity.

The gas may be the most reliable agent for the destruction of insects within a confined space that we have, but in general it is a mistake to consider it an infallible eradicator. The extent to which insects in a space are protected by the character of their coverings can be determined only by experiment, and then only roughly. Individuals among scale insects in masses on their food plants resist strengths of gas far in excess of what is uniformly fatal to isolated specimens of their kind. This we have observed in the orchard and demonstrated in the laboratory. As with the adults of scale insects, so with the eggs. We have found that the eggs at the end of the large ovisac of *Icerya purchasi* are destroyed by 1 to 300 gas, while those deep in the mass remain unaffected by 1 to 200. From experience we have come to consider it inadvisable to rely on strengths of gas inferior to 1 to 100 for the destruction of bedbugs or to have the exposure less than two hours. Under exceptional circumstances even this great strength has been found untrustworthy. Active bedbugs were taken from within door casings of a jail after the surrounding space had been exposed for three and a half hours to 1 in 90 gas, and two specimens out of seven, placed between box covers screwed together so that the insects were held but not crushed, survived two hours of treatment with 1 to 125 gas. A beam of light was visible between the boards, and the survivors were found within 3 inches of the edge. A thin covering of dry dust or earth seems a great protection. Living sow bugs and earwigs were found along with numerous dead ones on the surface dirt of the plague room mentioned above as having been treated for two hours with 1 to 125 gas. None of the creatures were in sight when the room was closed, and the presumption is that those that escaped destruction were disturbed from the rubbish on the earthen floor too late to get a lethal dose.

Grain insects have been experimented with to determine if a mass of grain was sufficiently penetrated by the gas to effect the destruction of those contained therein. A series of tests with this object in view was made in a tight glass-sided case inclosing 4.16 cubic feet of space. To insure accuracy the cyanide employed was weighed out on delicate balances. The results of the tests were most disappointing and have led to our abandonment of hopes that the gas would serve as a substitute for carbon bisulphid in the treatment of stored grain. Strengths of gas up to 1 ounce to 12 cubic feet (10 grams to the case) were found inefficient to destroy *Calandra oryza*, *C. granaria*, and other common grain insects in an exposure of forty-two hours. In the test with the strongest gas a grain bag containing about a half-bushel of refuse corn mixed with coarse mill screenings alive with the insects was exposed. The case was tight, the chemical reaction perfect, and the gas still strong at the end of the forty-two hours; yet scores of the insects escaped death. Throughout the series it was evident that the air within even small bulks of material remained harmless to the insects a short distance from the surface. The insects which crawled away from the mass and those at or very close to the surface were generally destroyed.

THE USE OF HYDROCYANIC ACID GAS FOR EXTERMINATING HOUSEHOLD INSECTS.

By W. R. Beattie, *Washington, D. C.*

With the growth of our population and the consequent crowding together of residences, the problem of the prevention and control of household insects is deserving of careful consideration from a sanitary standpoint, but one that is usually overlooked. These pests are to be found in fewer or greater numbers, both of species and individuals, in every dwelling, office, or storehouse, and no perfectly efficient means, either to prevent their gaining an entrance or to exterminate them when they are once established, has as yet been devised.

Recent successful applications of hydrocyanic-acid gas for the extermination of insects infesting greenhouse plants have suggested the use of the same remedy for household pests. It is now no longer a theory but an established fact that 0.10 gram of 98 per cent pure cyanide of potassium volatilized in a cubic foot of space will, if allowed to remain for a period of not less than three hours, kill all roaches and similar insects.

The experiments which led to this conclusion were made in a small building which is used for laboratory purposes by the Division of Botany. This structure has for some time been infested with several insect pests, the more numerous and troublesome of which was the common cockroach (*Periplaneta americana*). The building consists of one story and basement, the upper part being rather loosely built, as it is ceiled throughout with matched lumber. This method of construction provides numerous hiding places for the insects, and also renders fumigation difficult by permitting the gas to escape too quickly. Within the building are several sources of moisture, a rather high and constant temperature is maintained in some of the rooms, and large quantities of seeds and substances that serve as food for insects are stored, making conditions well adapted to the development of cockroaches.

During the early part of last year the roaches became so numerous as to be a detriment to the work of the laboratory, and it was necessary to adopt some means of checking them. On the evening of May 10, 1900, the building was closed, and after opening up the interior of the rooms as much as possible the entire structure was fumigated experimentally with about 0.08 gram of 98 per cent pure cyanide of potassium per cubic foot of space. The gas was allowed to remain during the night, or until it gradually escaped. When the rooms were entered the following morning there remained a perceptible odor of the gas, but this soon disappeared after opening the windows and doors. The ledges and window sills were strewn with dead house-flies and the floors bore abundant evidence of the effect of the gas on roaches. Not a single insect that showed indications of remaining life was to be found in the building. About a quart of the flies and roaches was gathered up and placed in a cage, where they were allowed to remain until the following day, when two roaches showed signs of life by slow movements. These, however, could not walk when placed upon their feet, and subsequently died.

For some time after this fumigation no roaches were to be found in the building, but eventually the eggs that had been previously deposited hatched and developed, adults were carried in from other buildings, etc., until in March of the present year the roaches had again become so numerous as to be a nuisance and a detriment to the work of the laboratory. The building was again treated with cyanide gas, this time at the rate of 0.10 gram per cubic foot of space, but it was allowed to remain only fifty minutes, when the windows were opened and the gas permitted to escape. The roaches were strewn over the floors and several mice were found dead. A large number of the roaches were again collected and kept in a cage until the following day, when it was found that fully 10 per cent of them had not been killed and were as lively as before treatment. The mice, however, showed no indications of life. The dose had been sufficiently strong, but had not been allowed to remain long enough to kill the more resistant of the roaches.

The third and most satisfactory experiment of the series was conducted on the evening of June 20, 1901, when an application of 0.10 gram per cubic foot was allowed to remain in the building overnight. On the following morning the gas had not entirely escaped, and house-flies, centipedes, spiders, cockroaches, and mice were dead, with the exception of a few roaches which had secreted themselves between the sash and frame of a loosely fitting window, and had thus secured enough pure air to prevent their being killed.

To convey an idea of the injury caused by the presence of large numbers of roaches in this laboratory, it might be stated that, frequently preceding this last fumigation, photographic plates placed on racks to dry and allowed to remain on a table for one hour were completely ruined by having films eaten from the glass; packets of seeds stored in mouse-proof tin boxes were so eaten as to allow the seeds to escape, and in many cases the seeds themselves were destroyed. Since this fumigatlon no inconvenience has been caused by the work of roaches or mice.

By aid of the results obtained from the above experiments, together with our present knowledge of the action of hydrocyanic-acid gas in exterminating greenhouse and scale insects, it may be stated that a dwelling, office, warehouse, or any building may be economically cleared of all pests, provided that the local conditions will permit the use of this gas. It probably would be dangerous to fumigate a building where groceries, dried fruits, meats, or prepared food materials of any kind are stored. Air containing more than 25 per cent of the gas is inflammable, therefore it would be well to put out all fire in an inclosure before fumigating. Hydrocyanic acid in all of its forms is one of the most violent poisons known, and no neglect should attend its use. There is probably no sure remedy for its effects after it has once entered the blood of any of the higher animals. When cyanide of potassium is being used it should never be allowed to come in contact with the skin, and even a slight odor of the gas should be avoided. Should the operator have any cut or break in the skin of the hands or face, it should be carefully covered with court-plaster to prevent the gas coming in contact with the flesh or the possibility of a small particle of the solid compound getting into the cut, which would cause death by poisoning within a few minutes' time.

Hydrocyanic-acid gas should not be used in closely built apartments with single walls between, as more or less of the gas will penetrate a brick wall. An inexperienced person should never use cyanide of potassium for any purpose, and if it be found practicable to treat buildings in general for the extermination of insects the work should be done under the direction of competent officials. Our experiments have shown that a smaller dose and a shorter period of exposure are required to kill mice than for roaches and household insects generally, and it readily follows that the larger animals and human beings would be more quickly overcome than mice, since a smaller supply of pure air would be required to sustain life in mice, and small openings are more numerous than large ones.

The materials employed and the method of procedure are as follows: After ascertaining the cubic contents of the inclosure, provide a glass or stone ware (not metal) vessel of 2 to 4 gallons capacity for each 5,000 cubic feet of space to be fumigated. Distribute the jars according to the space and run a smooth cord from each jar to a common point near an outside door where they may all be fastened; support the cord above the jar by means of the back of a chair or other convenient object in such a position that when the load of cyanide of potassium is attached it will hang directly over the center of the jar. Next weigh out upon a piece of soft paper 500 grams (about 17.1 ounces) of 98 per cent pure cyanide of potassium, using a large pair of forceps for handling the lumps, wrap up and place in a paper bag, and tie to the end of the cord over the jar. After the load for each jar has been similarly provided, it is well to test the working of the cords to see that they do not catch or bind. Then remove the jar a short distance from under the load of cyanide and place in it a little more than a quart of water, to which slowly add 1½ pints of commercial sulphuric acid, stirring freely. The action of the acid will bring the temperature of the combination almost to the boiling point. Replace the jars beneath the bags of cyanide, spreading a large sheet of heavy paper on the floor to catch any acid that may possibly fly over the edge of the jar when the cyanide is dropped, or as a result of the violent chemical action which follows. Close all outside openings and open up the interior of the apartment as much as possible in order that the full strength of the gas may reach the hiding places of the insects. See that all entrances are locked or guarded on the outside to prevent persons entering, then leave the building, releasing the cords as you go. The gas will all be given off in a few minutes and should remain in the building at least three hours.

When the sulphuric acid comes in contact with the cyanide of potassium the result is the formation of sulphate of potash, which remains in the jar, and the hydrocyanic acid is liberated and escapes into the air. The chemical action is so violent as to cause a sputtering, and frequently particles of the acid are thrown over the sides of the jar. This may be prevented by supporting a sheet of stiff paper over the jar by means of a hole in the center, through which the cord supporting the cyanide of potassium is passed, so that when the cord is released the paper will descend with the cyanide and remain at rest on the top of the jar but will not prevent the easy descent of the cyanide into the acid. The weight of this paper will in no way interfere with the escape of the gas.

At the end of the time required for fumigation the windows and doors should be opened from the outside and the gas allowed to escape before anyone enters the building. A general cleaning should follow, as the insects leave their hiding places and, dying on the floors, are easily swept up and burned. The sulphate of potash remaining in the jars is poisonous and should be immediately buried and the jars themselves filled with earth or ashes. No food that has remained during fumigation should be used, and thorough ventilation should be maintained for several hours. After one of our experiments it was noted that ice water which had remained in a closed cooler had taken up the gas and had both the odor and taste of cyanide.

For dwellings one fumigation each year would be sufficient, but for storage houses it may be necessary to make an application every three or four months to keep them entirely free from insect pests. The cost of materials for one application is about 50 cents for each 5,000 cubic feet of space to be treated. The cyanide of potassium can be purchased at about 35 cents per pound and the commercial sulphuric acid at about 4 cents per pound. The strength of the dose may be increased and the time of exposure somewhat shortened, but this increases the cost and does not do the work so thoroughly. In no case, however, should the dose exceed 0.22 gram, or remain less than one hour.

The practical application of this method of controlling household insects and pests generally is to be found in checking the advance of great numbers of some particular insect, or in eradicating them where they have become thoroughly established. This method will be found very advantageous in clearing old buildings and ships of cockroaches.

INSECTS OF THE YEAR IN OHIO.

By F. M. Webster and Wilmon Newell, *Wooster, Ohio.*

Broadly speaking, the past year has been marked by the unusual abundance of many of the more common insect pests.

During the past spring and early summer the chinch bug has done serious injury over the area which seems particularly favorable to it, viz, the country lying between the Scioto and Big Miami rivers, which section is, approximately, the most frequently and seriously affected by it. As in other years, *Sporotrichum globuliferum*, the fungus enemy of the insect, has been distributed to all that have applied, and the packages thus distributed amount to about 1,700 in number. As this fungus has been continually sent into this region since 1894, we can now state, with pretty good assurance of correctness, that the artificial introduction throughout this period has given us no evidence of its value in protecting the country from an annual recurrence of attack when meteorological conditions are favorable to the breeding of the insect. This year, however, we have started our cultures of this fungus with affected chinch bugs collected in the fields in 1896, the material having in the meantime been kept in a tight tin box in a dry room. It can not now be said by those who know that the use of this fungus against the chinch bug is an experiment. It will work satisfactorily in wet or moderately damp weather, but will not do so when a drought is prevailing.

Owing to the fact that wheat was almost universally sown late last fall, and only the earlier sown fields were attacked by the Hessian fly, that insect has not claimed the attention this year that it did last.

Over the northern portion of Ohio little or no wheat was so badly injured last fall as to necessitate plowing under this spring, unless it was sown before September 20, 1900, and comparatively little was seriously injured, north of latitude 40°, unless sown prior to September 25, 1900. Wheat plants that had been killed last autumn by the larvæ of the fly were collected in quantity from many sections of the State and placed in the insectary in order to learn the probable condition of the fly in the fields in the spring of 1901. Only in two instances did we secure Hessian fly in great numbers. In one of these cases the wheat had been sown September 12, 1900, and the other was from the experiment plats of the Ohio Agricultural Experiment Station at Wooster. In some instances we reared myriads of the little parasite *Polygnotus hiemalis* Forbes, and the number of these left no doubt of their efficiency in checking the increase of the fly; but in some other cases we reared only very few parasites, and even less flies or none at all, so that it seems possible that there was also another unknown influence which tended to reduce the number of adult flies that emerged this spring.

The rose-chafer (*Macrodactylus subspinosus*) has not been as abundant over the State before in ten years, always in near proximity to sandy lands. It is hardly worth while to state that we have found no practical measures of suppression, but it may be stated that a mixture of 5 pounds of arsenate of lead and 50 gallons of water had no perceivable effect upon them.

Two species of Epicauta (*E. vittata* and *E. pennsylvanica*) have been unusually troublesome, and, as usually follows, a lack in the number of grasshoppers.

The strawberry weevil (*Anthonomus signatus*) worked serious depredations in the strawberry fields of Scioto and adjacent counties, fully one-half the crop having been destroyed by the pest. Information of its ravages was not received in time to permit Mr. A. F. Burgess, who was sent to investigate the outbreak, doing more than to go over the infested fields and lay plans for work next year.

The heart worm (*Hydrœcia nitela*) was reported as working considerable injury in a wheat field in the central part of the State, and a florist in the northern part of the State complained bitterly of the ravages of the pest in his carnations set out of doors. Carnations in the experiment station greenhouses suffered severely in March from the attacks of cutworms (*Peridroma saucia*), which fed on the petals and burrowed into the unopened buds, working chiefly at night.

The Southern turkey gnat (*Simulium meridionale*) became quite abundant in Wayne County during May, causing considerable uneasiness among teams working in the fields near their breeding places. One of these places was located not far from Wooster, in a little brook fed by springs and flowing over a rocky bed. Adults were abundant May 11, and larvæ—some of them very small—and pupæ, as well as adults, were all found on the 16th of same month.

The Southern corn leaf-beetle (*Myochrous denticollis*) did not reappear in destructive abundance this year in the area where it did so much injury to young corn last year. We now know that it hibernates, in part at least, in the adult stage.

Bruchophagus funebris is widely distributed over the State, and its injuries to red clover seed are frequently reported during autumn.

The grapevine root worm (*Fidia viticida*), which was less destructive last year than it had been for some time, seems to have taken on a new vigor, and is this year again very abundant on the grape. Strangely enough, its ravages are still mostly confined to the grape region about Cleveland, extending therefrom much farther to the east than to the west. In a small nursery, near Tiffin, some 85 miles to the west, a small lot of young grapevines was attacked and the leaves very badly eaten, while in no other part of the grounds were the grapevines attacked. Arsenate of lead has not given us much satisfaction in fighting this pest, and the results of this year's experiments with this insecticide in the vineyards have not been very satisfactory, though not conclusive.

The canker worm (*Paleacrita vernata*) was present in many sections of the State in increasing numbers. There was some complaint of the inefficiency of arsenate of lead against these, but in all cases of failure investigated the spraying had been done in an inefficient manner, and the result could hardly have been otherwise than ineffectual.

The corn worm (*Heliothis armiger*) not only attacked young growing corn, but also worked in the broom corn, doing considerable damage to the latter.

The western corn root worm (*Diabrotica longicornis*), though it occurs locally eastward to the Atlantic coast, is not known as a pest east of central Ohio. Its advance across the State from the west has been observed by entomolcgists, and this advance throughout the corn-growing sections has been indicated in the bulletins of the experiment station. During the last nine years everyone connected with the entomological department of the station has watched carefully for the first appearance of the insect about Wooster, but not until last year had it been observed within a distance of 50 miles. A single individual was observed last summer on a garden sunflower in the city. Twenty-five years ago, in northern Illinois, where now its ravages in the corn field are only prevented by continual crop rotation, this insect was as unusual as it is at present at Wooster, Ohio.

Early in the spring of the present year the pea louse (*Nectarophora destructor*) appeared in the clover fields throughout localities where there had been injuries to the peas last year and later spread to the fields of growing peas. In Ohio those engaged in pea culture on a large scale only plant the earlier varieties, which are picked before the insect migrates from the clover.

The harlequin cabbage bug (*Murgantia histrionica*), which was exterminated by the severe winter a few years ago, except in the extreme southern part of the State, has begun its northward spread again, and has been reported as destructive at points along the Ohio River.

Last spring a number of the egg masses of *Mantis religiosa* were received from Professor Slingerland and placed in several portions of the State, including Wooster. We have watched these continually since placing them outside, and in no instance have we been able to note the hatching of the eggs. Unfortunately some of the masses were destroyed, apparently by mice, as they were protected by wire netting that would admit nothing larger.

As a repellant against the infestation of dwellings by ants, we have used naphthaline crystals with success.

As an indication of the somewhat gregarious nature of *Limenitis disippus*, 27 larvæ were found on a group of less than half a dozen Lombardy poplars only a few inches in height. These were observed in October near Cleveland.

Chrysomphalus dictyospermi was found in considerable abundance in the station greenhouses on *Chamerops humilis.* The close superficial resemblance of this species to *Aspidiotus perniciosus* renders it of special interest at the present time.

Much has been said and written relative to the danger of spreading the San Jose scale (*Aspidiotus perniciosus*) by the shipment and sale of infested fruit. While danger is admitted by entomologists, in no instance has an introduction been traced to this source. The following experiments, by no means conclusive, will indicate that introduction by this means is beset with difficulties when we try to do it:

October 15, 1900, fresh peelings from badly infested apples were placed within 4 inches of the base of a young apple tree, set from the nursery row some four years ago. On same date peelings from badly infested apples were placed against and around the base of a small apple tree, and on the 26th more of the infested peelings were wound around the base of the same tree. July 9, 1901, as well as on previous dates, inspections made by different entomologists revealed no scale on the trees.

October 15, 1900, peelings from a very badly infested pear were placed against and around the base of a very young peach tree, and on 26th of same month these were renewed. July 9, 1901, no scale could be found on the tree.

October 15, 1900, six badly infested plums were placed 4 inches from base of a young apple tree, and two infested apples were placed in similar proximity to another young apple tree. July 9, 1901, no scale was to be found on either tree, previous inspections by others having given the same results.

October 15, 1900, six infested plums were placed against the base of a young apple tree; an infested apple was placed against the base of another tree, also young; an infested pear was placed against the base of a young peach tree, and eleven days later another infested pear was placed against the base of this last tree. Up to July 9, 1901, none of these trees carried a single San Jose scale, so far as could be learned from repeated observations by different entomologists.

As indicating the activity of San Jose scale on fruit, during the period between October 15 and November 2, 1900, the following observations are of interest: October 9, 1900, a couple of windfall apples, very badly infested by San Jose scale, were placed under observation. October 13 young scale were alive and very active on both apples; on 18th one apple was nearly decayed and many of the females were dead, five, however, remained alive and contained living young; 19th, live females and active young found on both apples; 22d, one apple decayed, the females dead, and apple discarded, the remaining apple carried living females, but no young were observed. November 2, 1900, the remaining apple carried living females, but by 16th this apple also was decayed and the scale all dead.

In this connection it must be remembered that it was only after repeated attempts to introduce the San Jose scale in the insectary, by fastening sections of badly infested limbs to young trees growing therein, that we were able to succeed. While the foregoing does not and could not prove that infestation may not originate from infested fruit, it does show the great difficulty in causing it to do so.

In all of our microscopical examinations of scale insects *Aphelinus fuscipennis* has been found but twice, in both cases in San Jose scale. *Pentilia misella* is, however, on the increase.

The plum tree mite (*Phytoptus phlœocoptes*) seems to occur generally wherever the Damson plum is grown, as it has been observed or sent from all quarters of the State. Serious damage was this year reported from Wellsville.

Trirhabda tomentosa was observed in the act of defoliating young prickly ash (*Xanthoxylum americanum*) in August, in some cases the trees dying from the effects of these beetles.

Ischyrus nigrans has been reared from a species of Agaricus. *Anthaxia viridifrons*, *Eupristocerus cogitans*, *Sinoxylon basilare*, *Dorcaschema nigrum*, *Magdalis pandura*, and *M. barbita* have all been reared from hickory twigs. *Tomoderus constrictus* has been reared from the stems of *Helenium autumnale*.

Pholisora catullus has been reared from strawberry leaves in August.

Palthis angulalis, *Blastobasis glandulella*, and the parasitic species *Elachista protæteratis* were all reared from seed cluster of sumac.

Desmia funeralis with its parasite (*Habrobracon gelechiæ*), *Pyralis costalis*, *Blastobasis glandulella*, and *Galasa rubidana* have all been reared from masses of grape leaves collected in vineyards.

Dichelia sulfureana and *Eudemis botrana* with the parasite *Bracon mellitor* were all reared from seeds of the garden sunflower.

Lophoderus velutiana, *Oxyptilus tenuidactylus*, *Exartema permundana*, and a species of Glypta have all been reared from larvæ feeding on the leaves of blackberry.

Conchylis hunteana, together with the parasite *Bracon mellitor*, were reared from seed clusters of *Vernonia noveboracensis*.

Grapholitha prunivora was reared from berries of a species of Cratægus.

Mellisopus latiferreana and *Blastobasis glandulella* were both reared from acorns.

Tischeria malifoliella and *Ornix geminatella*, with the parasite *Pimpla indagatrix*, were all reared from leaves of the apple.

A number of spraying experiments were carried out with the following results: *Swift's* arsenate of lead, 3 pounds to 50 gallons water, was applied to potato vines badly infested with *Doryphora 10-lineata*, and, though there was a heavy rainfall the night following the application, all small and medium-sized larvæ were killed, and about half of those nearly or quite full grown. Later, the same experiment was tried, but again the application was followed by a heavy rain, despite which about 75 per cent of all larvæ were killed. As against *Lina lapponica*, on willow, 3 pounds to 50 gallons water killed small and medium-sized larvæ, but did not seem to affect the older and larger larvæ. In another experiment, where 5 pounds of the arsenate of lead was used in 50 gallons of water, all larvæ were killed and the foliage was not injured.

Adler's green arsenoid gave us the following results: For *Lina lapponica*, 1 pound to 100 gallons water killed small and medium-sized larvæ, but not the larger ones, with no injury to the willows upon which they were feeding. One pound to 50 gallons killed all larvæ, and also the foliage, though the latter put out anew later in the season. On rosebushes, and against *Monostegia rosæ*, 1 pound to 150 gallons water was apparently effective and did not injure the foliage.

Comparative experiments were carried out with green arsenoid and Paris green, with the following results: One pound to 100 gallons water, and 1 pound to 150 gallons water, with and without lime, did not appear to affect either the adult Doryphora or the foliage of the potato. The owner of one of the potato fields, however, applied green arsenoid, at the rate of 1 pound to 50 gallons water, and nearly ruined the potato vines.

Arsenate of lead has given the best results, with no injury to the foliage, while Paris green and green arsenoid give each about the same results, both being inferior to the arsenate of lead.

Experiments with whale-oil soap, Owens Standard brand, 1 pound to 2 gallons of water, had no effect on either larvæ or adult Doryphora. The same brand of soap was applied against *Diabrotica vittata*, at a strength of 1 pound of soap to 1, 2, 4, and 8 gallons of water. A mixture of 1 pound to 2 gallons of water, or weaker, did not prove successful as a repellant, while 1 pound to each gallon of water kept the beetles away, but seriously injured the cucumber plants to which the mixture was applied. One pound of this soap to 8 gallons of water was ineffective against Aphis on cherry, but the same strength completely repelled the three-lined plant-bug from chrysanthemums so that the plants were not again attacked by this insect.

Tobacco dust was ineffective against *Doryphora 10-lineata*, *Phyllotreta vittata*, and *Diabrotica vittata.*

FRUIT SERIOUSLY INJURED BY MOTHS.

By C. W. Mally, *Cape Town, South Africa.*

During May, 1900, numerous letters were received complaining of serious injury to fruit by moths, specimens of which were submitted to Mr. L. Peringuéy, assistant curator South African Museum, who determined them as *Ophiuza lienardi.*

With the exception of one specimen, this is the only species represented in the material received from the fruit growers. A summary of the correspondence has been given in the Agricultural Journal for July 5, 1900.

The moths were apparently most injurious in the East London district, serious complaints coming from East London, Komgha, Fort Jackson, Kentbury, and as far inland as Grahamstown.

It frequently occurs that a number of moths cluster on a single fruit, and some of the reports indicate that there was scarcely a fruit that was not covered with moths. One correspondent reports the moths as swarming on a load of pineapples that were being taken to market. Some idea of the seriousness of the injury may be gathered from the statement of Mr. Walter A. Edmonds, Komgha, that "20,000 extra fine oranges, on all of which, except those picked half green, directly the moths appeared, have been spoiled." Thus far injury to the following fruits has been reported: Apples, pears, plums, grapes, peaches, figs, oranges, guavas, bananas, pineapples, loquats, and medlars; also "native fruits, berries, and flowers."

The fruit growers agree as to the importance of the pest; but their observations on the habits of the adult are considerably at variance.

Some say they are nocturnal, readily attracted to lights, and easily destroyed by means of poisoned sweets. Others report observations to the contrary. The essential point seemed to be whether the moths punctured the fruit themselves or simply took advantage of some slight mutilation or an injury from some other insect, especially the fruit fly, during oviposition. There was no opportunity to make definite observations till the latter part of April, 1901. While en route to another farm, near Trapps Valley, Bathurst Division, it was convenient to stop with Mr. G. W. Smith for the night. On being asked whether he had noticed any unusual insect injury the present season, he replied that the fruit moth, though not unusual, was doing very serious damage to apples. We took a lantern and proceeded to the orchard at once. There were about 50 trees, located along a small stream, bearing a light crop of fruit. Numerous specimens of *Serrodes inara* Cram. (kindly determined by Mr. C. G. Barrett, London) were found, often from one to five on an apple, and scarcely a fruit could be found that did not show several punctures. The moths showed no signs of being disturbed by the presence of the lantern, much less attracted to it. I selected one specimen for study and placed the lantern so that every movement could be observed. The proboscis had been inserted through a very small round opening, the moth very contentedly withdrawing it till the tip was near the surface and then by moving the head back and forth rapidly laterally forced it down full length into the pulp of the fruit. This was kept up for some time. As the moth showed no signs of leaving or changing its position, I proceeded to observe numerous others and always with the same result, each one feeding quietly and continually withdrawing and inserting the proboscis. Several times a moth was seen to alight on an apple, but each time it began feeding through one of the several punctures present, which it seemed to detect instantly. A few were seen feeding through a slight mutilation or crack in the fruit. A careful examination of the proboscis and the punctures indicated that the moths were quite capable of taking care of themselves. No other insects were observed on the fruit. The following day not a moth could be seen. I examined the grass and bush along the stream without results. Soon after sundown they again put in their appearance and began feeding the same as before, gradually becoming more numerous. I kept as many under observation as possible, but they showed no intention of making fresh punctures. One specimen was finally selected and kept under continual observation. After it had been feeding for about thirty minutes it became restless and then, as if divining the cause of my devotion, deliberately moved about an inch to one side, placed the tip of its proboscis on the surface of the apple where I could see clearly that there was no opening, and began the same lateral motion of the head as before. With my hand lens I could see the two sections of the proboscis working up and down, the tips alternately striking the surface of the fruit and gradually effecting an entrance. No sooner was the opening nicely started than the moth quickly returned to the former puncture, as if to say, "More juice and less work."

This observation confirms the published statement by C. G. Barrett, who records the observations of his sister residing in the colony. (Entomologists' Monthly Magazine, June, 1900, pp. 140–144; July, 1900, p. 163; September, 1900, pp. 207, 208; also Entomologists' Record and Journal of Variation, July 1, p. 193, and October 15, p. 267, 1900; Nature, May 31, 1900, report of meeting of Entomological Society.)

The same moth was kept under close observation from 9 to 11.30 p. m., during which time it did not leave the puncture, but fed continually.

The moths do not make a single straight channel, but force the proboscis down at different angles, thus producing a conical injury one-half inch or more in altitude, penetrated by numerous very fine channels. The tip of the proboscis is black, very hard, finely pointed, and provided with spines, which seem to serve the purpose of rasping the pulp of the fruit, thus enabling it to be drawn up with the exuding juice. The fruit in the vicinity of the puncture is very pliable. On removing the surface layer the injured portion is seen to be quite hollow.

Apples do not decay speedily, but remain for some time, the slight decay perhaps rendering them the more readily detected by the moths.

While feeding the wings were usually in a horizontal position and motionless. At other times there was a slight but distinct rapid vibration. In some cases the wings were slightly elevated, occasionally vibrating as stated above.

On one occasion an egg seemed to drop from the ovipositor. I took precautions to secure any additional ones, but obtained nothing but small drops of liquid; found no trace of the eggs. I dissected a number of females, and in one found three light green eggs, ribbed very much like those of *Heliothis armiger* Hbn., but flatter and somewhat larger.

I revisited the orchard about half an hour before daybreak and found the moths still abundant and feeding as contentedly as before. Just at dawn they gradually disappeared. I singled out four to determine their hiding place. Touching two of them with my pencil, they flitted away, it being still too dark to follow them. The third soon darted away toward the ground and was out of sight. The fourth remained some moments longer, but, unfortunately, I looked away for an instant to rest my eyes.

During the following evening I secured about 30 for specimens. Occasionally one would flit away, and I could distinctly hear it strike the ground. On lowering the lantern it was not always easy to locate them, their colors being somewhat protective. They made no effort to escape till again disturbed, sometimes permitting themselves to be pushed into the cyanide bottle in an apparently lifeless condition, only trying to escape after the cyanide had begun to affect them.

This species (*Serrodes inara* Cram.) was only found on apples and guavas. Oranges, although ripening nicely in the same orchard, were left untouched. A few specimens of three other species, one of which attacked oranges, were also observed on apples.

To determine whether or not the moths could be readily attracted to poisoned sweets some tins of jam—strawberry, apricot, and plum—were procured and placed in some of the trees. In others the same materials were spread on sheets of paper and fastened to the branches near the fruit. With one exception not a moth paid any attention to the sweets. One opecimen was seen on the edge of the tin of plum jam, but disappeared before I could determine whether or not it was feeding.

Unless we succeed in destroying the insect in some other stage of development the only way to secure the fruit is to apply netting while the moths are abundant.

NOTES ON FOUR IMPORTED PESTS.

By A. H. Kirkland, *Boston, Mass.*

Up to the present summer Massachusetts has borne the unenviable distinction attaching to the only State harboring the gypsy moth (*Porthetria dispar* Linn). She now enjoys whatever benefit company affords misery, for during the present month a colony of the insect has been found at Providence, R. I. The infestation in this city is scattered over at least 2 square miles in the residential district. The first specimens were discovered August 1 by an amateur naturalist, Mr. Prescott Newhall, who carried them to Mr. James M. Southwick, formerly entomologist to the Rhode Island board of agriculture. Mr. Southwick rightly conjectured that they were gypsy moths, but to settle the matter beyond doubt, took specimens to the office of the Massachusetts board of agriculture, where the writer was able to corroborate the identification.

On August 2 the writer made an examination of the colony and found it in the incipient stage, no trees being defoliated. The street trees are quite generally infested, and it seems probable that the caterpillars have spread from the original centers of infestation by dropping on teams and that in this way a large part of the city may be infested.

Few facts are available at the present writing to show how the moth found its way to Providence, a distance of at least 35 miles in a direct line from the nearest infested point in Massachusetts. The colony in question does not show the characteristics of a natural infestation slowly spreading from a central point. Instead, there are several isolated points where numerous hatched egg clusters occur, none of these clusters apparently being over 3 or 4 years old, thus showing that there are many centers of infestation.

It was most unfortunate that the work against the moth in Massachusetts incurred the enmity of a large number of discharged employees. It was well known to them that the finding of the moth outside of Massachusetts probably would cause the State to abandon the work of extermination. When the matter of continuing the work was being discussed in the legislature in 1899, a persistent rumor was in circulation to the effect that the moth had been "planted" in Rhode Island. Efforts to trace these rumors to their source were not very successful, all the available clues being followed up without tangible results. While the occurrence of the moth in Providence may be due to some well-known means of distribution, in the absence of facts showing this to be the case it is hard to avoid the belief that the moth may have been deliberately carried to that city.

The Providence city authorities have acted with commendable promptness in the matter, and under the direction of Mr. Southwick competent men are at work destroying the egg clusters with creosote oil. It is earnestly hoped that the fight against the insect will be continued in order that its future spread may be prevented.

In Massachusetts the gypsy moth has spread unchecked since the cessation of the State work against it, February 1, 1900. To those who had tried to make this work a success it was gratifying to note that in 1900 practically no damage by the moth occurred throughout the whole infested district. The former infestations had been so severely dealt with that comparatively few scattered insects remained. In some of the larger infestations, particularly in the central towns, there were enough moths to serve as nuclei for colonies, and the present year in restricted localities numbers of trees have been defoliated. The season has been favorable to the increase of the moth, and at the present date (August 15) formidable numbers of the egg clusters may be seen in all of the central towns of the infested district. It seems probable that in a few years the insect, if unmolested, will be sufficiently abundant to repeat the widespread damage caused in 1888–1890.

Already there are indications that public sentiment is becoming more favorably disposed toward the past work of the gypsy moth committee. Without doubt in a few years the increase and activity of the moth will again make necessary some organized effort to reduce its numbers.

While the cessation of the work against the gypsy moth seemed unwise, and was a great disappointment to those familiar with it, yet it is fortunate that out of this work have come accurate and effective methods of dealing with the pest when it again appears in force. The value of these methods is well illustrated in the case of the Providence infestation. Within a day after the colony was discovered a trained man, equipped with the proper apparatus and insecticides, was placed at work destroying the egg clusters, and in a few days accomplished more than an amateur could have done in as many weeks.

While not as important in its injury to trees as the gypsy moth, few insects have created a greater local commotion than the brown-tail moth (*Euproctis chrysorrhœa* Linn.) in Boston and its suburbs the present summer. The caterpillars were sufficiently numerous to strip shade and fruit trees in many residential localities; pear trees suffering to the greatest extent, with apple, cherry, plum, and willow following in about the order named.

As is generally known, the hairs of the brown-tail moth caterpillar coming in contact with the human flesh produce a fierce and enduring irritation. As the caterpillars matured and commenced to migrate in search of shelter, large numbers of children and many adults were severely "poisoned" by them. So numerous were complaints from this source, and so prevalent was the belief that a new epidemic disease had appeared, that the Boston board of health gave a public hearing on the subject. At this hearing it was explained that the so-called epidemic was due to the caterpillar hairs, and that by the destruction of the winter webs which shelter the hibernating insects, future annoyance could be prevented. As has been determined by Mr. F. J. Smith, former chemist to the gypsy moth committee, the irritation caused by the caterpillars is probably of a mechanical nature and not due to any poisonous principle contained in the hairs. The hairs are barbed and very brittle, and when once lodged in the skin are easily broken, and require several weeks for their expulsion.

It has not been possible to continue following accurately the spread of this insect, but it is now known to occur in Brockton and in Hudson, Mass., and probably it has established itself throughout the territory lying between these localities and the known infested region, making a total infested area of over 1,200 square miles. More or less work has been done against this insect by local park and street boards, and where this has been carried on along approved lines the results have been very satisfactory.

It is noticeable that the moth is strongly attracted to lights, and hence the greatest infestation is usually where street lights are most numerous. The little European parasite, *Diglochis omnivorous* Walker, is very effective in destroying the pupæ, but its services have not been sufficient to restrict the increase of the moth.

Taking Massachusetts as a whole, the most general damage by any insect pest the past season has been that by the elm-leaf beetle (*Galerucella luteola* Muell.). This insect has now become established in nearly all of our cities and larger towns, and has finally invaded Boston, where it threatens to cause serious damage. It is noticeable that the spread of the insect has been chiefly along water courses and to a less extent along the main lines of railway.

The severe injury by the beetle in the larger cities of the Connecticut Valley several years ago led to the introduction of municipal spraying operations. The original methods of work have been improved until they are now very effective. The chief reliance is placed upon a thorough spraying with some form of arsenate of lead as soon as the foliage develops. It has been found most practical in large operations to use several powerful hand outfits, carrying two lines of hose, rather than to employ one or two steam outfits. The greater number of outfits permits the thorough treatment of the trees in an entire city as soon as the foliage has developed, and thus the beetle is not permitted to damage the trees in one part of a city while spraying is being carried on in another section. The work of the Springfield city forester, William F. Gale, has been particularly well carried out, and has served as a model for similar operations in other municipalities.

While the beetle, as a rule, has but a single brood throughout the State, a well-defined second brood occurs on Cape Cod and a partial second brood in the Connecticut Valley. In neither locality has this latter brood caused damage worthy of note.

Willows and poplars throughout the State are becoming more and more subject to attack by the imported weevil (*Cryptorhynchus lapathi* Linn.). This insect seems also to have followed the water courses while spreading through the State, although the transportation of nursery stock is responsible for a large part of its journeyings. Nearly all our nurseries are more or less infested with this weevil, whose life history the writer has worked out in detail. Late in the summer, after feeding for some weeks on the petioles and young shoots, the beetles drill small holes into the bark beneath leaf scars or other irregularities and in them deposit the eggs singly. The holes are then carefully filled with bark dust. The eggs hatch in a short time, and the young grubs feed in the bark for a few weeks and then enter hibernation. At this time the grubs may be detected easily, as their presence is revealed by the black outlines of their burrows, which are plainly visible on the bark. With the advent of spring the weevil enters the sapwood and grows rapidly to maturity. When full grown the grub returns down the burrow, enlarging it to a uniform diameter, then ascends to the upper end, prepares a tight chamber, and transforms. The beetles commence to emerge in June. There is quite a variation in the time of emergence, those insects breeding in young shoots emerging first, while those feeding in the older wood apparently require a longer time for their development. While the insects as a rule hibernate as young larvæ, individuals in all stages of growth are sometimes found in winter in the heartwood of old trees.

In Germany this weevil is known chiefly as a pest of the basket willow and alder. In Massachusetts we have noticed it more particularly as destroying ornamental poplars and willows. There are many localities, particularly along our coast, where cottagers are dependent almost entirely for shade upon the Balm of Gilead poplar and one or two species of willow. These trees, brittle at their best, when riddled by burrows of the weevil become easy victims of ice storms.

The remedial measures most in favor are the destruction of the grubs by hand in the fall or winter. Where a tree is badly infested it is hardly worth while to attempt to preserve it. Such trees should be cut and burned, and in their places should be planted the silver maple, three-thorned acacia, or other species, that thrive in damp localities.

DROUGHT, HEAT, AND INSECT LIFE.

By Mary E. Murtfeldt, *Kirkwood, Mo.*

Probably few localities in the Mississippi Valley have suffered so greatly from prevailing atmospheric conditions as has the suburb of Kirkwood during the present summer. Following an unusually dry spring there has been no appreciable rainfall since a brief, but heavy, shower on the 12th of June. Even of the two or three light showers that visited our city (St. Louis), but a few miles distant, scarcely a drop, or but a mere sprinkle, extended to Kirkwood. For many successive days the mercury ranged from 100° to 110° in the shade, and for only about six days since the middle of June has the maximum temperature fallen below 90°.

Under such conditions it would seem inevitable that insect life must be much affected. My personal observations, although extending over a very limited area, indicate that this is the case. Early in the spring Aphididæ of many species and in incomputable numbers occurred on grain and all varieties of fruit trees and threatened destruction to many choice ornamental shrubs. These insects would naturally be reduced as the season progressed, but usually some estivating individuals or forms can be found by the close observer. At present, however, the most careful examination fails to reveal evidence of any persisting species.

Cutworms, which were very destructive upon early vegetables in spring, find now no cultivated plants and no succulent weeds upon which to feed, nor have any species of the moths been noted for many weeks. The "corn ear-worm" or "tomato fruit-worm" of this region (*Heliothis armiger*) does not find for miles around either of these plants for its sustenance and can not, it seems to me, fail to be so reduced in numbers as to be practically innoxious for at least one or two succeeding seasons.

Curculio and codling moth, following a season in which both stone and pip fruits were practically a failure hereabout, are scarcely at all in evidence in the dwarfed and flavorless apples, pears, and peaches that still cling to the trees or have already dropped to the hard and heated earth.

A large prune tree on the grounds of the writer which has been in bearing for eight or ten years, but which is such a bait for *Conotrachelus nenuphar* that we have seldom been able to obtain a perfect fruit, yielded recently quite a crop of undersized but not wormy prunes. As entomologists all know, the pupæ of many moths and beetles require a certain amount of moisture to enable them to emerge from the ground, beneath which their transformation takes place, and to expand their wings. It would seem as though the midsummer broods had not been able to do this, as the strongest lights have for weeks failed to attract any Noctuids, Geometers, or Bombycids, and scarcely any leaf-feeding beetles are to be found even on such vegetation as is still green. Incidentally it may be said that for the student of the life histories of insects this is the most disappointing summer on record, but what its influence may be upon many well-known forms is a matter of not a little economic interest.

The horsefly, very numerous and annoying to cattle during May and June, entirely disappeared some weeks since, the manure drying out too rapidly to afford the larvæ time to develop. Even the house fly and other annoying Muscidæ are comparatively few in number.

At this writing in this immediate locality almost the only grasshoppers to be seen in meadows and pastures are in a very immature condition, and few in number. The chorus of other orthopterous species, usually so full and obtrusive during the evening hours at this season of the year, is very thin and interrupted. Occasionally one can distinguish the soft whirring of an Orchilimum or Xiphidium, and, at remote distances and intervals, the ear-splitting shrill of the "cone head."

The true katydid does not this year interrupt conversation in the evenings on the lawn or piazza with its hoarse iterations, neither does the angular-winged form with its noisy rattle. Butterflies have disappeared with the flowers from our gardens, and bees are consuming the stores accummulated for winter use. But insects, especially the obnoxious kinds, have great and inexplicable powers of adaptation and endurance, and there is much interest attaching to the problem of their survival and multiplication under present adverse conditions.

It must not be forgotten that there are a few species that seem to revel in the heat and aridity. Among these are the ants, large and small. With no showers to inundate their galleries and temporarily arrest their activities they have increased beyond computation, and have become an almost insupportable nuisance about dwellings. The black crickets also seem to have found in the heat and drought of the present summer circumstances exactly suited to their enjoyment and multiplication. Their shrill chirpings on field and lawn and about our dwellings replace the notes of arboreal insects and indicate their presence in very unusual numbers.

Still another insect that seems to find the heat and drought of the present season most congenial and favorable for its multiplication and enjoyment is that household pest the "silver fish" (*Lepisma domestica* Pack.). Everywhere among books and papers, on closet shelves, between piled dishes, on all folded clothing and curtains containing starch the little nuisances, large and small, may be seen darting to cover upon the slightest disturbance, and in many cases the damage done is very serious, especially to costly books, collections of pictures, and to lace curtains. The only resource of the housekeeper has been to dust pyrethrum powder profusely over her books and unframed pictures, to remove all ornamental papers from the shelves of china closets and sideboards, and to frequently examine and shake out draperies and clothing liable to attack.

There are a few other species that have for brief periods proved troublesome, but those noted are the most prominent and irrepressible.

What the effects of the unusual season will be upon field-crop pests remains to be ascertained. Earlier in the season chinch bug, Hessian fly, and grain-feeding Aphididæ were very prevalent and destructive in Missouri and adjoining States, and it can only be learned by the starting of fall crops in what numbers these have survived. It is to be hoped, and may reasonably be expected, however, that the great losses in almost all crops will be, in some measure, compensated by a marked reduction in the number of destructive insects.

The secretary read several letters from absent members expressing regrets at not being able to attend the meeting, including a letter from Secretary A. L. Quaintance, who was detained on account of pressing work, and also a letter from Director William Trelease, of the Missouri Botanic Gardens, cordially inviting the Association to hold its meeting of 1903 in St. Louis during the Louisiana Purchase Exposition.

The committee on nomination proposed the following officers for the ensuing year:

President, A. D. Hopkins, Morgantown, W. Va.

First vice-president, E. P. Felt, Albany, N. Y.

Second vice-president, T. D. A. Cockerell, East Las Vegas, N. Mex.

Secretary, A. L. Quaintance, College Park, Md.

The report of the committee was accepted and the above-named officers elected.

The committee on resolutions made the following report, which was accepted and adopted:

Resolved, That this Association, at its first meeting since the death of Dr. Otto Lugger last May, desires to place upon record its deep regret at the loss it has sustained by his untimely removal. Economic entomology has been deprived of an able exponent, and the members of this association feel also that they have personally to lament a true and warm-hearted friend. Dr. Lugger has long been identified with economic entomology in this country, and aside from his scientific ability he was a man of admirable qualities and wide information.

Resolved, That the Association of Economic Entomologists desires also to express its sense of loss through the death of Miss E. A. Ormerod, of England. Long before this body came into existence, at a time when economic entomology was ignored in England, Miss Ormerod took up the study of injurious insects, and published numerous valuable reports directing the farmers how to recognize and deal with their insect foes. She not only did this for England, but extended her researches through the aid of correspondents to the colonies, and always took a lively interest in the work done in America. As an example of private initiative and unselfish devotion to the public interest Miss Ormerod's work deserves to rank with that of Lawes and Gilbert at Rothamstead.

Resolved, That we request the Honorable Secretary of Agriculture to publish the proceedings of this meeting, and that we express to him our hearty appreciation of such action in previous years.

Resolved, That we express our thanks to the officials of the Denver High School, to the people of Denver and the local committee of the American Association for the Advancement of Science, to the Association, and to the local press for courtesies extended.

A. D. HOPKINS,
W. H. ASHMEAD,
E. D. BALL,
Committee.

On motion of Mr. Felt it was voted to hold the next annual meeting at the same place with the next annual meeting of the American Association for the Advancement of Science, on the last week day preceding and the first week day of the meeting of that Association, which will be held in Pittsburg, Pa., June 28–July 3.

Adjourned.

A. L. QUAINTANCE, *Secretary.*

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[1] Deceased.

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U. S DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY—BULLETIN NO. 32, NEW SERIES.

L. O. HOWARD, Entomologist.

INSECT ENEMIES OF THE PINE IN THE BLACK HILLS FOREST RESERVE.

AN ACCOUNT OF RESULTS OF SPECIAL INVESTIGATIONS, WITH RECOMMENDATIONS FOR PREVENTING LOSSES.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST.

By A. D. HOPKINS, Ph. D.,

Vice-Director and Entomologist of the West Virginia Agricultural Experiment Station.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

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Artist: Miss L. Sullivan.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 22, 1902.

SIR: In the temporary absence of Dr. L. O. Howard, Chief of the Division of Entomology, I have the honor to transmit herewith the manuscript of a paper entitled "Insect Enemies of the Pine in the Black Hills Forest Reserve," by Dr. A. D. Hopkins, Entomologist of the West Virginia Agricultural Experiment Station. The extensive losses occasioned in recent years by insects to forest lands in various portions of the United States, and particularly in the North and Northwestern regions, have attracted great attention, and have necessitated investigations as to the character of the injury in order that the most appropriate methods of control may be advised. The present contribution is the third of a series bearing upon the insect enemies of coniferous trees, and comprises a summarized account of results of a special investigation that was made during the year 1901 under instructions from this Division and with the cooperation of Mr. Gifford Pinchot, Forester of this Department, together with a consideration of valuable suggestions for preventing losses, based upon studies by Dr. Hopkins extending over a number of years. I recommend its early publication as Bulletin No. 32, new series, of this Division.

Respectfully,

F. H. CHITTENDEN,
Acting Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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INSECT ENEMIES OF THE PINE IN THE BLACK HILLS FOREST RESERVE.

REQUEST, AUTHORIZATION, AND INSTRUCTIONS.

The work herein reported was undertaken by request of Mr. Gifford Pinchot, Chief of the Bureau of Forestry, under authorization from the honorable Secretary of Agriculture and instructions from Dr. L. O. Howard, Chief of the Division of Entomology.

THE INVESTIGATING TRIP.

The investigations were conducted, in company with Mr. Pinchot and his chief field assistant, Mr. Griffith, on September 1 to 4, 1901, along a route traversed through the reserve from Spearfish, via Iron Creek, Bear Gulch, and Cement Ridge, South Dakota, Rifle Pit, Wyoming, and Spearfish Creek, to Lead, S. Dak.

THE CONDITIONS OBSERVED.

Vast numbers of rock pine (*Pinus ponderosa scopulorum*) that were dying, or had died within recent years, of sizes ranging in diameter from 4 inches to the largest trees, were observed along the route. The dying trees occur in clumps of from a few examples to many hundreds, and in some sections, as viewed from the summit of Cement Ridge and other favorable points, the dying, recently dead, and old dead trees cover large areas.

THE AMOUNT OF DEAD TIMBER.

Mr. H. S. Graves[a] estimated in 1897 that about 3,000 acres of pine in the Black Hills Forest Reserve had been killed. Further data furnished by the Bureau of Forestry show that the actual amount of dead timber, as determined by Mr. Griffith and party in a detailed survey of the timber resources of the reserve in 1901, is, "An average stand of 1,956 feet board measure of bug-killed timber on 116,000 acres, giving a total of 226,890,000 feet board measure."

HISTORICAL REFERENCES.

It is the general opinion among settlers and others who have had an opportunity to note the conditions affecting the pine that the dying timber commenced to attract attention about six or seven years ago, or about 1895.

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[a] Nineteenth Annual Report U. S. Geological Survey, 1897–98, Part V, p. 87.

The evidence found by the writer in old dead standing and felled trees indicates that the pine-destroying beetle has been present for a much longer time. It was also evident that much of the devastation supposed to have been caused by forest fires was caused, primarily, by insects.

Mr. Graves, in his exhaustive report on the Black Hills Forest Reserve,[a] refers, on page 87, to insects and the dead pine timber as follows:

On the high limestone divide, from near Crook Tower to the head of Little Spearfish Creek, there are numerous patches of dead and dying timber. These patches are usually rectangular in shape and follow the tops of the divide and ridges, or run lengthwise up and down the slope. This forest has for the most part not been lately burned, and there is a heavy matting of litter and humus on the ground. The injury is confined to the limestone formation and to high elevations. The trees are in many cases second growth and apparently perfectly thrifty. This injury is probably caused by insects. On all dead and dying trees examined were found bark borers, a species of the Scolytidæ, working under the bark. In most cases the leaves were clinging to trees which had been dead for several seasons. While these borers do not, as a rule, attack vigorous trees, no other cause of the death of this timber could be found.

Mr. H. E. Dewey, writing to the Division of Entomology from Lead, S. Dak., on August 12, 1899, stated:

* * * There have been none in the trees this year until last Wednesday, the 9th. On that day there was a southwest wind, and a swarm of them came. My dwelling is in what was a grove of young native Black Hills pines. The bugs settled on the house like a plague of locusts. At night they left the house and scattered about. I have examined the trees, and with one exception do not find that they attacked them. This one excepted tree is a sight. Hundreds of bugs settled on it during the night, and by morning they had buried themselves out of sight in the trunk. As they bored their way in, the dust from their boring, which was very fine, filtered out from the top to the bottom of the tree like fine sawdust, and fell about the tree on the ground. They could be plainly heard at their work as they bored into the wood. The tree was a vigorous young pine about 15 feet high and 6 inches in diameter at the ground, and there is no apparent reason why they should select it more than others. Last year they were here in June.

The following copy of a letter addressed to the Department of the Interior, Division of Forestry, was submitted to the author from the Division of Entomology, with a specimen of the insect, which, together with the specimens sent with Mr. Dewey's letter, formed the material from which the species was named and descriptive notes were made. The letter is dated Piedmont, S. Dak., August 14, 1898, and reads as follows:

Many of the pine trees in this vicinity are dying. Small holes appear in the bark, a reddish pitch exudes, the leaves turn brown, and in a few weeks the tree dies. I think the mischief is done by the small black insect inclosed herewith, which I found in one of the holes. Is there any remedy?

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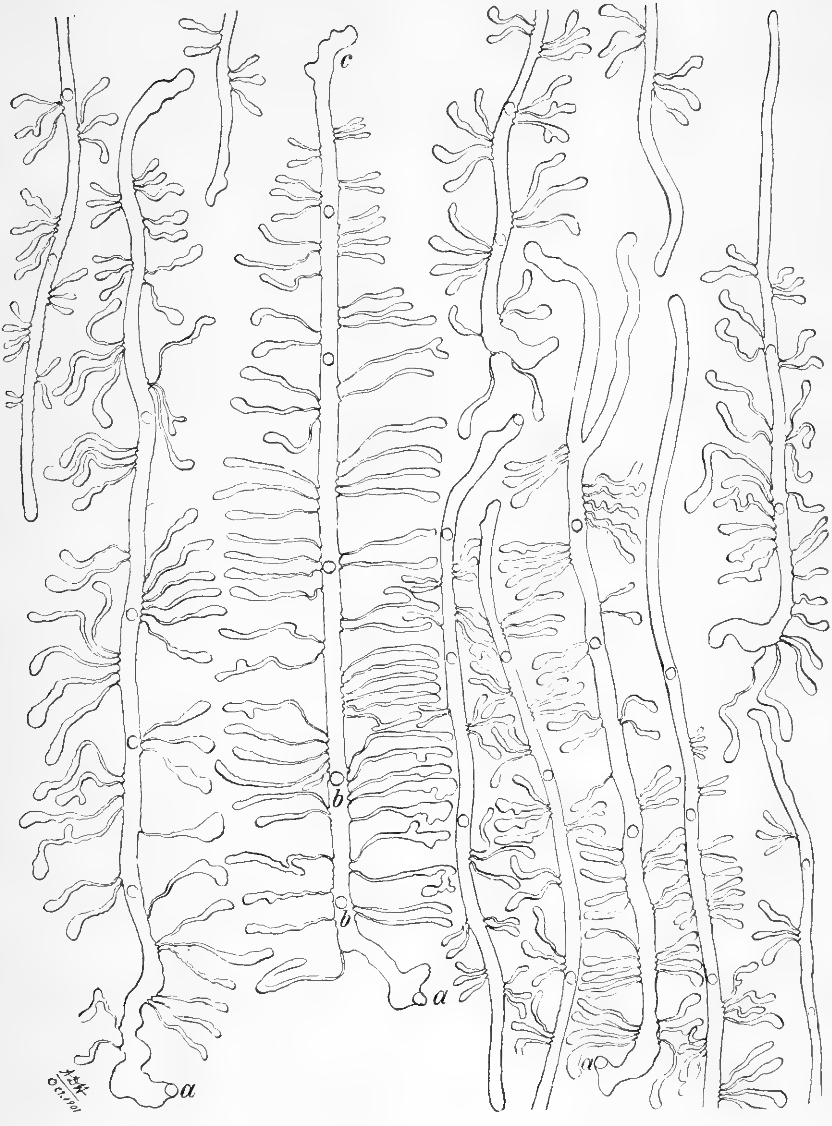
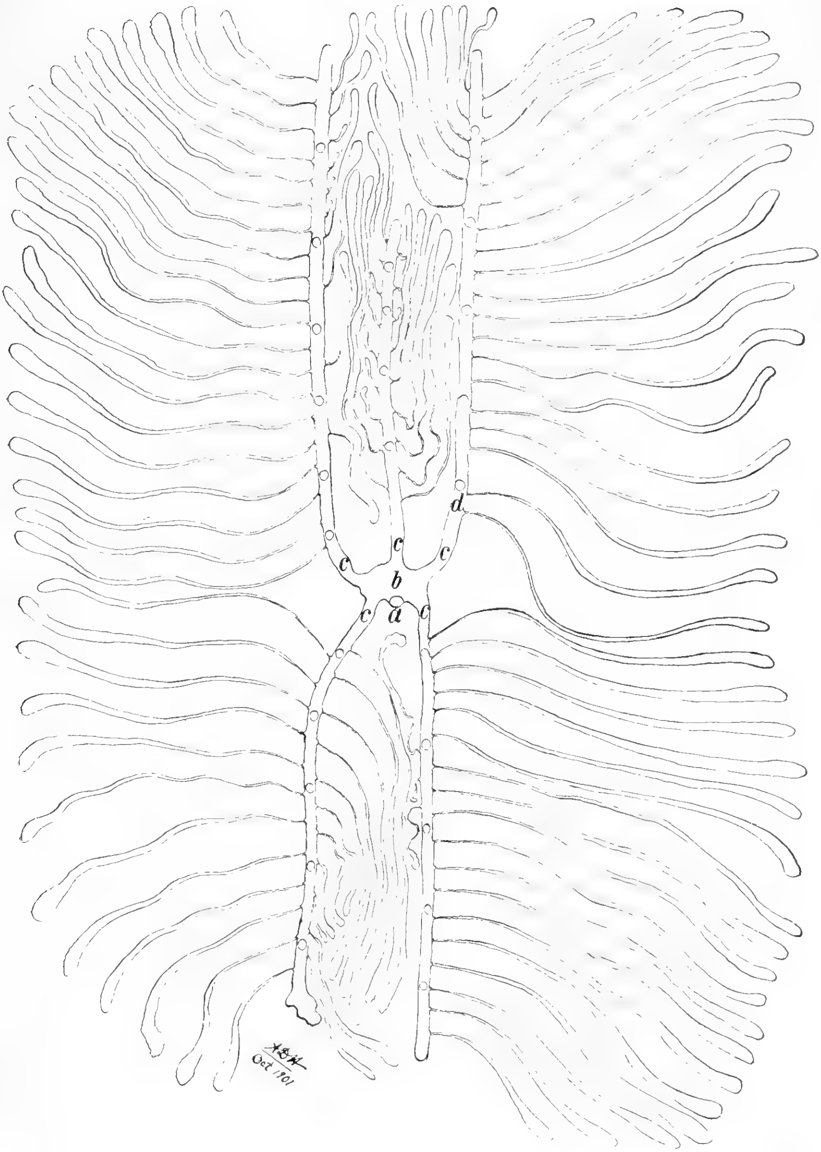
[a] Nineteenth Annual Report U. S. Geological Survey, 1897–98, Part V, pp. 67–164.



WORK OF THE PINE-DESTROYING BEETLE OF THE BLACK HILLS (DENDROCTONUS PONDEROSA N. SP.). PRIMARY GALLERIES AND LARVAL MINES IN INNER SURFACE OF LIVING BARK.

a, Entrance and basal chamber; *b*, ventilating holes in roof of gallery; *c*, termination. The larval mines radiate from the primary galleries. About one-half natural size. (Original.)



WORK OF THE COARSE-WRITING TOMICUS, IN INNER SURFACE OF BARK FROM DYING PINE.

a, Entrance; *b*, central chamber; *c*, primary or egg galleries. Reduced about one-half. (Original.)

THE TROUBLE CAUSED BY INSECTS.

The evidence obtained from a study of all stages of the afflicted timber, including the living, dying, recently dead, and old dead trees, of all sizes, and under widely varying conditions of altitude, exposure, geological formation, soil, and character of growth, indicates quite clearly that this widespread, unhealthy, dying, and dead condition of the timber is the work of insects.

THE PRIMARY ENEMY.

The evidence found also clearly indicates that the insect which makes the first attack on the living trees, and therefore the primary cause of the trouble, is a small, black, bark-boring beetle, belonging to a species heretofore unknown to science, and appears to be peculiar to the Black Hills region.[a]

NAME OF THE BEETLE.

Since this primary enemy has not been distinguished from a number of other bark beetles found in the infested trees, it has not been desig-

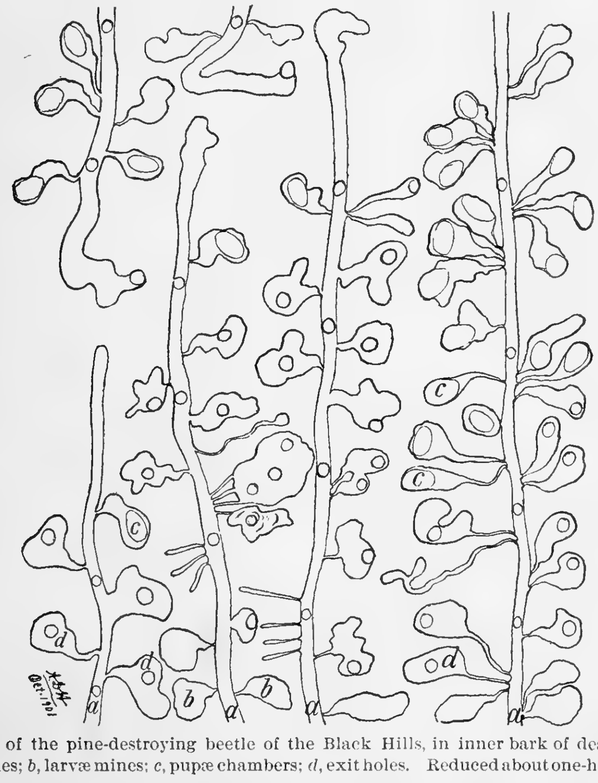


Fig. 1.—Work of the pine-destroying beetle of the Black Hills, in inner bark of dead tree. *a*, primary galleries; *b*, larvæ mines; *c*, pupæ chambers; *d*, exit holes. Reduced about one-half (original).

nated by a local name. I would therefore suggest that hereafter it be designated as "the pine-destroying beetle of the Black Hills," and by

[a] Since this was written it has been reported from Colorado.—A. D. H.

the technical or Latin name *Dendroctonus ponderosa*.[a] The adult is a stout, dark-brown to black beetle, individuals of which vary in length from 4 to 7 mm. (about one-sixth to one-fourth inch). They attack living and healthy large and small pine trees, enter the bark on the main trunk, and each pair excavates a long, nearly straight, longitudinal gallery through the inner bark (Pl. I and fig. 1), usually grooving the surface of the wood. Eggs are deposited along the sides of this primary gallery and hatch into minute white grubs (larvæ), which excavate mines through the bark at right angles to the primary gallery (fig. 1, *b*). These mines are extended and enlarged as the larvæ increase in size, and when full grown each individual excavates a broad, oval cavity in the bark (fig. 1, *c*), in which it transforms to a soft, white pupa, and then to the adult, which bores out through the bark (fig. 1, *d*), and flies, with other adults of the same and other broods, in search of other living trees in which to excavate galleries and deposit eggs for another brood.

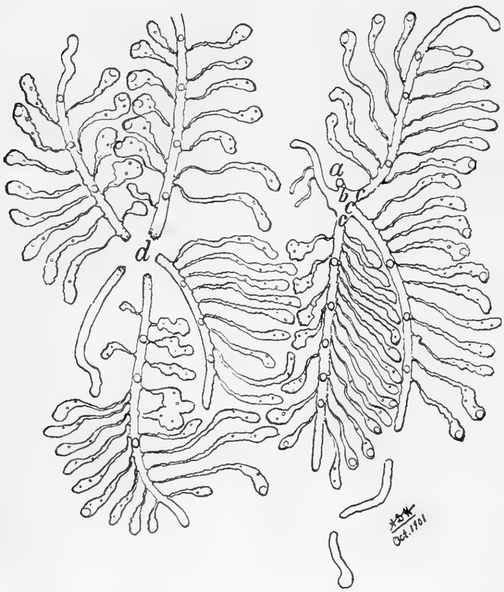


FIG. 2.—Work of the Oregon Tomicus (*Tomicus oregoni* Eichh.). Primary galleries and larval mines in inner bark. *a*, Entrance; *b*, central chamber excavated through inner bark; *c*, egg galleries; *d*, location of central chamber not excavated through inner bark. Reduced about one-half (original).

SECONDARY ENEMIES.

Many other species of bark beetles and other bark and wood infesting insects were found associated with the primary enemy in the partly living bark of infested and dying trees, but none of them were found making an independent attack on living trees. Therefore they must be considered as secondary enemies, which follow the leader in the attack, and merely contribute to the rapid and certain death of the trees thus infested.

The Oregon Tomicus (*Tomicus oregoni* Eichh.).—This is a small reddish to black bark beetle, individuals of which vary in length from 3.5 mm. to 4 mm. It follows closely the attack of the pine-destroying beetle, and enters the bark on the large and medium sized branches and toward the top of the main stem. Several females excavate radi-

[a] This species has heretofore been erroneously identified as *D. terebrans* and *D. rufipennis*, and will probably be found so labeled in some collections.

ating galleries from a single entrance and a central chamber (fig. 2, *a* and *b*). The central chamber may (*a*), or may not (*b*), extend through the inner layers of bark and groove the surface of the wood, but the radiating galleries are nearly always grooved in the surface of the wood, as are also the egg cavities, which are excavated at short intervals along the sides (figs. 3 and 4). These grooved and notched carvings are often very conspicuous in the surface of the wood of trees and logs for many years after the bark is removed or has fallen away. The number of galleries branching from the central chamber varies from two to five or six, but the normal number is four—two above and two below the entrance. The mode of development of the young stages is the same as in the preceding species. (See Pl. V.)

This is a common enemy of the rock pine (*Pinus ponderosa scopulorum*) throughout the Rocky Mountain region and of *P. ponderosa* west of the mountains. It is ever ready to attack and prevent the recovery of trees of all sizes which are suffering from weakened vitality. It is also attracted to recently felled trees, and breeds in enormous numbers in the bark on the tops and branches. The species was found to be exceedingly common in trees infested by the pine destroyer and on the logs and tops of those felled by the lumbermen.

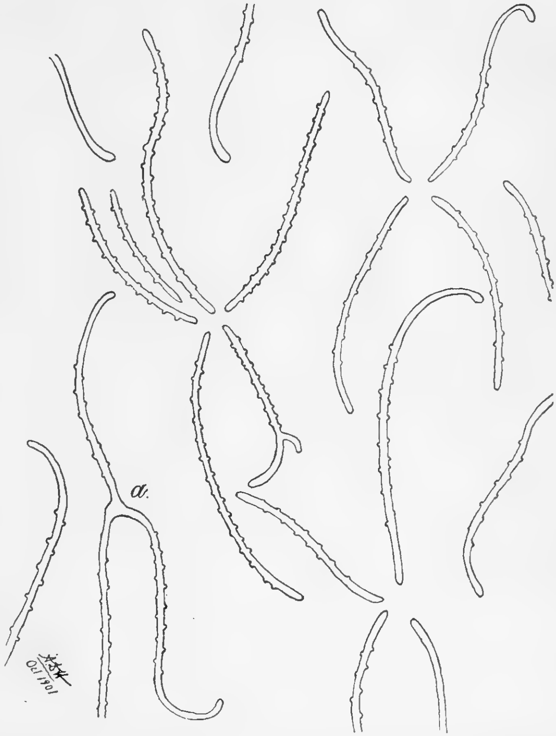


Fig. 3.—Work of the Oregon Tomicus. Primary galleries engraved in surface of wood. Central chamber not extending into wood except at *a*. Reduced about one-half (original).

The coarse-writing bark-beetle (*Tomicus calligraphus* Germ. var. *occidentalis*).—This is much larger than the Oregon Tomicus, but is of the same color and general form. Individuals vary in length from 4.5 mm. to 6.5 mm. This species also follows closely the first attack by the pine destroyer. It enters the bark from near the base to toward the top of the tree, and excavates three or four long longitudinal galleries from a single entrance and broad central chamber (Pl. II). The central chambers and galleries are usually grooved in the surface of the wood, but can be readily distinguished from those made by the Oregon Tomicus. It is a common and widely distributed species over the greater part of the pine-producing areas of the United States from the Atlantic coast to and including the Rocky Mountain region.[a] It attacks all of the Eastern and Southern pines, and doubtless several of the Western pines in addition to the rock pine, in which it was found in large numbers in the Black Hills region.

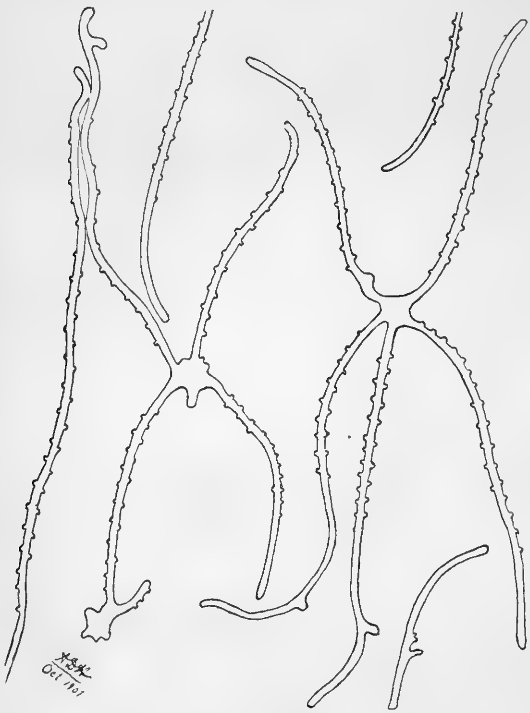


FIG. 4.—Work of the Oregon Tomicus. Primary galleries engraved in surface of wood. Central chamber extending into wood. Reduced about one-half (original).

The wood-engraving Tomicus (*Tomicus cælatus* Eichh.).—This is a much smaller and more slender bark beetle than the two preceding species. Individuals vary in length from 2.6 mm. to 3.2 mm., and in color from dark red to dull black. This is also a common, widely distributed, and variable species. It extends from the Atlantic to the Pacific, and infests all of the Eastern and Southern pines and spruces. A variety (var. *scopulorum* n. var.) was found in the rock pine of the Black Hills, and has been collected by the writer from a number of other species of Western pines. It attacks and breeds in the inner bark on the roots, trunks, and branches of weakened and dying standing trees of all ages and sizes, from the very young to the oldest and largest. It also breeds in immense numbers in the stumps, logs, and tops of recently felled trees.

The dark-red turpentine beetle (*Dendroctonus valens* Lec.)—This is the largest of the known North American bark beetles. The adults vary in length from 6 mm. to 9.5 mm. It attacks the bark on the base of liv-

[a] The Western form seems to be sufficiently different in some minor characters to warrant this distinction in variety name—*occidentalis*.

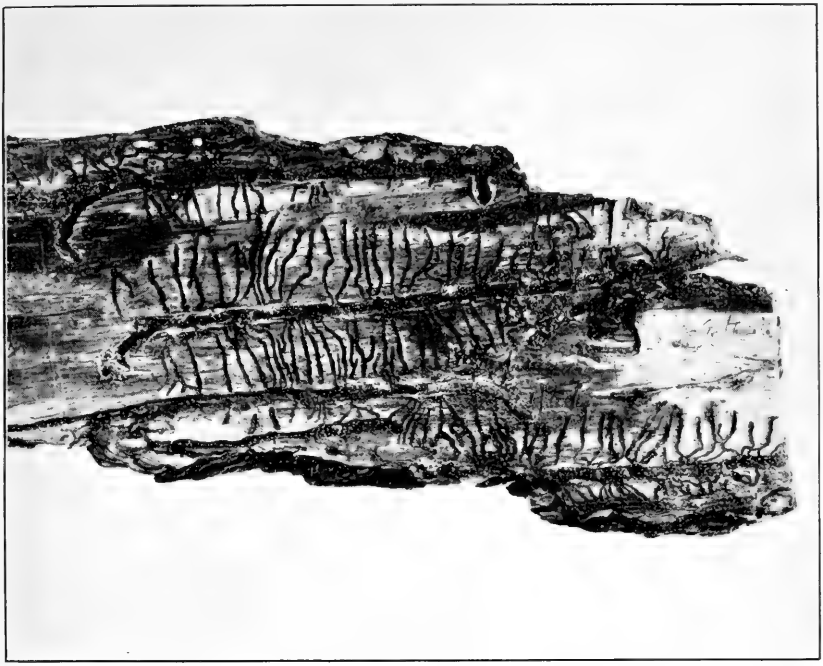


FIG. 1.—PRIMARY GALLERIES AND LARVAL MINES IN INNER BARK. ABOUT ONE-THIRD NATURAL SIZE. (ORIGINAL.)

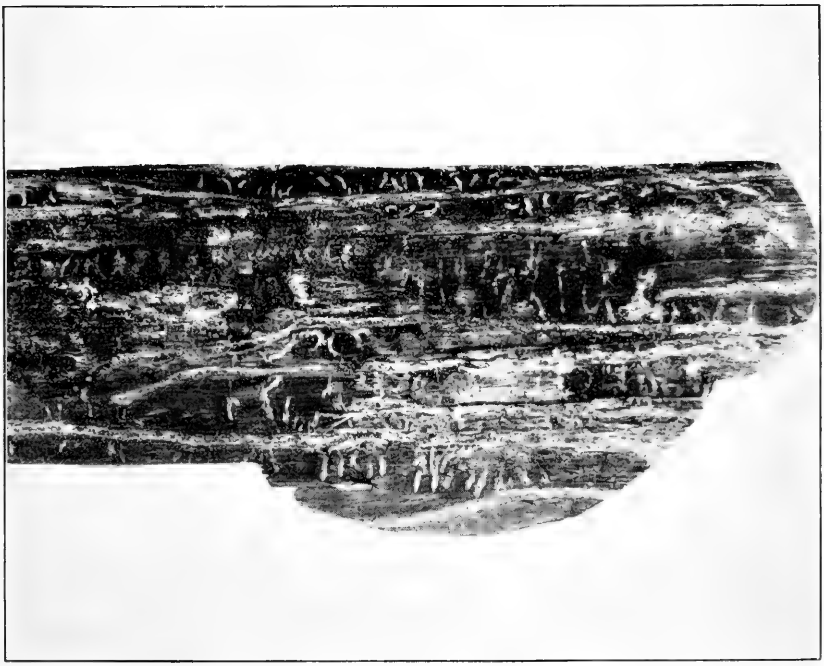


FIG. 2.—MARKS OF PRIMARY GALLERIES ON SURFACE OF SCORING CHIP. ABOUT ONE-THIRD NATURAL SIZE. (ORIGINAL.)

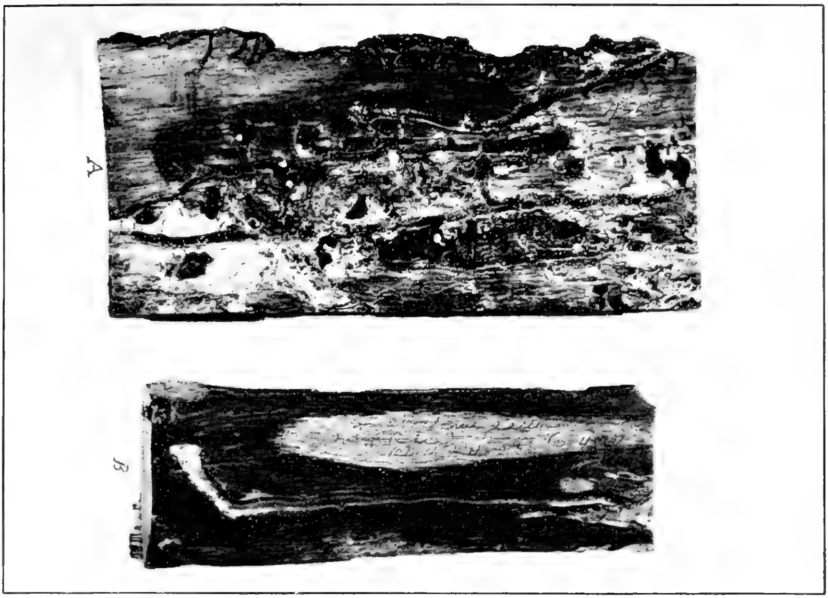


FIG. 1.—A, PRIMARY GALLERIES, LARVAL MINES, PUPA CASES, AND EXIT HOLES; B, PRIMARY GALLERIES GROOVED IN SURFACE OF WOOD IN CHIP CUT FROM RAILROAD TIE. (ORIGINAL.)

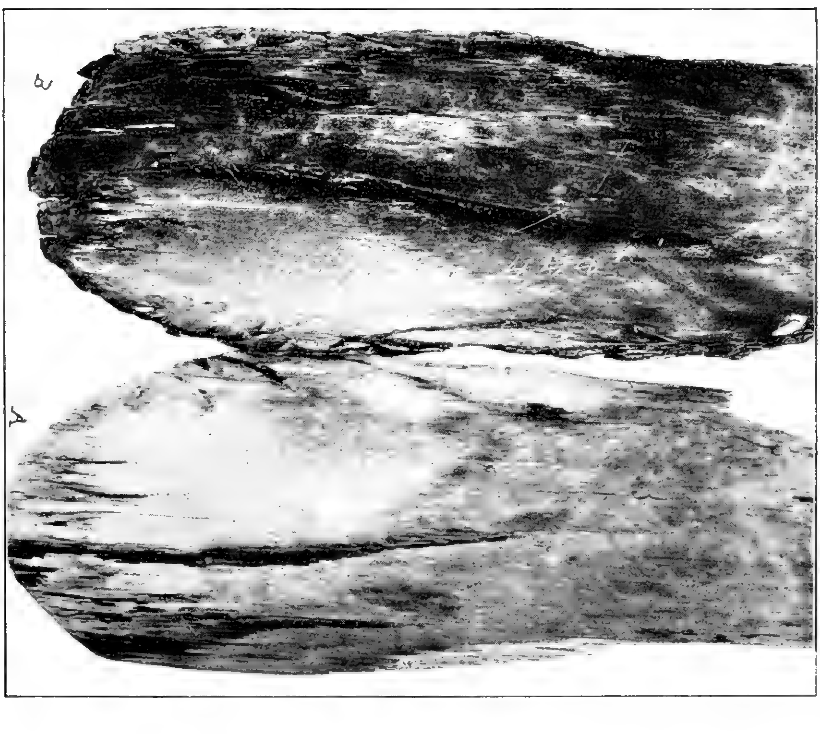


FIG. 2.—EVIDENCE OF CUTTING OF LIVING TREES. A, SCORING CHIP FROM RAILROAD TIE, SHOWING SURFACE OF WOOD NOT MARKED BY INSECTS; B, INNER SURFACE OF BARK FROM SAME CHIP. ABOUT ONE-THIRD NATURAL SIZE. (ORIGINAL.)

ing and dying standing trees and the stumps of felled ones, and excavates a broad, crooked, longitudinal gallery. The eggs are deposited in masses along one side, and when they hatch the larvæ work together and excavate a broad chamber, instead of making individual larval burrows, as is the rule with most other species. One of the striking peculiarities of this insect is the habit of the adult and larva of living in the quantity of semiliquid pitch or turpentine which accumulates in the primary gallery and brood chamber. While this beetle is capable of attacking and developing its broods in the bark of a living, healthy tree, it seldom causes the death of trees unaided by other insects. It does, however, contribute to the death of trees attacked by the pine-destroying and other destructive beetles. It is a common insect in the Rocky Mountain region and west to the Cascades. A variety (*Dendroctonus valens orientalis*) is common in the East, attacking in the same manner all of the Eastern pines.

The Western pine Hylurgops (*Hylurgops subcostulatus* Mann.).—This is a common, dull brown to black bark beetle, ranging in length from 3.5 mm. to 4.5 mm., which attacks and breeds in the bark on the roots and bases of dying trees and the stumps and logs of felled ones. It excavates a single longitudinal gallery, and the broods develop in confused or irregular larval mines in the inner bark, but rarely groove the surface of the wood. This is one of the commonest bark beetles from the Rocky Mountain region to the Pacific coast, and will evidently be found wherever the rock pine or Western yellow pine grows.

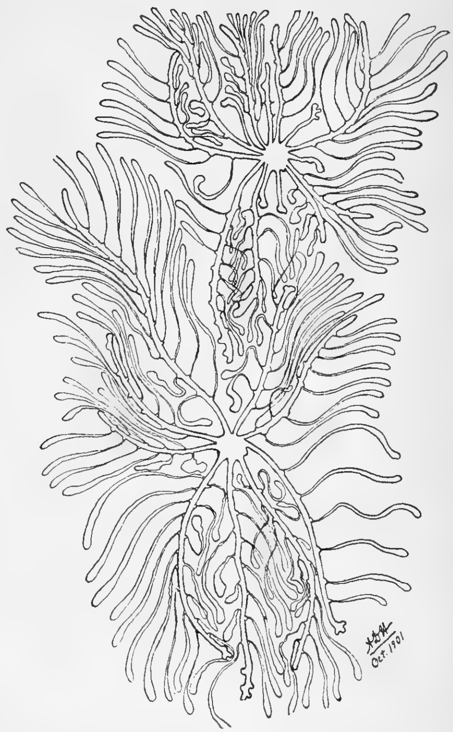


Fig. 5.—Work of the rock pine wood engraver (*Pityogenes carinicеps* Lec.). Primary galleries and larval mines in inner bark and surface of wood. Reduced about one half (original).

The pine-root bark-beetle (*Hylastes porosus* Lec.).—This is a black, elongate, slender bark beetle, varying in length from 4 mm. to 5 mm. It attacks the bark on the roots of the Western pine and excavates a single longitudinal gallery from which the brood burrows radiate, and the broods develop in the usual manner. It was found in the bark on the roots of young seedling pines which had recently died, and also in the bark on the roots of the stump of a recently felled tree in the Black Hills. This is also a common species of the Rocky Mountain pine regions.

Branch and twig beetles.—The large and small branches and terminal twigs of the trees that were dying from the attack of the pine-destroying beetle were found to be infested by a number of described and undescribed species of the genus Pityophthorus and by *Pityogenes cariniceps*, all of which attack the bark as soon as the trees commence to die, and contribute, more or less, to hastening the death of the trees.

Ambrosia or timber beetles and wood-boring grubs.—The wood of the trees was found to be infested by the Western hemlock wood stainer (*Gnathotrichus sulcatus* Lec.), the Western pine wood stainer (*Gnathotrichus occidentalis* Hopk. MS.), and several unidentified Buprestid and Cerambycid larvae, which attack the trees, and when they commence to die bore into the sapwood and contribute to its rapid decay by giving entrance through their burrows to wood-decaying fungi.

SMALL TREES DYING FROM OTHER CAUSES.

The rock-pine pitch worm.—In addition to the trees killed by the pine-destroying beetle, quite a number of young pines 2 and 3 inches in diameter were found in the vicinity of Spearfish and Crow Peak that were seriously injured by the larva of an undetermined Sesiid moth working in the living bark of the main stem and causing ugly wounds. Successive attacks on the same tree weaken its vitality and attract the Oregon Tomicus and species of Pityogenes and Pityophthorus, which infest the main stem and branches, while a number of the root-infesting bark beetles and a pine weevil attack the base and roots, and the tree soon dies. Only a dead and dry larva and a dead chrysalis of this insect were found. The characters exhibited by these specimens do not agree with the descriptions of the larva of the sequoia and pine-destroying Sesiid (*Bembecia sequoia* = *Vespamima sequoiæ* Hy. Edw.[a]) or of the larva and chrysalis of the pine Sesiid (*Harmonia pini* = *Parharmonia pini* Kellicott[b]).

The destructive habits of this class of enemies of trees (which includes the common peach-tree borer) suggest that this may be a common and destructive enemy of "reproduction" pines in the Black Hills and other pine-producing areas of the West.

The pine weevil.—In another section near the Wyoming and South Dakota lines many young trees were observed which were apparently dying from the attack of a pine weevil (*Pissodes* sp.), or the combined attacks of this insect, a root fungus disease, and a number of species of bark beetles.

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[a] Mem. Am. Mus. Nat. Hist., vol. 1, part vi, Mongr. Sesiidæ. Am. North of Mex. 1901, p. 263, with bib. ref.

[b] Ibid., p. 264.

INSECT ENEMIES OF THE FOLIAGE.

Little time was had to collect or study the enemies of the foliage, but from general observations there was no perceptible injury from this class of depredators.

NATURAL ENEMIES OF THE DESTRUCTIVE AND INJURIOUS INSECTS.

Numerous species of predaceous and parasitic insects were found associated with the primary and secondary enemies. Some evidence was found of the beneficial work of birds, and a few examples of the pine-destroying beetle were found that had been killed by a disease, but in no case was there sufficient evidence to indicate that any of these natural enemies, or all combined, were in sufficient numbers to render any special service toward bringing the trouble to an end. They were undoubtedly rendering some service, however, in preventing the rapid multiplication of the pine destroyer, which would otherwise occur.

PREDACEOUS ENEMIES.

The bluish-green predaceous beetle (*Trogosita virescens* Fab.).—This is an elongate, flattened, shining, green beetle, varying in length from 10 mm. to 13 mm., and in width from 3 mm. to 4 mm. The larva is a long, slender, reddish to whitish worm, with shining black head and prothoracic plates. This recognized predatory enemy of bark-infesting insects was frequently found associated with colonies of the pine-destroying beetle and the secondary enemies, and a few adults were found hiding beneath the flakes of outer bark. This widely distributed insect in North America has not been sufficiently studied to determine its true relation to the destructive enemies of the trees, but it is evidently quite beneficial.

Clerid beetles and their larvæ.—The slender, reddish larvæ of undetermined species of this class of predaceous enemies of bark beetles were found in small numbers in the bark with the broods of the destructive and other species of bark beetles. This class of beneficial insects usually renders great service in reducing the numbers of the destructive and injurious species. Therefore their scarcity in this region may have had much to do with the rapid multiplication and spread of the pine-destroying Dendroctonus. While collecting specimens of bark beetles from saw logs in a mill yard at Boulder, Colo., on August 25, one of these Clerids (*Clerus nigriventris* Lec.) was very common. The active, ant-like adults, which are black, marked with transverse patches of gray, vary in length from 6 mm. to 8 mm., and in width from 2.5 mm. to 3 mm. The larva is a slender, pale red worm. The adult feeds on and destroys great numbers of the adult bark beetles before they enter the bark and when they emerge, while the larva destroys the larva and broods in the bark.

A red-bug enemy of bark-beetles.—A small, red to brown Hemipterous bug of the family Acanthiidæ and subfamily Anthocorina was found in all stages of development, associated with colonies of the pine-destroying beetle and its allies, in the bark of recently attacked living and dying trees. These little relatives of the bedbug and the flower bugs are recognized as aggressive enemies of bark beetles, both in the East and West. The one found in the Black Hills is evidently *Pizostethus californicus* Reut. The adult is about 3 mm. long, slender, grayish, and exceedingly active. The young forms are usually bright red, active little creatures which attack and suck out the liquids from the bark beetles and their larvæ. The adult bug also attacks and kills the adult bark beetles. While this is a common and active enemy of the smaller bark beetle, it probably does not render much service toward checking the ravages of the destructive species.

Other predaceous beetles.—There are also a number of predaceous beetles of the families Colydiidæ, Tenebrionidæ, Histeridæ, and Staphylinidæ which were found in greater or less numbers in the bark of infested trees, but their exact relation to the destructive beetle was not determined.

PARASITIC INSECTS.

Several parasites belonging to the order Hymenoptera and families Braconidæ, Chalcididæ, and Proctotrupidæ were found to be enemies of the smaller bark beetle larvæ and adults, but none were found attacking the pine-destroying species. Therefore there does not seem to be much service rendered by this class of insects, which are usually so efficient in reducing the numbers of bark beetles.

PARASITIC FUNGI.

A few examples of the adults and larvæ of the pine-destroying beetle were found which had evidently been killed by a fungus disease, but this was by no means common enough to have rendered any service in checking its ravages.

BIRDS AS ENEMIES OF THE DESTRUCTIVE BEETLE.

A few old dead trees and some which had been recently infested which showed evidence of the beneficial work of woodpeckers were observed in some localities, but hundreds of other insect-killed trees showed no trace of work by the birds. Therefore there appears to be very little service rendered from this source. This is evidently due to a scarcity of the birds and to the fact that the habit of the insect transforming to the adult in the inner bark makes it less accessible to the birds than are the spruce-destroying beetle and other bark beetles which undergo this change in the outer bark.

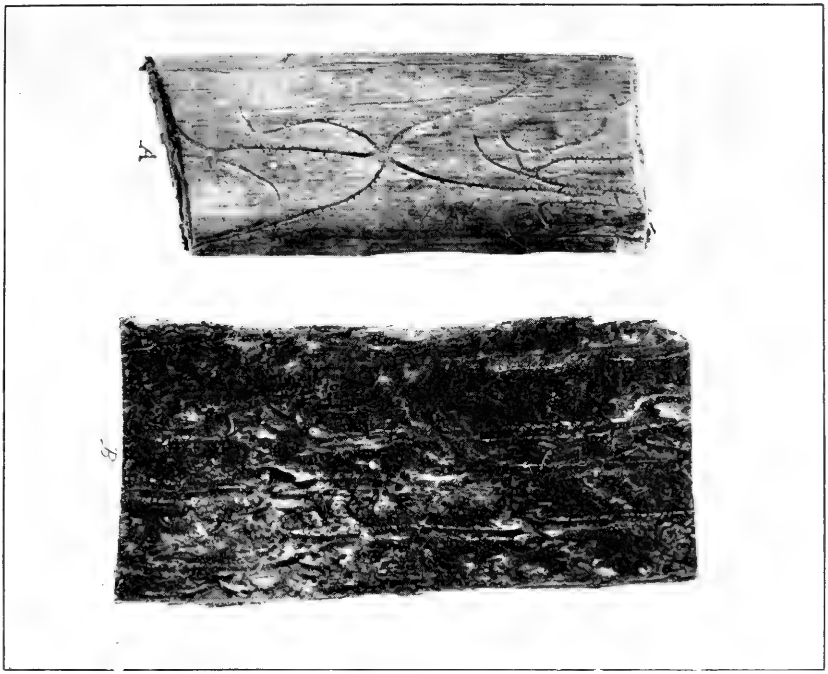

Fig. 1.—A, Galleries engraved in Surface of Wood cut from old dead Tree; B Bark with inner Portion destroyed by Galleries and Larval Mines. About one-third Natural Size. (Original.)

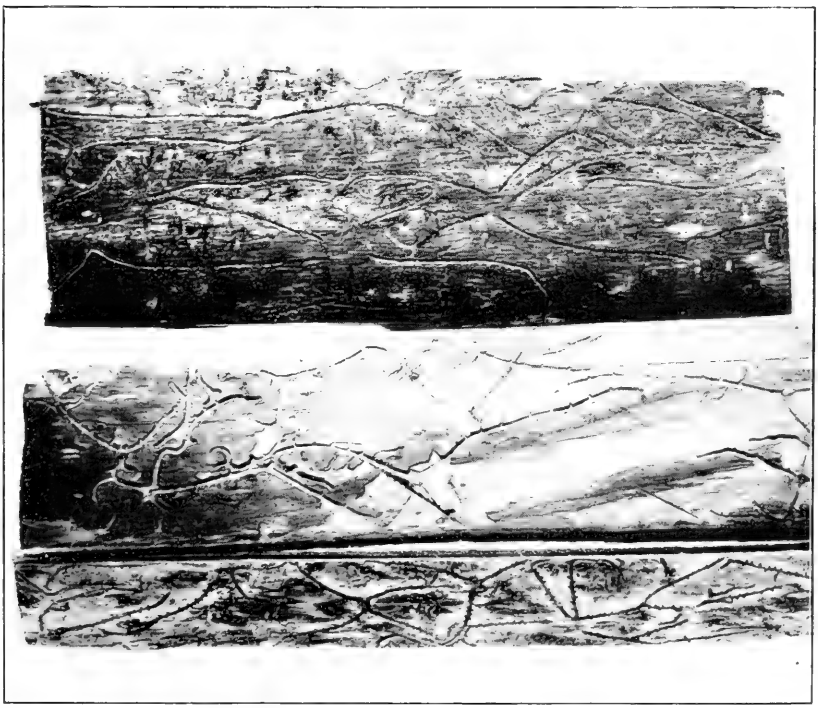

Fig. 2.—Galleries in inner Bark and Surface of Wood of Railroad Ties and edging Strips. About one-third Natural Size. (Original.)

WORK OF THE ROCK PINE-WOOD ENGRAVER (PITYOGENES CARINICEPS LEC.). GALLERIES IN INNER BARK AND SURFACE OF WOOD. ABOUT ONE-THIRD NATURAL SIZE. (ORIGINAL.)

HOW THE TREES ARE ATTACKED AND KILLED.

Many hundreds of trees were examined during the investigation, including those that were living and perfectly healthy, living and freshly attacked, infested and dying, recently dead, and old dead ones which bore evidence of having been killed by the pine-destroying beetle. All stages of the insect, including the adult, the egg, different stages of the larva, the pupa, and recently transformed beetles, were observed and studied, as were also all stages of the primary entrance, the gallery and brood mines in the living, dying, and dead bark, and also the primary gallery grooves on the surface of the wood of old dead trees and logs from which the bark had fallen and decayed.

The evidences gathered from these studies, and from information conveyed in Mr. Dewey's letter, quoted on another page, indicate that the principal attack is made in August, when it would seem the beetles migrate in swarms from the dying trees and settle on the living ones, which they attack and infest in large numbers from near the base to the upper part of the main trunk or stem.

The trees that are attacked by a sufficient number of the beetles to overcome the resistance exerted by the vital forces of the plant commence to decline, and by winter or the following spring they die and the leaves turn yellow and red. Those not attacked by sufficient numbers of the beetles to overcome this vital resistance recover and are usually exempt from future attacks; the wounds heal and are covered over by subsequent layers of wood, thus causing pitch spots or gum-streak defects in the wood.

The details of the work of the attacking force of beetles on a living tree may be briefly described as follows:

Both sexes settle on their victim, usually in large numbers, and the males (?)[a] commence to excavate the entrance burrows, which are usually hidden in a crevice or beneath a flake of the outer bark. The reddish, sawdust-like borings thus produced and thrown out fall to the ground around the base and lodge in the loose outer bark on the trunk. When they enter the inner living bark, or bast, the tree commences to exert its resistance by throwing out pitch to fill and heal the fresh wounds in the living tissue. Then the struggle between the resisting force of the plant and the beetles begins in earnest. Each female joins her mate, and together they continue the excavation. The borings and pitch are disposed of by being pushed out and formed into a pitch tube at the mouth of the entrance burrow (Pl. VII, figs. 1, 3, and 4). The inner bark is entered obliquely and subtransversely to the cambium and surface of the wood, where a broadened cavity is excavated for the accommodation and temporary occupation of the

[a] While it was not positively determined that the male of this species excavates the first entrance, it is the habit of many other bark beetles, and is probably followed by this.

pair, probably until the principal flow of pitch is exhausted. The gallery is then extended (probably by the female) transversely or subtransversely for a short distance (seldom more than an inch), and then longitudinally up or down the tree, but usually up, varying from a few inches to a foot and a half, the normal length being about 1 foot. As soon as the gallery has been extended 1 or 2 inches from the entrance and basal cavity, small notches, or cavities, are excavated in the sides of the gallery, in each of which an egg is deposited, and so on until the gallery is completed. As the eggs are deposited, the borings, instead of being thrown out at the entrance, are closely packed in the entrance burrow, basal cavity, and gallery, except near the farther end, which is kept open, enlarged, or extended to one side or the other, as it is occupied by the parent beetles, after their work of constructing the egg gallery is completed, until they die (Pl. I).

The bark of an infested tree is usually occupied by one of these primary galleries in every 1 to 6 inches of circumference from near the base to near the middle of the trunk (Pl. VII, fig. 2). Therefore they effectually check the normal movements of the sap, and the larval mines, which radiate from the primary gallery, destroy the intervening bark and complete the girdling process.

Ten or twenty, or even forty or fifty pairs of beetles, attacking a tree 6 or 8 inches in diameter, would have little or no effect on its vitality if scattered over the trunk from the base to near the top, but if concentrated on a limited space on the upper part of the trunk, and distributed so that there is a gallery at intervals of about every inch of the circumference, forty or fifty galleries are sufficient to so seriously affect the tree that other insects are attracted to it, and it soon dies from the girdling effect of the primary galleries and brood mines. The marks of as many as seven galleries were observed in a single chip, 6 inches wide and 12½ inches long (Pl. III, fig. 2), cut from a tree that had been killed by the beetles. This, with many other observations relating to the number of pitch tubes on freshly attacked trees and the galleries in the bark of dead and dying ones, indicates that the average tree killed by the beetles has from one hundred to two hundred galleries in 30 to 40 square feet of bark from the middle to base of the main stem or trunk. The number of eggs deposited in each gallery depends on the number of galleries within a given area of bark and the success of the attack. They vary from one or two to about one hundred, but the normal number appears to be about forty to fifty. If only one-half of these develop to adults there are four thousand or five thousand beetles to emerge from a single tree 8 to 10 inches in diameter. Therefore the number of beetles that may emerge from the thousands of trees that die in a single year would make a swarm of millions of individuals. Even if this number were reduced one-half, it will be readily seen how the trouble may be rapidly extended over vast areas of forests.

CHARACTERISTIC FEATURES OF THE LIVING, DYING, AND DEAD TREES INFESTED AND KILLED BY THE BEETLE.

The characteristic features which are of importance to the forester and lumberman in identifying the presence and the work of the pine-destroying beetle are as follows:

BORINGS AND PITCH TUBES.

The first indication of attack is the red dust or borings lodged in the loose bark and fallen around the base of the tree. The next and more conspicuous evidence is the presence of numerous small masses of pitch or so-called pitch tubes on the outer bark at the mouth of the entrance burrows. (Pl. VII., figs. 1, 3, 4.) If the pitch is fresh and mixed with reddish and white borings, it indicates a recent attack and the presence of the living beetles in the bark. If, however, the pitch is dry and hardened, without traces of fresh borings or the presence of living beetles, and the tree is living, it indicates an abandoned attack and that the tree will recover.

APPEARANCE OF THE LEAVES.

The leaves of trees dying from attack by the beetle present first a pale-yellow appearance in the tops and tips of the branches, followed by a general yellowing of all the leaves, thus presenting from a long distance a marked contrast to the dark, healthy green of the surrounding living foliage. If the bark is stripped off and examined when the trees are in this condition, all stages from eggs to fully-developed broods will usually be found, together with numerous other secondary enemies of the trees and enemies of the insects. The leaves do not fall from the twigs for possibly two or three years after the trees die and the broods of beetles emerge, but they soon change from yellow to red, and thus become even more conspicuous. The normal length of time the leaves remain on the twigs has not been determined, but the greater number evidently fall during the second or third year, leaving the twigs almost bare, with the exception of a few leaves on the tips which may adhere for a much longer time.

APPEARANCE OF THE TREES THAT HAVE BEEN DEAD THREE YEARS OR MORE.

Little opportunity was had to obtain information on the characteristic appearance at different stages of deterioration, but it would appear from such observations and general comparisons as could be made that the twigs and some of the branches commence to fall within three or four years, and that after the fourth year rapid decay sets in, and the tops commence to break off.

EVIDENCE OF THE WORK OF THE BEETLE ON OLD DEAD TREES.

After the trees have been dead many years most of them decay at the base and fall, while the main trunks or snags of others remain standing; yet as long as the surface of the wood remains sound the characteristic longitudinal gallery grooves will be more or less distinct, and serve to indicate that the trees were attacked while living. Pieces of the old bark will also usually show traces of the galleries and indicate by the pitch-preserved tissue that the galleries were excavated in living bark. Traces of the pitch tubes may also remain on the outer bark for many years and serve to indicate the cause of the trouble.

RELATION OF WOOD-BORING INSECTS AND WOOD-DESTROYING FUNGI TO THE RAPID DETERIORATION OF THE WOOD.

As previously indicated, there are a number of wood-boring insects which bore into the sapwood of dying and dead trees. Some also penetrate the heartwood. Some of these wood-infesting insects enter the wood as soon as the tree commences to die, others after it is dead, and still others at different stages of the decline and decay as long as there is anything left for them to work in. It is only those, however, that enter the wood while it is yet of value for commercial purposes that need to be specially mentioned in this connection. Next to the one that makes the primary attack, those borers which enter the sound wood are probably of the greatest importance. They not only cause pin-hole and wormhole defects, which depreciate the value of the lumber and other products into which the wood of the dying and dead trees may be converted, but they give entrance to wood-decaying fungi, causing rapid decay of the wood of the standing trees which would otherwise remain sound for a much longer period.

While the injuries by these wood-boring insects are by no means as common where there are a great many dead and dying trees as where there are only a few, it was found to be sufficient in some sections to cause, in connection with the wood-decaying fungi, a worthless condition of the timber over large areas. Indeed, it would seem from such observations as we were able to make that unless the trees are cut and converted into lumber, ties, cordwood, or other commercial products within two or three years after they commence to die, very little of value is left.

SUGGESTIONS FOR PREVENTING LOSSES.

The limited time devoted to the study of this new insect was not sufficient to determine the details in its life history and habits which are usually so necessary in the consideration of remedies, but some general features were noted, which, in connection with the information acquired from special investigations of the closely related destructive

Fig. 1.—Small freshly attacked Pine Tree, showing Pitch Tubes.

Fig. 2.—Marks of primary Galleries on the Surface of Wood when Bark is removed.

Fig. 3.—Freshly attacked Tree, showing Pitch Tubes. Adjoining Tree not attacked.

Fig. 4.—Dead Tree; outer Bark removed by Woodpeckers.

SCENES IN THE PINE FORESTS OF THE BLACK HILLS FOREST RESERVE.

pine-bark beetle[a] of the middle Appalachian region and the spruce-destroying beetle[b] of the Northeast, will warrant, it is believed, some suggestions for the prevention of losses.

METHODS OF COMBATING THE ENEMY AND PREVENTING LOSSES FROM ITS RAVAGES.

When a trouble has been going on six or seven years and has reached the magnitude of the one under consideration, it is very plain that unless some natural agencies appear to either modify or check it, its control is beyond all human effort. On the other hand, if there are beneficial influences at work which are reducing the numbers of the insect and checking its destructive ravages, there is much that can be done toward aiding nature in the suppression and subjugation of an unruly species. The evidences found indicate that the latter is true in regard to this trouble. While many freshly attacked living trees and thickly infested dying ones were observed in different sections of the reserve, showing that great numbers of the beetles are at work and continuing the trouble, it was plain that the force of the attack has from some cause been materially weakened.

TO REDUCE THE NUMBERS.

It appears that the pine-destroying beetle of the Black Hills, like its Eastern relatives, depends on the trees killed by it for the augmentation of its numbers and the perpetuation of its power of killing more trees. Therefore it is only necessary that the attacking force be further reduced to a point where it can no longer overcome the vital resistance of the trees on which it concentrates its attack, in order to successfully defeat it and secure its extermination.

The fact that the attacking force of the enemy is already weakened from natural agencies suggests that they can be reduced by artificial means below their power of killing more trees next season, and thus bring the trouble to an end. Therefore the following are suggested and recommended as probably the best methods of accomplishing this result:

(1) Determine the location and extent of areas in which trees were attacked during the summer and fall of 1901 and the number of trees now infested with living broods of the pine-destroying beetle.

(2) Select those areas in which there are the largest number of infested trees and mark the same for cutting.

(3) Secure, by sale contracts or otherwise, the cutting of these trees and the removal of the bark from the infested parts of the main trunks and stumps prior to the 1st of May, 1902. The drying of the removed

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[a] *Dendroctonus frontalis* (Zimm.) var. *destructor* Hopk., Bul. 56, W. Va. Agric. Exp. Station, 1899.

[b] *Dendroctonus piceaperda* Hopk., Bul. 28 n. s., Div. Ent., U. S. Dept. Agric., 1901.

infested bark and surface of the wood will effectually destroy the insects. In addition, the logs so treated will be protected next spring and summer from the attack of wood-boring insects, and thus be almost or quite as valuable for all commercial purposes as if cut from living trees.

It is not necessary that all infested trees in the reserve or those of all other infested areas should be thus cut and barked, but it is important that a large per cent should be so treated in order to insure a sufficient reduction of the beetles to check their destructive ravages.

SUGGESTIONS FOR PREVENTING FURTHER TROUBLE.

It is believed that the prevention of further trouble may be effected by means of girdled and otherwise treated trap trees, but the best method of treating the trees and the proper time or periods to do the work remain to be determined.

No experiments of this kind have been conducted with the rock pine, and it is not positively known when the beetles commence to fly or what is the period of their greatest abundance or swarms. Therefore it is suggested that a special line of experiments be conducted, between the 1st of May and the 1st of September, to determine the best methods of providing trap trees and the best time to do the work to secure the desired end, viz, that of attracting the migrating beetles to certain trees or sections of the forest, where they can be subsequently destroyed by cutting the trees and removing the bark.

TO PREVENT LOSSES FROM WOOD-BORING INSECTS AND WOOD-DESTROYING FUNGI.

The evidence found relating to the work of wood-boring insects and wood-destroying fungi, which cooperate in effecting a rapid deterioration of the trees killed by beetles, suggests that all trees should be cut within three or four years after they commence to die, the sooner the better, and be worked up into lumber, ties, mine timbers, and cord wood, in order to prevent the great loss of valuable products which would otherwise follow. Such material, if in excess of the demand for immediate consumption, might be stored where it would keep dry and be protected from fire. It would thus remain sound for many years and serve to supply the demand for material which would otherwise have to be drawn from the living timber.

THE PROTECTION OF LIVING TIMBER.

Since it is of the greatest importance that the living timber in the reserve should be protected and preserved for the heavy demands upon its resources which, owing to the vast mining, commercial, and other interests, it will be required to meet, the prevention of unnecessary cutting on account of injuries, or alleged injuries, from insects should receive special attention.

EVIDENCES OF UNNECESSARY CUTTING OF LIVING TIMBER.

One of the special objects of the investigation was to determine whether or not unnecessary cutting of living timber had been done by certain contractors who had purchased, at a reduced price, the specified "bug-infested" and "bug-killed" timber. Therefore, upon the request of Mr. Pinchot, the writer made a careful study of the conditions found in an extensive cutting in a "draw" east of Dead Ox Canyon of Big Spearfish Creek.

Much conclusive evidence was found that a large per cent of the trees cut here and worked into railroad ties had been living and uninjured by insects when felled. The evidence may be briefly stated as follows:

All trees that are attacked and injured by the pine-destroying beetle, whether in small or large numbers, plainly show the characteristic work of the beetles in the bark and on the surface of the wood, as previously described (p. 17) and illustrated (Pl. III, fig. 2; Pls. IV, VII). The character of the work will also indicate whether or not a given tree was living, dying, or dead when felled and the bark removed. The operation of scoring, hewing, and barking the ties in this particular cutting had evidently followed closely the felling of the trees. Therefore the inner portion of the bark and outer or adjoining portion of the wood of the scoring chips and the barked surface of the ties from "bug-infested" and "bug-killed" trees bore abundant evidence of the work of the insect and the condition of the tree when felled, while those from healthy living trees, not injured or infested by bark-boring insects, showed no traces whatever of the work of the beetle or of any other "bug" or insect.

The records of ties, counted as observed in the woods and examined for the work of insects, show that out of 207 ties only 55 bore evidence of having been cut from "bug-infested" and "bug-killed" trees, while the other 152 bore no evidence of insect work on the barked surface, but showed from the condition of this surface that they had been cut from healthy, living trees; also that some of the trees had been cut in the winter when the sap was down and that others had been cut in the spring when the sap was up and the bark would peel. Therefore it would appear that a large amount of living timber had been cut which it was plainly evident the Government desired should remain standing.

SUGGESTIONS CONCERNING TIMBER-CUTTING CONTRACTS.

In order to provide or guard against the cutting of living, uninfested trees, along with the seriously injured and dying ones, it might be suggested that it be plainly stated in contracts and instructions that no living tree shall be cut which does not show, in the inner bark next to the wood, the presence of large numbers of living insects, of the species known as the pine-destroying beetle, or any other insect or insects which may hereafter be designated as destructive enemies of the trees.

NEED OF FURTHER INVESTIGATION.

While considerable evidence was found during the time devoted to the investigation, there yet remains much to be determined by detailed study and experiments relating to the peculiar conditions which bring about the invasion of a rare or new insect and the conditions which contribute to its rapid multiplication and destructive work, as well as those which contribute to its decline and sudden disappearance. There are also many facts, yet to be determined, relating to the life history and peculiar habits of the pine-destroying beetle and other numerous enemies of the trees, and the natural enemies of such insects. The determination of these facts is very necessary in order to suggest the best methods of preventing losses in the future. It will also help us to utilize nature's methods of protecting such of the species as are of use to man and destroying those that are objectionable.

Cutting and barking the infested trees this winter would be an experiment of great importance, not only in its prospects of ending the trouble, but in demonstrating whether or not it is a practicable method to be adopted under similar conditions in the future. It will also be of interest, and probably of considerable economic importance, to note the effect that this process of insect destruction will have on the other injurious and beneficial insects involved.

The experiments of girdling, cutting, and treating trees with a view of rendering them attractive to the migrating beetles, and thus providing traps for them, is a line of work which should receive special attention next summer. It would serve to demonstrate, or at least indicate, several things which it is quite necessary to know in order to adopt successful methods of preventing future trouble from insect ravages on the pines of this reserve. It would demonstrate whether or not the beetles that emerge from the infested trees which have not been cut and barked could be attracted to trap trees; how and when the rock pine can be girdled or treated to exert the greatest attraction to the principal enemies, and how the insects thus trapped can be best destroyed. It would also contribute greatly to the study of the life history and habits of the primary and secondary enemies of the trees and the enemies of the insects.

There are other features relating to the kinds of insects and fungi that attack trees girdled by different methods, or girdled and felled at different times of the year, which should be determined. Indeed, there are many and varied subjects relating to the insects of the rock pine which should be studied during the progress of the present trouble, in order to accumulate data that will be of service in preventing and checking future destructive invasions in the pine forests of the Rocky Mountain region.

O

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY—BULLETIN No. 33, NEW SERIES.

L. O. HOWARD, Chief of Division.

SOME INSECTS INJURIOUS TO VEGETABLE CROPS.

A SERIES OF ARTICLES DEALING WITH INSECTS OF THIS CLASS.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST,

BY

F. H. CHITTENDEN,

ASSISTANT ENTOMOLOGIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

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Artist: Miss L. Sullivan.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., April 15, 1902.

Sir: I have the honor to transmit herewith a manuscript containing a large number of accounts of insects injurious to vegetable crops, which have been drawn up, as a result of his investigations, by Mr. F. H. Chittenden, Assistant Entomologist. Mr. Chittenden has been devoting himself assiduously to this work for some years, and has learned a great deal that is valuable to truck farmers and to economic entomologists. I recommend that this manuscript be published as Bulletin No. 33, new series, of this Division.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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PREFACE.

The present publication comprises a series of articles and notes brought together in bulletin form in continuation of work begun several years ago, the earlier results of which were published in Bulletin 10 of the present series, in the Yearbooks of this Department for 1896 and 1898, and in several circulars of this office. Bulletin 23 of this series was devoted exclusively to the subject of insects injurious to garden crops and Bulletin 19 mainly to the same subject. This contribution is therefore the third bulletin of the series, and is entitled "Some Insects Injurious to Vegetable Crops."

The various species of noxious insects discussed have, with few exceptions, been destructive during the years 1900 and 1901, but a few came under observation at an earlier date. The work is therefore, to a certain extent, a report on the principal insects which have been injurious and whose ravages have been brought to the attention of this office as affecting the vegetable crops of the country during the past two years. Circumstances beyond the writer's control have prevented the publication of this matter until the present time.

The initial article treats of the potato stalk weevil, which has been very injurious for a number of years but has never received extensive notice in any of the publications of this Department; hence, all available facts concerning it, together with an original illustration, have been brought together. The Northern leaf-footed plant-bug attracted more attention during the last two years than ever before in its history, and its abundance in the vicinity of the District of Columbia enabled a study of its habits and the practical completion of a knowledge of its life history, the results of which are here given.

We have to record the appearance of a new insect enemy of carrot, celery, and some other umbelliferous crops in this country. The insect in question, the carrot rust fly, has been present in Canada since 1885, but was not known as the cause of injury to any crop plants in the United States until the past year, when it occasioned the ruin of 6,000 plants of celery on one farm in New York State. The probabilities are that this species will continue to spread and that it may become an important pest; in fact, the most serious drawback to the cultivation of carrot, parsnip, celery, and other umbelliferous crops. Another insect now holds this distinction. It may be known as the carrot beetle, as it is to carrot that it does most injury, although parsnip, potato, and other root crops and some other cultivated plants are subject to its depredations. This latter has been quite prominent in recent years, and is therefore deserving of attention.

Although the beet army worm has been destructive since 1899, there are some facts that have been learned in regard to it and its distribution and origin that have not been recorded. Since sugar-beet growing is just now engrossing the attention of legislators and farmers in many sections of the country, it seems appropriate that as complete an article as possible in regard to this, one of the most important enemies of beets, be published. Three species of webworms, one of them more particularly destructive to the sugar beet, the second an introduced and important enemy of cruciferous crops in the South, and the garden webworm, a species of omnivorous habits, have also been the occasion of considerable correspondence.

Several species of insects injurious to cruciferous crops have been under observation. Hitherto no account of the red turnip beetle has appeared in Departmental publications; hence, an account based on injuries in the Northwest is presented. The insect is more particularly destructive in the Dominion of Canada, but also inhabits the United States, and it seems probable that injuries will increase with time. This species is related to the Colorado potato beetle, and at any time an outbreak may be apprehended. The cabbage looper, a common pest throughout the South, and frequently making its appearance as far northward as Long Island in destructive numbers, has, after an almost complete disappearance, returned to the more northern points which it had previously invaded. It is considered in connection with two related species, one of which is new as an enemy of cabbage, and the other known as the celery looper. The cross-striped cabbage worm, or so-called "cabbage Pionea," has a similar distribution to the common cabbage looper, and an account of it is also given. Some shorter notes are presented in regard to some cabbage insects whose habits have not been thoroughly studied, as well as some observations on insects affecting late cabbage and similar crops, the latter article forming the basis for an appeal for clean farming.

A number of insects injurious to beans and other leguminous crops have been prominent during recent years, and four of these, the seed-corn maggot, the bean leaf-roller, the pea moth, and the bean cutworm, are the subjects of articles. The remaining species are treated in an article comprising many subjects. It should be mentioned at this point that the destructive green pea louse continued its ravages during 1900, extending its depredations in the West particularly; but as this species has been given much attention by entomologists in Delaware and Maryland, the writer's notes are withheld. What there was that seemed desirable for early publication was brought out in the form of a circular. It should be added, however, that injury during 1901 was very light, although some damage was done over small areas.

The season of 1900 was rather remarkable for irruptions of different forms of flea-beetles in various portions of our country, several species doing very considerable damage, in some cases unprecedented.

Assistance has been rendered in the preparation of this bulletin by the writer's associates, which is duly credited in its proper place: but it should be especially mentioned that Mr. F. C. Pratt assisted in the collation of the literature of many of the species treated. Credit is also due to Mr. Th. Pergande for some of the notes, and particularly the rearings made in earlier years, nearly all of those of a later date having been conducted by the writer. Twenty-six of the figures which illustrate this bulletin have been drawn by Miss Lillie Sullivan, under the writer's personal supervision, from selected and fresh material wherever this was obtainable.

F. H. Chittenden.

SOME INSECTS INJURIOUS TO VEGETABLE CROPS.

THE POTATO STALK WEEVIL.

(*Trichobaris trinotata* Say.)

One of the important insect enemies of the potato, and a common species almost everywhere east of the Rocky Mountains and south of New England, is a little gray weevil, whose larva works normally in the stems of wild Solanaceæ, such as horse nettle, ground cherry, and jimson weed, in most fields where these plants are allowed to grow.

The habits of this insect and its manner of attacking potato have been known for half a century, the first instance of injury having been noticed in 1849 near Philadelphia, Pa. Since that time the injuries inflicted by it to potato have attracted considerable attention, periodically and locally, especially during the last decade, and there is reason to believe that it is often present and doing damage, though undetected, in potato fields, where the insect itself has never been seen. Its habit of living within the stem in its larval condition, and the small size of the beetles, together with their habit of dropping from the plants when disturbed, is accountable for injury by the species so often escaping notice. Hence it happens that, although a pest of long standing, the insect is unknown to many potato growers.

During 1900 this species was reported to have done injury near Philadelphia, Pa., and South Holland, Ill., and to have been quite prevalent in Maryland on potato; but injury was without doubt much more extensive than reported. In 1901 the potato crop of Sheridan County, Nebr., was nearly ruined by this insect, and it made its initial appearance in Canada, doing much damage on Pelee Island.

In earlier years more or less damage to the potato crop was committed in other portions of Nebraska, Illinois, Pennsylvania, and Maryland, as well as in Kansas.

DESCRIPTION.

The beetle.—The adult potato stalk weevil is a small ash-gray weevil, or snout-beetle, of the family Curculionidæ. Its real color is black throughout, but its surface is covered with minute gray scales, which give it a nearly uniform gray appearance. The head, however, appears black, and there are three black impressed spots at the base of the elytra or wing covers—one scutellar and two lateral—from which the insect has derived its Latin name, *trinotata*. The rostrum or snout is robust and rather strongly curved, and the antennæ, like those of other Curculionids, are elbowed and clubbed at the ends. The body is oval and somewhat depressed or flattened above. The male is credited with being generally larger than the female—something rather unusual in insects. The length is about one-sixth of an inch (3 to 4.5^{mm}) and the width less than half that (1.2 to 1.75^{mm}). The beetle is shown in the accompanying illustration (fig. 1, *a*).

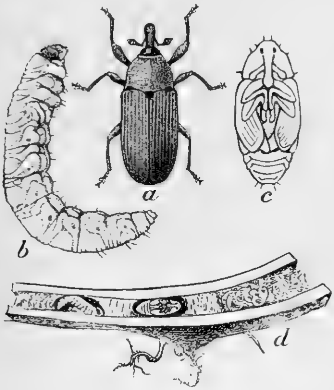

FIG. 1.—*Trichobaris trinotata: a*, beetle; *b*, larva from side; *c*, pupa; *d*, section of potato stalk opened to show larva and pupa *in situ*—*a*, *b*, *c*, five times natural size, *d*, natural size (original.)

The egg is of the usual white color and oval form seen among the Rhynchophora, and, according to the measurements of Faville and Parrott, is about 0.6^{mm} in length and 0.4^{mm} in width.

The larva, or grub, as it appears when first hatched from the egg, does not appear to have been described. It is, however, whitish at this stage, and without feet. When full grown it is remarkably elongate in form, about eight or nine times as long as wide, with small circular pale-brown head, the whole having the appearance shown at *b* (fig. 1). It reaches a length of about two-fifths of an inch (9 to 11^{mm}), and is only moderately curved when in natural position in the stems. Instead of legs these larvæ are provided with feebly defined thoracic leg pads. The color at this, as in the pupal condition, varies from nearly white to rather bright yellow, the color in one instance, in an individual taken from the root stem of *Solanum carolinensis*, being of a decidedly rosy or light pinkish hue.

The pupa looks like that of other weevils, and presents no very noticeable features for description. A ventral view of a pupa is shown at *c* (fig. 1). At *d* a larva and pupa are figured natural size within an opened stalk of potato.

DISTRIBUTION.

The potato stalk weevil is rather generally distributed throughout the Carolinian and Austroriparian regions. Northward the limit of injurious occurrence was reached in Pennsylvania and New Jersey in the East, and in Illinois and Iowa in the West; recently, however, the species has become a pest in Canada. Southward the insect is found to Florida and westward to Texas. A list of localities follows:

Titusville, Little Silver, Freehold, Hopewell, New Brunswick, and Trenton, N. J.; Yorkana, Germantown, Westchester, Pawling, Philadelphia, Allegheny, and Pittsville, Pa.; Newark, Del.; Belair, River View, Cabin John, Marshall Hall, Greenwood, and Baltimore, and Howard, Washington, and Montgomery counties, Md. (Johnson); Rosslyn and Deep Creek, Va.; District of Columbia; North Carolina; South Carolina; Kentucky; Wayne, Cobden, Anna, Carbondale, and Normal, Ill.; Kansas City, Kirkwood, and Cadet, Mo.; Fort Scott, Onega, Wilder, Topeka, Fairmount, Edwardsville, Manhattan, Lawrence, and Connor, Kans., well distributed over the eastern part of the State; Ames, Adel, Davenport and Marcus, and Polk and Boone counties, Iowa; Omaha, Albany, and elsewhere in Nebraska; Cincinnati, Aberdeen, and Gallipolis, Ohio; Detriot, Mich.; Key West and Jacksonville, Fla.; St. Anthony Park, Minn. (Lugger); and Pelee Island, Canada.

NOTE.—In the southwest this species is replaced by a few others of the same genus and of very similar appearance and habits, but not injurious to the same extent. One of these, *T. mucorea* Lec., is common in Arizona and southern California; and *T. texana* Lec. is a well-known form in Texas, New Mexico, and Colorado.

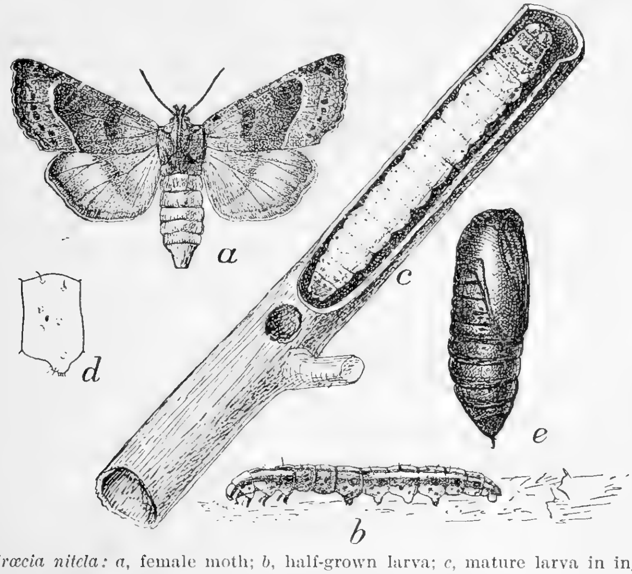

FIG. 2.—*Hydrœcia nitela*: *a*, female moth; *b*, half-grown larva; *c*, mature larva in injured stalk; *d*, lateral view of abdominal segment of same; *e*, pupa—all somewhat enlarged (original).

T. compacta Casey, according to Cockerell, breeds in *Datura meteloides*, and is common in the Mesilla Valley of New Mexico. It has not been reported to damage potato, perhaps because this vegetable is not much grown in that State. Without doubt all the species of Trichobaris feed on Solanaceæ.

The potato stalk weevil is also known as potato stalk borer, and several other species of insects, the larvæ of moths resembling those which produce cutworms, are sometimes known by the same name. The most common species (in literature) is *Hydrœcia* (*Gortyna*) *nitela*, known as the stalk borer, heart worm, etc. An equally common species in some localities which has practically the same habits is known as *Hydrœcia nebris* Guen.

Even as late as 1897 *Hydrœcia nitela* was referred to as the potato stalk borer, and as doing injury to potatoes in western Maine, damage being due to the larva's boring into the pith of potato stalks, causing them to wilt. It will thus be seen that although the stalk weevil and the stalk borers are entirely different, belonging to different groups, they do injury in a similar manner, and are therefore apt to be confused by those not thoroughly conversant with them. We present a figure of the species of stalk borer under consideration which will serve as a fair sample of this group. The moth (fig. 2, *a*) is medium brown in color, and marked as shown. The young larva is quite peculiar in having the first three or four abdominal segments suffused in such a manner as to give the insect the appearance of being diseased (see *b*). The larva when mature has more or less the appearance shown at *c*, which, however, will answer almost equally well for other species of the genus. Careful comparative study is necessary in order to establish the differences between these species in their larval stages. An abdominal segment of *Hydrœcia nitela* in the larval stage is shown at *d* (fig. 2), while at *e* is shown the female pupa or chrysalis. This insect was reported during 1901, by Mr. F. M. Webster, as having done much injury to wheat and carnations in portions of Ohio. It is to be regretted that several other species are undoubtedly confused with this insect because of their great similarity in the larval stages. The writer, as well as Mr. Pergande, of this office, has reared the moth from the stalks of common pigweed (*Ambrosia trifida*), and there is no doubt of Harris's record of injury by this species to corn. It is credited with having done injury to the stalks of tomato, spinach, cauliflower, eggplant, pepper, dahlia, aster, lily, spiræa, salvia, thistle, milkweed, pigweed, ragweed, smartweed, cocklebur, and castor bean; and to the twigs of blackberry, currant, apple, and peach, as well as to wheat and corn.

RECENT INJURY.

During 1897 Messrs. Kirkpatrick & Son, Connor, Wyandotte County, Kans., sent specimens of the larvæ of this weevil in potato stems, writing July 2 that about one-fourth of the vines at that place were affected, and other fields looked to be over half destroyed. Larvæ were found in vines that looked to be perfectly healthy. To find the insects it was necessary to pull the vine and split it open. September 8 of the same year specimens of this species were received from Mr. George W. Pickering, Wayne, Du Page County, Ill., with the statement that they had been found inside the stalks of potato.

In 1898 Mr. Pickering again sent specimens, July 5 and 30, of larvæ in the stalks. Some presented foliage partly dead, while others which were also inhabited by this insect showed no evidence of infestation. Some hills of potato yielded but few tubers, while others contained a normal yield. It was noted that the infested stalks generally pull easily and break off just below the surface. They appeared rather rusty as a rule, and some had what appeared to be a fungus-like excrescence at the bottom of the stalk.

During 1900 Mr. Samuel Carter, Philadelphia, Pa., sent larvæ within the stalks of potato, with accompanying information, under date of August 15, that this species infested the whole potato crop of that vicinity. He expressed the opinion that the crop was an entire failure, the yield being just about one-eighth of what it should have been.

During 1901 a single report of injury by this potato stalk weevil reached this office. This was made in December by Mr. James Egan, Albany, Nebr., who stated that the potato crop in Sheridan County had been nearly ruined by this insect. Mr. G. W. Pickering, who reported injuries in Illinois in 1897 and 1898, stated that since that time the insect had done no damage, although he had looked for injury in his vicinity. A gentleman of his acquaintance, who had raised potatoes in one of the potato districts of Pennsylvania, said that this species, as a rule, had little effect on the general crop there. Mr. H. M. Kirkpatrick, who reported injury in 1897, stated that no further damage had been noticed in Wyandotte County, Kans.

From Mr. Edwin Taylor, Edwardsville, Kans., was received information that this species had been present in that vicinity for a good many years, but that it had never injured the potato crop seriously. Writing December 23, 1901, he stated that this insect was less observed that year than usual.

From the above and other sources of information it would seem that this species is unusually periodical, and injuries are generally to be attributed to the growth of potatoes on or in the vicinity of land that has been permitted to run to Solanaceous weeds, nearly all of which furnish food for the potato stalk weevil. A list of these will be furnished later on in the present article.

EARLIER DIVISIONAL RECORDS.

August 1, 1884, vines containing this larva were received from Mr. Richard B. Taylor, Westchester, Pa., with the statement that this borer had destroyed two-thirds of his potato crop (Ann. Rept. Com. Agr. for 1884, p. 411). September 6, 1892, Miss Mary E. Murtfeldt reported the rearing of this curculio from *Solanum carolinense* at Kirkwood, Mo. (Insect Life, Vol. V, p. 135). July 20, 1893, larvæ of this species were received from Mr. H. Still, Deep Creek, Va., found boring in the stems of eggplant, with the statement that the plants were dying by the hundreds daily. August 5, 1895, Mr. W. T. L. Taliaferro, Belair, Md., sent larvæ in stalks of potato. August 26, 1896, we received larvæ and sections of potato stalks killed by this species from Mr. G. C. Brown, Yorkana, Pa., who stated that the insect was new to that locality so far as injuries were concerned. A few other records of injury have been published in the columns of Insect Life and in bulletins of the Division of Entomology.

LITERATURE AND HISTORY OF THE SPECIES.

The potato stalk weevil was first described as *Baridius trinotatus*, in 1831, by Thomas Say (Descr. N. Am. Curculionides, etc., p. 18).

In the year 1849 this insect attracted some attention by its ravages in the vicinity of Germantown, Pa., and Camden, N. J., as related by Miss M. H. Morris, in a communication published in the American Agriculturist of the following year (April, 1850, Vol. IX, pp. 113, 114). The account in question, which is the first that was published concerning this insect, is headed "The Potato Curculio," and is erroneous in some particulars, owing to the fact that the disease known as potato rot was attributed to this insect, on which assumption it was stated that the ravages of the weevil were traced from Mexico to Maine. The description of the egg and oviposition is wrong, the eggs being described as bright red instead of white in color. During the same year Harris published in the New England Farmer (June 22, 1850, n. s., Vol. II, p. 204) a short account of this species, quoting freely from Miss Morris, entering somewhat into detail to show that it was probably not the cause of the disease of potato. Harris is credited with publishing two more accounts of this species in the next year, but they appeared in popular publications, now inaccessible, which is true of a large proportion of accounts of this insect published by other persons. The writer has references to about 60 communications in regard to this weevil, for the most part short notices of injury and brief general accounts, usually compiled, and containing nothing original or of value otherwise. For this reason mention will be omitted of many of them. In Harris's Insects Injurious to Vegetation a brief popular account is given, based as before on Miss Morris's writings. A short general account was published by Walsh and Riley in 1868 (Am. Ent., Vol. I, p. 22), with illustrations of the insect in three stages, and a similar account by Riley, followed in his First Missouri Report, published in 1869 (pp. 94, 95), with mention of the insect's injurious occurrence in Missouri the previous year.

Several accounts of little consequence followed during succeeding years until 1890. During that year the insect became troublesome in the State of Iowa, and was the subject of study by Prof. C. P. Gillette (Bul. 11, Iowa Agr. Exp. Sta., pp. 490–492). In this account it is stated that this weevil was one of the worst insect pests of the season, and the estimate was made that *half a million of dollars* would probably fall far short of making good the loss that it occasioned to the potato crop in the State of Iowa alone. Two years later the insect was again very injurious in Iowa, as reported by F. A. Sirrine (Bul. 19, Iowa Agr. Exp. Sta., pp. 589–594). Considerable is added to our knowledge of the insect and its wild food plants in this last account. In 1893 it was reported to be injurious in Virginia, New Jersey, Iowa, and Ohio. In 1894 this weevil is mentioned by R. C. Schiedt (Report Penna. State Board of Agriculture, 1894, p. 194) as one of the worst insect pests of that year in Pennsylvania. The same year it attracted attention by its ravages in New Jersey, and was studied by Prof. J. B. Smith, the result taking form in an eight-page article published originally in Bulletin 109, New Jersey Agricultural College Experiment Station (pp. 25–32). This account includes three original illustrations. The following year this weevil was even more widespread in New Jersey than in 1894 (Annual Report N. J. Agr. Col. Exp. Sta. for 1895, p. 390).

During 1896 the potato stalk weevil was quite troublesome in Maryland, and was briefly reported by Prof. W. G. Johnson (Bul. 57, Md. Agric. Exp. Station, p. 5). During that year serious damage was done to the potato crop in Kansas, with the result that the insect was given special study by Messrs. Faville and Parrott in a 12-page leaflet (Bul. 82, Kansas State Agric. College Exp. Station). This is a very full account and includes 15 illustrations. A short summary of this article was published as Press Bulletin 19 in December, 1898, and republished in Bulletin 86 (pp. 35–37). Injury was also inflicted the same year in Pennsylvania, complaint having been made at Pawling, in the vicinity of which place infestation was stated to have been evidently quite general (2d An. Rept. Pa. Dept. Agr. for 1896 [1897], pp. 361–363).

In 1897 the potato stalk weevil was reported as doing much injury in Baltimore County, Md. (Bul. 9, n. s., p. 81).

In the Rural New Yorker for August 27, 1898, correspondence is published, with answer by Mr. Slingerland, concerning the occurrence of this species in potato vines at Pittsville, Pa., that year. Owing to its extensive depredations in the potato fields in northeastern Maryland, especially in Harford County, during 1898, an account by Prof. E. Dwight Sanderson was published in the National Stockman and Farmer for December 8, 1898.

During 1899 no reports of injury came to the writer's attention. Moreover, the species was rare wherever sought for in the vicinity of the Distrit of Columbia.

In the Rural New Yorker for August 11, 1900 (p. 544), a short note is published on the occurrence of this species at South Holland, Ill., where it had injured nearly every stem of potatoes, destroying about half the crop. An answer by Mr. Slingerland accompanied this note.

In Dr. Fletcher's report as entomologist and botanist for the experimental farms of Canada (p. 234, 1902), he makes mention of the occurrence of this species for the first time as a Canadian insect. The report is on the authority of Professor Lochhead, and is in brief that many vines were completely destroyed by the potato stalk weevil, present in all stages in September, at Pelee Island. It was stated that the island exported 30,000 bushels of potatoes the previous year, but in 1901 it would have no more than enough for its own consumption and none to spare. This report is followed by a short general account of the insect, with remedies.

NATURE OF INJURY; FOOD PLANTS.

Frequently, more often perhaps than not, injury by this potato pest is attributed to drought or blight. It is more conspicuous in seasons of prolonged drought and most severe on early varieties of potato. The undermining of the stalks of potato by the larvæ causes them to wilt, and the wilting and the dying of the leaves is the first and only outward manifestation of attack. When the insects are present in the field it is often stated that the plants are "blighted." The diseases of potato, particularly one caused by bacteria, are apt also to be mistaken for the work of the weevil, as in both cases the leaves look as if sunburned, particularly after the vines have been affected for some time. Not infrequently the field will be found to suffer from the combined effects of dry weather, disease, and stalk weevil. To detect the presence of the weevil it is only necessary to cut open the infested stalks, when the insect will be found in some stage in the pith. The weevil's presence is generally shown first in the withering of the lower branches, but in dry, hot weather the whole plant may be affected.

The beetles feed on the leaves of potato and other Solanaceæ, but do no appreciable injury in this stage.

This insect attacks, in addition to potato, nearly all of the Solanaceæ growing wild within its natural range. The list of food plants includes, besides potato, eggplant (*Solanum melongena*), horse nettle (*S. carolinense*), bull nettle (*S. rostratum*), jimson weed (*Datura stramonium*), purple thorn apple (*D. tatula*), ground cherry (*Physalis longifolia*, *philadelphica*, *lanceolata*, *heterophylla*, and *virginiana* var. *ambigua*). According to Faville and Parrott this insect also attacks cocklebur (*Xanthium canadense*). Tobacco and tomato appear exempt.

The presence of a single larva in a potato stalk is not sufficient to injure it to any extent, although it must have a weakening effect, but when many larvæ occur in the same stalk destruction is complete. As many as 5 or 6 individuals may sometimes be found in a potato stalk, and 8 have been observed in the stems of a ground-cherry plant.

LIFE HISTORY.

The beetles have been observed in the vicinity of the District of Columbia as early as May 20 on wild Solanum and Datura, which at that time were only 2 or 3 inches high. It seems probable that the beetles seldom put in an appearance earlier than the middle of May, as the plants are scarcely far enough advanced before that time for food. Pairing was noticed a few days afterwards, and oviposition probably begins normally before the end of the month of May, although farther north it does not commence until June. The female weevil deposits her eggs singly, in small slits or holes about one-twelfth of an inch in length, made in the stalks of the insect's food plants and occasionally in the branches. In about a week or ten days, according to temperature, the larva hatches from the egg and begins to feed by making small channels, which increase in size with the growth of the insect, downward toward the bases of the stalks. After working downward for a distance—usually to the roots—the larva turns about and begins the enlargement of the old channel for a portion of the way upward. The undermining of a stalk by the tunneling of several larvæ has the effect of impairing the vitality of the plant and causing the leaves to wilt and die. Upon attaining full growth the larva makes a cell of castings and woody fibers in which to transform to pupa and ultimately to adult. The pupal stage varies from eight to eleven days, according to temperature. In the District of Columbia the pupal period was passed in nine days in warm August weather; larvæ have been noted to obtain full growth by the second week of July, and imagos of the new generation have appeared as early as July 24. In more northern localities development is slower, the beetles seldom appearing before August and maturing as late as September. The pupal cells may be constructed in any portion of the stem, but are preferably placed near the roots, where the stalk is firmest and where the beetles will be best protected during their hibernation. All beetles mature by September and hibernation is therefore always as a beetle, and the knowledge of this fact is of value in the control of the species, as will presently be fully explained.

NATURAL ENEMIES.

The potato stalk weevil is subject to the attack of a small dark-colored four-winged parasite fly known as *Sigalphus curculionis* Fitch, a well-known hymenopterous enemy of the plum curculio. A species of chalcis fly was reared at this office from material received in 1896 from Yorkana, Pa. The larvæ, according to Professor Gillette (Insect Life, Vol. III, p. 247), sometimes fall a prey to wireworms. Messrs. Kirkpatrick & Son, previously mentioned in connection with recent injury, sent the larva of *Drasterius amabilis* July 2, 1897, with the statement that several of these wireworms were noticed in the stems of potato that had been infested by the weevil.

REMEDIES.

The potato stalk weevil is not a difficult insect to deal with. About the only remedy that is necessary is to pull up infested vines as soon as they commence to wilt and show evidence of attack, and spread them out so that they will be exposed to the sun and will dry and thus prevent the escape of the insects which they contain. Then all stalks in infested fields should be burned as soon as the crop is off. By thus destroying the weevils the crop of insects for another year will be greatly lessened. In connection with this remedy it is also advisable to keep down all Solanaceous weeds which serve as breeding places for this and other insects and are therefore a standing menace to the culture of potatoes. The time for the destruction of the weeds is in July, after they have attracted the hibernated beetles to them for egg laying, or any time thereafter before the seeds are ripe. For perfect success in this treatment of potato fields, the cooperation of neighboring farmers is essential.

A liberal use of fertilizers in an infested field will often aid the injured plants to recuperate from insect attack. Unfortunately, injury is not apt to be detected until it is far advanced and the plants begin to die. As soon, therefore, as a plant shows weakness its stalk should be split open to ascertain the cause.

It should be remembered that early potatoes are more subject to injury than later ones, and that the latest varieties are practically exempt from injury.

THE NORTHERN LEAF-FOOTED PLANT-BUG.

(*Leptoglossus oppositus* Say.)

During the season of 1900 this injurious species of plant-bug occurred in great abundance in and about the District of Columbia, and was also reported to be troublesome in Arkansas, Missouri, and Oklahoma. After the publication of the writer's first article on this insect (Bulletin No. 19, n. s., pp. 44–46), it was brought to his attention, first by correspondence and afterwards by observation, that the species of Leptoglossus subsist in all their stages preferably upon the fruit of the plants subject to their attack. The first intimation of this fact came from correspondence with Mr. Henry J. Gerling, St. Charles, Mo., who wrote under date of August 8, 1899, that *L. oppositus* was attacking the fruit of cucumber and the fruit and buds of nest-egg gourd in his vicinity. When first observed the nymphs were about a quarter of an inch long and blood-red in color. After they had pierced the fruit, a waxy secretion exuded from the wounds, such exudation often showing all over the fruit affected.

We have now, as a result of recent investigation, a knowledge of the full life history of the species, which will be presented in detail.

INJURY DURING 1899 AND 1900.

Damage by this plant-bug to gourd and cucumber at St. Charles, Mo., in 1899 has already been mentioned. The fruits or vegetables from which our material was obtained were said to be literally covered with the insects. September 13, 1899, Mr. F. C. Pratt observed attack to the fruit of cucumber at Alexandria, Va. September 25 we received from Mr. Thos. I. Todd, Athens, Ga., specimens of nymphs in different stages, with the report that this insect was injuring the stems of young watermelon.

In 1900, Mr. H. Guibor, House Springs, Mo., sent the young of this species, June 14, mostly in the second stage of the nymph, but with one in the third stage, with the report that they were attacking the fruit of pear. June 25, Mr. John G. Bauranel, Clarksville, Johnson County, Ark., sent specimens with the statement that this plant-bug was preying upon peach and cantaloupe in that locality. Peaches, when ripe, were sometimes found full of imperfect spots, manifested by a roughening of the skin. When peeled a dark, circular spot caused by the puncture of this insect, which our correspondent likened to the perforation of an awl, could be seen. The insects were present in great numbers on the peaches, quietly sucking the juice. Cantaloupe vines would appear to be perfectly healthy in the morning, and perhaps by noon would be wilted and dying, although roots and stems appeared to be sound. Specimens of this species were observed about the middle of July, and Mr. Otto Heidemann, of this office, states that he saw nymphs of a related species still earlier. July 25, Rev. Fred M. Dickey, Deanewood, D. C., stated that he had recently observed the insects *in copula* on his plums and cherries. July 30 a considerable number of insects were received from the last mentioned locality, some in copulation when received. August 3, Mr. August Busck reported this species very abundant on peach trees in the District of Columbia, most of the specimens captured having been found paired. From the date just mentioned to August 16, Mr. Pratt observed this plant-bug on three occasions at St. Elmo, Va., on stalks of corn where no other crop was growing and on August 27 he found numerous individuals puncturing tomatoes. There were several colonies at work and the majority of the individuals were in the third stage of the nymph. In the first week of September Mr. Pratt noticed that much injury was being done to seed cucumbers, many plants being completely covered with the bugs in their various stages. The following week the same observer found the insect doing some harm to cymlings, near Deanewood.

OCCURRENCE DURING THE SEASON OF 1901.

During 1901 this plant-bug came under frequent observation, more especially by Mr. Pratt at St. Elmo and elsewhere in Virginia. He noticed it on pear, plum, and peach attacking the fruit; he also saw it puncturing corn in milk and tomatoes, and he states that it was as common as in 1900 on cantaloupe and other cucurbits. September 20, Mr. John S. Seibert, Cumberland, Md., sent specimens of the nymph in the last stage, with the information that they were puncturing the fruit of hazel nut, transmitting at the same time nuts showing puncture scars.

This insect is accused of more injury than the mere puncturing of fruits. There is no doubt whatever that in feeding it injects a certain liquid, the same as or similar to that which is secreted by the common squash bug, and that this poisons the plant, causing the fruit to be distorted or checking its growth. It has also been accused of being a transmitter of fungus diseases of pear and other fruit trees. It seems quite probable that this is the case, although further observations are necessary to settle the matter. It was reported too late in the season for careful investigation.

Aside from their preference for fruit as food, the species of Leptoglossus very closely resemble the squash bugs (Anasa) in many of the details of life economy. The eggs are of similar color and net-veined like those of Anasa, but are of different shape and deposited lengthwise instead of in somewhat irregular masses. During the early stages of the nymph the predominating color is red, but in the last stage the close resemblance to Anasa is quite evident. In the length of the stages of the life cycle the two genera do not appear to differ.

THE EGG AND OVIPOSITION.

The eggs are laid in the same manner as those of *L. phyllopus*, in single rows or chains along the stems or leaf-ribs of the plants upon which the insects feed. They evidently differ in coloring from those of *phyllopus*, however, all that have been observed being pale bronze to dark bronze-brown, none of them golden. The eggs are semicylindrical, looking from one end, as shown in figure 3, *c*, and are rather strongly flattened on the lower surface, where attached to a plant. The outline, as seen from above, is short oblong, the eggs being placed so close together end to end that they form what appears to be a stiff, cylindrical rod, of which each egg is a joint or cell. At one end of the egg, covering a little more than half of the distance from that extremity to the other, there is a circular area with a surrounding circle of light color and bearing a transverse curved row of from 4 to 6 elevated points. This circular area comes off like a trapdoor (*e*) for the issuance of the young. Under a microscope of moderately high power the entire surface is seen to be finely reticulate, with rather regular pentagonal and hexagonal areas (*d*). The length of an egg is about 1.4^{mm}, and the width $1-1.15^{mm}$, the height being a trifle less. A chain of eggs is shown at *b* (fig. 3), and the sculpture of an egg at *d*. Chains vary in length from those having half a dozen eggs, and measuring about three-eighths of an inch, to others having 26 eggs and measuring 1¼ inches in length.

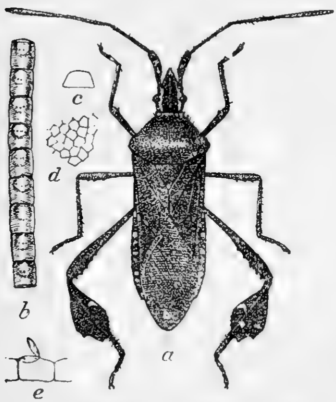

Fig. 3.—*Leptoglossus oppositus: a*, mature bug; *b*, string of eggs; *c*, egg from end; *d*, sculpture of egg; *e*, egg from side, showing opening from which young has escaped—all except *d* about twice natural size (original).

THE NYMPHS.

The nymphs when first transformed have the legs and antennæ rose-colored, the body pale orange-red, the eyes reddish or reddish-brown. The ground colors change, in all except the fifth stage, to brighter orange or vermilion with dark-brown or black legs and antennæ, while the amount of black on other portions of the body increases with each successive molt.[a]

First stage.—The nymph when first hatched from the egg is pale coral red in color, with long, dark brown or nearly black legs, the proximal half of the antennæ being of the same color and the remainder pale coral, becoming darker soon after hatching. The antennæ and legs are of nearly equal length, about one-fourth longer than the body (with the head). The rostrum, which is kept closely folded under the body when the insect is not feeding, is of the same color as the legs and about three-fourths as long as the body. The posterior portion of the body is sparsely tuberculate, the arrangement being as shown in the accompanying illustration (fig. 4) at *a*. The legs and antennæ are clothed with sparse short black hairs. The tibiæ of the hind legs

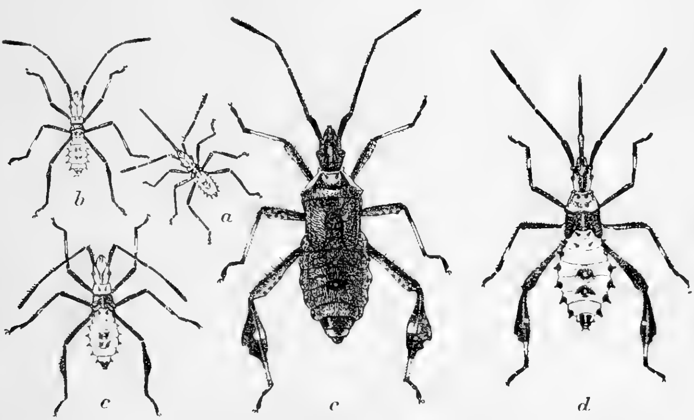

FIG. 4.—*Leptoglossus oppositus*: *a*, nymph of first stage; *b*, second stage; *c*, third stage; *d*, fourth stage; *e*, fifth stage—all about two and one-half times natural size (original).

show no evidence of the expansions which appear in later stages. The length of the body when first hatched is about 2.3^{mm}, and the width is about 0.8^{mm}.

Second stage.—With the casting of the first skin, the nymph takes on a more elongated appearance generally, the head, body, antennæ, and legs all being longer and more cylindrical, while the tubercles become more pronounced. The two dorsal abdominal tubercles and the anal extremity become black, and a pair of minute tubercles usually show just behind the pair back of the hind legs. The hind tibiæ shows slight evidence of enlargement. Length when fully matured, 6^{mm}. This stage is illustrated at *b*, fig. 4.

Third stage.—Superficially this stage (fig. 4, *c*) looks but little different from the second. The thorax is longer than the head, the black por-

[a] The differences between the nymphs of this species and of *L. phyllopus* are not nearly so marked as in the two cucurbit-feeding Anasas, *tristis* and *armigera*.

tions of the body are darker and more conspicuous, and the abdominal tubercles more prominent. The antennæ and legs are wider, the latter with the lateral tibial expansions just beginning to show, being now about the same width as the tibia itself, and without teeth. The tubercles are larger, but the dorsal spines are scarcely longer than in the second stage. The haustellum immediately after the molt projects beyond the abdomen to a distance about equal to the length of the head. Length of body just after molt, 6^{mm}.

Fourth stage.—The appearance of this stage is shown at *d*, fig. 4. The antennæ, hind legs, and body are subequal in length, the haustellum a little shorter when first transformed, the width of the body at this time only a little over 2^{mm}, becoming about 3.5^{mm} before the next molt. When "full colored" the body is of about the same appearance as in the third stage, but the red ground color becomes lighter and duller orange before molting, while the black coloring extends farther. The wing pads are bronzy black, occupying more than half the thorax; the tibiæ each marked with a whitish band just below the middle; lateral expansions about two-thirds wider than tarsi, with one more or less feebly marked lateral tooth toward apex. Length when first molted, 9^{mm}.

Fifth stage.—This stage is illustrated at *e*, fig. 4. With the casting of the fourth skin the nymph begins to show the appearance of the mature bug; the antennæ and legs are still shining black, the latter yellowish at the extreme apex, and the tarsi have each a whitish band, as in the preceding stage. The lateral expansions are several times as broad as in the preceding stage, strongly bidentate on the lateral surface, and rather feebly unidentate on the inner portion, which is marked with a medial white spot. The head and body are black, thickly covered with gray pubescence, thickest on the head. The prothorax is narrower at the apex, where it is of about the same width as the base of the head, and broader than the thorax at the base; the sides are nearly straight, with wide orange margin. Just behind the apex of the thorax there is a pair of small, rounded orange tubercles placed rather closely together. Length when first molted, 11^{mm}.

The adult.—A full description of the mature insect has been given by the writer in the article previously mentioned (p. 45), but for the benefit of those who may not have opportunity to refer to that description it may be stated that the parent insect is a large, chocolate-brown heteropterous bug of the same family as the squash bugs, the Coreidæ, from which insects it may be readily distinguished by its more slender form, acutely pointed head, and longer antennæ and legs, but more particularly by the leaf-like expansion of the hind legs (see fig. 3,*a*). The length is 18 to 21^{mm}, and the width across the thorax 5 to 6^{mm}.

DISTRIBUTION.

Leptoglossus oppositus is Austro-riparian in distribution, although it extends about halfway into the Carolinian region and sometimes even farther north, such occurrence, however, in the writer's opinion, being rare and in some cases perhaps accidental. With recorded distribution and the localities furnished during the year, we know that this species occurs in Georgia, Texas, Arkansas, Missouri, Indian Territory, North Carolina, Virginia, Maryland, District of Columbia, Kentucky, Indiana, New York, and New Jersey. In the last-mentioned State it is recorded from Shiloh in September, and it was captured on Staten Island, New York, in October, by Mr. W. T. Davis.

LIFE HISTORY AND HABITS.

The life cycle.—The life history of this plant-bug, as previously intimated, practically duplicates, as regards the length of the different stages, that of our two common species of Anasa, *tristis* and *armigera*. Eggs that were deposited in extremely hot weather in early August produced nymphs in eight days and the first molt of the nymph took place in three days.

The nymphs do not thrive in confinement as well as do those of the species of Anasa, and the working out of the periods of the different stages would, therefore, have been laborious. Assuming the periods to be practically identical, we have the egg stage eight days, the first nymph stage three days, as previously ascertained, and can surmise the second and third nymph stages to be five to seven days each, the fourth five or six days, and the fifth seven or eight days, the minimum period of the entire life cycle probably being about five weeks, and the maximum seldom more than six weeks, except in the case of some of the late broods which occur in the fall.

As with Anasa, there is only a single generation produced each year.

The first appearance of this plant-bug in the neighborhood of the District of Columbia is probably not far from the first day of July, the earliest date when it has been observed. This is two or three weeks later than the appearance of *Anasa tristis*. The first eggs obtained were deposited August 9. Nymphs were first seen August 13; the second stage, August 16.

The first imagos of the new generation developed September 10, and during the next few days many more were seen both in our rearing cages and in the field. The hibernated bugs disappeared a week or two earlier, so that there was no overlapping of generations observable. The second stage of the nymph has been observed during different seasons as late as the middle of September and an individual of the third stage September 23. A belated adult was observed in the second week of November.

Food habits.—It may be well to sum up what is now known of the food and other habits of this species. It is obvious that cucurbits are the favorite food of both adults and nymphs, although the earlier arrivals or hibernated adults are more often found upon fruit trees. The nymphs are most abundant on cucurbits, which naturally is true of adults of the new generation which remain on or in the vicinity of the plants upon which they developed until time for seeking winter quarters. Plums, cherries, peaches, and tomatoes are frequently punctured by the insects in all stages, tomatoes appearing to be preferred in our rearing jars to other food. Green corn is fed upon readily. There is record of occurrence on corn published by Dr. Lintner in the Country Gentleman of October 7, 1886 (p. 753). Of other published records of food habits we have Mr. Ashmead's mention of this species in his enumeration of the insect enemies of cotton; also note of the occurrence of eggs and nymphs on a hedge plant and on Russian apricot. Grape has been recorded as a food by Dr. Lintner (loc. cit.). The natural wild food plant remains to be discovered.

In the report of the Oklahoma Agricultural Experiment Station for 1900–1901 mention is made of this bug as having been received from various parts of Oklahoma, accompanied with the report that it was injuring the fruits of peach and plum by puncturing them and sucking out their juices. The species occasioned considerable alarm there, and farmers were asked to send specimens whenever found, in order that several points in its life history might be determined.

Other habits.—The nymphs, as soon as hatched, group themselves about the chains of eggs and remain there during the day and probably till nightfall. Afterwards they may be found in other locations, and those which have been under observation, both in the field and in confinement, at once selected a place for congregating where they were to be seen throughout the day, the individuals of a colony or those which hatched from a single egg mass always remaining by themselves. In one rearing cage a colony established itself at the base of a squash leaf near the stalk, which appears to be a favorite resting place for this as well as other plant-bugs, including the squash bugs; and another colony formed at the apex of the same leaf, as far as possible from the first colony. Here they remained day after day without mingling. Finally a stray nymph from a third egg mass, and larger than the others, joined the lower colony and remained with them. With the assumption of the third stage, the nymphs kept under observation deserted their original congregating places and collected in another portion of the cage, where they were joined by a newly hatched colony. With later stages it is a matter of common occurrence to find in the field three or four stages in a single group.

A fully matured nymph was observed to shed its last skin October 2, at 11.30 a. m. At this time it was a light carmine; in the afternoon it had changed to the normal dull black color.

This plant-bug has a similar but much fainter odor than the common squash bug, but in ordinary handling of the creatures, nymphs and adults, it would scarcely be noticed.

NATURAL ENEMIES.

Quite frequently the adults of this plant-bug are noticed with Tachinid eggs on the upper surface of the thorax. During the first week of August a fly was reared from hibernated adults, which proved to be *Trichopoda pennipes* (fig. 5). An adult of the squash bug, *Anasa tristis*, was found September 14 with a nymph of the second stage of this plant-bug affixed to its beak.

FIG. 5.—*Trichopoda pennipes:* adult, fly three times natural size (original).

REMEDIES.

This plant-bug can, in the case of ordinary attack, be controlled by hand-picking or by capturing the insects in inverted umbrellas, bags, or specially prepared nets saturated with kerosene; the best time for their capture being in the early morning or late in the evening, as they are apt to be active, taking wing readily, in the heat of the day.

A certain measure of relief should be obtained by the free use of kerosene emulsion, which will at least kill the younger nymphs.

Some of the remedies in use against the striped cucumber beetle[a] and other insect enemies of cucurbits will assist in the control of this species when it occurs on cucurbits. Among these are the protection of young plants with coverings; the use of repellents, such as land plaster or gypsum, saturated with kerosene or turpentine; the planting of an excess of seed to distribute attack; the stimulation of the growth of the plant by manures or other proper fertilizer; and, lastly, clean cultural practice. If, as soon as the crop is harvested, the vines be gathered and burned, many bugs in their different stages will be destroyed and the crop of insects will be reduced for the ensuing year.

With a knowledge of the natural wild food plant or plants of this species, we might be able to control it in the same manner as suggested for its congener, *L. phyllopus*, which feeds normally upon thistles. This matter is considered on page 48 of Bulletin No. 19, present series.

[a]See Circular No. 31, 2d ser., The Striped Cucumber Beetle, pp. 4–7.

THE CARROT RUST FLY.

(*Psila rosæ* Fab.)

This imported pest, which has been noted as injurious to carrots in Canada since 1885, made its appearance during the season of 1901 in New York, and did considerable injury.

November 14 and 19, 1901, Mr. James Granger, Broadalbin, N. Y., sent specimens of the maggot which proved, on rearing, to be this species, and which he found at work in a celery field during the summer. The larvæ seemed to begin eating into the thick part of the root when the plant was about half grown, stunting it so as to make it worthless for market. About 6,000 plants had been ruined during the season, and traces of the ravages of the maggot were found all over a field containing 60,000 plants.

It is to be regretted that the rearing and subsequent identification of the species was made so late in the season that it was impossible to make any biological observations. The importance of the species as a pest in Europe and its prospective increase and injuriousness in this country are such, however, that it is deemed advisable to present at this time what is known concerning the insect and its life history. All that has been hitherto published on its occurrence in America is from the pen of Dr. James Fletcher, Dominion entomologist of Canada.

Attack on carrots is not difficult of recognition. The leaves of the young plants early in the spring turn reddish, and the roots are found to be blotched with rusty patches, particularly toward their tips. The roots when stored for winter, although not always manifesting any degree of injury on the outer surface, may at times be perforated in all directions by dirty brownish burrows, from which the whitish or yellowish larvæ may be found sometimes projecting.

DESCRIPTIVE.

This species is quite minute, the adult or parent fly measuring only about one-sixth of an inch (4^{mm}) in length, with a wing expanse of a little more than three-tenths of an inch (8^{mm}). The color of the body is dark green, described by some authors as black, and it is rather sparsely clothed with yellow hairs. The head and legs are pale yellow, and the eyes are black. The general appearance of the two sexes is shown at ♂ and ♀, respectively (fig. 6). It will be noted that the male abdomen is rounded at the apex, while that of the female is prolonged into a rather acute point. A more detailed description is given by Curtis.

The larva, about half grown, is figured at *f*, *g*. It is paler than the more mature larva. The full-grown larva resembles rather closely that of the cheese maggot, to which this species is nearly related, but is much darker in color, being rather dark brown, with the segments well marked, the head, as is usual with related maggots, being minute, while the posterior extremity is truncate. The general appearance is shown at *b*, the spiracles at *c*, and the anal segment at *d*. The length of the mature larva is a little less than three-tenths of an inch (7^{mm}).

The puparium (*e*) is of about the same color as the larva, and the anterior portion is obliquely truncate, recalling the appearance of the anal segment of the Scolytidæ or bark-beetles. The length is nearly one-fifth of an inch (4.5^{mm}).

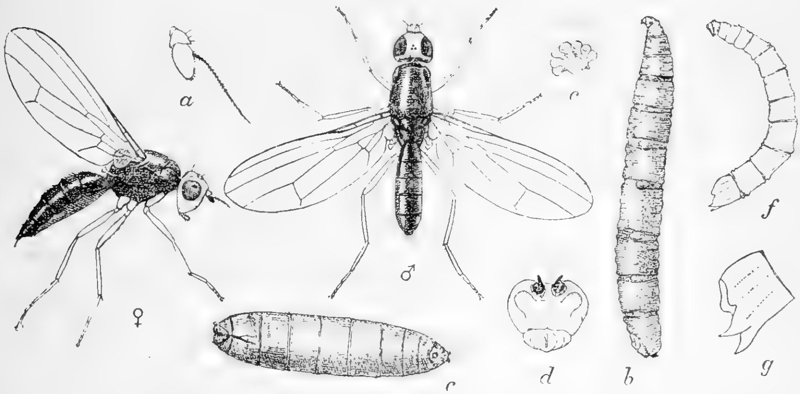

FIG. 6.—*Psila rosæ:* ♂, male fly; ♀, female fly, lateral view; *a*, antenna of male; *b*, full-grown larva, lateral view; *c*, spiracles of same; *d*, anal extremity from the end; *e*, puparium; *f*, young larva; *g*, anal segment from side—flies, young and mature larva, and puparium, eight times natural size; other portions more enlarged (original).

According to Curtis, when the imago issues from the puparium an oval lid on this portion lifts up, permitting the fly to crawl out. The posterior extremity ends in two minute and not prominent dark tubercles.

DISTRIBUTION.

The carrot rust fly is a pest in England and Germany and probably elsewhere on the continent of Europe. It was originally described from Kilia, in Bessarabia. Just when it was first introduced in this country does not appear to be known, but ravages were not apparent until 1885, and until the present year the species seems to have been confined to Canada, although we have in the National Museum a single specimen received from Mrs. A. T. Slosson, labelled Franconia, N. H. New York is apparently, therefore, an unrecorded locality and celery a new food plant. It frequently happens that a species introduced from one country into another, particularly from the Old World into America, assumes new habits and acquires new tastes as regards food. The localities in which the species has been observed in Canada will be mentioned further on.

From the known distribution of the carrot rust fly it would seem probable that this species will not be troublesome far southward, its establishment in Canada for at least eighteen years indicating its adaptability to a cold climate. It will perhaps not extend farther south than the Upper Austral life area, and for a number of years at least would be most injurious in the more northern portion of that zone and in the Transition. There is little doubt that it will in time spread westward, and may some day become a pest in the celery fields of Michigan.

OCCURRENCE IN CANADA.

The first record of the occurrence of the carrot rust fly in America appears to be that published by Dr. Fletcher, who, as already remarked, has written all that has hitherto been known of the occurrence of this species on this continent. In 1885 carrots purchased in the market at Ottawa were seen to be much mined by small white maggots, which proved by rearing to be the carrot fly (Rpt. Ent., Dept. Agr., Can., 1885, p. 15). In 1886 Dr. Fletcher found young plants of carrot in a garden at Ottawa badly attacked in the spring. The same year a great deal of damage was done, particularly to roots stored for the winter. Mr. F. B. Caulfield, an entomologist of Montreal, reported that in February, 1887, nearly all the carrots that he had seen exposed for sale were more or less attacked. At Nepean, Ontario, early carrots were badly attacked, nearly every root showing signs of the insect's presence, two-thirds of the crop being seriously injured for the market (Rpt. Ent. and Bot., Exp. Farms, Dom. of Can., for 1887 [1888], p. 21).

In 1897 the species was reported as occasioning complaints during the previous ten or twelve years, chiefly in the Province of New Brunswick, but also in Ontario and Quebec. Attack is described as being a serious one, carrots stored for winter use being rendered useless for the table from the discolored burrows of the numerous maggots which sometimes occur in a single root.

In 1895 a correspondent at Rothsay, Kings County, N. B., whose crop had suffered severely from the ravages of this insect, noticed that late sown carrots were less injured than those sown at the ordinary time. Late planting has since been recommended and adopted with considerable success (l. c. for 1897 [1898], pp. 19 –198). Specific mention is made of injury at Upper Sackville, Brookville, and Clifton, N. B. In the first locality injury was noticed in 1894 and 1895, at Brookville in 1895, and at Clifton for several years. In the last locality few carrots were raised "of late years on account of this pest." The following year (l. c. for 1898 [1899], pp. 193–194) specific injury to carrots at Noulton and Ste. Marie, Quebec, was noticed.

EUROPEAN LITERATURE OF THE INSECT.

The original description of the carrot rust fly, by Fabricius, appeared in 1792 (Entomologica Systematica, Vol. IV, p. 356) and under the name of *Musca rosæ*, the specific name evidently being suggested by the capture of the mature fly upon a rose bush, but this is not explained in the text, which reads "*Habitat in Kiliæ floribus.*" In subsequent years the species was redescribed by Fallen, Meigen, Macquart, and Zetterstedt, and in 1834 Bouché (Naturgeschichte der Insekten, pp. 97, 98) gave some account of its habits. In 1837 a popular account was published by Vincent Köllar (Schädliche Insekten, p. 168). Köllar's account is translated in the London edition published in 1840 (pp. 160, 161) the insect being referred to as the "negro fly." The same year John Curtis published, in Farm Insects (pp. 404–407), a still more extensive article with illustrations and descriptions of all stages. Accounts also appeared in subsequent years by Miss E. A. Ormerod (Manual of Injurious Insects and other publications), by Taschenberg, and others. It is probably this fly which Joshua Major mentions in his "Treatise on the Insects most Prevalent on Fruit Trees and Garden Produce," published in London in 1829. On page 183 he states, under the head of carrots, that "the greatest pest to this plant is a small white larva of a small fly (*Pollydismus Complanatus*)". He furnishes the information that moist weather appears to be the most productive of the depredations of this species, stating that under such atmospheric conditions it is not uncommon to see "whole and extensive crops laid waste and rendered useless, by their perforating and defacing the Carrot from one end to the other, which effect gives rise to the common term canker, which gardeners have so much to complain of in this vegetable." On page 199 he also refers to this species as "grub (*Pollydismus Complinatus*)—See on Carrots." He adds that he can suggest nothing for the destruction of the pest since the maggots are so deeply fortified in the plants which they attack that nothing can be applied that will reach them without destroying the plants. He, however, recommends rotation with crops not affected by this species, and avoiding plots that have had carrots the year before.

Zetterstedt quotes Dahlbom (Dipt. Scand., Vol. VI., p. 2403) as having reared this species from larvæ at the roots of turnip (*Brassica rapa*), and rape (*B. napus*).

HABITS OF THE SPECIES.

The life history of the carrot rust fly does not appear to have been worked out. What we know is from the authors that have been quoted. The writer is inclined to believe that in the United States the species will be found to pass the winter usually as a puparium, possibly occasionally also as a larva; but as larvæ work also on carrots in store the flies will develop in winter, as happened in the writer's laboratory, which is kept unusually cool for a working room and still cooler at night during the colder months. Hence we have great irregularity of development, making generalization impossible until we have an opportunity to make observations in the field. As the larvæ go deep into the ground upon the approach of cold weather it is quite probable that they may be able to survive as such.

In any case, the insect develops rather early in the season. Attack begins with young carrots which turn of a rusty color, and upon examination the roots will be seen to be disfigured with rusty patches, more especially toward the tips. Both flies and maggots are found throughout the warmer months, but the latter desert the roots for pupation in the earth, the last generation probably descending much deeper into the earth than the earlier ones. According to Curtis the summer generations develop in three or four weeks. No one appears to have surmised how many generations are produced. There must be at least two, and probably more. Miss Ormerod states that the fly goes down into the ground for oviposition where she can find a crack or other opening about the roots of the carrot (or other food plant affected), and the maggots when hatched work their way into the roots; when this is quite small they often destroy the lower portion.

NATURAL ENEMIES AND ASSOCIATES.

Curtis found a species of parasitic four-winged fly which he described as *Alysia apii* (Farm Insects, p. 420), and which he presumed was a parasite of this species and connected with its economy.

Polydesmus complanatus Linn. is stated by Curtis to be attracted to the roots, which have been previously perforated by the maggots of this species, sometimes congregating in such vast numbers that he supposed that it was this creature which was reported to have devoured carrots by the acre in Scotland in 1831. This is a European millipede several times reported to be introduced in this country,[a] and it is sometimes accompanied by a centipede known as *Scolopendra electrica*, said to assist in depredations.

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[a] Prof. O. F. Cook, who is our best American authority on the Myriapoda, informs the writer that, although this species has been recorded as occurring in the United States, it has not yet been positively recognized on this continent, he having never seen specimens. It seems probable that notwithstanding the fact that this insect must have been brought to this country in potted plants and in earth perhaps thousands of times, it has, for some unknown reason, failed to gain a permanent foothold.

In response to the inquiry of the writer as to whether any of the Myriapoda, better known as thousand-legged worms, millipedes, etc., were capable of original damage to plant tissue, Professor Cook stated that their mouth-parts were not formed either for biting or chewing, and that they were only capable of eroding or scraping diseased tissue, and, to some extent, soft, delicate plants. In this way, however, they can do occasional damage by constantly scraping plant growth like the tubers of potatoes affected with scab and similar diseases, and young, delicate plants that might recover if they were not attacked.

METHODS OF CONTROL.

As with other species which feed beneath the surface of the ground, the carrot rust fly is a difficult one to reach with insecticides. Our principal dependence is therefore based upon methods of tillage which will serve to avert attack.

Kerosene emulsion prepared in the proportion of one part to ten of water and sprayed upon the carrots along the rows with a knapsack or other sprayer, or sand, land plaster, or ashes, with which kerosene has been mixed at the rate of half a pint to 3 gallons, sprinkled along the rows, are (with the exception of crude carbolic acid at the rate of half a pint in 5 gallons) about the only applications which have been made with good results. In Canada, according to Dr. Fletcher, one or the other of these applications should be made once a week through June from the time the roots begin to form, and particularly after the rows have been thinned.

Late sowing has also been practiced to great advantage, several persons attesting its value.

Rotation of crops should always be practiced in the case of such species as the present one, and this means the planting of a new bed each year as far as possible from land infested the previous season. Many of those who have complained of injuries have admitted planting carrots on the same ground year after year, and some have testified to the value of rotation.

Destruction of the insects in stored carrots.—Where carrots are stored for winter use in earth this should be treated to destroy the larvæ or puparia which leave the roots to enter the soil for transformation. This may be accomplished in several ways: (1) By burying the earth deeply; (2) by spreading it in thin layers where it will be exposed to the elements; (3) where possible, by throwing it into pools where it will be frozen; or (4) by exposing it to heat or steam in any manner which may be most convenient.

Treatment of the insect in celery beds.—Now that we know that this insect also infests celery, it is obvious that celery should not follow carrots nor carrots celery in rotation. Clean cultivation should be practiced, which means the destruction of all remnants after the celery crop has been harvested, and if the insect is found to destroy celery in store in the same manner as carrots, the earth, after the larvæ have entered it, should be treated in the same manner as described above.

After harvesting, it would be a good plan to give the celery fields a light raking or cultivating of sufficient depth to expose the larvæ or puparia that they may be destroyed by frost; early the following spring, before the flies have time to issue, if the earth be plowed deeply, it will, with little doubt, have the effect of destroying most of the insects; and such as have not been killed by frost and survive cultivating and raking would be buried so deeply under the ground by the spring plowing that they would not be able to effect their escape.

THE CARROT BEETLE.

(*Ligyrus gibbosus* Dej.)

A very common beetle along the Atlantic coast from Long Island to the Gulf States, and at many points inland, has been reported as the cause of injury to carrots and other root crops, and to some other plants. It first attracted attention from its injury to sunflower and has been given the name of sunflower beetle; but as its record shows it to be the worst insect enemy to carrot and parsnip known in the United States at present, the name of carrot beetle is suggested as more appropriate. It is somewhat of a general feeder, and, as we learn more of its habits, we will doubtless find that it will, on occasion, attack many other plants than those which will be specified.

During the year 1900 it was destructive to corn in Louisiana and Mississippi, and the following year to sunflower in Illinois and to root crops in Indiana.

DESCRIPTION.

The beetle (fig. 7).—From three other species of Ligyrus, *gibbosus* can be distinguished without much difficulty. It is of robust form, like *ruginasus*, the Pacific coast form, and *relictus*, but from both it may be known by its much smaller size. It measures between one-half and five-eights of an inch in length, and its width is more than half the length. The surface of the elytra is strongly sculptured and coarsely punctate, characters which will distinguish this genus from Lachnosterna. The color varies from reddish brown to nearly black on the dorsal surface. The lower surface is reddish brown, and the legs, which are still brighter colored, are clothed with reddish-yellow hairs. The remaining species, *rugiceps*, is restricted to the South, and is narrower than the others, with a different facies.

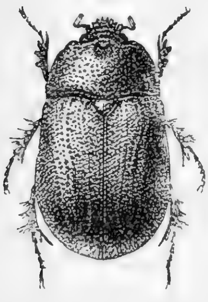

FIG. 7.—*Ligyrus gibbosus*: beetle—about twice natural size (original).

The species may further be distinguished from *ruginasus* (with which it agrees in having the thorax impressed in front, and with a small tubercle, and in having the anterior tibiæ tridentate) by the structure of the clypeus which is bidentate or two-toothed, the clypeus in *ruginasus* being unidentate or single-toothed.

The egg is of the usual scarabæid appearance, when recently laid measuring 1.70^{mm} in length and 1.45^{mm} in diameter, but when ready to hatch the length is about 2.30^{mm} and the diameter 2.20^{mm}. In almost every respect the egg is a counterpart of that of Lachnosterna, which was described by the writer in Bulletin No. 19 of the present series (p. 75). It is perfectly snow-white with just a perceptible luster when laid, but becomes grayer when near the hatching time. The larva and pupa have never been described, to the writer's knowledge.

DISTRIBUTION.

The list of localities in which *Ligyrus gibbosus* has been observed, and by which it is represented in most cases in the National Museum, includes territory from Long Island to California and Oregon, as well as the Gulf States. It indicates a very wide distribution, but so far as we know at present the species does not occur in the Northern States in the Transition or even in the more northern portions of the Upper Austral life zones. For example, although it is extremely abundant about the city of New York, it does not occur in the central portion of the State. A list of known localities follows:

New York, Staten Island, Long Island, N. Y.; in New Jersey at Trevose, Brigantine, and Highlands, and "throughout the State, but much more common along the shore at light" (Smith); Pennsylvania; Maryland; Cobb's Island, Pennington Gap, Fortress Monroe, and Virginia Beach, Va.; District of Columbia; Keokuk, Iowa; Thomson, Ill.; Purdue and Chesterton, Ind.; Moody, Ark.; Topeka, Riley County, Onaga, and Atchison, Kans.; St. James and Glencoe, Nebr.; Capron and Crescent City, Fla.; Craig, Miss.; San Diego, Plainview, Rock Hill, and Gainesville, Tex.; Salt Lake, Utah; Las Cruces, Albuquerque, Mesilla Valley, and Water Canon, N. Mex.; Yuma and Wilcox, Ariz.; Bayou La Fourche, Mer Rouge, and Ville Platte, La.; Grand Rapids, Wis.; Pueblo, Colo.; Los Angeles, Kern County, and southern California; Hood River, and Dalles, Oreg.

RECENT INJURIOUS AND OTHER UNRECORDED OCCURRENCES.

April 21, 1900, Mr. René L. Derouen, Ville Platte, La., sent specimens of this insect with the report that the species was concerned in the destruction of the corn crop of that vicinity. The beetles were described as cutting the corn just above the roots. The previous year's crop was lost through its depredations, and fear was expressed that the country might suffer very much indeed through the ravages of this pest. Mr. James Lambeth, Craig, Miss., sent specimens, with the information that many of these insects were to be found in a cornfield about an inch deep in the ground.

During 1901 we received in June specimens of the beetle, with information from Prof. W. G. Johnson, associate editor American Agriculturist, that this species was found injuring the roots of sunflower and sweet potato at Thomson, Carroll County, Ill. October 10 we received specimens of beetles eating the roots of celery, carrots, and parsnips, and sent by Mr. F. J. Dickinson, Chesterton, Ind. He stated that the carrot crop appeared to be in good condition, judging from the tops, but when the plants were pulled it was seen that the roots were full of little holes. The beetles appeared to work entirely under ground, and our correspondent stated that they had ruined the carrot and celery crop that fall. December 5, Mr. Dickinson again wrote in regard to investigations which he had conducted at the writer's request. He succeeded in ascertaining that carrots, at least in that locality, were the chosen food of the beetles, but celery and sweet potatoes were greatly damaged. Of parsnips an occasional root was found that had been eaten into, but not to seriously damage it. Celery was greatly injured by the beetles' gnawing into the roots so that the plants were killed and dwarfed, sometimes so badly that the crop was practically worthless for market. One-half of Mr. Dickinson's sweet potatoes were not marketable on account of the holes made by these beetles.

LITERATURE AND RECORDED INJURIES BY THE SPECIES.

The first account which the writer finds of injuries by the carrot beetle was published in the report of the Commissioner of Agriculture for 1880 (p. 274). About the middle of August of that year specimens were received from St. James, Nebr., where it was reported at the roots of sunflower plants of sickly appearance, from 5 to 25 of the beetles to each plant. They had eaten the bark from the root and scored long grooves in the wood. The larvæ were found in the same situation doing apparently the same work. Later in the fall of the same year a correspondent at Glencoe, Nebr., wrote that this species often nearly exterminated wild sunflower by working at its roots. He had also observed it on cultivated sunflower and dahlia. June 4 of the same year we received from Mr. D. Donaldson, Rock Hill, Bexar County, Tex., a lot of larvæ of this species—which were subsequently reared to adults—with the report that the species was doing much damage to potatoes. Of this lot, one changed to pupa June 14 and others June 16, the beetles issuing June 28 and July 1, respectively. It will thus be seen that the pupal condition for this season required about fourteen or fifteen days. Pupation took place in an oval cavity in the earth formed by the rolling and twisting of the larva. September 16 Mr. J. H. Wayland, Plainview, Tex., sent beetles with the report that they were numerous and doing much damage to shrubs and vegetables of different kinds by working upon their roots, first cutting small roots and afterwards the tops. From 1 to 50 beetles could be found in the ground around the roots of single vegetables, weeds, and small shrubs.

It is plain from the above that injuries must have been quite extensive in the year 1880.

In September, 1889, Mr. F. M. Webster reported the occurrence of this species in destructive numbers on carrot at Purdue, Ind. The carrots were found to be gnawed to the depth of 2 or 3 inches, the cavities thus formed being large and irregular. Injuries continued during that month and October and up to the 6th of December. (Insect Life, Vol. I, p. 382). During the year 1890 *Ligyrus gibbosus* was reported by Professor Bruner as having been quite destructive to the sugar beet over limited areas toward the western part of the State of Nebraska. It attacked the roots, into which the mature insects gnawed great holes, sometimes entirely embedding themselves. They worked for the most part on old ground and where irrigation was practiced. The work upon the roots extended from the surface to a considerable depth, but was most apparent at about 3 or 4 inches below the surface. In some instances it reached a depth of fully 7 inches (Bul. 23, o. s., p. 17). In 1894 Mr. Webster again reported this species to be destroying sunflowers by eating the roots, the beetles going from hill to hill to continue their depredations. This occurrence took place in Indiana, as before, in St. Joseph County (Insect Life, Vol. VII, p. 206; Ohio Farmer, July 5, 1894, p. 17).

In Bulletin No. 36 of the Mississippi Agricultural Experiment Station, by H. E. Weed (Nov., 1895, pp. 156, 157), an interesting note is published on the occurrence of this species in Mississippi. The injury by the beetles is described as somewhat resembling that of corn billbugs. When a stalk of corn is attacked it presents a wilted appearance, but after a few days of favorable weather it may recover. An excellent illustration of the cause of attack is given, well worth repeating, in Mr. Weed's own language.

> In June of this year many reports were received from Adams County of damage being done by these beetles and we were at a loss as to how to account for the injury. Upon investigation, however, we found the following to be the situation: The beetles were doing damage only in a limited locality, and had done the most damage upon a plantation where some 3,000 head of cattle were pastured last year. The land was not plowed until spring and the corn was planted immediately afterwards. These facts explained the whole matter. The beetles were attracted to the pasture last year by the droppings of the cattle and had deposited their eggs in the grass. The larvæ fed on the roots of the grass last season and changed into mature beetles just before the ground was broken. The corn immediately after was attacked by the beetles, as it was the only vegetation on the land. If the land had not been broken up the beetles would probably have fed on the grass and deposited their eggs as usual.

The substance of this report of injury is repeated in the eighth annual report of the same station (p. 71).

A short general account of this species is given by Messrs. Forbes and Hart in Bulletin No. 60 of the University of Illinois Agricultural Experiment Station (p. 152), which includes an original illustration of the beetle.

SOME DIVISIONAL RECORDS OF ATTACK.

May 9, 1898, Mr. Geo. Davenport, Mer Rouge, La., mailed specimens of this beetle with the report that, although there were few of this insect in corn in that vicinity the previous year, during 1898 they were very numerous. The beetles went down under the surface of the earth and completely shredded the cornstalk between the surface and the roots. They were described as playing havoc with stands of corn in that region. September 19, of the same year, Mr. B. M. Vaughn, Grand Rapids, Wis., sent specimens of the beetle working in carrot tops and in tubers of dahlia.

During 1899, Mr. J. P. Baker, Moody, Drew County, Ark., sent specimens of beetles, June 3, reporting that they were cutting late plantings of small corn and cotton, as many as 7 or 8 being found on a single plant. Older growth of these crops seemed exempt from attack, evidently owing to their firmer, more woody texture. August 28, Dr. W. H. Ridge, Trevose, Pa., sent specimens of the beetle, stating that they had been destroying great quantities of carrots by boring down and eating the roots off, leaving the ground full of holes.

SUMMARY OF FOOD AND OTHER HABITS.

Our knowledge of the life economy of the carrot beetle is still incomplete. It would appear that in many respects it closely resembles the brown fruit-chafer (*Euphoria inda* Linn.), which has been treated in Bulletin No. 19 (n. s.), pages 67–74. Larval injury has been noted, but there is little doubt that the grubs feed also on humus, manure, and decomposing roots and tap roots of herbaceous plants. The writer has observed larvæ feeding in earth where there was no opportunity for plant attack. Most cases of reported injury have been due to the operations of the beetles, and damage is more pronounced on young plants than on older growth, the latter appearing, in some cases at least, to be exempt from attack, owing to their firmer and more woody texture. Injury may be accomplished both by hibernated individuals in the spring from April to June, according to locality, and by recently transformed specimens in late summer and in autumn.

Like the fruit-chafer again, the species is with little doubt single-brooded. Eggs have been observed by the writer June 8 from which larvæ hatched ten days later. Pupation takes place in an oval cavity in the earth, formed by the rolling and twisting of the grub within, as in the case of allied insects; and the observed pupal period is about fourteen or fifteen days in the warm weather of late June and early July. As these observations were made on material received from Texas, it seems probable that farther north, as, for example, along the coast of New Jersey and Long Island, pupation taking place at a later period requires a longer time. Hibernation, without much doubt, occurs in the adult condition. The favorite food of the beetle is evidently carrot, and after this corn in the Southern States; elsewhere parsnip and celery appear to be chosen. Sweet potato and Irish potato are subject to much damage. Sunflower and dahlia are to be included as food plants, and sugar beet is sometimes injured, as is also cotton.

The writer has found the beetles in numbers about the roots of pigweed (Ambrosia), and other persons have noticed them about weeds. Although the species is rather unusually periodical in injurious attack, it is obviously capable of doing much damage in years when it develops in great numbers.

NATURAL ENEMIES AND METHODS OF CONTROL.

One bird, the chuck-will's-widow, is recorded as having fed on the beetles of *Ligyrus gibbosus* at Gainesville, Tex. (Ins. Life, Vol. II, p. 189).

It is to be regretted that when this insect is present in large numbers in cultivated fields there is little, owing to its manner of working, that can be accomplished in the line of control. About the only thing that can be done is to trap the beetles at night by means of stationary lanterns and pans of water placed below the lanterns, on which is floating a thin scum of kerosene. The lanterns should be stationed at intervals about the field, particularly around the borders. The beetles are strongly attracted to electric lights, but it is not certain that they could be lured from the fields after beginning to feed.

A correspondent reports that by scattering lime through infested fields the beetles have been apparently driven away. It is possible that this or some other similar substance might have a deterrent effect, but it is rather doubtful.

After the crop has been harvested, if the insects continue in numbers in the ground, either in the adult, larval, or pupal stage, it would be profitable to turn in hogs, which soon find and root up such insects from the ground. Chickens also learn to follow the plow after these and similar insects. Crop rotation should also be practiced.

THE BEET ARMY WORM.

(*Laphygma exigua* Hbn.)

Simultaneously with the occurrence of the fall army worm (*Laphygma frugiperda*) in the eastern United States in such unusual and destructive numbers in 1899, as previously reported by the writer (Bul. 29, n. s., pp. 5–46), a similar outbreak of a related species known in American literature as *Laphygma flavimaculata* Harv. occurred in Colorado and New Mexico. The outbreak in Colorado has been mentioned by Prof. C. P. Gillette in several publications, but no comprehensive account of the species has yet been published, and recent studies of literature show that there is such a strong possibility of this species becoming a serious pest eastward that it becomes a practical necessity to bring together all that we know about it. All that has been published in regard to its food habits and ravages in America are from the observations of Professor Gillette, but through the kindness of Dr. H. G. Dyar, of the National Museum, I have been referred to numerous articles on this species going to show that it is widely distributed and cosmopolitan, although in the United States restricted to an area considerably west of the Mississippi Valley.

Although this insect is obviously of foreign origin, there is probability of its some time migrating in the same manner as did the Colorado potato beetle in the late sixties and early seventies; and it is nearly equally possible that this insect may become as great a foe to the culture of the sugar and garden beet, as well as to other vegetables, as the Colorado beetle has been to the potato, though this may not happen in the near future. It does not confine itself to foliage, but after devouring this eats off the crown of a plant and then the roots.

DESCRIPTIVE.

This species, as might be expected from their relationship, is similar to the fall army worm in all stages, but the resemblance is not close.

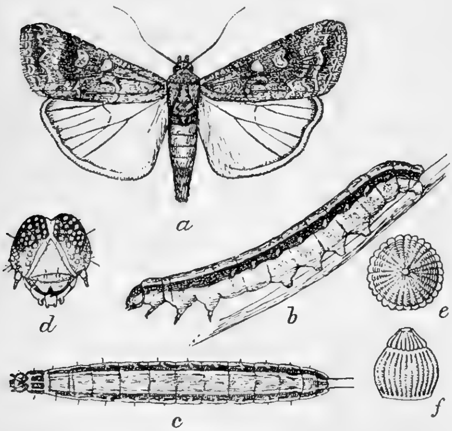

FIG. 8.—*Laphygma exigua*: *a*, moth; *b*, larva, lateral view; *c*, larva, dorsal view; *d*, head of larva; *e*, egg, viewed from above; *f*, egg, from side—all enlarged (*a-d*, original; *e, f*, after Hofmann).

The moth (fig. 8, *a*) resembles more nearly the plain gray form of *L. frugiperda*, but the fore-wings are broader and paler, the reniform and other spots as well as mottlings are more distinct, but the hind-wings differ very slightly, the veins, particularly the central ones, being a little more distinct. The body is of similar color, but a little more slender. The wing expanse is less than an inch and one-fourth.

A technical description is furnished by Hampson (Fauna of British India, Moths, Vol. II, p. 259), which is quoted herewith:

> Pale ochreous brown. Fore-wing with the subbasal, ante-, and post-medial double lines indistinct; the orbicular small and round, pale or ochreous; the reniform usually less prominent, with ochreous or dark center; the submarginal line pale, angled below the costa, and with some slight dark streaks before it at middle; a marginal series of dark specks. Hind-wing semihyaline opalescent white; the veins and outer margin tinged with fuscous.

The eggs are also similar, being ribbed as in the case of most Noctuid moths, but according to the figure and description furnished by Hofmann, they differ by being pyramidal, something unusual in the Noctuidæ. The general appearance of the egg is shown in the illustration at *e* and *f*. It will be noticed that the upper third has the appearance of being surmounted by a cap, and this portion is separated from the lower two-thirds by a white ring.

The larva.—The few specimens of the larva available for description are small or not quite mature, the longest measuring less than an inch and one-fourth, and with much narrower head than that of the fall army worm. The ground color in life is greenish or olivaceous, but this does not show in inflated and alcoholic specimens. The lateral stripe, however, is strongly suggestive of *frugiperda*, although the surface is not marked by the large tubercles present in the latter species. The head is mottled dark brown, with V-mark well indicated; the thoracic plate scarcely different from the abdominal segments save in bearing piliferous warts, while the remainder of the body, with the exception of the head, which is strongly marked with dark brown undulating lines, is faintly clothed, only a few extremely short hairs appearing at intervals. Below the lateral stripe the surface near the spiracles is pinkish. The larva is shown, lateral view, at *b*, and dorsal view at *c*, figure 8; an enlarged section of the first proleg segment of the larva is illustrated in figure 9.

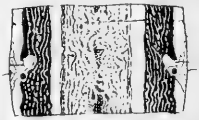

FIG. 9.—*Laphygma exigua:* enlarged section of first proleg segment, dorsal view (original).

Through the kindness of Messrs. Coquillett and Dyar, the following more technical descriptions of the larva are furnished:

The young larva.—The young ones are pale green with a whitish dorsal, subdorsal, and stigmatal line, spiracles white, ringed with black, the head dark brown. Later in life the head becomes green dotted with blackish and the coloring of the body differs considerably in the depth of the coloring even among the different individuals of the same brood and in the same stage of development. In some the ground color is light green, in others the suprastigmal space varies from dark green to almost black.

When first hatched the larvæ spin a web about them and live gregariously for several days, after which they disperse and live separately without any protection. [D. W. Coquillett.]

The mature larva.—Head round, oblique, apex in joint 2; sordid luteous with a few white flecks on the vertices of the lobes; width about 2^{mm}. Body cylindrical, equal, normal, joint 12 scarcely enlarged. Cervical shield smoky or green, cut by three sordid white lines. Green or olivaceous in darker larvæ. A straight subdorsal line a shade paler than the ground color, and a straight broad substigmatal one of the same color but broadly green, filled so as to appear only at the edges, or else in the dark form, blotched in dull red centrally on the segments. Between these lines the lateral space is gray to black, strongly dotted with whitish. Dorsum dotted and lined confusedly in green or blackish, heaviest centrally, defining a narrow obscure pale dorsal line. A bright white speck on tubercle iv, which is at the upper corner of the spiracle. Subventral region pale, mottled in whitish. Feet normal, green, the thoracic ones brown shaded. [H. G. Dyar.]

THE QUESTION OF NOMENCLATURE.

Considering the cosmopolitan distribution of this species, the question of nomenclature becomes important. In Smith's list of Lepidoptera of Boreal America published in 1891 (p. 47) the insect is recorded as *Caradrina flavimaculata* Harv. In its larval as well as adult stage, and in its habits, however, it bears so close a resemblance to the fall army worm (*Laphygma frugiperda*) that it is obvious that the two species belong in one genus. Sir G. F. Hampson in his Fauna of British India (Moths, Vol. II, p. 259), mentions this species as *Caradrina exigua* Hbn., giving a rather long list of synonyms, of which *Caradrina flavimaculata* Harv. is one. He mentions it in Fauna Hawaiiensis (Vol. I, pt. 2, Macrolepidoptera, p. 153) as *Spodoptera exigua* Hbn., again giving *flavimaculata* Harv. as a synonym. In Staudinger and Rebel's "Catalog der Lepidopteren," published in 1901 (p. 195), the species is referred back to the genus Caradrina, with remarks on synonomy and distribution.

DISTRIBUTION.

There can be no doubt that the beet army worm has been introduced, probably originally on the Pacific coast, and has thence made its way eastward to eastern Colorado and New Mexico. With the possible exception of two army worms, the common army worm and the fall army worm (both of which *may* have been introduced originally many years ago from South and Central America), all of the cutworms which are most destructive and assume the army-worm habit in seasons of unusual abundance are of foreign origin. There are no species positively known to be native which migrate in numbers.

In accepting the opinion of European authorities, Meyrick, Staudinger, and Rebel, as to the identity of this insect with the European *Caradrina* (*Spodoptera*) *exigua* Hbn., we must also adopt the credited distribution which shows it to be truly cosmopolitan. Its range thus includes middle and southern Europe, England and its near-by insular possessions, Borkum, Mauritius, Madeira, Canary Islands, Africa, Asia Minor, Syria, Armenia, Japan, China (?), India, Australia, and the Hawaiian Islands.

Harvey described this species in 1876 from material from Oregon and California (Can. Ent., Vol. VIII, p. 54). So far as the writer is aware, however, it has never occasioned injury on the Pacific coast, which is not a little singular, considering the fact that its favorite food plant, sugar beet, is extensively cultivated in portions of California, and that the insect was doubtless introduced there even before 1876. As to its origin, nothing appears to have been surmised. It is doubtless like so many pests, oriental, and perhaps came from India or Australia by way of Hawaii to California.

From present knowledge of its distribution it is obviously capable of flourishing in both the Lower and Upper Austral life zones, and of doing injury even in the Transition, but it may be that it agrees with its congener, the fall army worm, in being better adapted to the Lower Austral zone.

A single specimen was captured in northern Sonora, Mexico (Biol. Centr.-Amer. Lepidoptera Heterocera, Vol. I, 1900, p. 280).

We have little definite information regarding the region of North America which this species inhabits. The list of localities includes Oregon; Los Angeles, San Bernardino, and other points in California; Fort Collins, Palisades, Delta, Grand Junction, and Montrose, Colo.;

Roswell, Mesilla Valley, and Carlsbad, N. Mex. Both the Colorado and New Mexico localities are east of the Rocky Mountain range, and it appears to be only a matter of time when this species will succeed in invading the great sugar-beet regions of Nebraska; perhaps in time it will also travel farther eastward and become a pest in the Eastern States. It does not seem, however, that there is any immediate danger of general spread as in the case of the Colorado beetle; first, because the insect is a general feeder capable of thriving on plants belonging to several botanical orders, and hence does not need to migrate for food; and second, because the migration of the Colorado beetle is something almost unprecedented in entomological history; third, because according to present evidence the insect is Lower Austral and perhaps Tropical in origin, while the sugar beet grows best in the Upper Austral or Transition zones. From observations of Professor Gillette it is obvious also that this insect, like the fall army worm, although it may invade the Upper Austral area, is not apt to survive severe winters; hence, if it becomes introduced very far northward its ravages will without doubt be sporadic and dependent upon the occurrence of winters sufficiently mild to favor its hibernation.

PROBABLE METHOD OF SPREAD.

As previously surmised, this species has doubtless come to our shores from Australia, India, or somewhere else in the Orient, possibly via the Sandwich Islands, and originally through the "Golden Gate," Los Angeles, or at some intermediate point on the California coast. If it was introduced in the northern portion of California, it drifted southward, as would any other species of semitropical or Lower Austral origin (which zones we conclude must have been the original home of the insect). From southern California its distribution eastward was a matter of easy accomplishment, by short flights of the moths aided by favoring winds through Arizona, possibly extreme northern Mexico, and New Mexico, where few high mountains barred its course, to Colorado, where, according to available data, its further spread appears to have ceased.

In some respects this introduction has been accomplished in what we may surmise was the manner of establishment of certain other injurious insects, examples of which are the potato tuber worm (*Gelechia operculella*) and perhaps the imported cabbage web-worm (*Hellula undalis*), both of which inhabit California. They probably originated in the Orient, and evidently followed a similar course, with this difference, however, that as one feeds in the tubers of potatoes and the other in the heads of cabbage, and both are small species, it is more likely that they were introduced in part by "commercial jumps," which accounts for their being found farther east throughout the South. Both have spread to the Atlantic seaboard, the former occurring in North Carolina, and the latter in South Carolina. Neither (so far as records show) has invaded Colorado.

ECONOMIC LITERATURE.

The first account that the writer finds of injury by this species in America is entitled "The Sugar-Beet Caterpillar," and was issued as Special Press Bulletin, dated August 19, 1899, of the Colorado Agricultural Experiment Station, C. P. Gillette being the author. Injury in the vicinity of Palestine, Grand Junction, and Fruita is specially mentioned, and some facts on the insect's occurrence are also given, the main portion of the bulletin, however, being devoted to the discussion of remedies. In Press Bulletin No. 3, from the same station and author, a similar account appears.

During the same year also the writer mentioned furnished for Bulletin No. 26, n. s., of the Division of Entomology, an account of this species and its occurrence during 1899, adding as localities infested Delta, Montrose, and Rockyford. From this it appears that although beets were principally devoured, the caterpillars also attacked potato, which in some cases suffered badly, as also small fruit trees where beets were planted in orchards.

In a report of the same writer (12th Report Agl. Expt. Sta. of Colorado for 1899–1900, p. 39) similar injury is cited, the estimate being made that two or three hundred acres of beets were completely ruined in three localities during August. The insect matured in enormous numbers, and was noted to be passing the winter as a moth.

The same writer published in the 22d Annual Report of the State Board of Agriculture of Colorado some additional facts in regard to this insect's life economy (pp. 128–129). This account states that the species disappeared as suddenly in 1900 as it had appeared the preceding season. Since parasitism was not especially noticeable, it was surmised that the insect failed, although for no assignable reason, to properly survive the winter. Three new food plants were added to the list previously furnished, including lambsquarter (Chenopodium), Russian thistle, and saltbush (Atriplex). Mr. E. D. Ball observed that the moths were flying abundantly about the middle of May; caterpillars began hatching the first week in June, and by the middle of that month were abundant. Their ravages were worst on earliest planted beets, late plantings suffering injury only when near weeds or patches of early beets. Thousands of the worms were seen migrating, and they were found to travel two or three feet a minute.

In "The Economic Entomology of the Sugar Beet" (Bul. No. 60, Exp. Sta. Univ. Ill.), by Messrs. Forbes and Hart, an account of this species also appears in which some new facts are given. These include wild sunflower, Cleome, pea, and leaves of apple as food plants, the data having been derived from observations communicated by Professor Gillette. It is stated that this species evidently hibernates as a moth, and at least two generations of larvæ may be expected each year—the first about June, and the second in August.

A similar account to the last is given by Prof. E. D. Sanderson in "Insects Injurious to Staple Crops," page 262.

An account of this species and its habits, as occurring in Europe, was given in 1893 by Dr. Ernst Hofmann in "Die Raupen der Gross-Schmetterlinge Europas," page 109. This includes a characterization of the genus and descriptions of all stages, with figures of the egg and larva.

The following synonymical list is furnished by Hampson (Fauna British India, Moths, Vol. II, 1894, p. 259):

Caradrina orbicularis, Wlk. Cat. x, p. 294.
Caradrina venosa, Butl. Ent. Mo. Mag. xvii, p. 7; C. & S., no. 2115.
Spodoptera cilium, Guen. Noct. i, p. 156; C. & S., no. 2117.
Spodoptera insulsa, Wlk. Cat. xxxii, p. 648.
Spodoptera erica, Butl. P. Z. S., 1880, p. 675.
Laphygma cycloides, Guen. Noct. i, p. 157.
Laphygma macra, Guen. Noct. i, p. 157.
Laphygma? caradrinoides, Wlk. Cat. ix, p. 190.
Caradrina flavimaculata, Harv., Grote, New Check-list, p. 30.
Caradrina insignata, C. & S., no. 2112 (*nec* Wlk.).

Huebner's description appeared some time in the early part of the century in Sammlung europäischer Schmetterlinge, Noct. fig. 362. This publication, however, is not available at the present writing, and the exact date of its issuance can not be determined.

RECENT DIVISIONAL REPORTS OF INJURY.

The first intimation that the writer had of the occurrence of the beet army worm in injurious numbers in this country was received through Prof. J. B. Smith, who wrote in February, 1900, that it had been reported by Professor Gillette as destructive in Colorado during the season of 1899. In response to inquiry, Professor Gillette wrote that there had been a considerable outbreak in Colorado during that summer, and prior to that season only three specimens of the insect had been present in the college collection. The caterpillars were very abundant during August at Grand Junction, Palisades, Delta, and Montrose, and specimens of the insect were also received from Rockyford, where they were reported to depredate on beets. Hundreds of acres of beets were not harvested because of the ravages of this species in the region about Grand Junction.

It was noticed that but little destruction of the last brood by insect enemies was observed, and that the moths appeared during the latter part of August and September in prodigious numbers.

"The moths spend the winter evidently in hibernation," since examination of the ovaries of many of the females appearing in the fall failed to show the ova developed in any case.

During the same season Mr. Vernon Bailey, of the Biological Survey of this Department, observed this beet army worm in large numbers on the foliage of young sugar beets in a field near Eddy, now Carlsbad, N. Mex. According to Mr. Bailey's notes (which were accompanied by specimens), the first occurrence was noted June 19, 1899, and the larvæ were doing much damage to sugar beets in the Pecos Valley near Roswell and Eddy. Extensive areas, including in some cases entire fields, were destroyed, necessitating replanting and sometimes the abandoning of the crops. The crop of that region was generally injured. Mr. Bailey informs the writer that a sugar-beet factory started at Eddy has since been put out of operation, and sugar beets have been raised there since only to a limited extent for feeding stock. The cultivated portion of the valley lies mainly in the Lower Sonoran life zone, but is so near the Upper Sonoran zone as to have a mixture of the species from the latter.

During the summer of 1901 Mr. A. N. Caudell, of this office, spent some time in the collection of insects in portions of Colorado, and gathered some material found injurious to cultivated crops. Among this was the beet army worm, all stages of which were found on sugar beet at Palisades, Mesa County, and at Delta. At the latter place larvæ were captured also on table beet, although they did not occur on this variety of the plant in injurious numbers.

In a letter dated February 4, 1902, Prof. T. D. A. Cockerell furnishes the writer the information that this species, which he listed on page 35 of Bulletin No. 24 of the New Mexico Agricultural Experiment Station, as occurring in Mesilla Valley, New Mexico, had been reared by him from the larva depredating on cultivated onion.

EARLIER RECORDS.

The first record that appears to have been made, unpublished hitherto, however, was by Mr. D. W. Coquillett, when employed as field agent of this Division in California. May 25, 1882, he found the larva at Anaheim, Cal. The following day the larvæ spun their cocoons, and moths began issuing on the 14th of the following month. At the latter date more larvæ were found, of all sizes, feeding on corn, *Chenopodium album* and *Amaranthus retroflexus*. Some of the largest were placed in rearing cages, and June 22 crept beneath the litter in the cages and spun very thin cocoons. The moths issued the second week in July. An extended search for larvæ was made in the field July 8, but without success. November 5 still other larvæ were found in the above-mentioned locality feeding on a species of mallow (*Malva borealis*). Some of these began spinning their cocoons three days later, and by November 14 all had spun up. Two produced moths December 12. October 24, 1886, a larva was found at Los Angeles, Cal., feeding on *Nicotiana glauca*. This produced a moth November 21. Two years later, February 18, Mr. Coquillett captured a moth much worn.

The above notes are of particular interest as showing new food plants and as verifying Professor Gillette's observations on the hibernation of the species in the adult condition.

We would naturally expect a somewhat different life history as regards dates of appearance and disappearance in localities in southern California, so different from that of Colorado. According to Mr. Coquillett's observations, moths were rare in April, but became abundant the latter part of May and during June. Adopting the hypothesis, if it can be called such, that hibernation takes place as moth, some moths must appear in early April in order to produce mature larvæ as early as May 25. With the somewhat incomplete notes on actual field observations, it would appear that this species, like many other Noctuids, such as common species of cutworms, has a spring brood and a late autumn brood, but differs from most cutworms in the stage of hibernation. Between the first and second generations there is evidently a very long season of æstivation or complete quietude passed under the ground when the larva does not feed.

SUMMARY OF FOOD PLANTS.

As with other larvæ that frequently or occasionally migrate in numbers, the beet army worm is liable to attack most forms of vegetation in its line of march. Sugar beet appears to be the favorite host plant, but table beets are also relished, and the larvæ feed quite as well on lambsquarters (Chenopodium) and pigweed (Amaranthus). They also attack saltbush or saltweed (Atriplex), all plants rather closely related to beets. When numerous they affect corn, potato, pea, onion, wild sunflower, the leaves of apple, mallow (Malva), *Nicotiana glauca*, Cleome, and plantain (Meyrick). They are also said to feed on wild grasses.

NATURAL ENEMIES.

A single enemy appears to be recorded for the beet army worm, a Tachina fly, reared at this office May 29, 1897, from a caterpillar received May 17 of that year from Mr. S. A. Pease, San Bernardino, Cal. This is *Frontina archippivora* Will., a rather common species on the Pacific coast, although it occurs eastward also. It is a parasite of *Agrotis ypsilon*, a destructive cutworm, as well as of other moths and some butterflies (Tech. Ser., No. 7, Div. Ent., p. 15).

METHODS OF CONTROL.

Several remedies were tried in Colorado during the year of greatest infestation there with satisfactory results. These included Paris green and kerosene emulsion. Both killed the insects, checking their numbers for the following year. Paris green was applied in the form of a spray and dry, mixed with flour. Used with flour it cost about 80 cents an acre. Two sprayings with the liquid preparation were found to be most effectual.

When this species occurs in fairly injurious numbers the remedies that have been specified should be sufficient. When it is unduly abundant, however, army-worm remedies should be applied. The latter form of remedies is discussed in Bulletin No. 29 (n. s.), a copy of which will be furnished to anyone desiring it.

NOTES ON WEBWORMS.

During the last two years three species of webworms that occur in gardens and do more or less injury to various crops have been reported as the cause of damage in various parts of our country. These are the garden webworm, beet webworm, and imported cabbage worm, each of which will be considered under a separate heading.

THE GARDEN WEBWORM.

(*Loxostege similalis* Guen.)[a]

The reported injurious abundance of the garden webworm during the year 1900 in localities in three different States indicate that this species was somewhat generally destructive in that region that year. It is rather singular that, although the insect is widely distributed, real injuries by it appear to be confined to the States bordering the Mississippi River in the South. Some of the notes given show that it has even a longer list of food plants than have yet been credited to it.

May 14, 1900, Mr. J. D. Mitchell, Victoria, Tex., reported this webworm as abundant in his vicinity, where it was known locally as the grass worm, a name which it shares with the better-known grass worm or fall army worm (*Laphygma frugiperda*). Its favorite food in that

[a] In early works this species has been generally referred to *Eurycreon rantalis* Guen., and now to *Phlyctænodes similalis* Gn. The following synonymy is credited by Sir G. F. Hampson (Pr. Zool. Soc. Lond., p. 210, 1899), in addition to eight names bestowed by Walker:

Phlyctænodes similalis Guen. Delt. & Pyr., p. 405.
Nymphula rantalis Guen. Delt. & Pyr., 405.
Botys posticata Grote and Rob. Trans. Am. Ent. Soc., 1, p. 22, pl. 2, f. 25.
Eurycreon communis Grote. Can. Ent., ix, p. 105.
Eurycreon occidentalis Pack. Ann. N. Y. Lyc., x, p. 260.

The list of Walker's names includes: *Ebulea murcialis*, *Botys licealis*, *B. siriusalis*, *Scopula nestusalis*, *crinisalis*, *thoönalis*, and *diotimealis*, and *Nephopteryx intractella*.

locality, according to our correspondent's observations, appears to consist in the finer and softer forms of grasses, such as buffalo, crab, and joint grasses. In some seasons the caterpillars did great damage in patches. In ordinary years they were found here, as elsewhere, "worming" the so-called "careless weed" (*Amaranthus* spp.), particularly in cotton fields. When other foods failed the larvæ attacked young cotton, but if the field was kept clean and well cultivated it was not injured. June 13 Mr. W. J. Patton, Springdale, Washington County, Ark., gave information that the moths were found everywhere in field and orchard in prodigious numbers, and that the greatest apprehension was felt lest the larvæ which would develop from the eggs deposited by the moths would do great damage. July 24 Prof. H. A. Morgan, Baton Rouge, La., wrote that this webworm was a pest upon cotton and alfalfa in the northern portion of his State.

In the three instances of injury that have been cited communications were accompanied by specimens.

The larva at maturity is somewhat variable in color, but such individuals as have come under the writer's notice from different sources are usually dull pale green above and dull greenish yellow on the lower surface. The dorsal surface is strongly marked with large shining jet-black piliferous spots, more or less distinctly relieved by a paler border, and there is a median double pale line in well-marked individuals and a lateral single whitish line, while below this line the piliferous spots are lighter. The head is dull gray, mottled with brown. The hairs proceeding from the tubercles are mostly single and black; some are in pairs, and those of the dorsal surface are surrounded by a small area of white, and of the ventral surface by a much larger area. Just before transformation larvæ become paler yellow. The length when full grown is a little less than an inch ($21\text{–}23^{mm}$).

ORIGIN AND DISTRIBUTION OF THE BEET WEBWORM.

(*Loxostege sticticalis* Linn.)[a]

For some reason writers on this species, which is shown in fig. 10, appear to have overlooked the fact that it is not native, but introduced from abroad, presumably on the Pacific coast, whence it has found its way eastward to Colorado and Nebraska. From specimens in

[a]The following synonymy has been indicated by Hampson (Proc. Zool. Soc. Lond., 1899, p. 211):

Phlyctænodes sticticalis Linn. Faun. Suec., 1354.

Pyralis fuscalis Hübn. Pyr. f., 45.

Pyralis tetragonalis Haw. Lep. Brit., p. 385.

Pyralis lupulina Cl. Icon., pl. ix, f. 4.

The species is mentioned by Kaltenbach as *Botys sticticalis* Linn., and Meyrick (Handb. Brit. Lep., 1895, p. 418) preserves the better-known name of *Loxostege sticticalis* Linn.

the National Museum it seems that the insect was collected at Palmer, Utah, in July, 1869, which is evidence that it must have been introduced many years earlier. In 1873 it was found in central Missouri. It has been taken by Messrs. Dyar and Caudell in Denver, Salida, and Sedalia, Colo., by Cockerell on the top of the range between Sapola and Pecos rivers in New Mexico at about 11,000 feet elevation. It is also recorded from Winnipeg, Manitoba, as well as from several localities in Nebraska, Kansas, and Michigan. It does not appear to have been observed in Illinois, although search has doubtless been made for it on sugar beets cultivated in that State. Dr. Dyar, in a note to the writer, generalizes that the species is rather common throughout the Rocky Mountain range.

Meyrick records this species as inhabiting England, Ireland, western and central Europe, and northern Asia, as well as North America, and mentions its occurrence on the upper side of the leaves of *Artemisia vulgaris* and *campestris*. Kaltenbach also records Artemisia as a food plant.

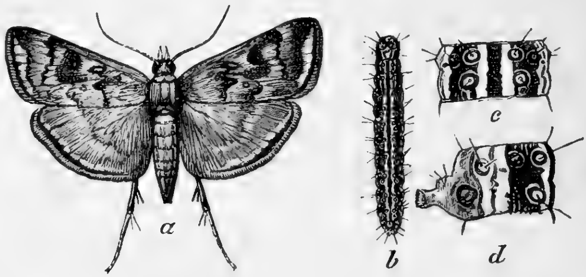

FIG. 10.—*Loxostege sticticalis*: *a*, moth, twice natural size; *b*, larva, less enlarged; *c*, upper surface of first proleg segment of larva; *d*, side view of same, *c*, *d*, more enlarged (reengraved after Insect Life).

There seems no reasonable doubt that we have another case of introduction from Asia into the Pacific States of this country, analogous to that of the beet army worm treated in preceding pages. There is this difference, however, that the present species was introduced many years earlier, has a much wider range, and is capable of sustaining life in several zones, from the Lower Austral, perhaps to the Transition. There is no doubt about the establishment of the species in the Colorado localities, but larvæ do not appear to have been observed in the localities mentioned in New Mexico and Manitoba, which are obviously transitional.

THE IMPORTED CABBAGE WEBWORM.

(*Hellula undalis* Fab.)

Up to November 19, 1900, only one complaint of injury effected by the imported cabbage webworm reached this office. It was, however, reported from a new locality in Georgia by Mr. H. Walter McWilliams, of Griffin, in a letter dated November 15. He stated that this insect had been very destructive during the season. December 1 he sent specimens, and stated that the insect had cost some of his neighbors several hundred dollars, the larvae having simply eaten the buds from all the ruta-bagas and turnips in the settlement, causing the plants to rot and fail to develop roots. May 7, 1900, Mr. J. H. Heard, Montreal, Ga., wrote that this webworm had made its appearance in his vicinity the previous year.

During 1901 Mr. W. M. Scott, State entomologist, Atlanta, Ga., wrote, July 1, that this species was still prevalent in southern Georgia. During 1900 it appeared in injurious numbers at Augusta, Tifton, Albany, Marshallville, Fort Valley, and Meansville, its occurrence in these localities indicating that it was generally distributed throughout the southern part of that State. A Mr. Long, Leesburg, Ga., had informed Mr. Scott that only the week before writing this webworm had practically precluded the possibility of growing late cruciferous vegetables in that section. In 1900 his crop of late turnips was entirely destroyed by this pest as if by fire. October 28 Mr. H. Walter McWilliams reported this species still present at Griffin, Ga., and likely to remain. It devoured cabbage, ruta-baga, turnip, rape, etc. He had tried several mixtures, but without any noticeable good effects. November 9 Miss Blanche Dix sent larvae of this species from Beech Island, S. C. In an earlier letter she referred to having observed this species present on cruciferous crop plants in that locality.

THE RED TURNIP BEETLE.

(*Entomoscelis adonidis* Pall.)

In a letter dated March 9, 1900, Mr. Percy B. Gregson, Waghorn, Alberta, Northwest Territory, wrote that this species was very abundant in several districts in his vicinity, and that even so late as October, 1899, he had letters from farmers complaining of it. June 29 our correspondent sent specimens of the beetles noticed *in coitu* at the time of gathering them, and when they reached this office July 9, eggs were found in the soil in which they had been packed. In 1901 this insect was also troublesome in the same region.

This species is occasionally troublesome through its ravages on turnip, cabbage, and other crucifers in the Northwest. Up to date, however, it has attracted little or no attention in the United States, receiving frequent mention, however, in different Canadian publications, chiefly by Dr. James Fletcher, in his annual reports as Entomologist and Botanist of the Dominion of Canada.

DESCRIPTIVE.

The beetle.—The adult of this insect, as its common name would indicate, is red; at first glance nearly scarlet. The under surface of the body is black, as are also the eyes, legs, and antennæ. The dorsal surface is mostly red, with the middle portion of the thorax black. The elytra are ornamented with three stripes, a rather narrow sutural one, and a shorter black stripe on each side, about midway between the suture and the margins. (See fig. 11.) The punctation of the elytra is dense and rather fine. The form of the body is elongate oval. The length is about one-fourth inch or longer. The species belongs to a genus represented by several forms in Europe, but it is the sole representative of its genus in this country. Zoologically, Entomoscelis is placed near Chrysomela; hence this insect is a relative of the Colorado potato beetle (*Chrysomela* [*Doryphora*] *decemlineata*). It is characterized by having a long metasternum and closed front coxal cavities, having the tibiæ gradually but not strongly dilated at the apices, the outer face deeply concave, the distal edge obtusely angulated, and the claws simple.

FIG. 11.—*Entomoscelis adonidis*—much enlarged (original).

The egg is elliptical in form, twice or a little more than twice as long as wide at its greatest diameter, deep blood-red in color, and finely hexagonally granulated, the areas being just discernable with a one-fourth-inch hand lens. Length, 1.50 to 1.60^{mm}; width, 0.75 to 0.80^{mm}.

The larva has been fully described by Doctor Fletcher and others, who will be quoted. When first hatched it is orange, with black spots, but turns black in twenty-four hours. It is then wedge-shaped, and measures about 2^{mm} in length. It undergoes two molts. In the second stage it measures 3.25^{mm} when not extended. The body is now slug-shaped, flattened below and rounded above; not narrowed at the thorax, as is the case with the larva of the Colorado potato beetle. In the third stage the larva measures about 5^{mm}, and does not differ materially from the second stage. When fully mature the larva reaches a length of about one-half an inch (12^{mm}).

The pupa is bright orange in color, the wing, antennal, and leg cases, honey-yellow, the first mentioned bearing each three longitudinal striæ.

DISTRIBUTION.

This species is common to North America, Europe, and Asia, and evidently belongs to what is known as the circumpolar fauna; in other words, it is not of recent introduction, but is native to the boreal regions of both the old and new world.

According to Doctor Hamilton (Trans. Am. Ent. Soc., Vol. XXI, 1894, p. 397), it is to be found everywhere through the Rocky Mountains at 8,000 to 11,000 feet elevation (Bowditch). A more exact list of localities includes Montana, Hesterburg's Lane, Colorado (Cockerell); British Columbia; Fort Simpson and Mackenzie River, Alaska (Leconte); the Hudson Bay region, Minnedosa, Elkhorn, Brandon, and

Lorlie, Manitoba; Alberta, Saskatoon, Yorkton, Grenfell, Pheasant Forks, and Regina, Northwest Territory. According to Fletcher, it is rare toward the eastern and western limits of its range. The foreign distribution comprises southern Europe, including France, Austria, Germany, Roumania, Western and Eastern Siberia to Turkestan.

DIVISIONAL RECORDS.

Writing December 1, 1900, Mr. Gregson stated that immediately after the receipt of the writer's letter, dated August 22, he paid a visit to the farm where Swede turnips were being injured by this species. Many of the beetles were still feeding, and he succeeded in securing a number of eggs, as many of the individuals captured were in copulation. About this time the weather turned very cold, snow falling to a depth of many inches, with an extremely low temperature for September, the result being that none of the eggs hatched. The eggs obtained by the writer at Washington during the extremely hot weather also failed to hatch.

These observations are in uniformity with those made by M. Lesne in Roumania and Dr. Fletcher and his correspondents in the Northwest Territory of Canada, conclusively showing that eggs do not hatch until the following spring.

According to Mr. Gregson's observations, the eggs are never found on growing foliage. They are deposited invariably under dead leaves and in similar rubbish on the ground, or under a small clod of earth or other shelter about the roots of turnip or other food plant. The larvæ appear to attack plants chiefly at night.

Writing August 15, 1900, our correspondent stated that he had recently left a district very badly infested with this species. One of the farmers whose crop was inspected had just planted out his third lot of young cabbages, and had also resown his turnips three times, each crop having been destroyed by this pest, larvæ and beetles of which were at work.

September 6, 1901, Mr. Gregson stated that he had kept careful watch for this species during the year, and had made special visits to farms where in ordinary years he had always reckoned on finding plenty of the beetles. He had also received letters from different farmers who had been on the lookout for this species, but the insect had apparently entirely disappeared, at least temporarily, from that portion of Alberta, Northwest Territory. It is probable that atmospheric conditions have been responsible for the insect's nonappearance during the year. In that vicinity an unprecedentedly wet year was experienced in 1900, and a still wetter spring and summer followed in 1901. Assuming that this has been prejudicial to the beetles, it is quite evident that this species is largely dependent upon the weather for its multiplication, and that it prefers dry weather. This statement is borne out by M. Lesne, who writes that "droughts favor its multiplication while cold and rainy weather greatly retard it." Had it appeared in considerable numbers, Mr. Gregson writes he would certainly have heard of it.

HISTORY AND LITERATURE.

Entomoscelis adonidis was given its specific name by Pallas in 1771 (Reisen durch versch. Prov. des Russ. Reiches, etc., Vols. I, 2, p. 463), the description appearing under the genus Chrysomela. It has also been placed in the genus Phædon (Kirby, Fauna Bor. Am.) and was described by Fabricius as *trilineata* (Gen. Ins. Mant., 1777, p. 219). Künstler, Köppen, Weise, Tömösvary, Lesne, and other European writers have furnished descriptions of the larva. (See Rupertsberger Biol. Lit. Käfer Europas von 1880 an. etc., 1894, p. 259.)

Rape (*Brassica napus*), *Cochlearia draba*, butter-bur (*Petasites petasites* [*officinalis*], and *Adonis autumnalis* have been recorded as food plants by European authors, as also thistle and barley (Korn).

Of recent publications the reader is referred to Erichson's Naturgeschichte der Insecten Deutchlands (Vol. VI, p. 310–312) and Lesne in the Annales de la Société Entomologiques de France for 1890 (Vol. VI, pp. 177–179, figs. 1–9), for technical descriptions and bibliography, as also to Dr. Fletcher's works, which will presently be mentioned. M. Lesne's article is accompanied by an illustration of the larva.

What appears to be the first instance of attack by the red turnip beetle on cultivated plants in America was recorded by Dr. Fletcher in his report as entomologist and botanist for the year 1887 (1888, p. 19). He states briefly that he collected this species on turnips at Regina, Northwest Territory, in August, 1885. The beetles were noticed to be sluggish in their habits, like the Colorado potato beetle, and it was said that they did not occur in sufficient numbers to do much injury, although they were sufficiently abundant to show that with the increase in cultivation of its food plant the species might in time develop into a troublesome pest.

In his report for 1891 (1892, p. 202), the same writer gives additional notes in regard to the occurrence of this species in Northwest Territory and Manitoba. Extracts from correspondence are given from six different localities showing attack on turnip, cabbage, and radish, it being noticed that rutabaga was very little troubled, provided other more preferred crucifers were available. The choice food plant appeared to be rough-leaved varieties of turnip in preference to smooth-leaved varieties and some other plants.

In his report for the following year (pp. 152–155) Dr. Fletcher gave a still longer account of this species, with extracts from correspondence from several sources and detailed descriptions of the different stages with references to European publications.

In 1893, according to the same writer's report for that year (1894, p. 17), the species again attracted attention, it being noticed that the beetles made their first appearance according to Mr. Thomas Copland, Saskatoon. Northwest Territory. June 17, and that the beetles fed upon a common cruciferous weed, the prairie wall flower (*Erysimum parviflorum*).

Brief mention is made of this insect by Dr. Fletcher in the Transactions of the Royal Society of Canada for 1899–1900 (vol. V, 2d ser., p. 212).

NATURAL HISTORY.

From the sources of information that have been furnished, it appears that eggs are laid normally in autumn, although sometimes earlier, and that the species hibernates in this stage. The larvæ hatch in early spring long before cultivated crucifers appear above ground. According to Dr. Fletcher, the larvæ feed both in the daytime and by night, and are comparatively active, although, as is well known, the larvæ of the larger leaf-beetles are mostly rather sluggish. When disturbed they drop from their food plant.

The beetles seem to make their first appearance in the Northwest Territories during July and August, and do their worst injury throughout September, continuing in the field in some instances as late as October. The occurrence of the beetles in the latter part of June, as noted by Mr. Gregson, at Waghorn, is perhaps rather exceptional.

Eggs are laid in clusters, loosely fastened together in the same manner as those of the Colorado potato beetle, and are deposited under clods or in cracks in the soil in similar locations.

Larvæ have been noticed to bury themselves in the earth to a depth of about an inch, and to change at once, in small smooth cavities, to pupæ.

REMEDIES.

The measures to be employed for the destruction of this turnip beetle are practically the same as those used against the Colorado potato beetle. Paris green is the best of these, and may be applied dry, mixed with from ten to twenty parts of cheap or spoiled flour, fine plaster, or air-slaked lime; or as a spray, mixed with lime or Bordeaux mixture at the rate of a quarter of a pound of the Paris green to 40 gallons of the diluent. In order to insure success, where the insect abounds in great numbers the wild food plants of the insect should also be treated.

Hand-picking or jarring the beetles from infested plants into pans or other receptacles containing a little water on which a thin scum of kerosene is floating may also be employed. It follows, as a matter of course, that rotation of crops is advisable; and the planting of crops subject to the attack of this species, particularly crucifers, should be avoided in the vicinity of wild plants affected by the same species.

THE CROSS-STRIPED CABBAGE WORM.

(*Pionea rimosalis* Guen.)[a]

This destructive enemy of cabbage and other cruciferous crops, after an apparently complete absence from the neighborhood of the District of Columbia in 1899 made its appearance in great numbers in May and June of 1900 in different fields of cabbage at Brookland, D. C., and was found later in most gardens in which cabbages were grown in near-by localities in the neighboring States of Maryland and Virginia. In nearly every case that came under notice that year the species was much more abundant on cabbage than the larva of the common imported cabbage butterfly (*Pieris rapæ*), and it was noticed that although it works in much the same manner as this latter species, it dug still more deeply into the heads, and in many cases completely destroyed cabbage by eating out the hearts while young and tender.

The insect continued to be the most destructive cabbage pest in this vicinity until late August, when it was replaced by the cabbage looper, and in some restricted localities and on other plants than cabbage—horse-radish, for example—by the harlequin cabbage bug.

This species first became known as an enemy of cruciferous crops over twenty years prior to the date of writing, but since that time has not attracted the attention that would seem to be warranted by its manner of attack. For some reason it does not seem to have multiplied to any great extent during that time, except locally, until 1900. When conditions favor its increase there is no reason why it should not take rank as one of the foremost cabbage pests.

DESCRIPTIVE.

The moth is pale ocher yellow in color, the fore-wings much suffused with fuscous and brownish black, the pattern formed being about as shown in fig. 12, *a*, subject to some variation. The hind-wings are paler, nearly transparent except at the anterior angle, where they are infuscated. There is also a row of five or six small, dusky spots between the middle of each hind-wing and the inner border. The wing expanse is about 1 inch (25^{mm}), and the length of the body less than half an inch (10^{mm}).

The eggs (fig. 12, *b*) are laid in masses, and, being flattened and overlapping like the scales of a fish, strongly resemble the masses deposited by Tortricidæ. The outline of an individual egg is rounded oval, the longest diameter being 1.2^{mm} and the shortest diameter 0.9 to 1.0^{mm}. The eggs are rather bright light yellow in color, and so thin that the green of the leaf on which they are deposited can be seen through

[a]This species has been restored to the genus Evergestis by Sir G. F. Hampson (Rev. Pyraustidae, Pt. II, Pr. Z. S. Lond., p. 186, 1899), and the genus Pionea is reserved for other species.

the middle, the yellow color showing strongest about the margins. The sculpture is fine, but strong and very irregular, the areas showing as irregular triangles, quadrangles, and pentagons (*c*). They are usually deposited on the under surface of the leaf and in masses of from one to two score, although smaller masses of from two to three or five eggs are not uncommon.

The newly-hatched larva is nearly uniform gray in color, with small black tubercles and no visible evidence of striation. The head is round and prominent and nearly twice as wide as the body, and the hairs of the body are sparse and about as long as the width of the head.

The full-grown larva.—The larva when mature is bluish-gray above, with conspicuous transverse black stripes. The head is yellowish or light brown, the thoracic plate mottled (fig. 12, *d*), and each segment has three or more well-defined, nearly straight or curved, transverse stripes. (On the second and third thoracic segments the first stria curves forward between the anterior tubercles.) The dorsal tubercles,

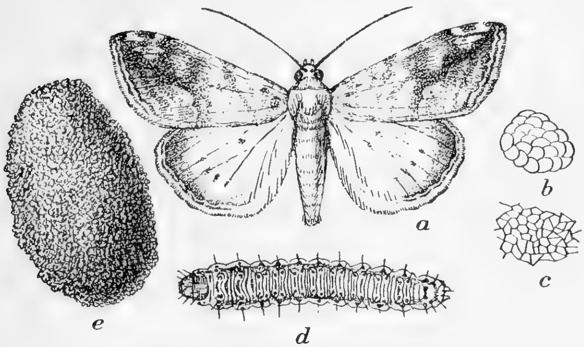

FIG. 12.—*Pionea rimosalis:* *a*, moth; *b*, egg mass; *c*, sculpture of egg; *d*, larva; *e*, cocoon—*a*, *d*, *e*, twice natural size; *b*, much enlarged; *c*, more enlarged (original).

of which there are two pair of prominent ones in each segment, are gray, partially encircled with black. There is a wide stigmatal line of bright yellow extending from the second to the last segments, and above each spiracle there is a large prominent black tubercle. The ventral surface is green, somewhat mottled with yellowish, and the tubercles bear each a long, black hair about half as long as the width of the body. In form the larva is subcylindrical, moderately slender, about six times as long as wide, and the segments of the body show strongly at the sides. The length of the mature larva is about six-tenths of an inch, 15^{mm} in repose, 17^{mm} when fully extended, and the greatest diameter is about 2.5^{mm}.

The pupa is of the usual pyraustid form, the wing-cases and head dark brown and the abdomen light yellowish brown. "Head small, rounded, with a slight transverse notch anteriorly; wing, antennal and posterior leg-sheaths extending nearly to tip of fifth abdominal joint. Abdominal joints with sutures plainly marked, the two terminal joints closely welded together and forming a conical tip, at the extremity of which are two very minute brown tubercles" (Riley). The length is 11 to 12^{mm}, or a little less than half an inch.

The cocoon.—Transformation to pupa takes place in a cocoon formed of earth and constructed near the surface. The appearance of a cocoon is well illustrated at *e* of figure 12. The measurement is a little less than five-eighths of an inch in length, and three-eighths of an inch in diameter. The outer grains of sand are rather loosely held together, but the interior is fairly substantial, the lining being of light-gray color, nearly white.

DISTRIBUTION.

So far as the writer is aware, no comprehensive list of localities of this species, or other data that give any idea of the insect's distribution, have ever been published. From material received at this office and at the National Museum, and from reports of correspondents, the following list of localities has been compiled:

Newark and Dover, Del.; Cabin John, Marshall Hall, and elsewhere in Maryland; Cameron's Mills, Carterton, Chesterbrook, St. Elmo, and Alexandria, Va.; Brookland and elsewhere in the District of Columbia; Lexington, Ky.; Springfield, Ohio; Aurora and Lafayette, Ind.; Mount Juliet, Tenn.; Carbondale and Anna, Ill.; Raleigh, N. C.; Montreal, Athens, Macon, and Storeville, Ga.; Alabama; Lone Star, Oxford, and Agricultural College, Miss.; West Point, Nebr.

From the above list it would seem that the southern distribution of this species and its southern origin are well established. The moth has been recorded as occurring farther west and north, but injurious occurrences are lacking, at least in reports of injuries sent to this office. It seems, therefore, that the species attains its highest development in the Lower Austral life zone, although occasionally it invades the Upper Austral and even, perhaps, the Transition area. This, however, is only temporary.

RECENT INJURY.

During 1899 we received this species from Mr. E. Dwight Sanderson, at that time at Raleigh, N. C., September 18. They were found in numbers on cabbage. July 28, Mr. S. S. Simms, Storeville, Forsyth County, Ga., sent this species, also found on cabbage. September 18, Mr. Thos. I. Todd, Athens, Ga., sent the species, with the accompanying information that it did great damage that year feeding in the buds and tender leaves of cabbage and turnip, and stated also that it was known as "the common webworm," in contradistinction to the imported cabbage webworm (*Hellula undalis*). He stated that this species succumbed to Paris green and pyrethrum dusted upon the plants, where the imported species did not.

In 1900, Mr. J. H. Heard, Montreal, Ga., sent this cabbage worm, July 5, with information that it was concerned in attack on cabbage in that vicinity. We received, August 6, specimens of this species from Dr. E. K. Harding, Carterton, Va., where they were attacking cabbage.

NUMBER AND OCCURRENCE OF GENERATIONS.

Observations conducted during the season of 1900 indicate the presence of four generations in the District of Columbia and vicinity. From larvæ obtained in the latter days of May and in early June in different fields of cabbage, in and near the District of Columbia, moths were obtained during the last days of June and until July 6.

The second generation produced from the first of these moths and placed in a rearing cage July 2, issued August 1, having passed all stages in just thirty days, which will come very near to being the minimum period for this latitude, since the heat was excessive during the greater part of the month of July.

The third generation began to appear in the rearing cages, on September 1, from moths which issued August 1, or in thirty-one days, the temperature during that period, with the exception of a few days, having been about the same as in July.

The fourth generation, as might naturally be expected, failed to develop in confinement, and it seems probable that this was the last generation produced in the field. This was only apparent, however, for after repeated failures to find the larva in the field, a colony was taken September 21 in a small head of cabbage. This last colony was obtained on the Department grounds, and was evidently the progeny of moths which had purposely been liberated from our rearing jars, so that it represents in all probability the normal fourth generation.

It must not be supposed from the above that there is any such regularity of development except in a single season and in a given locality. At other times, from specimens gathered where the temperature was somewhat different, moths were reared July 14; larvæ were obtained, nearly all mature, July 30. From other lots moths have issued August 9 and 10. In one instance larvæ were noticed to mature August 20, and to develop as moths September 1, giving ten days for the period occupied by the larva in the cocoon. Perhaps two or three days elapsed before the larvæ changed to chrysalides. In still another case larvæ were found to enter the earth August 29 and 30, and moths developed September 9, giving about the same period as just mentioned.

SUMMARY OF LIFE HISTORY.

Observations conducted by the writer go to show that in many respects this cabbage worm, although the larva of a moth, conforms very closely in its life economy to the imported cabbage butterfly. It is attacked by some of the same natural enemies, and appears to differ from the imported species only in unimportant details. Like the imported worm, it makes its first appearance some time in April in the vicinity of the District of Columbia.

The eggs hatch in six days in hot July weather, a longer time being required in a cooler atmosphere. The stage passed in the cocoon in warm weather has been observed to be ten days. Part of this time the larvæ were probably quiescent. The exact pupal stage was not observed, but probably varies from six days to considerably longer, according to temperature. The period of the larva varies from two to three weeks, and perhaps longer in cool weather.

NATURAL ENEMIES.

The cross-striped cabbage worm is subject to the attack of small four-winged parasites of the genus Apanteles, and a few other natural enemies, including wasps, destroy it.

Apanteles congregatus Say is recorded as having bred from material received in 1880 from Mississippi (Report Com. Agr., 1883, p. 127).

A. utilis French was reared from material received from Lone Star, Miss., October 17, 1879 (Insect Life, Vol. III, p. 16).

A. xylina Say was reared from cocoons on and with its host by Dr. A. D. Hopkins, Morgantown, W. Va., July 26. Of this latter occurrence, Dr. Hopkins (l. c., Vol. IV, p. 259) remarked: "This species was found plentifully wherever the host was observed. Gardeners generally were destroying the cocoons, supposing they were the eggs of the caterpillars."

A. læviceps Ashm. issued September 30 from larvæ obtained in 1899 from Athens, Ga.

A. alamedensis Ashm. was reared July 16, 1900, from larvæ obtained from Montreal, Ga., and sent to this office by Mr. J. H. Heard. Fully half of the larvæ (a large number) were parasitized.

Meteorus indagator Riley MS., issued from material received from Oxford, Miss., September 1880 (l. c., Vol. III, p. 59).

REMEDIES.

In treating this species it should be borne in mind that "worms" of other species as well as other cabbage pests are more often present than otherwise.

Arsenicals.—The best remedy is Paris green applied either dry or wet, preferably, however, as a spray, at the rate of about one pound of the poison to 150 gallons or a little less of water, and it should be used when the plants are first set out, to insure its reaching the young larvæ or caterpillars before they have burrowed far into the heads; in other words, this poison should be applied in the same manner as for the imported cabbage worm, as the two species have much the same habits. Other applications should follow frequently, as required, and can be made with safety until the heads are about half formed, and even later, as the poison, under ordinary circumstances, disappears from the plants within three or four weeks after being applied.

Bran mash.—A mixture of bran with Paris green, a standard remedy for cutworms and grasshoppers, is, according to the testimony of those who have used it, successful against cabbage worms. It is best to mix the bran with water and sugar before adding the poison. The proportions are two or three ounces of sugar or other sweetening, and a sufficient amount of bran (about one pound to the gallon) to make, when stirred, a mixture that will readily run through the fingers. This is to be sprinkled either wet or dry upon affected plants.

Kerosene emulsion has been used for many years against the imported cabbage worm, but is not as efficient as the arsenicals, because it is necessary for this spray to come into direct contact with the larvæ, in other words, to hit them in order to kill them.

Pyrethrum has been used for some years as a remedy against the common cabbage worm, and is of use against the present species. It has the advantage of not being poisonous to human beings, but is said by some cabbage growers to discolor the leaves, and if its use is not continued at frequent intervals the larvæ recover and continue their destruction. It is therefore more expensive than the other remedies that have been mentioned.

Mechanical methods.—For small gardens where for any reason it may be undesirable to use arsenicals hand-picking can be practiced and is of especial value when the plants are first set out.

The corn-meal remedy.—Corn meal dusted on cabbage, according to the testimony of Prof. Lawrence Bruner, causes the worms of the imported cabbage butterfly to drop off and protects cabbage and other crops until washed off by rains. It is advised to apply it in the morning while the dew is on. The meal acts as a deterrent.

Clean cultivation and trap crops.—If cooperation in clean farming could be secured, together with the use of arsenicals, the losses due to the ravages of this as well as other leaf-feeding pests of cabbage might be largely averted. The practice of leaving cabbage stalks in the field after the main crop has been secured is reprehensible. Remnants should be gathered and destroyed, with exception of a few left at regular intervals through a field as traps for the females for the deposition of their eggs. These plants should be freely poisoned with arsenicals, where feasible, so that the last generation will not develop.

Water as a remedy.—Washing the plants with a stiff stream from a hose is of value where this can conveniently be done.

Hot water at a temperature of about 130° F. has been advised as a remedy against cabbage worms. Applied at this temperature it does practically no harm to plants and destroys all insects with which it comes in contact.

THE CABBAGE LOOPER.

(*Plusia brassicæ* Riley.)

The remarkable scarcity of this species during the entire spring, summer, and autumn of 1899 has been mentioned in an earlier article (Bul. 22, n. s., p. 59). It was, therefore, a cause of considerable surprise to find larvæ in abundance during the last week of November in 1900, the work of this species and *Pieris rapæ* being quite noticeable on the older leaves of cabbage. The finding of larvæ only a quarter grown showed that eggs had been deposited during the month.

Larvæ were kept in a cool indoor temperature and fed freely on cabbage leaves. All but one, however, sickened and died within a week after capture. The last larvæ of this lot died when full grown, December 11. Numerous larvæ, however, were still living in the fields where this species was under observation, all of the living ones observed being in first-class condition December 13. One larva was found less than half grown, showing that eggs had been deposited about the last week of November.

The cabbage looper is an unusually voracious species, developing rapidly, and a single individual is capable of doing considerable damage, as when at work on pea. On cabbage, while the larvæ are feeding on the outer leaves, the plant can more readily withstand defoliation. One looper was noticed to eat more than its own bulk each day.

DESCRIPTIVE.

The moth which produces this looper is of somewhat obscure appearance, although its markings are fairly regular and constant. The upper wings are grayish brown, mottled with gray, whitish, and blackish. Just on the inner side of the inner half of the wings there is a variable white mark, looking, particularly in the male, something like the letter Y. The hind-wings are paler brown, with the latter half more or less infuscated, and both wings are strongly scalloped, as shown in the illustration. The veins of the hind-wings are rather strongly defined. The lower surface is pale brown, and both the upper and lower surfaces are shining. The wing expanse varies from about an inch and one-eighth to an inch and three-eighths.

The egg.—The egg is silvery white in color, with no appearance of iridescence, and as it rests upon a green leaf, the color of the leaf showing through causes it to appear pale green. It is of the usual semiglobular Noctuid form, the surface strongly marked with radiating vertical ribs, about forty-eight in number as counted from the sides from which they project rather feebly but distinctly, and forty as counted from above where some vanish. Cross striæ are not distinct, but the spaces between the ribs are filled with rounded concave areas. The lower surface of attachment is nearly smooth and not ribbed. The diameter is about 0.6^{mm} and the height 0.4^{mm}.

The larva derives its name of looper from its habit of "looping" in walking, due to the absence of legs on the sixth and seventh segments. It is from the first a pale-green, fragile-looking creature. It varies considerably in color when mature; a large proportion of specimens that have come under observation are darker green than normal, and these are usually rather more strongly marked with the white lines shown in figure 13 at *c*. Upon attaining full maturity the longitudinal white lines frequently disappear. In some individuals also there are rounded spiracular spots on the three thoracic segments.

An immature larva is shown in figure 14.

The cocoon and pupa.—When the larva becomes full grown it constructs for pupation a remarkably fine, white, gauzy cocoon, which it usually attaches to the broad surface of a cabbage leaf or other plant on which it has fed. Strictly speaking, this is seldom a perfect cocoon, although some such can be found, as it uses the surface of the leaf for protection on one side and the gauze on the other. It seems probable that this is quite efficient against many of its enemies; and it is in the larval stage that the insect usually succumbs to the numerous natural enemies which will presently be mentioned. The chrysalis varies somewhat in color, being rather pale for a Noctuid, the wing-pads moderate brown, and the abdominal segments yellowish. The total length is a little less than three-fourths of an inch. It is shown in its cocoon at *d* (fig. 13).

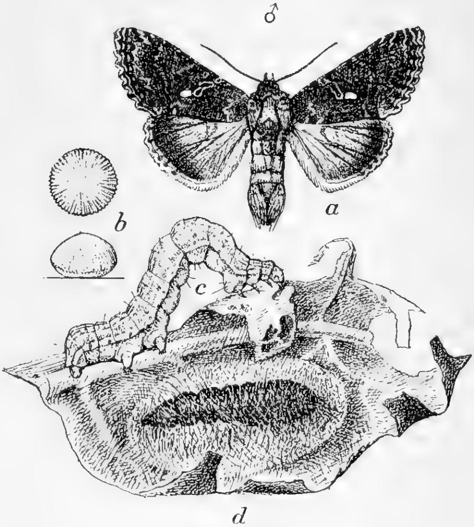

FIG. 13.—*Plusia brassicæ: a*, male moth; *b*, egg shown from above in upper figure and from side in lower; *c*, full-grown larva in natural position feeding; *d*, pupa in cocoon just before development of moth—*a*, *c*, *d*, about one-third larger than natural size; *b*, more enlarged (*a*, *c*, *d*, adapted from Howard; *b*, original).

TECHNICAL DESCRIPTIONS OF THE STAGES OF THE LARVA.

Stage I.—Head higher than wide, bilobed, mouth projecting, clypeus high, nearly reaching vertex. Antennæ long; free from joint 2, somewhat flattened; luteous brown, the sutures of clypeus dark brown, area around mouth black, epistoma reddish, antennæ pale; width 0.25^{mm}. Body slender, moniliform, smooth. Whitish, translucent, pale green from the blood. Abdominal feet on joints 9, 10, and 13. Cervical shield trapezoidal, black, small but distinct. Thoracic feet blackish, abdominal ones grayish outwardly, no distinct shields. Joint 12 enlarged. Tubercles small but round and distinct, normal, no subprimaries. ia to iib on thorax separate, iv of abdomen below the corner of the spiracle, halfway to v on joint 11.

Stage II.—Head higher than wide, mouth broad projecting, squarish shallowly bilobed, flattened before. Green, the broad sutures of the high clypeus blackish; width 0.45^{mm}. Large ocelli black, in a close semicircle, jaws reddish. Body slender, moniliform, joint 12 enlarged dorsally. Feet on joints 9, 10, and 13. Translucent green, a narrow white subdorsal (below tubercle ii) and stigmatal lines. Tubercle iii on joints 5 to 7 and less so on 8, enlarged, black. Others also black but minute. Setæ long, black, pointed; subprimaries present, normal. Feet all pale and concolorous; no shields.

Stage III.—Head high, flattened before, held obliquely, vertex against joint 2, clypeus two-thirds to vertex, the paraclypeal pieces broader than before and concolorous with the head. Antennæ moderate, blackish ringed. Green, ocelli black, whitish ringed, setæ black; width 0.7^{mm}. Body humped up in the legless part; joint 12 slightly enlarged. Green, tubercles whitish with narrow black hair points, iii on joints 5 to 7 somewhat larger and black, largest on joint 6, not very conspicuous. Fine, irregular white lines, viz, geminate dorsal, small and subobsolete, addorsal (above ii), subdorsal (below ii), and stigmatal somewhat broader than the others yet narrow. Setæ blackish, rather long. Tubercles of joint 12 somewhat enlarged. Feet absent on joints 7 and 8. Thoracic feet brownish at tips. Spiracles pale, concolorous; tubercle iv below the stigmatal white line.

Stage IV.—Head as before, green, ocelli black centered; width 1.2^{mm}. Body slender, joint 12 a little enlarged; feet on joints 9, 10, and 13. Cylindrical, incisures a little narrowed. Translucent green, the ♂ sex glands in joint 9 large, pale yellow,

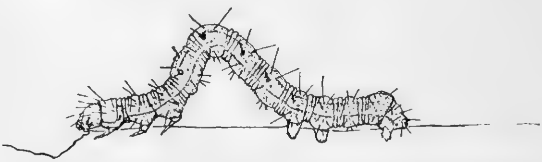

FIG. 14.—*Plusia brassicæ:* larva about half grown—somewhat enlarged.

conspicuous. White addorsal line narrow, a broader subdorsal (above ii, over i), narrower lower subdorsal (below ii and near the subdorsal), narrow white stigmatal lines, all as before. Tubercles distinct, a little elevated, small, white, iii of joints 5 and 6 black. Feet concolorous, claspers and spiracles whitish; no shields. Setæ blackish, rather long. Tubercle iv behind the spiracle on joint 5, below the lower corner on 6 to 8, opposite the corner on 9 and 10, halfway to v on 11, at the lower corner on 12. Tubercles i and ii on joint 12 in a square. Lines irregularly edged and broken at the extremities.

Stage V.—Head rounded squarish, slightly bilobed, flattened before, oblique, free from joint 2. Translucent shining green, antennæ and palpi yellowish, ocelli black; width 1.8 to 2^{mm}. Body normal, moderate, joint 12 enlarged dorsally. Green, no shields marked with white lines. Addorsal narrow, crinkly; subdorsal (between i and ii) broader, upper lateral (below ii) and stigmatal narrow. Tubercles white, iii of joints 5 to 7 black, but small and inconspicuous. Spiracles white, narrowly black-rimmed. Feet green, the abdominal ones on joints 9, 10, and 13. Tubercle iv below the spiracle. Setæ blackish but obscure. The larva occasionally comes darker colored. The ground color is darker green, more transparent, especially along the dorsal vessel and above the stigmatal line, making the lines more contrasted and whiter. Tubercles iii are black the whole length, largest on joints 6 to 8, but plain on 5 to 12. Head brownish on the lobes.

(Larva had only 5 stages.) [H. G. DYAR.]

DISTRIBUTION.

Although the cabbage looper remained undescribed until 1870, and there is no doubt that it is a native species, it has now become widely distributed throughout that part of the United States lying east of the Rocky Mountains, together with Utah, and from Maine to the Gulf. It is probably of somewhat remote southern origin, and is much more destructive in the southern portion of its range than in the most northern, if we except a few localities like New Jersey and Long Island, where it is periodically troublesome. We have no reports of destructive occurrence in Maine, and it is possible that the species is recorded only from fugitives there; and the same applies to some other northern localities which appear in our divisional records. The moth appears to be a strong flyer, and has been recorded as far north as Winnipeg, Manitoba (Hanham), from captures; but it does not seem probable that injury has been committed there.

RECENT INJURY.

During the past three years much complaint has been made of the ravages of cabbage "worms," but, as a rule, the letters of complaint have not been accompanied by specimens, and we have thus not been able to identify the species. It seems probable, from the abundance of the cabbage looper, that this insect was often the cause of injury, although attack is frequently complicated by the presence of *Pieris rapæ*, the common imported cabbage worm, and other species.

During the year 1899 we received complaints of this looper from Athens and Montreal, Ga., and Rollover and China Spring, Tex. Mr. James I. Todd, of Athens, Ga., reported that in his locality this caterpillar fed mainly on the older and lower leaves of cabbage, turnip, and rutabaga, but did nearly as much damage during 1899 as *Pionea rimosalis*, which is treated in another paper in the present bulletin. At Evansville, Ind., where Mr. J. B. Walsh reported this species as injurious during the same year, it was currently reported that the gardeners of that vicinity considered the species new as a cabbage pest. During the next two years we received complaints, accompanied by specimens, from Mr. J. L. Phillips, Blacksburg, Va., who stated that this looper was doing considerable damage to peas near Norfolk, having almost displaced the destructive green pea louse in point of injuriousness. Specimens were also received from Carterton, Va., and Corpus Christi, Tex., in both cases complaint being made of injury to cabbage. In the latter locality this insect was called the common cabbage worm. In the vicinity of the District of Columbia the writer and Mr. Pratt at different times found this larva attacking pea, asparagus, common pigweed (*Amaranthus retroflexus*) growing between rows, lamb's-quarters (*Chenopodium album*), mullein, plantain, and tomato.

ECONOMIC STATUS.

It is nearly as difficult to define the exact status of an insect as regards destructiveness as it is to obtain reliable estimates of its injuries. What is true of one is about equally true of the other. We can obtain reliable information as to the relative injuriousness of an insect compared to others which affect a given crop in a given season over a small area, and we sometimes receive valuable estimates of injuries that have been inflicted over such small areas, but it is only with slight hesitation that the writer places the cabbage looper among the first three cabbage pests of this country, considering what has been written in regard to it. In view of its much wider distribution, its manner of attacking cabbage, and its destructive appearance so much earlier in the season, there can be no doubt that the imported cabbage worm (*Pieris rapæ*) is our worst enemy to cruciferous crops; and next in order comes the harlequin cabbage bug (*Murgantia histrionica*), after which comes the cabbage looper as the third in rank.

Writing of this insect in 1870, Riley stated that, next after the cabbage worm mentioned, this was the most common insect which attacked cabbage in Missouri—a remarkable fact, considering that the species had not hitherto been described (2d Mo. Rept., p. 110). The same author, writing again in 1883 (Rept. Commr. Agric. for 1883, p. 119), said that the larva of this species was the most destructive enemy to cabbage and other cruciferous plants known to the Southern gardener, and shared that distinction with the imported cabbage butterfly as far north as Illinois and New Jersey. Since the time of the publication of that statement, however, the harlequin cabbage bug has become much more widely distributed and injurious, and has alone destroyed many fields of cabbage, as the writer can testify from personal observation.[a]

As previously intimated, owing to the fact that the cabbage looper comes late in the season, its injuries are not so noticeable, as ordinarily it confines itself to the outer leaves of cabbage. It has a much wider range of natural food plants than the other two species mentioned, and there is no doubt that some injuries done by it are attributed to the common cabbage worm, as the latter is better known.

Professor Sanderson has recorded an instance of unusual abundance in Maryland during 1898 (Practical Farmer, December 31, 1898). He states that most of the large cabbage growers of Maryland had lost between 75 and 90 per cent of their crops, and rarely could first-class heads be found in a kitchen garden. When from twenty-five to forty loopers were greedily devouring a single plant, as he frequently found

[a] At the present writing, however, this species is held in check in many localities in its northern range by weather that has been inimical to its multiplication, and it may be a matter of some years before it regains the lost footing.

them, this is not surprising. The writer noticed much the same condition of affairs in portions of Maryland, Virginia, and the District of Columbia which he visited that same year, entire fields being practically failures, the growers not taking the pains to gather any of the plants on account of the ravages of this pest. In most cases, however, the writer had noticed other insects at work earlier in the year, and the loopers took what was left. The following year, as the writer has already recorded, the species was very rare, on account of the extreme cold and the sudden changes of the winter of 1898–99.

LITERATURE OF THE SPECIES.

Comparatively little has been published in regard to the cabbage looper when we take into consideration its excessive injuriousness. In addition to the accounts that have been quoted, Lintner published an article on this species in his Second Report on the Insects of New York (1885, pp. 89–93), in which, however, little is added to our knowledge of it, but the report in question gives a very full bibliography to date; and in Bulletin No. 23 of the Geneva Station, published in 1894, an account, by F. A. Sirrine, is given, on pages 667–671, with photographic illustrations. In 1893 Mr. G. C. Davis (Bul. 102, Mich. Agr. Expt. Sta., p. 27) made the statement that this insect was taken on celery in Michigan, the moth appearing July 14.

In the American Florist for March 3, 1900 (Vol. XV, pp. 912, 913), Mr. Sirrine gave a short account of this looper in connection with injury to carnations, stating that it and the variegated cutworm were the worst of the transient enemies of this plant. Like the cutworm, he writes, it feeds usually at night on the buds. It can be carried in the house on plants, but more commonly the female moth finds her way indoors through open ventilators.

FOOD PLANTS.

This species feeds normally on Cruciferæ, favoring cultivated forms, and, when such are to be had in abundance, it is not often that the loopers feed to any extent on other plants in the same neighborhood. It appears to greatly prefer cabbage and cauliflower, but during its seasons of abundance attacks also turnip, rutabaga, radish, both cultivated and wild, kale, mustard, and the like. Peas are frequently the object of attack, while cowpeas and beets are also eaten. Sometimes the insect is quite destructive to celery and lettuce, and will feed also upon tomato and, less frequently, on asparagus beds, clover, and possibly tobacco.

It is sometimes a pest in greenhouses, when it does damage to carnations, mignonette, and German ivy (*Senecio scandens*). Other food plants include dock, dandelion, lamb's-quarters, Japan quince (*Cydonia japonica*), plantain, mullein, and pigweed.

LIFE HISTORY.

The pupal period varies greatly, according to the season. Thus, in hot weather in July a number of loopers were observed by the writer to transform to pupæ July 5 and to issue as moths on the 11th, or in six days, the temperature indoors averaging about 85°. Another lot of pupæ taken from celery in the field October 7 did not develop moths until the 29th, or in twenty-two days. The weather was cool, but the temperature was not noted, so it is plain that we have a pupal period, varying according to temperature, of from one to three weeks. No definite records can be found of the duration of the egg or larval periods, but assuming three generations for the Upper Austral zone, where this species seems to attract more attention than in the South, we can safely assume from analogy with the observed pupal periods and other knowledge of related species that the egg period will vary from four to ten or more days, according to temperature; that the larva may undergo all its changes (five stages in number) in from two to four weeks, the minimum of two weeks being estimated from the fact that the larvæ grow so rapidly, and the maximum, four weeks, from our knowledge that the insect breeds later in the season than nearly any other injurious species of its kind.

In reviewing the life history of this species, Dr. Lintner (l. c.) stated that there were only two generations produced during the year, and this is perhaps true of its extreme northern limit. Mr. Sirrine, however, states that it is apparently three-brooded on Long Island, and that hibernation probably occurs both as adult and pupa.

If the last generalization is correct it would seem probable that four generations may possibly be produced in the District of Columbia, but the writer is inclined to believe that there are only three, and that hibernation takes place chiefly in the pupal stage. A fourth generation is evidently attempted, but fails to survive the winter.

The time when the moth makes its first appearance in the District of Columbia or elsewhere appears not to be recorded. Few individuals survive the winter northward, but the propagation of the species is so rapid that by the time autumn is reached great numbers of larvæ are produced which do much damage to crops in cultivation at this time.

NATURAL ENEMIES.

PARASITES.

This cabbage looper is unusually susceptible to bacterial and fungus diseases; it is also preyed upon by birds and other insectivorous animals and by parasitic and predaceous insects. Its most efficient insect destroyer in the field in Maryland, Virginia, and the District of Columbia is a minute chalcis fly (*Copidosoma truncatellum* Dalm.), an imported European parasite, which has evidently selected this looper as its favorite host in this country. In Europe this chalcis fly is also particularly attached to the genus Plusia, although known to parasitize larvæ of several other genera of Noctuidæ as well as other families. The habits of this parasite were described by Dr. Howard in the American Naturalist for February, 1882 (pp. 150, 151). An interesting instance of its value as a destroyer of the looper is cited in the annual report of this Department for 1882 (1883, p. 121). In the fall of 1880 nearly fifty larvæ were collected, with the intention of rearing the moths, but all, with a single exception, were eventually destroyed by this parasite, only 2 per cent of the larvæ having reached the imago state. As parasitized loopers approach full growth they lose their characteristic pale longitudinal stripes and become uniform pale green or yellow in color. As a rule, in the writer's experience, the larvæ spin up before succumbing, and in a few days parasitism by this chalcis fly is clearly evident, since the pupæ do not develop and the larvæ assume a peculiar twisted form. Almost without exception the bodies of the parasitized larvæ are completely filled with these almost microscopic parasites. By actual count 2,528 chalcis flies issued from a single parasitized larva. In recent experience the parasitic flies have been reared only from their host during the last week of September and in October.

Apanteles congregatus Say, a well-known parasite of the imported cabbage worm (*Pieris rapæ*) and other noxious species has been reared from this looper.

It has been noticed on several occasions that when the larva of the looper forms its characteristic gauzy white cocoon on other plants than those on which larvæ have fed, the individual is usually diseased or parasitized. Thus, on one occasion the writer took five chrysalides from eggplant, although no evidence whatever could be found that the larvæ had fed on this plant. Larvæ were found on eggplant, but not feeding, and all of these, although kept in the best of condition, died of disease or were parasitized by the *Copidosoma truncatella*. It may be interesting to note of this parasite that the adults issued in late September, sixteen days after their detection in the body of the host. At Brookland, D. C., on one occasion all of the pupæ that could be collected were parasitized, an evident case of complete parasitism.

PREDACEOUS ENEMIES.

A medium-sized white-spotted black spider, *Phidippus audax* Hentz., was observed by the writer July 13, destroying the moth of this insect. This spider appears to be specially adapted to prey upon Plusia, since the web spun by it looks almost precisely like that of the looper. Other species of spiders crawl into the empty cocoons of the moth, and it seems probable that they feed on the larvæ also when these are just about to transform.

Several species of Carabidæ and other predaceous Coleoptera have been recorded to occur in badly infested cabbage fields, with the presumption that they had been feeding on the looper. (Rept. Dept. Agr. 1883, p. 120).[a]

Mr. J. B. Dunn, Corpus Christi, Tex., wrote that he knew of only one insect that fed on this worm, a large black beetle locally known as "pinch bug." This insect was not sufficiently abundant, however, to keep the looper in subjection. Specimens kindly sent to this office proved to be the larva of a species of Calosoma, probably *calidum*, and the beetle *Pasimachus californicus*. He also wrote October 14 that a bird locally known as jackdaw, and which Dr. C. H. Merriam identifies as either the great-tailed or boat-tailed grackle (*Quiscalus macrurus* or *Q. major*), was particularly fond of these cabbage loopers. These birds would alight in the fields and feed on the larvæ daily until they would "clean them up and save the crop." During recent years, however, hunters and others had slaughtered these birds to such an extent that they now shunned civilization. Our correspondent thought this bird deserved protection.

DISEASES.

Bacterial disease.—During July some recently collected larvæ were found to be suffering from a disease. A larva thus affected first grows pale and yellow, and in a very few hours becomes weak and flaccid, upon death assuming an ashy gray color, which later may turn to brown or blackish. Diseased larvæ usually become fastened by the prolegs to the plant upon which they have fed, and hang head downward, in time often becoming a putrid mass much like that observed of the common cabbage worm when diseased. In the jar in which these larvæ were fed a cabbage leaf had been placed which was not quite fresh, and, evidently as a result of feeding upon that, the remaining larvæ contracted the distemper, and all were dead two days after the first appearance of infection.

Diseased larvæ were referred to Mr. B. T. Galloway, Chief of the Bureau of Plant Industry, who wrote that, to the best of his knowledge, the organism concerned in the infection had never been described or named, but was apparently a species of bacillus.

What is perhaps the first mention of a disease of this insect, and probably the same as under present observation, was by Prof. Herbert Osborn (Bul. No. 30, n. s., 1892). He states briefly that larvæ were attacked by a disease that swept off many of them. In Mr. F. A. Sirrine's account, previously cited (l. c., p. 670), mention is also made of the disease and its occurrence in 1894 on Long Island. Mr. Sirrine

[a] The following is the list: *Cratacanthus dubius*, *Harpalus caliginosus*, *H. faunus*, *H. pennsylvanicus*, and the larvæ of *Collops quadrimaculatus*, *Hippodamia convergens*, and *H. parenthesis*.

states, however, that it was not noticed until the cold, wet weather of October and November set in. It should be added that the writer observed the same disease upon Plusia in the field during the last week of July, and that pupæ also suffered from it. This disease is readily communicable from one larva to others, and it frequently happens that if a diseased one is placed in an ordinary tin collecting box over night all of the others that may be confined with it develop the disease in a day or two.

Fungus disease.—One of the fungus diseases from which Plusia larvæ die is *Botrytis rileyi* Farlow. The affected worms, according to Riley, become sluggish and then die, after death appearing stiff and brittle and firmly attached to the leaves or stems upon which they have died. They are profusely covered with a greenish mold.

REMEDIES.

The same remedies as advised for the cross-striped cabbage worm should be used against the present species. It should be observed, however, for the benefit of our correspondents, that they must be used with great persistency at frequent intervals in order to insure perfect success, and should be applied to the lower surface of the outer leaves. The killing off of the first generations of the insect should be particularly observed, but this will be of little or no avail if other cabbage growers within several miles of the same locality do not take the same precautions. One of our correspondents, Mr. Dunn, previously referred to, tried Paris green and lime, and succeeded in killing all of the common cabbage loopers.

Notwithstanding this, however, the writer noticed during September, in the vicinity of the District of Columbia, an entire field of cabbage which had been liberally dusted with Paris green and plaster mixed at the usual rate of 1 pound of poison to 20 pounds of plaster, with no perceptible effect upon these insects. The first application had been made about two weeks previous, another had been made within five days, and yet the larvæ were feeding quite contentedly on the lower surfaces of the leaves in their usual manner and no dead were to be found under the plants or elsewhere. This simply indicates that the poison, as previously stated, should be applied to the lower surface, and preferably in the form of a spray. Mr. Pratt, who observed this species at Chesterbrook, Va., noted the same results. After a rainfall eggs hatch, and the larvæ are able to do injury without being affected by the poison.

A NEW CABBAGE LOOPER.

(*Plusia precationis* Gn.)

The larvæ of this species in different stages of growth were observed during 1899 and 1900 attacking cabbage and some other plants in two gardens in the District of Columbia. The same insect was observed the previous year in less numbers in the same gardens. Cabbage does not appear to be recorded as a food plant of this insect, and in fact its habits are little known.

RECENT ATTACK.

June 1–3, 1899, this species first came under the writer's notice, when a few larvæ nearly grown and several less mature were observed on cabbage. June 5 an immature individual was brought to the writer by Mr. T. A. Keleher, of this office, who found it feeding on cultivated morning glory, and June 19 a larva was taken by the writer feeding on common pigweed (*Ambrosia artemisiæfolia*). The individuals found were so few in number that it was impossible to trace the species through its life history. The following June, however, larvæ were present in greater abundance, all on cabbage.

DESCRIPTIVE.

The moth of this species is a little larger and more graceful than that of the cabbage looper. The general color of the fore-wings is a beautiful bright shining brown, variegated with bronze, purple, and pale-fawn color. The fore-wings are not so strongly scalloped as in the species mentioned, but the hind-wings are similarly colored, and

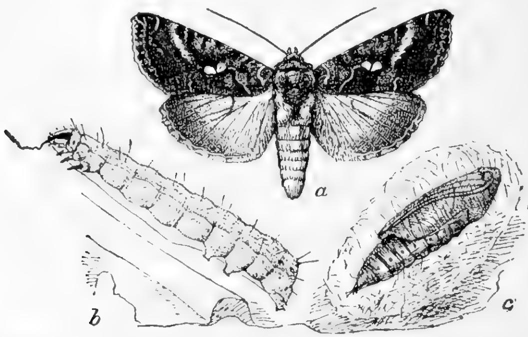

FIG. 15.—*Plusia precationis*: *a*, female moth; *b*, larva extended, feeding; *c*, pupa in cocoon—all somewhat enlarged (original).

the veins are equally noticeable. In the common looper the white spots on the fore-wings are chalky-white, while in this species, although they are of very similar form, they are decidedly silvery, and the two portions are usually well separated (see fig. 15, *a*.) The thorax is also brown, and the abdomen fawn-colored, while the lower surface is similarly but a little more strongly marked than that of the common looper. The wing expanse of specimens at hand shows a variation from an inch and an eighth to nearly an inch and a half.

The penultimate stage.—In next to the last stage this larva lacks the characteristic markings of the mature form. It is very much more slender, and looks, in fact, more like a Geometrid than a Plusia.

It is of nearly the same green color, but the sides of the head and the legs are not marked with black. There are two white undulating stripes on each side of the middle of the dorsum and a broad yellowish white stripe above the stigmata. In most individuals one or more of the abdominal segments bear on each side a black suprastigmatal tubercle.

The last stage.—In the last stage the larva may be readily distinguished from the common cabbage Plusia by the long eye-like elliptical spots on each side of the head. The hind pair of thoracic legs are nearly black, the middle pair a little lighter, and the front pair still paler. The dorsum is mottled with white, the lines being irregular, and the dorsal tubercles, of a green color, being quite prominent. The lateral stripe of the abdomen is broad, white, and well defined. In some individuals on the first two or three abdominal segments the suprastigmatal tubercles are black, but imagos hatched from larvæ thus colored look no different from those hatched from unmarked larvæ. There is also considerable difference in the arrangement of the white marks on the back, the same being true of the common cabbage Plusia. In some individuals these white marks show as four strong undulating stripes, while in others half a dozen or more very irregular striped markings are seen. In one individual the black lateral spot on the head was much less strongly defined than in the others. When fully matured the larva measures in its natural slightly curved position about one inch in length. In figure 15, *b*, a larva is shown extended in a position which it often assumes.

The pupa (*c*) does not appear to have been described. It is not likely that it differs in any important particular from that of *P. brassicæ*.

The eggs have not been compared with those of *P. brassicæ*, but it is more than probable that they are nearly identical, and, in fact, the species differs very little in structure and life history from that of the common cabbage looper.

DISTRIBUTION.

Smith states that this species occurs in the United States east of the Rocky Mountains from May to October, also in Canada. Exact records of localities are rather meager. They include Canada; Cambridge, Mass.; Sharon, Pa.; Dayton, Ohio (Pilate); Woodstock, Ill.; Wisconsin; and the District of Columbia. Hanham states that this species is rare at Winnipeg, Manitoba. It does not seem probable that the insect breeds there, but is merely a stray from a more southern and congenial locality.

HISTORY OF THE SPECIES.

The biological literature of this looper is quite limited, which is to be explained by its seldom having been found attacking useful plants.

In the year 1869 Dr. A. S. Packard made mention of this species in his first edition of the Guide to the Study of Insects. He states on the authority of Mr. Saunders that the larva, of which he gives a brief description, feeds on the hollyhock in August. He also makes mention of Plusia larvæ figured by Glover in his work on insects injurious to the cotton plant, but as this work was never published, in the true sense of the word, it need not be further mentioned here.

In the late Dr. Riley's second Missouri Report (p. 112), published in 1870, this species is briefly treated in connection with a discussion of *Plusia brassicæ*. He states that it occurs commonly on thistles and proposes the name of thistle Plusia. The larva is said to differ from the cabbage Plusia only in having the sides of the head, the thoracic legs, a row of spots above the lateral light line, and a ring around the breathing pores, black.

In the Canadian Entomologist (Vol. XIII, pp. 21–23) for February, 1881, Mr. D. W. Coquillett, now of this office, published an article entitled, "On the early stages of *Plusia precationis* Guenee." Subsequently, in the same publication (Vol. XIV, p. 60), Mr. Coquillett calls attention to the wrong identification of the species, the insect which he had under observation being *P. simplex* and not *precationis*.

The species is again referred to in connection with a consideration of *Plusia simplex* by Mr. Coquillett in the Eleventh Report of the State Entomologist of Illinois in 1882 (pp. 38–42). From studies made at that time of the larvæ of these three species of Plusia, deductions were made that *Plusia simplex* differs from *brassicæ* only by the black rings around its breathing pores, and that both of these larvæ differ from *precationis* by lacking the black stripes on each side of the head. Unfortunately, as the writer has previously observed, some examples of *brassicæ* also have these black rings about the breathing pores.

No extended observations have been made on the life history of this species, but it is probable that it will be found to agree perfectly with *P. brassicæ* when it occurs in the same localities. Such individuals as were under observation by the writer transformed to pupæ in seven, eight, and eleven days, pupation beginning in three instances in early June, and in two in late June, the eleven-day period being passed in unseasonably cool weather.

It should be added that there is in the National Museum a moth reared October 4, 1882, on *Gerardia pedicularia* (presumably in the District of Columbia), and of a Proctotrypid, bred from the cocoon of this species March 29 of the same year.

The name of eyed-cabbage looper is proposed for this insect.

REMEDIES.

This species would yield to the same remedies as advised for the common cabbage looper, namely, Paris green, best applied in the form of a spray, but it is usually not abundant, and hand-picking would suffice on small patches of cabbage or other plants affected.

THE CELERY LOOPER.

(*Plusia simplex* Guen.)

In some portions of our country, as, for example, in Illino s, this species to a certain extent takes the place of the cabbage looper (*Plusia brassicæ* Riley). It is stated to be the commonest species of its genus in Illinois, and is rather generally distributed in the United States east of the Rocky Mountains, from Canada to New Mexico. In most places, however, where it has come under observation it is considerably rarer. It is described by Messrs. Forbes & Hart as a very destructive celery insect, and has been bred by them from sugar beet, and by Mr. Coquillett from lettuce as well as celery. To the latter we are indebted for our principal account of the species.

DESCRIPTIVE.

The moth (fig. 16) is decidedly dissimilar to that of the cabbage looper, having a greater wing expanse, nearly two inches, entirely different coloration, and differently shaped upper wings. These differences are brought out quite distinctly in the accompanying illustration. The lower edges of the fore-wings have a well-defined conical projection. The border is not scalloped, the color is somewhat purplish brown, the darker shades being velvety brown. The silver marks are very distinct, and form the pattern illustrated. The hind-wings are ochreous or yellowish brown, strongly banded with dark fuscous, particularly toward the white border. The ground color of the thorax, fore-wings, and abdomen is duller than that of the hind-wings. The lower surface is pale ochreous, with a rather distinct darker band running through both wings near the middle.

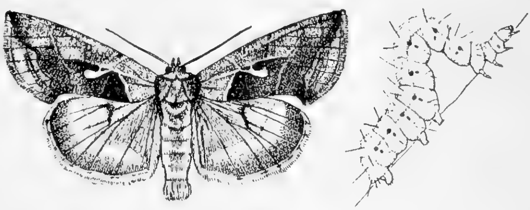

FIG. 16.—*Plusia simplex:* male moth at left, larva at right—somewhat enlarged (original).

The egg is described by Coquillett as milky white, flattened, globular, or turnip-shaped, sometimes with an impressed spot in the center of the upper surface. The upper half of the egg is grooved vertically; the grooves are narrow and the spaces between them roughened. The transverse diameter is about $\frac{1}{60}$ inch.

The larva (fig. 16) is similar to the cabbage looper, and in the examples seen rather more robust posteriorly. The color is very pale yellowish green, and the markings are very similar to those of the cabbage looper, but all of the larvæ examined have the supra-spiracular spots black, which only occasionally happens with the cabbage species. The length is about the same, $1\frac{1}{2}$ inches when fully extended.

The pupa has never been described by comparison with related species. It is in most respects like that of the cabbage looper.

A more detailed description of the moth has been given by Thomas in his fourth report as entomologist of the State of Illinois (9th Report, St. Ent., Ill., pp. 47, 48), which is quoted in Mr. Coquillett's account, which was published in the Eleventh Report of the State Entomologist of Illinois, 1882 (pp. 38–43).

DISTRIBUTION.

The celery looper appears to be a Transition species, but it is frequently taken also in the Upper Austral region, where it breeds in certain localities, particularly westward. Possibly its being more abundant in cold climates will account for the scarcity of reports of injury. Smith reports its occurrence in Hudson Bay territory, Canada; in the United States east of the Rocky Mountains—Colorado at 12,000 feet, and New Mexico; also that it appears throughout the season. Our National Museum collection, with some other sources of information, shows the following list of localities in addition to those that have been mentioned above:

Maine; Massachusetts; Rochester, Rhinebeck, and Poughkeepsie, N. Y.; Washington, D. C.; Westpoint, Nebr.; Caney, Kansas; Merino Valley, New Mexico; Longs Peak, Colo.; Wisconsin; St. Louis, Mo.; Portland and Albina, Oreg. Several of these localities are furnished on authority of Dr. H. G. Dyar. In New York, in the region specified, he captured specimens on different occasions during the last week of July; in Oregon, during the second week of May.

DIVISIONAL RECORD.

There is a single divisional record in regard to the biology of this species. April 10, 1893, we received from Mrs. J. S. Maurice, Caney, Kans., a moth stated to have been observed on blossoms of apple. This had deposited eggs en route, and some larvæ began feeding as soon as received. By May 2 they had nearly completed their growth, and the following day the first larva spun up. As it takes from one to three days for larvæ to transform, and the first moths did not issue till May 20, the pupal stage in this instance may be placed at fifteen or sixteen days. The larval stage during the same period was approximately three weeks. Larvæ fed on weeds with which they were supplied, but as there is no evidence that these were natural foods their names need not be mentioned.

We have no information as to any natural enemy of this species.

REMEDIES.

The same remedies advised for the cabbage looper would, of course, be applicable to this species when it occurs in injurious numbers. It is necessary, however, that whatever remedy is employed be used also on wild food plants, including weeds, which this insect affects.

NOTES ON DIPTEROUS LEAF-MINERS ON CABBAGE.

The leaves of cabbage, radish, and other cruciferous plants are liable to injury from the attack of maggots of the families Drosophilidæ and Oscinidæ. Three species have been identified with such attacks in this country, and a fourth can now be added. It seems probable if the leaves of cruciferous crops in various portions of the country were carefully examined, we might find that several more species have this habit. They are not of themselves particularly destructive, but they contribute their share toward the injury of these plants, different species of cabbage worms being the principal enemies, except in regions where such other pests as the harlequin cabbage bug and the cabbage plant-louse are most numerous.

The Imported Turnip Leaf-miner (*Scaptomyza flaveola* Meig.). This appears to be the most abundant species, and has received attention by Mr. D. W. Coquillett in an article in Insect Life (Vol. VII, 1895,

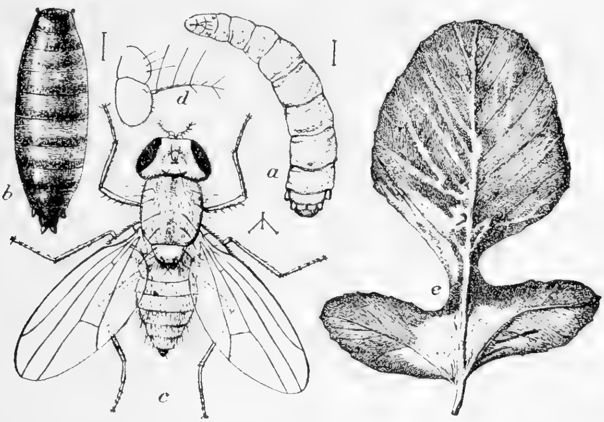

FIG. 17.—*Scaptomyza flaveola: a*, larva; *b*, puparium; *c*, adult; *d*, antenna of fly; *e*, work in radish leaf—natural size; all others enlarged (reengraved after Coquillett).

pp. 381–383). Since that publication was issued the writer reared the same species from the leaves of cabbage in the District of Columbia, the adult issuing June 7, 1900. October 4 of the following year the same species was obtained from cabbage at Tennallytown, D. C. It was noticed that the mature flies were quite sluggish in the cool temperature which prevailed at that time. Being interested in this group of insects, the writer obtained from Prof. H. Garman, of the State agricultural experiment station at Lexington, Ky., a specimen of the species which he described and figured on pages 46–51 of Bulletin No. 40 of that station as *Drosophila* sp. This was pronounced by Mr. Coquillett to be the same as that figured in Insect Life, and mentioned under the name of *Drosophila flaveola*. It is illustrated herewith (fig. 17). Mr. Coquillett has since adopted the generic name of Scaptomyza. A short notice is given of this species by Dr. W. E. Britton (19th An. Rept. Conn. Agr. Expt. Sta. for 1895 [1896], p. 204). He mentions it as a leaf-miner of the cauliflower, and states that some plants growing in the shade were seriously injured, while others finally died.

In looking through the material in the National Museum references have been obtained to rearings of this species which have evidently never been made public. Adults were reared September 9, 1885, from "bolls" of horse-nettle (*Solanum carolinense*)—no locality given, but with little doubt the District of Columbia or vicinity. July 15, 1894, the flies were reared from Iceland poppy (*Papaver medicinale*) received from Mrs. Celia Thaxter, Appledon, Isle of Shoals, off Portsmouth, N. H.; and April 21, 1900, flies were again reared, from the District of Columbia, from larvæ mining the leaves of mouse-ear or thale-cress (*Stenophragma thaliana*), a cruciferous plant naturalized from Europe.

The Native Cabbage Leaf-miner (*Scaptomyza adusta* Loew.).—This was reared with the preceding from the same locality, adults issuing from December 22 to 28. They outnumbered the preceding species three to one, and it is not improbable that this is the most abundant form of dipterous leaf-miner attacking cruciferous crops in the South. We have an earlier record of the rearing of this same species from a growth resembling a gall or fungus on the stems of water lilies, obtained by Mr. Albert Koebele in Virginia, near the District of Columbia, August 24, 1883. The flies issued September 8, and four days later a different species was reared.[a]

We have no very complete knowledge of this insect's distribution. It occurs, however, from Maine to Florida, and westward as far as Illinois. From specimens in the Nutional Museum we have the following localities; Eastport, Me.; Washington, D. C.; Virginia; Biscayne Bay, Fla.; Augusta, Ga.; Algonquin, Ill. The insect was described from the United States, and is evidently indigenous to our soil.

The Imported Cabbage Leaf-miner (*Scaptomyza graminum* Fallen).—This was reared December 22, 1898, from leaves of cabbage received from Augusta, Ga. This is the second rearing of the species from cabbage, the first having been made by Dr. A. D. Hopkins in West Virginia. It is probable that in time this miner will be found to develop in many other plants, since in Europe it is known to attack chickweed, cockle, lamb's quarters, and two genera of catchfly or campian (Viscaria and Silene).

April 5, 1902, Prof. H. A. Morgan, Baton Rouge, La., sent specimens in all stages, with the statement that this species was found with the corn stalk-borer in sugar cane in that vicinity, and the larvæ were confused with the young of the true borer.

In Europe this species is common and widespread, and the same is true of its distribution in this country, although it appears to be

[a] This was determined by Mr. Coquillett as *Crassiseta nigriceps* Loew.

more abundant in the North. Possibly, however, this is only apparent, and it may be found to occur also throughout the South, as it was once taken at Texas College Station by Prof. F. M. Webster on wheat. The distribution taken from specimens in the National Museum includes, besides the District of Columbia and West Virginia, White Mountains, N. H.; Beverly, Mass.; Connecticut; and Detroit, Mich.

It is subject to parasitism, but the species of parasite does not appear to have been identified.

The Native Clover Leaf-miner (*Agromyza diminuta* Walk.).—During the year 1900 this species was several times reared at this office by Mr. Th. Pergande and the writer from larvæ mining the leaves of hedge mustard and smooth rock cress (*Arabis lævigata*) as well as cabbage. The adults issued from the third week in May to the first week in June. The species is treated in the Annual Reports of this Department for 1879 (p. 200) as *Oscinis trifolii*, and 1884 (p. 322) as *O. brassicæ*. The above name is suggested to distinguish it from preceding forms.

REMEDIES.

Nothing of value of a remedial nature has been attempted in the treatment of these leaf-miners, as far as the writer is aware, and it seems improbable that the application of any poisonous mixture would destroy the larvæ at any stage of their growth. Fortunately none of these leaf-miners is, as a rule, very injurious; at least we have no records of injuries to large interests. In small kitchen gardens the insects can be controlled by clipping the infested leaves as soon as the larval mines are found, and destroying them.

It is possible that the flies might be attracted to cans of decomposing turnip or cabbage leaves, slightly sweetened to assist fermentation, and that, if a slight amount of Paris green, arsenic, or other arsenical be dropped in these cans, it would effect the destruction of many flies. Such cans should be distributed about infested fields. The cabbage grower should know by observation when to expect the flies in his vicinity.

THE FOUR-SPOTTED CABBAGE FLEA-BEETLE.

(*Phyllotreta bipustulata* Fab.)

Throughout the summer, from May to September, during the past three years the writer has found this species of flea-beetle, though somewhat sparingly, in the District of Columbia and neighboring parts of Maryland, on cabbage, turnip, hedge mustard (*Sisymbrium officinale*), charlock (*Brassica arvensis*), and shepherd's purse (*Bursa bursa-pastoris*).

Phyllotreta vittata, the striped cabbage flea-beetle, was comparatively rare the first year, and *bipustulata* was apparently more numerous than in former years, which will account for its being noticed on so many plants. The latter has not previously been recorded, to the writer's knowledge, to occur on any particular plant, although it is not improbable that observing collectors are familiar with its occurrence on Cruciferæ. Its life habits have apparently never been studied, so it is not known whether the larva is a leaf-miner or root-feeder. The beetle appears here at about the same time as the more injurious *vittata*, the first observed date being toward the end of April. Egg deposit has been observed as late as August 4.

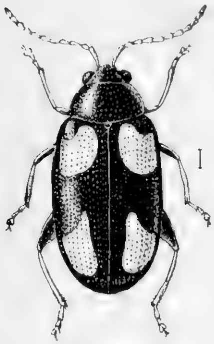

FIG. 18.—*Phyllotreta bipustulata*: beetle—highly magnified (original).

The name above used is suggested for the species.

This flea-beetle (fig. 18) resembles *vittata* but averages slightly larger, and each elytron is ornamented with two large irregularly oval yellow spots, one humeral, the other subapical. The basal 5 joints of the antennæ are paler than the remainder and the legs are more or less rufotestaceous. The above characters will serve to distinguish it from individuals of *vittata* in which the vitta is broken near the middle.

The distribution accorded by Horn (Tr. Am. Ent. Soc., Vol. XVI, 1899, p. 300) is from Pennsylvania to South Carolina. The writer has a series from Ithaca, N. Y., and these localities, together with those from the Hubbard and Schwarz and other collections in the National Museum and a few recorded localities, give the following list:

Lancaster, New York, Ithaca, N. Y.; Camden, Anglesea, Orange Mountains, Fort Lee, Hudson County, and elsewhere in New Jersey; Pennsylvania; Marshall Hall, Md.; Washington and Tennallytown, D. C.; Rosslyn and St. Elmo, Va.; Grand Ledge, Mich.; Marietta, Ohio; Berkeley Springs, W. Va.; central Missouri; Iowa; South Carolina; and Columbus, Tex.

MISCELLANEOUS NOTES ON SOME CABBAGE INSECTS.

The Cabbage Curculio (*Ceutorhynchus rapæ* Gyll.).—This species, an account of which was published in Bulletin 23 (n. s., pp. 39–50), made its appearance in still greater numbers in 1900 than in the previous year, and was found in some localities in abundance where it was scarcely seen on previous occasions.

At Cabin John, Md., all of the cabbage plants examined showed attack by this beetle, one or more individuals being always to be found on each plant. The beetles confined their feeding to the edges of the leaves, as previously noticed. Kale was attacked in about the same proportion, the beetles attacking the pods. Attack was confined to the individuals of the new generation, but the extent of injury could not be estimated. Shepherd's purse (*Bursa bursa-pastoris*) was found on different occasions to harbor the beetles, and it seems probable that this plant and kale serve as food for the larvæ as well as for the beetles.

Dr. Sylvester D. Judd reported to the writer that of six specimens of the rough-winged swallow (*Steligidopteryx serripennis*) shot at Marshall Hall, Md., July 8, 1898, three had eaten this beetle, as shown by an examination of the contents of their stomachs.

The Seed-stalk Weevil (*Ceutorhynchus quadridens* Panz).—After the publication of the writer's note (Bulletin 23 n. s., p. 51) on the identity of this species with *C. seriesetosus* Dietz., reference was noticed to the same species in Mr. M. V. Slingerland's Bulletin 78, of the Cornell University Agricultural Experiment Station, page 503. The remarks in question form a footnote in the discussion of the cabbage-root maggot, and the statement is made that this weevil is a very serious pest in the great cabbage seed-growing region on Long Island. To make certain of the identity of the species, Mr. Slingerland kindly sent specimens from Nattituck for comparison with named specimens.

Pemphigus sp.—February 14, 1901, Mr. S. A. McHenry, of the Beeville substation of the Texas Experiment Stations, sent specimens of an unknown species of Pemphigus, stating that it was doing injury to the roots of cabbage in the vicinity of Beeville, some of the fields being reported as totally destroyed. One person who furnished material wrote that as soon as the lice attacked the roots of the plants the leaves turned yellow and the plants soon died. He stated that several fine patches had been utterly destroyed.

Wasps as destroyers of cabbage worms.—During July and August, 1900, different species of wasps, and particularly *Polistes pallipes* St. Farg., were observed hovering about worm-eaten cabbage plants in several gardens. In one garden they were always numerous in the western part of a large patch of cabbage. At the extreme eastern end the plants were more or less protected by shade, particularly in the afternoon. At this end larvæ of Plutella, Pionea, and Plusia were at work, but no Pieris, while in the sunshiny places, where the wasps were flying freely, no larvæ at all could be found, although holes in the leaves were evidence that they had been present. The wasps were carefully watched on several occasions, and it was plain from their manner of work that they would first destroy the imported cabbage worms, afterward the loopers, and that the Pioneas would be the last to be captured, as these bored directly into the hearts of the cabbage, concealing themselves between two leaves in such manner that it would be difficult for the wasps to find them in the cursory manner of their search. The Plutellas, owing to their smaller size, might possibly evade discovery.

Singularly, in spite of utmost endeavors, it was impossible to detect a wasp in the act of destroying a cabbage worm, nevertheless circumstantial evidence was so strong that the writer felt no hesitation in attributing the absence of the "worms" in the sunny portion of the garden to the presence of the wasps. The "worms" working on plants growing in shade were nearly free from wasp attack. The wasps would hover about a plant and then alight and walk about it, but, finding nothing, would continue to the next plant, and so on to another. The following year, in the latter days of August, the writer observed this wasp attacking the larva of *Pieris rapæ*, leisurely chewing it before flying away to provision its nest.

It is evident that this habit of wasps has been observed before. The following was published in Dr. Lintner's third report as State Entomologist of New York, for 1886 (1887, page 135): "Mr. C. R. Moore, of Johnson Town, Va., states that he has seen the common brown wasp (? *Polistes fuscatus*) seize the green worms on cabbage (? *Pieris rapæ*), sting them repeatedly, and then carry them away."

The Cabbage Root Maggot injurious to celery.—Mr. James Granger, Broadalbin, N. Y., mentioned in preceding pages as having reported injury to celery by the carrot rust fly (*Psila rosæ* Fab.), sent, under date of November 19, 1901, a larger larva than that of the rust fly, stating that it occurred in the heart of celery, and that he believed it to be causing "rot." He was aware that the same species, or a similar one, infested radish in the same field, and there is little doubt that this insect spread from the radish to the celery. The cabbage root maggot, as its name implies, attacks cabbage, including all its varieties, as well as most other forms of cruciferous plants. As Mr. Granger has shown himself a good observer by his correspondence, there can be no doubt of his statement that these larvæ occurred in celery. He distinguished the two species, and sent the cabbage maggots in about equal numbers with the rust fly maggots. Celery appears to be a new food plant for the cabbage root maggot. The early rearings were without doubt unnatural, caused by the overheating of the rooms in which the rearing jars were kept.

While there is no doubt that this cabbage maggot is quite closely restricted to cruciferous plants for food, it will occasionally, in case of emergency, attack plants of other botanical orders. Miss Ormerod has quoted Mr. Meade as saying that maggots were reared in 1882 from "earth round partly decayed clover roots," while Lintner has stated on one occasion that the larvæ had been detected mining the leaves of beet (Bul. 78, C. U. Agr. Expt. Sta., 1894, p. 513).

OBSERVATIONS ON INSECTS AFFECTING LATE CABBAGE AND SIMILAR CROPS.

Some attention has been given by the writer in recent years to the study of some of our common insect enemies of cruciferous crops, with a view to ascertaining more in regard to them, and the notes which follow were made to determine just how far careless methods of culture are to blame for injury by these insects. Brief mention has been made in Bulletin 22 (n. s., pp. 55–61) and in Bulletin 30 (n. s., pp. 63–75) of the effects of cold and of parasitic attack in limiting the increase of these insects. This work has been continued, with some results which appear to justify the furnishing of more details.

The study of extreme cold and its effect upon insects affecting crucifers was continued until late in December, after which time it usually happens that we have severe freezes which put a practical end to the breeding of most insects. Some species were actually found breeding upon winter cabbage as late as December 24, and this in spite of the fact that, with the exception of perhaps seven days distributed at intervals through November and December, there had been continuous nightly frosts from the time when observations began in the last week of November until their completion. Observations were conducted in the District of Columbia and at near-by points in Maryland. The species under particular observation were five in number. There was no great difference as to the number of individuals or injuriousness. The approximate order, however, was as follows: The cabbage plant-louse (*Aphis brassicæ* Linn.), diamond-back moth (*Plutella cruciferarum* Zell.), harlequin cabbage bug (*Murgantia histrionica* Hahn.), imported cabbage butterfly (*Pieris rapæ* Linn.), and the cabbage looper (*Plusia brassicæ* Riley). Of these the diamond-back moth was the most active, and the looper and the larva of the imported cabbage butterfly the most injurious.

Like many introduced, and Southern forms of insects which have recently migrated northward from the South, these species remain feeding in the field long after most of our strictly native forms, or those which have long been established in the District and vicinity, have sought winter quarters.

The Imported Cabbage Butterfly (*Pieris rapæ* Linn.).—Larvæ were noticed the last week of November feeding with the others which have been mentioned on late cabbage. The work of this species and the cabbage looper was noticeable on all old leaves. Many larvæ were not above half grown at this time, showing that egg deposit had taken place not earlier than the last week of October, and perhaps in early November. Larvæ taken at this time fed freely on cabbage, and most of them attained maturity during the second week of December.

It was quite noticeable that when rains and freezing weather occurred during December, the larvæ crawled deeper into the large heads of cabbage, where they appeared to be abundantly protected.

It was noticed throughout the season, and particularly in late autumn and early winter, that this species was remarkably free from disease as compared with Plusia occurring on the same beds and same cabbage plants, a fact, however, that has been observed by others.

The Diamond-back Moth (*Plutella cruciferarum* Zell.).—In recent years this species has always been found in about the same abundance in spring and summer, but it sometimes occurs, like the other species, more abundantly late in the year than earlier in the season. During the last week of November larvæ have been seen nearly grown, with about an equal number of pupæ at the same time. Moths captured then deposited eggs even in a quite cold temperature. As with the imported cabbage worm, most larvæ transformed to pupæ during the first week of December. Moths began issuing from this lot December 9.

An interesting feature in connection with the late occurrence of this species was the presence at the same time of one of its most active parasites, an Ichneumonid *Limneria tibiator* Cr. These parasites began issuing the same time as the moths just noted, showing that the enemy has about the same time of appearance in the fall as its host, and perhaps this is the same in the spring. Such coincidence in the time of occurrence of a parasite and its host, however, the writer believes to be rather exceptional.

Moths were seen on a warm day, December 13, flying in the sunshine. This was after three or four days of very cold weather. Nearly every head of cabbage that was touched was found to harbor one or more moths, while others were flying about other vegetation of the vicinity. At no time during the entire year were moths seen in anything like the same abundance as at this time in mid-December. Larvæ and pupæ were also observed.

The Harlequin Cabbage Bug (*Murgantia histrionica* Hahn).—This insect was exposed to the same atmospheric conditions as the preceding species, and was observed feeding with them until late in November. When fields were visited during the middle of December, however, none of the bugs were to be found in exposure upon the plants, although, as has been said, the diamond-back moth was flying freely in the bright sunshine. Under leaves which touched the ground some specimens were found, and such stalks as were pulled up and shaken showed that many of the bugs had crawled in between the leaves into protected places. They were dislodged in some numbers, two score and more being found in single large heads. When the infested cabbage fields were visited a month later it was seen that the more severe frost which had occurred during the month had killed great numbers. By gathering numbers of the bugs and taking them home for counting, an estimate was made that 85 per cent had been killed. Cold spells which followed afterwards doubtless killed many more.

As a result of study of this species for several seasons, it has been ascertained that the bugs do not, as a rule, issue from hibernating quarters until near the end of April. Eggs were first noticed on the 28th of that month, but in some seasons the bugs may lay earlier. The first imagos of the new brood have been observed to develop during the last week of June, the 26th being the first observed date of their development. The second generation usually begins to develop about the beginning of the third week of August.

The wheel bug (*Prionidus cristatus*) was observed attacking the nymphs of this bug on several occasions during June.

The Cabbage Looper (*Plusia brassicæ* Riley).—The observations which were conducted on this species were much the same as for *Pieris rapæ*, with which it was associated. Numerous larvæ were still living in the fields as late as the middle of December. At this time one larva was found less than half grown, showing that the eggs had been deposited about the last week of November.

The Cabbage Plant-louse (*Aphis brassicæ* Linn.).—Of this species it was observed that numerous individuals, but no winged forms, were still present in cabbage fields by the middle of December, mostly, however, in the hearts of cabbage where they had crawled for protection. No parasites or other enemies could be observed at this time.

A number of individuals of this plant-louse were kept in the insectary of this Department in the coolest temperature that could be obtained, the object being to have them furnish food for ladybirds. It was noticed that they survived a temperature of 20° F., which occurred during three successive days in February, and that they were active a few degrees above the freezing point, seeming to be able to fly, since winged individuals were found at the top of rearing cages a foot above the plant on which they had been feeding at a temperature a little below 40° F. Meanwhile the ladybirds, although not dormant, were inactive, responding feebly to stimulation.

CONCLUSIONS.

The practice of planting late cabbage and other crucifers is calculated to be of great benefit to several species of insects, particularly those just mentioned, and the particular reasons are that, as a rule, natural enemies, such as parasites and wasps, and diseases are less active in cool weather, while their hosts are seemingly nearly as active as in warm weather. This, of course, is not really the case; they do not work so many hours in a day, and their growth is slower. The trouble is that the farmer and truck grower generally, at least in those parts of Maryland and Virginia lying near the District of Columbia, appear to think that the insects have disappeared to such an extent that it is not necessary to apply remedies. For the imported cabbage worm, the looper, and the larva of the diamond-back moth, this is the best time to make applications of poisons, as the crops are not needed until a considerable time after poisons are applied, and this does away with any danger of poisoning to human beings. Many individuals of the insects mentioned, without doubt, perish for lack of food, as most wild crucifers are dead at such times.

Such cabbage as is pulled and "heeled in" and covered with underbrush is apt to carry with it many individuals of all of the five cabbage pests under discussion, and when the cabbage heads are covered with brush this affords a fine shelter against storms and cold. A very large percentage of injury to cabbage in the spring (and this is the time when the principal damage by the imported cabbage worm is done) could be avoided by treating the cabbage freely with Paris green, and the same applies to stalks left in the field for sprouts. Stalks that are not needed for this purpose should be pulled up and burned as rapidly as their uselessness is manifest, and all rubbish should be destroyed in the immediate vicinity of the gardens.

Not alone cabbage, but all other crucifers should be freely poisoned, and if this were practiced over considerable areas the effect the following spring would soon be observable. If plant-lice are found to be at work, kerosene emulsion should also be applied to the crucifers where this would not interfere with their food qualities. Where the cabbage is destined to be soon eaten, pyrethrum, or Persian insect powder, should be applied.

It does not seem that the present methods of growing late crucifers has any appreciable effect upon the development of the harlequin bug, but care should be used not to permit accumulations where the insects can hibernate, and a trap crop of kale should always be left in the field, or planted as early as possible in the spring, and from this trap crop the insects can be collected, or after the main portion of it is taken out for use the remainder can be burned, with the insects which it contains.

In one field recently visited in the latter days of April, a patch of about half an acre of kale was found to be infested rather freely along one side by harlequin bugs. The gardener was advised to burn this side of the patch, using straw to facilitate the operation. This was done, and when the garden was visited two weeks later not a single specimen of the bugs could be found in a walk about this patch. The same was true of the cabbage grown in the same vicinity.

THE SEED-CORN MAGGOT.

(*Phorbia fusciceps* Zett.)

For a number of years economic entomologists in several portions of this country and Canada have had frequent complaints of injuries by a maggot working on young growing beans. More recently this maggot has been found to destroy peas in the same manner.

Considerable doubt has been expressed in some early publications on this insect as to its identity, whether it is the same species as the cabbage root maggot or specifically distinct. This was caused by the fact that both species attack the roots of cabbage, sometimes acting in concert and by the further fact that the group to which these insects belong, two-winged flies of the family Anthomyiidæ, had not been carefully studied. The species under discussion, known by several popular names besides seed-corn maggot, including "bean fly," has received no less than seven Latin names showing its description that many times as a supposedly new species.

A careful perusal of the notebooks of this office as well as of literature go to show that this maggot is considerably more destructive to beans than to corn, and as many of our Divisional notes have not been recorded they may be mentioned here in connection with reports of injury.

DESCRIPTIVE.

The parent fly of this maggot looks to the casual observer much like a small house fly. It can best be identified by the male (fig. 19, *a*). The principal characteristics of the male consist in a row of short, rigid, bristly hairs of nearly equal length on the inner side of the posterior tibiæ or shanks. The female can scarcely be distinguished

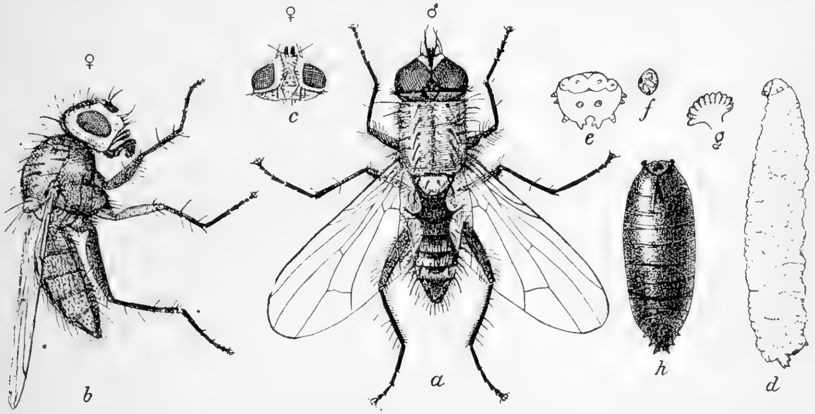

FIG. 19.—*Phorbia fusciceps:* *a*, male fly, dorsal view; *b*, female, lateral view; *c*, head of female, from above; *d*, larva, from side; *e*, anal segment of larva; *f*, anal spiracles; *g*, thoracic spiracles; *h*, puparium—all much enlarged (original).

from those of related species, such as the adults of the cabbage root maggot and onion maggot. The length of the body is about one-fifth inch (5^{mm}) and the wing expanse about two-fifths (9.5^{mm}).

The larvæ also resemble the species mentioned. Like other maggots, they are footless and of cylindrical form. As will be seen by illustration 19, *d*, which represents a larva in profile, they are narrowed at the anterior extremity and enlarged posteriorly. They are, however, considerably smaller than the onion maggot, measuring about one-fourth of an inch (6^{mm}) in length and about one-sixth as wide at the thickest portion. Alcoholic specimens are very pale yellow in color, and the chitinous or harder parts at the ends are usually considerably darker. The anal segment is shown at *e*; *f* represents the anal spiracles, and *g* the thoracic ones. There appear to be only 6 or 7 divisions in the cephalic spiracles, whereas in the onion-feeding species there are usually 11 or 12 such divisions.

The puparium (*h*) is barrel-shaped, of elliptical outline, and light brown in color. It measures about three-twentieths of an inch (4^{mm}) and is about one-third that in diameter.

DISTRIBUTION.

The fact of this fly having been described first in Germany in 1845 and of its not having been identified in this country until more than a decade later is indicative of European origin. It appears to have been first recognized in New York State by Dr. Fitch in the year 1856. Like so many other flies, it ranges through several life areas, and we know of its occurrence in Canada and Minnesota, southward to the Gulf, and westward to the Pacific.

The following list of localities has been compiled from published records and from specimens in the National Museum:

Holderness and White Mountains, N. H.; Beverly, Mass.; Greenport, Ithaca, Long Island, Albany (?), and Elmira, N. Y.; Ridgewood, Palisades, Atlantic Highlands, Westville, Jamesburg, and Riverton, N. J.; Travilah, Md.; Washington and Benning, D. C.; Falls Church, Va.; Van Wert County, Ohio; Lexington, Ky.; Tippecanoe County, Ind.; Algonquin and Altamont, Ill.; Grand Rapids, Mich.; Plainfield, Wis.; Park Rapids, Wadena, Alexandria, Camden Place, Rockport, and St. Paul, Minn.; University, N. Dak.; Tabor, Iowa; Nebraska; Hiawatha, Lawrence, and Parsons, Kans.; Eureka, Mo.; South Carolina; Augusta, Meansville, and Atlanta, Ga.; Florida; Auburn and Boligee, Ala.; Mississippi; Shreveport, La.; Rollover and College Station, Tex.; Las Cruces and Beulah, N. Mex.; Salida, Colo.; Los Angeles, Cal.; Ottawa, Ontario, and Chateauguay Basin, Quebec; Lambton County, Aitkens Ferry, and Prince Edward Island, Canada.

RECENT OCCURRENCES.

During 1899 this fly was found in privies and reared sparingly with other insects inhabiting human excrement. (Howard, Proc. Wash. Acad. Sci., Vol. II, p. 584.) January 4 it was reared from cabbage received from Augusta, Ga., and infested also with the imported cabbage webworm (*Hellula undalis*).

March 27 we received specimens of the larva from Mr. F. S. Earle, Auburn, Ala., who wrote that the species was destroying a planting of garden peas at that place, eating out and boring the underground stems of young plants, sometimes destroying the plant before it could get above ground. April 2 he wrote that an entire planting of peas had been destroyed. The previous year he lost many plants of snap beans in much the same manner, attributing the loss to the same species.

June 23 the writer reared a considerable number of the flies from beans in a somewhat novel manner, and one that suggests itself as of considerable utility in rearing root-feeding species. In the course of experiments it was found necessary to place gauze frames over several hills of beans on an experimental plat. These were left in place for a week, and were fitted tightly to the earth. At the end of this time many flies were found and a number captured for identification.

During the same month Mr. E. E. Ewell, assistant chemist, called the writer's attention to injury to bean stalks grown on the Department grounds, due to the work of a maggot and to other causes. Some were collected and reared to the adult, which proved to be *Phorbia fusciceps*. The fly issued June 11.

November 6 to 15 the species was again reared from cabbage from Meansville, Ga.

In 1900, May 15, we received larvæ from Mr. E. A. Wilson, Rollover, Tex., where they were doing much damage to the roots of cabbage. June 20 we received information of the occurrence of the flies in alarming numbers at Falls Church, Va.

EARLIER DIVISIONAL RECORDS OF INJURY AND OCCURRENCES.

March 5, 1880, we received from Mr. J. S. Newman, Atlanta, Ga., a lot of turnips infested by the maggot of this species.

April 8, 1884, a fly appeared from among a lot of Tineid galls collected by Mr. A. Koebele on poplar at Holderness, N. H.

December 4, 1885, we received from Mr. J. G. Jack, at that time at Chateauguay Basin, Province of Quebec, Canada, specimens of this fly with the statement that the larvæ had been very destructive to beans that summer. This attack will be mentioned more at length under the heading "Literature of the species."

June 7, 1889, we received larvæ from Mr. F. N. Tillinghast, Greenport, N. Y., with the report that the species was doing much damage to the roots of young cabbage.

April 30, 1890, we received from Mr. Clark, Benning, D. C., some young cabbage plants ruined by this maggot.

During 1894 we received, August 6, from Mr. M. V. Slingerland, Ithaca, N. Y., larvæ about which he has published, as will be presently mentioned. Later we received from the same correspondent adults reared from cabbage roots on Long Island. September 14 we received this species in cabbage heads from Mr. L. H. Reed, Grand Rapids, Mich. From this lot the mature flies issued June 14, 18, and 20 of the following year.

June 14, 1895, Mr. Reed sent bean plants showing injury by this species from Plaintield, Wis. (See Ins. Life, Vol. VII, p. 429.) February 5, 1895, we received word from F. A. Young & Co., of New York City, that this species was causing considerable trouble to cabbage crops in South Carolina. It appeared to confine its operations to the stems and roots, and was more plentiful in new land.

LITERATURE OF THE SPECIES.

Dr. Fitch's account of this species is brief. He noticed that the fly occurred in abundance upon the heads of wheat the latter part of June in New York, presumably in the neighborhood of Albany, and as this fly had been currently regarded as the parent of the wheat midge (*Diplosis tritici* Kirby), he gave the insect some attention, and, finding it new to our fauna, described it as the deceiving wheat fly (*Hylemyia deceptiva*) (1st Rept. Ins. N. Y. for 1856, p. 301, Pl. I, fig. 3). Nothing was known by Fitch of the habits of this species further than that the flies hovered over and alighted upon wheat heads at the time when they were in flower. In 1869 Dr. Riley redescribed this species (1st Mo. Rpt., pp. 154–156, Pl. II, fig. 24, text figs. 86 and 87), giving it the name of the seed-corn maggot (*Anthomyia zeas*),[a] also the corn Anthomyia. The maggots were noticed attacking kernels of sprouting corn in the vicinity of Ridgewood, N. J., and in other fields in the same (Bergen) county. Mere mention of the species was made the same year by Riley, and the case is cited here to show the tendency that existed even in those early days, as well as later, to multiply book names for insects. He refers to the species as the "seed-corn flower-fly" (American Ent., Vol. II, p. 137). In 1877 Dr. Riley's third account of this species appears under the title "The Anthomyia egg-parasite" (*Anthomyia angustifrons* Meigen). The statement is made that in the fall of 1876 the maggot destroyed about 10 per cent of locust eggs in Missouri, Kansas, and Nebraska, and in some localities a much larger percentage; it was quite common also in Iowa and Minnesota and occurred in Colorado and Texas (1st Rept. U. S. Ent. Com. for 1877 [1878], pp. 285–289).

During 1885 this species was injurious to beans at Chateauguay, Quebec, Canada (John G. Jack, Can. Ent., Vol. XVIII, p. 22; 17th Ann. Rpt. Ent. Soc. Ont., 1887, p. 17). The beans were planted June 15, and in that part of the field that was most seriously injured at least nine-tenths of the crop was destroyed. Ten days after planting, as few beans had appeared above the surface of the ground, examination was made as to the cause, and it was then found that nearly every bean was infested by from 1 to 25 maggots. Both stems and seed leaves were attacked. By the 28th of June many larvæ had pupated, and scarcely a maggot was found after July 2. The adults issued July 10. Mr. Jack, in reporting this occurrence, stated that "if this bean-feeding habit of the insect should become general, it might prove very annoying."

In Insect Life (Vol. VI, p. 372) Dr. Howard, in referring to parasites of the sugar-beet webworm, makes mention of this species, stating, among other things, that the fly had been reared by Dr. Riley

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[a]Spelled on both pages 154 and 155 "*zeas*," without doubt a typographical error.

from the roots of cabbage and radish. It was surmised that the larvæ fed upon beet roots and perhaps crawled into the larval cases of the webworm for pupation. The writer indorses this opinion, and it would seem that beet is to be added as a food plant of this insect.[a] As in previous cases of reported injury, the maggots attacked the plants before they appeared above ground, and were found in the stems after the plant had reached a height of about 2 inches.

In the year 1894 this species did damage to bean plants in Tippecanoe County, Ind., and Van Wert County, Ohio, as reported by Mr. F. M. Webster (Insect Life, Vol. VII, pp. 204–205). Adults were reared June 10 to 18. The nature of attack was as usual with this species.

In the late Dr. Lugger's first annual report as entomologist of Minnesota for 1895 (1896, pp. 111–114, pl. 14, fig. 58), injury to young bean stalks by what is probably this insect is treated, the species receiving mention as the bean-fly (*Anthomyia* sp.). Whole fields of beans, in many places containing many acres, were reported as being completely ruined in the vicinity of Park Rapids, Minn. At Wadena, Minn., injury was also noted. After the seed had been planted about ten days and had not come up, Mr. H. W. Fuller, the correspondent in question, had dug into the hills and found the beans gone. It was not until he had opened several hills that he succeeded in finding the maggots. According to Dr. Lugger, about one-third of the State was more or less infested with this enemy, which was new as regards known injury there. On some farms the insect destroyed nearly all bean plants, while on others farmers were forced to reseed their fields. Another locality specifically mentioned as having suffered losses from this insect was Alexandria, Minn., where about 25 per cent of the crop was destroyed, necessitating replanting.

In 1897 this maggot was concerned in injury to seed-corn at Aitkens Ferry, Prince Edward Island, Canada. The corn was planted June 5 about 3 inches deep, and very little showed above ground. The spring was described as very wet and cold in that locality. This is recorded by Mr. M. V. Slingerland (Rural New Yorker, September 11, 1897, p. 596).

In the year 1900 Prof. W. Lochhead, Guelph, Canada, reported what is also in all probability the seed-corn maggot[b] as injurious during that year in Lambton County, Canada. His note is published under the caption of "The Bean fly (*Anthomyia radicum*)", and he states that in June many complaints reached him regarding the attacks of "grubs" on beans. Hundreds of acres were being destroyed,

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[a] Mention is made of the synonymy of this species, but the insect is unfortunately referred to as *Phorbia fuscipes* Zett.

[b] There is very little doubt that the insect which was so injurious in 1895 in Minnesota and in 1900 in Canada was *Phorbia fusciceps*, but specimens are not available, hence the identification can not be positively made at present.

many beans did not germinate at all, owing to the fact that the maggot ate the interior of the seed, while many stems failed to develop through the destruction of the central portion of them. Professor Lochhead was of the opinion that injury might have been due to deep planting. The note in question, 31st Rept. Ent. Soc. Ont. for 1900 (1901, p. 73), was illustrated with a figure adapted from Dr. Lugger's.

A review of the known history of this species was given by Dr. Lintner in 1882 (1st Rpt. Ins. N. Y., pp. 181–184), and later, in 1894, Mr. Slingerland gave a similar review (Bul. 78, Cor. Univ. Agr. Exp. Sta., 1894, pp. 499–501). Dr. Forbes also published an account in 1894 (18th Rpt. St. Ent. Ill. for 1891 and 1892, pp. 16–19), which includes a few notes on occurrences in the seed of corn and dates of rearing, and detailed descriptions of the larva, puparium, and imago, with original illustrations. Some shorter accounts have been published that add little to our knowledge of this seed maggot.

Although this insect is not restricted to either corn or beans, it seems to the writer that the name "seed-corn maggot," bestowed upon it years ago by Dr. Riley, may be retained in preference to "Fringed Anthomyiian," which has recently been proposed. It has priority, and the latter name would not be apt to be adopted by the average person engaged in agriculture.

The following are among the synonyms of *Phorbia fusciceps* Zett.:

Aricia fusciceps Zett., 1845; *Hylemyia deceptiva* Fitch, 1856; *Chortophila cilicrura* Rond., 1866; *Anthomyia zeæ* Riley, 1869; *Anthomyia radicum* var. *calopteni* Riley, 1877; *Anthomyia angustifrons* Meigen, 1878; *Phorbia cilicrura* Rond (Meade), 1883.

SUMMARY OF FOOD HABITS.

From what has been related of the habits of this species it will be seen that real injury is practically confined to planted seeds and very young sprouting plants, particularly of Indian corn and beans of different kinds. When young plants of bean, corn, and cabbage are not available it will attack other plants, and future study will undoubtedly show that it has a wide range of these. Peas are attacked in the same manner, but this does not appear to have previously been recorded. It may be, from the fact of Fitch finding the flies so abundantly in wheat fields, that the insect also attacks sprouting wheat, as the fact that injury has not been detected is no indication that attack is not made. There is little doubt that beets are attacked. Turnips and radish are known to be infested, and it seems more than probable that the insect may feed on decaying vegetable and perhaps animal matter, as the larvæ are so frequently found on such portions of plants as have first been attacked by other insects. The rearing of the fly from galls on poplar, previously mentioned, is an unusual indication of the last-mentioned habit. Dr. Riley's account of the species having been beneficial upward of a quarter of a century ago by feeding upon locust eggs should not be overlooked. It does not necessarily show more than an occasional carnivorous habit, as the attack under consideration occurred during extreme abundance of the locusts. The onion has been recorded as a food plant in England, seed potatoes have been attacked, according to Lintner, and hedge mustard has been recorded as a food plant by Slingerland.

LIFE HISTORY.

The life economy of the seed-corn maggot is very imperfectly understood. In spite of the many writings on this insect the species has evidently never been under continuous observation in any locality, and what has been published affords evidence only of a single generation. It has been surmised that the species agrees with others of its kind in passing the winter in the adult condition, although it is possible also that it hibernates, in some localities at least, as a puparium. Of one thing we may be tolerably certain, that only a single generation is developed in corn, but it is quite probable that two generations might be produced in beans and peas owing to the longer period in which these crops are kept in the field, and the second and third plantings that are made in many localities. In the Gulf States the flies have been reared as early as January 4, and the rearing notes which have been cited for that region show that the flies may appear through the first three months of the year. The fact that larvæ were received from Texas in the middle of May would indicate a second generation in the South, the progeny of the flies appearing in the earlier months. Flies have been reared also in or from different localities in June, July, August, September, and December, and it seems probable that where weather conditions favor, several generations are normally produced each year, although there must be a period in midwinter in which breeding ceases, and possibly another in midsummer.

Professor Forbes has admitted the probability that later generations might appear than that observed by him on corn, the adults from which emerged from June 11 to August 7. In the Northern States it is probable that we have at least two generations, the first injurious in May and June to such seedlings as are then to be found, and the second generation feeding upon weeds or dead or dying plants, in excrement and in refuse, without their presence being manifested.

It would be interesting to learn if most of the injuries occasioned by the seed-corn maggot are not due to the attraction of the winged fly for oviposition on manure used in the field or to the decomposition of a portion of the seeds (something which must always happen) or to the presence of other decomposing material, due to natural causes, to fungus attack, or to infestation by primary pests.

NATURAL ENEMIES.

The seed-corn maggot undoubtedly has many insect enemies, but none appear to have been recorded.

June 21, 1897, we received from Mr. E. F. Bouchville, Boligee, Ala., a large number of flies of this species with their bodies distended by a white powdery growth caused by the presence of a fungus disease, identified at the time as *Empusa americana.* It belongs to the same genus as the house-fly parasite (*Empusa muscæ*).

Frequently the latter disease causes much mortality among flies living out-of-doors, as happened during the summer of 1891. (See note by C. L. Marlatt in Insect Life, Vol. IV, pp. 152, 153.)

REMEDIES.

Owing to the great difficulty of destroying subterranean larvæ and the cost of the chemicals that are used for this purpose, such as bisulphid of carbon, we have to depend more upon methods of prevention. One of the best means of deterring the parent flies from depositing their eggs consists in sand soaked in kerosene—one cupful to a bucket of dry sand—placed at the base of the plants, along the rows. This also kills young larvæ that might attempt to work through the mixture.

Fertilizers, preferably kainit and nitrate of soda, are also useful as deterrents, particularly when employed just before or after a shower has thoroughly wet the ground. They should be applied as nearly as possible to the roots, and the earth should be turned away from the plants for this purpose. This remedy has the advantage of acting as a fertilizer as well as a preventive of insect attack.

As soon as plants show signs of wilting, and this maggot is known to be present in the field, the injured plants should be promptly pulled and destroyed.

The above methods of control have been used with success against onion maggots and similar root-feeding species.

THE BEAN LEAF-ROLLER.

(*Eudamus proteus* Linn.)

In October, 1901, Mr. William R. Polk, Orlando, Fla., complained of what he described as a green leaf-roller on snap beans. No specimens were received at the time, but the adult insect was identified by our correspondent as being the indirect cause of the injury. At the time of writing he stated that it had been busy laying eggs, and the leaf-roller or leaf-curler worm, as it was also called, was "destroying much of his beans by cutting and curling the leaves." November 12 our correspondent sent specimens of the butterfly as well as larvæ in different stages of growth.

The same month we received by request from Prof. H. A. Gossard, Lake City, Fla., specimens of the larva of this species found on cowpea, with the accompanying information that two hours' search in a patch of velvet beans failed to find any of these caterpillars. Mr. Gossard was not certain that velvet beans were exempt from attack, but it is evident that they must be comparatively so.

DESCRIPTIVE.

The butterfly.—This leaf-roller is the larva of a butterfly called the "swallow-tailed skipper," and is quite unique among garden pests. The butterfly is illustrated in figure 20, *a*. It has a robust body and wide head, and the antennæ are curved at the tips as figured. Its color

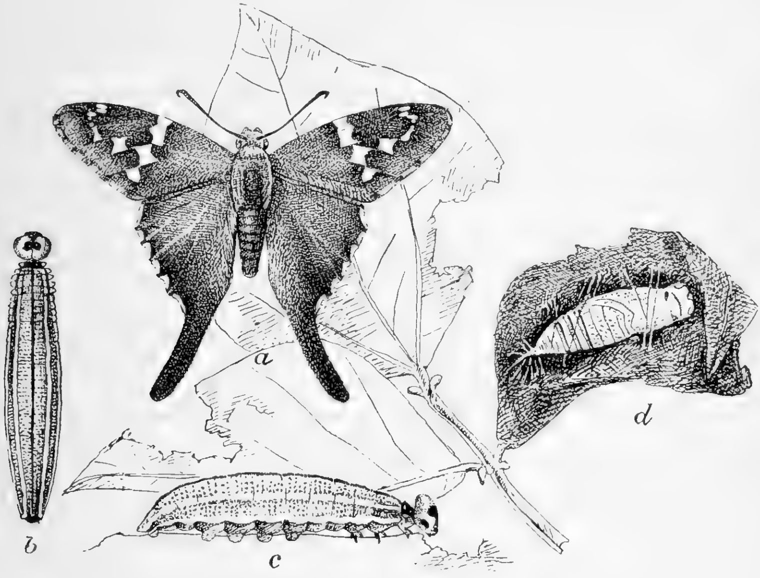

FIG. 20.—*Eudamus proteus*: *a*, butterfly; *b*, larva, dorsal view; *c*, larva, lateral view; *d*, chrysalis in rolled-up leaf—somewhat enlarged (original).

is velvety brown, with long metallic-green hairs on the thorax and contiguous parts of both pairs of wings. The fore-wings are ornamented with white spots and the hind-wings are bordered with a zigzag line of white; the latter terminate in two long, dark-brown tails. The wing expanse is from $1\frac{3}{4}$ to 2 inches. The lower surface is much paler brown, with broad bands of darker brown.

The egg is nearly spherical, depressed below, and marked with ridges, converging at the polls. The eggs when first deposited are glistening white, but soon become yellow. They measure nearly a millimeter in diameter and about 0.8^{mm} in length.

The larva is of the peculiar appearance shown in the illustration (*b*, *c*), nearly cylindrical, with narrow neck and prominent head. The ground color is yellow, dotted with black, and the surface is covered with numerous short, pale hairs. The head is black, with orange spots near the mandibles, and the apical third is reddish. The thoracic plate is also black. It measures, when full grown, about $1\frac{1}{5}$ inches.

The pupa (fig. 20, *d*) is shining brown, the eyes brownish-black. Two or three days after being formed the pupa becomes covered with a peculiar white flocculent coating. Its length is about seven-eighths of an inch.

DISTRIBUTION.

This species is tropical, and apparently injurious only in Florida, although it is recorded to occur in South Carolina, Georgia, and southern Texas. Along the Atlantic seaboard it sometimes extends, probably only by flight of the adults, to a considerable distance north, individuals having been captured in New York City and about New Haven, Conn. It is probably not possible for the insect to breed in the Northern localities. It does not appear to be found very far inland.

As to the foreign distribution of this species Scudder has not indicated special localities with the exception of Mexico. Through the kindness of Dr. Dyar the following localities, based mainly upon material in the National Museum, may be added: Cuba, Jamaica, Trinidad, Guatemala, Venezuela, Buenos Ayres, Argentina, and Paraguay.

GENERAL REMARKS ON BIBLIOGRAPHY AND HABITS.

For many years this caterpillar, known as the bean leaf-roller or "roller worm" (*Eudamus proteus* Linn.), has been recognized as an enemy to leguminous and some other crops in the Gulf States. Injury is usually confined to beans and to cultivated beggar weed (*Desmodium tortuosum*); but according to Prof. J. H. Comstock, who gave an account of this insect in 1880 (Annual Report U. S. Dept. Agr. for 1880, p. 269), cabbage and turnip may also be affected. The article cited has long been out of print, and as the species has not received any attention, or been figured in any later publication of this Department, the opportunity is taken to present illustrations of the insect in all its stages, together with such brief descriptions as are necessary for identification, to which is added a summary of the life habits. For the benefit of anyone who desires to go more deeply into the subject, it might be added that an extensive account of this species, with illustrations and bibliography up to 1889, may be found in Volume II of Dr. S. H. Scudder's Butterflies of the Eastern United States and Canada, pp. 1386–1393. A more recent account has been given by Mr. A. L. Quaintance (Bul. 45, Fla. Agr. Expt. Sta., 1898, pp. 55–60).

NOTES ON DIVISIONAL RECORDS.

Our Divisional records of injury by this species, including the reported damage by Professor Comstock, comprise the following:

February 5, 1880, at Rock Ledge (Brevard County) and Enterprise, Fla., it was destructive to beans, turnip, cabbage, etc. The larva was generally known by gardeners as the roller worm. February 21 larvæ were received which were found feeding upon the cowpea growing wild along the banks of the St. John's River at De Land Landing, Fla. November 4, 1881, larvæ were received from Mr. J. C. Neal, Archer, Fla., where they were destructive to *Desmodium* (*Meibomia*) *canescens*. December 2, 1895, we received from Mr. C. K. Babbitt, Lakeville, Fla., larvæ found feeding on bean and cowpea.

An individual of this species kept at Washington in confinement in a moderately heated room (60 to 70° F.) transformed to pupa October 30, and it was noticed that the pruinosity appeared the next day, increasing in intensity for two or three days. The butterfly matured December 15, the individual having passed six weeks in the pupal condition. In its exit from the chrysalis it left the skin nearly intact.

HABITS AND LIFE HISTORY.

A few plants other than those mentioned serve as food for the larva; these include different species of Wistaria and Clitoria. Frequently larvæ are so abundant as to nearly destroy otherwise promising fields of beans.

According to the observations of Mr. Quaintance (l. c.) the first generation appears in early spring, and successive generations continue until cool weather. In the extreme south of Florida, however, development may be nearly continuous throughout the year, as larvæ have been noticed there during the last of December and in January. In the heat of summer the life cycle is short, requiring, in some cases, only twenty-four days from the deposition of the eggs until the emergence of the adult. The eggs may hatch in four days, the larvæ go through their five molts, and in two weeks from the time of hatching have been noted to enter the pupal state, the latter stage requiring a period of six days. In colder weather in October and November the life cycle may require as long as 37 days. It is probable that the species hibernates as pupæ.

Eggs are deposited on the lower surface of leaflets of bean in groups of from one to six. After feeding a short time the larva prepares a retreat by folding over a flap of a leaf. From this shelter the larvæ crawl out sometimes 6 or 7 inches, and feed upon the surrounding foliage. This species does not differ from other butterflies in being diurnal in habit, larvæ and adults moving about freely at all times of day.

REMEDIES.

Paris green has been used with success by Mr. Quaintance in the treatment of this species on beans in Florida, applied at the rate of a pound to 150 gallons of water, which is sufficiently strong to destroy the larvæ. Quicklime should always be added, in the preparation of this spray, as it neutralizes the arsenious acids which might otherwise be produced when rain follows the spraying. Equal amounts of lime and Paris green are the proportions. Arsenate of lead would probably be more satisfactory, because not apt to scald the foliage.

THE PEA MOTH.

(*Semasia nigricana* Steph.)

In New Brunswick, Nova Scotia, and Ontario, in the Dominion of Canada, where pea-growing is an important industry, there is, in addition to the pea weevil discussed in previous pages, a seed-infesting insect known as the pea moth, the larva of which develops in ripening peas in the pods. This species first attracted attention near Toronto, Ontario, in the year 1893, and since that time yearly complaints have been made of its ravages.

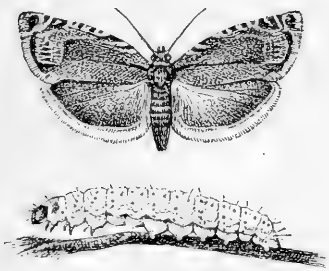

FIG. 21.—*Semasia nigricana* Steph.: moth above, larva below—about three times natural size (original).

DESCRIPTION.

The moth is a small Tortricid, with a wing expanse of half an inch. The fore-wings are dark fuscous or dusky, tinged with darker brown and mottled with white, about as shown in figure 21. The hind-wings are nearly uniform, dark fuscous, and bear a rather long fringe with an inner line.

The larva, shown also in figure 21, is whitish-yellow with pale brown head and thoracic shield, the latter inconspicuous. Its length when mature is about the same as the wing expanse of the moth. The tubercular spots are also inconspicuous, and the hairs are short and sparse.

The pupa does not appear to have been described.

DISTRIBUTION.

This is a comparatively new importation from the Old World, where it has been known for many years as an enemy of the pea. It does not appear to affect any other plant, and injuries are most notable on late crops. It is practically unknown in the United States, but since it is an imported species, there are the best of reasons to believe that it will in time invade New England, New York, and other Northern States, and pea growers should be warned against it.

NOMENCLATURE.

Considerable confusion might be caused if one did not have at hand a rather full literature bearing upon the classification of the pea moth. In a catalogue of Lepidoptera issued by Staudinger & Wocke in 1871, two species are placed in the genus Grapholitha, the pea moth being represented by *nebritana* Tr., with *nigricana* Steph., and *pisana* Gn. as synonyms. There is also a *nigricana* H-S. In Meyrick's handbook of British Lepidoptera, published in 1895, the pea moth is placed in the genus Laspeyresia, *proximana* Walk. being indicated as a synonym, while our other species is listed as *Epiblema nigricana* H-S. This latter is stated to breed in the buds of *Pinus picea*. It is shown herewith for comparison with the true pea moth (see fig. 22).

HISTORY AND HABITS.

It is somewhat singular, considering the time that this species must have been present in America in order to be destructive as early as 1893, that it has not occasioned losses also in our Northern States. Even as early as the date mentioned it was stated to be the principal obstacle encountered in the cultivation of the pea in Canada, the attack frequently resulting in destroying the usefulness of from 10 to 20 per cent of the crop.

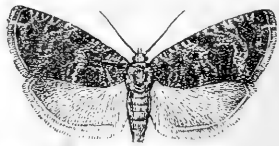

FIG. 22.—*Epiblema nigricana* H-S: moth, about three times natural size (original).

The full life history of this species has not been studied. It is known that the moths fly about sometimes in large numbers around pea blossoms a short time after sunset. The females lay from 1 to 3 eggs on very young pods or ovaries. The caterpillar, according to observations in Europe, is hatched in fourteen days, and goes into the pod and attacks the seed, the opening made in the margin of the pod closing afterwards. Pods thus affected usually ripen early. When the pod opens the mature caterpillar creeps out and enters the earth, there to spin a cocoon-like covering formed of silken threads. Authorities differ as to the state of hibernation. Miss Ormerod (Manual of Injurious Insects, p. 163) states that the larva winters over, and in spring turns to a chrysalis, the moth appearing in June, while Dr. J. Ritzema Bos, in his work on Agricultural Zoology (London, 1894), says that "the pupæ live through the winter." The peas attacked are always covered while in the pod with the cross-grained excrement of the caterpillars, and frequently two or three are joined together by web fibers.

Recently it has been ascertained that the pea moth larva does not injure to any extent the earliest and latest varieties of peas.

REMEDIES.

What has just been said indicates the value of planting the earliest and the latest varieties of peas, and this will probably hold as a good remedy in many localities where the species occurs injuriously. Mr. W. T. Macoun has named Alaska, American Wonder, Gregory's Surprise, Gradus, Nott's Excelsior, and McLean's Little Gem as among the best early varieties. The first three mature as early as June 17, before the appearance of the moths. Crops grown for seed are more difficult to protect.

It has already been advised that clean culture would be found a valuable means of riddance of this insect, and if during the picking the plants are found to have been infested, as soon as the crop is off the remnants should be gathered and burned.

Early fall plowing has also been recommended, but it does not seem that this is necessary if the fields are burned over promptly. In Dr. Fletcher's report for 1900 (1901, p. 214), the results of some experiments that were made in New Brunswick are given. They consist in the use of a spray of Paris green, 1 pound to 100 gallons, with 4 pounds whale-oil soap added, in order that the mixture shall adhere to the waxy pod of the pea. The results were so promising as to show them of importance. Three sprayings are suggested; the first to be applied when the blossoms begin to fall, the second a week later, and the third ten days later than that.

THE BEAN CUTWORM.

(*Ogdoconta cinereola* Guen.)

A caterpillar which has been called the bean cutworm does injury to the foliage and pods of beans, at times stripping the vines bare. The species has long been known to collectors of Lepidoptera, but although widely distributed little has been published concerning its habits, although all of its stages except the egg have been described. It appears to be recorded as doing injury only in the States of Florida and Mississippi.

DESCRIPTIVE.

This species belongs to the family Noctuidæ, or owlet moths, which includes many cutworms, but it is not related to any of the true cutworms, and has never been observed, so far as the writer knows, to be nocturnal or to cut tender plants. Hence it is probable that it is not a cutworm at all and the above name is a misnomer. It is more closely related to the cabbage looper and similar forms.

The moth is a tolerably well-marked species, having a wing expanse of a little over an inch, the fore-wings being light brown and marked with a transverse paler band on the outer third. The reniform mark is distinct, as are other similar markings between that spot and the thorax. The pattern is about as shown in fig. 23, *a*. The hind-wings are nearly uniform gray, with the veins showing plainly and the base of the cilia also well defined. The under surface is nearly uniform grayish-brown, like the hind-wings, but with a more satiny luster.

The larva (*b*) when full grown resembles rather strongly a small cabbage looper (*Plusia brassicæ*), and when disturbed has the same habit of looping like a geometer. It is pale green with three moderately distinct white stripes—median, lateral, and one midway between these two. The length when full grown is about an inch or a little over.

The pupa is shining, rather pale brown, and strongly and deeply punctured on the dorsal surface. It measures about four-tenths of an inch.

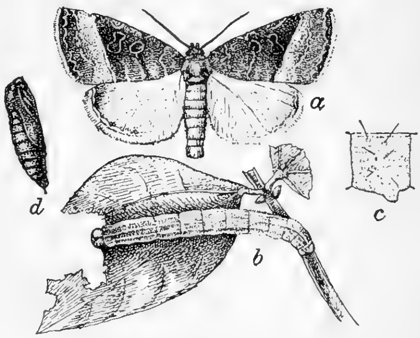

FIG. 23.—*Ogdoconta cinereola*: *a*, moth; *b*, larva; *c*, abdominal segments of larva; *d*, pupa—all enlarged (original).

DISTRIBUTION.

This Noctuid is generally distributed over the United States east of the Rocky Mountain region, from Canada and Minnesota southward to the Gulf States and the West Indies. It is recorded or is known from New York, Delaware, Virginia, District of Columbia, Florida, Mississippi, Texas, Kansas, Nebraska, and Illinois.

Professor Snow has reported it common in Kansas. In Florida, according to Mr. Ashmead, it is rare, and from what can be learned it seems probable that with the exception of a few States, like Mississippi and Kansas, where it has been found abundant, it is not particularly common.

HISTORY AND LITERATURE.

Until quite recently this species was known to collectors and in literature as *Telesilla cinereola*. It was first described by Guenée in 1852 (Spec. Gen. Noct., Vol. II, p. 316) under the genus Placodes. In 1880 Mr. D. W. Coquillett published a description of the larva observed at Woodstock, Ill., with the remark that larvæ were found in a wheat field from June 15 to July 20, but that the food plant was unknown. Transformations were observed to be made under ground. (No. Amer. Ent., Vol. I, p. 52.) The following year Mr. Coquillett again described this larva (10th Rept. St. Ent. Ill., 1881, p, 180), adding the ragweed (*Ambrosia artemisiæfolia*) as a larval food plant. In 1887 Mr. W. H. Ashmead made a more detailed description of the larva and a brief one of the pupa, adding that the larvæ feed on the leaves and pods of bean, sometimes stripping the vines bare. (Bul. 14, Div. Ent., U. S. Dept. of Agr., pp. 21, 22.) In 1890 a brief note by Mr. G. H. Kent, Roxie, Miss., was published in Insect Life (Vol. II, p. 283), in which the statement was made that this larva was feeding on bean pods, doing considerable damage to the crop.

UNPUBLISHED DIVISIONAL RECORDS.

October 7, 1883, Mr. Albert Koebele, then of this office, found in Virginia, near the District of Columbia, several larvæ feeding on cocklebur (*Xanthium strumarium*). They were on the under sides of the leaves, and when at rest were stretched generally on the midrib and some of the larger ones on the stems of the leaves. November 7 oblong cocoons were found in the earth, of which they were formed. The moths from this lot issued in confinement June 3 of the following year. September 3, 1885, Mr. Th. Pergande found larvæ in the District of Columbia feeding on sunflower (Helianthus). Moths from this lot issued in confinement the following year, May 10, 11, and 13. It does not seem probable that this species is limited to the bean among cultivated plants for food. On the contrary, it may now be, or may develop into, a somewhat general feeder, as it has been shown that it breeds normally upon composite plants, such as ragweed, cocklebur, and sunflower.

No parasitic or predaceous enemies appear to have been recorded.

REMEDIES.

An arsenical spray, preferably of arsenate of lead, would kill this insect when it occurs in numbers on beans, but care should be used when it attacks the pods, if these are soon to be used for food, to guard against possible poisoning of human beings. The destruction of the insect upon its wild food plants, such as pigweed and cocklebur, is also advisable, and it would be well to keep these plants down in regions where the bean cutworm has once been injurious.

NOTES ON INSECTS AFFECTING BEANS AND PEAS.

Under the above title the writer has brought together certain short notes on different species of insects that have either been treated in a popular or general manner in earlier publications, or that have not yet been made the subject of special study during recent years. All that will be mentioned have come under observations through their occurrence on beans, peas, cowpea, and related legumes, and have been actually detected feeding upon one or more of these plants. Certain of the data that have been acquired concerning this class of insects have been made public in an article which took the form of condensed and popularized accounts of the more common and injurious forms. This was published in the Yearbook of this Department for 1898 (pp. 233-260), and is also issued in popular form. Other articles and notes have appeared in Bulletins 8, 9, 19, and 23 of the present series, or are included in previous pages of the present bulletin. The notes which follow have been made since the publication of certain of the articles and notes referred to, or were necessarily excluded for lack of space or as inappropriate to a popular consideration of the subject. The facts at hand are not deemed of sufficient importance of themselves to justify more complete treatment at the present time.

The Gray Hair-streak Butterfly (*Uranotes* [*Thecla*] *melinus* Hbn.).—Among other garden insects observed by Mr. A. N. Caudell upon the occasion of his collecting trip in Colorado during the summer of 1901 was the caterpillar of this pretty butterfly, feeding on the pods of Windsor bean, in the garden of Mr. E. J. Oslar, at Denver. Normally they live in that region on *Astragalus mollissimus* Torr., a leguminous and, it might be added, pestiferous plant, growing on prairie land and commonly known as "loco weed."

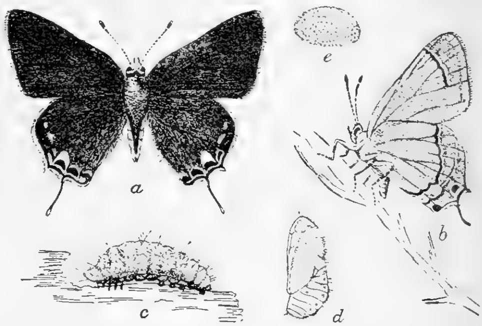

FIG. 24.—*Uranotes melinus*: *a*, dorsal view of butterfly; *b*, butterfly, with wings closed; *c*, larva from side; *d*, pupa; *e*, egg—all somewhat enlarged, except *e*, greatly enlarged (all except *e* redrawn from Howard).

During the last four years this species has been under observation as an enemy of beans. In fact, the bean, although not perhaps a special food plant, appears to be attacked every year by this insect, although injury is not as a rule severe.

In 1897 Prof. W. G. Johnson observed it on bean in Maryland (Bul. 9, n. s., Div. Ent., p. 83).

The next year the writer observed the larva on hog peanut (*Falcata* [*Amphicarpæa*] *monoica*) and tick trefoil (*Meibomia* spp.). The resemblance of the larva to the pods of the last-mentioned plant is striking. A number of other wild food plants are recorded, including among the legumes, bush-clover (Lespedeza).

July 8, 1899, numerous moths were noticed by the writer at Cabin John, Md., between rows of Lima beans, late in the afternoon, hovering about and alighting upon the blossoms. Some were captured for identification, but further observations were not made. During the same month and year larvæ were observed working on pea pods and devouring the peas at Carthagenia and Wooster, Ohio, and in the silk of corn at Clifford, Ohio (Webster, 30th An. Rept. Ent. Soc. Ont., pp. 56, 57, 1900).

Attack by this species to pole Lima beans at St. Elmo, Va., was reported by Mr. Pratt, August 27 and later in 1900. It seems that even a single boring in a pod of beans is enough to insure injury. He estimated that about 25 per cent of the crop of that vicinity was damaged.

An illustrated account of this insect, entitled "The gray hair-streak butterfly and its damage to beans" was published in Insect Life (Vol. VII, pp. 354, 355).

It is illustrated in its various stages in the accompanying figure 24.

A natural enemy of this insect has been observed in a small ichneumon fly *Anomalon pseudargiole* How.

This species seldom does very severe damage, hence little precaution need be observed in the treatment of it early in the season. It would be well, however, to destroy all affected bean pods, that the insect may not develop and do injury in after years.

The Bean Leaf-beetle (*Cerotoma trifurcata* Forst.)—This insect has already been reported by Professor Johnson in Bulletin No. 26 (n. s., p. 81) as having been very destructive in 1900 to wax and Lima beans throughout the trucking area of Maryland.

May 14, of the same year, the writer found this species at work on bean at Cabin John, Md., doing, it would seem, the greatest damage ever observed in the East. Not a single leaf had escaped its ravages; all were pitted full of large holes or had been stripped to the midrib.

The following day Mr. Henry Olds, of this Department, reported this insect injuring bean at Woodside, Md., and Mr. Pratt noticed the same insect at work on beans at St. Elmo, Va.

May 26, Mr. B. M. Hampton sent specimens from Peacocks Store, N. C., with report that this beetle was known locally as the "terrapin bug" (a name which it shares with *Murgantia histrionica*), and that it was a perfect nuisance, doing much injury to snap beans by eating holes in the leaves.

A second visit was made to the infested garden at Cabin John June 12, a month after infestation was first noticed. The rows of beans that had been first planted and that were noticed to be most injured were practically ruined. They had not made such good growth as other rows planted later, and many of the leaves had dried up and fallen off. The later rows, though they had made better growth, looked, as an observer remarked, "as though they had been shot full of holes from a shotgun."

The Lima-bean Vine-borer (*Monoptilota nubilella* Hulst.).—This species, an account of which was given by the writer on pages 9–17 of Bulletin No. 23, n. s., made its appearance the past year on Lima beans, and in a new locality. August 27, 1900, Mr. Pratt reported the larvæ at work on pole Lima beans at St. Elmo, Va., and late in September found that the same species was working on bush

Lima beans—something that it was not observed to do in previous seasons.

October 8, he made examination of different plants growing in his own garden and reported that at least 50 per cent of the galls examined showed that the occupants had escaped. From observations made at this time he concludes that this vine borer is capable of doing severe damage, the part of the stem above the galls seldom producing beans, and in some cases dying. Injury, however, is not readily apparent owing to the fact that from 4 to 6 plants often grow on one pole and injured portions are usually concealed by the numerous leaves. In one instance no less than 17 galls were counted on a single plant, while the other plants in the same hill were scarcely affected. In another instance galls were observed at the roots of the plants on a level with the soil, the gallery extending an inch below the surface.

At Cabin John, Md., where this species occurred in 1898 and 1899, it reappeared, but in much diminished numbers.

After the publication of the writer's article, previously cited, Dr. Hopkins's note entitled "A Lima bean borer" was remembered, too late, however, for insertion in the bulletin mentioned. This note appeared in Volume VII of Insect Life (p. 146.) As the publication mentioned is not available to everyone, his note may be repeated here:

> September 8, a Lepidopterous larva was found causing considerable damage to Lima-bean vines in Wood County, W. Va. The larva was about one inch long, the body uniform purple above and light blue beneath. It occupied about two inches of the vine, causing a swelling or kind of gall, in this respect resembling the habits of the common stalk borer (*Gortyna nitela*). When more than one larva occurred in a plant it died from the injury. I also failed to rear the adult of this insect.

Dr. Hopkins's as well as the writer feels little hesitancy in stating that this is the same species, *Monoptilota nubilella* Hulst.

A new natural enemy of this insect was observed by Mr. Pratt at St. Elmo, Va., the larva of a species of soldier beetle, either *Chauliognathus pennsylvanicus* or *Ch. marginatus*. This larva was detected in the act of devouring a vine-borer larva, and several dead larvæ of the moth and of the soldier beetle were found in the galls.

Diabrotica atripennis Say.—July 10, 1899, the adults of this species were observed by Mr. Pratt attacking the blossoms of Lima beans at Travilah, Md. Specimens brought to this office continued feeding on bean blossoms in confinement. This is the first observation of the food habits of this species of which the writer has knowledge. The larval habits are unknown, but larvæ doubtless feed about the roots of some wild leguminous plant in the same manner as *Diabrotica vittata* feeds upon cucurbits and *12-punctata* at the roots of cereals.

The Mexican Bean Weevil (*Spermophagus pectoralis* Shp.). —Under date of July 26, 1900, Mr. Enrique R. Margarit, Habana, Cuba, transmitted specimens of black beans infested by this species, present in all stages at the time of receipt, August 1. Our correspondent stated that these beans were raised in Mexico, in hot regions, and immediately after harvest were taken to cold regions, where the seed was kept for a long time, sometimes even for two years, but as a result of being in Cuba even ten days seed commenced to show evidences of attack and soon destruction was complete. In winter this seed keeps in Cuba about thirty days. The same happens to black beans harvested in Cuba.

The species does not appear to have been previously recorded from the West Indies.

From the material obtained and kept under observation it is now positive that this species has practically the same life habits as the other pea and bean weevils, accounts of which the writer has given in the Yearbook of this Department for 1898 (pp. 234–248).

The Pea Weevil (*Bruchus pisorum* Linn.).—So far as known to the writer, no parasite of the pea weevil has been recorded. A single species of the family Chalcididæ, however, *Bruchobius laticollis* Ashm. MSS., was reared from peas infested exclusively by this weevil and received in October, 1898, from Fayetteville, Ark. This parasite is much more abundant on other species of Bruchus which affect bean and pea, our two bean weevils and the cowpea weevil.

The Boll Worm, or Corn-ear Worm (*Heliothis armiger* Hbn.).—This species, after a year of comparative rarity in Virginia, Maryland, the District of Columbia, and northward, became quite numerous during the year 1900, particularly toward the close of the season, doing considerable damage to late corn and some other crops, including Lima bean, the seeds of which it devoured. During 1899 also we received this insect with reports of its having been found on what appear to be new food plants, as follows: October 21, 1899, the larva was found boring into the stems of peanut by Mr. T. I. Todd, Athens, Ga.; June 14, 1900, Mr. F. S. Earle, Auburn, Ala., reported this larva to be eating into and destroying seeds in the pods of hairy vetch (*Vicia villosa*); October 15, larvæ were found by Mr. F. C. Pratt in considerable numbers in an experimental plat of chick-pea or gram (*Cicer arietinum*) on the Potomac flats near the Department of Agriculture.

It may be well to mention in this connection an extreme instance of injury to beans reported by Mr. J. H. Matheny, Long Beach, Miss. May 20, 1899, he sent larvæ, with the accompanying statement that they destroyed the bean crop in that vicinity nearly every year, the damage being estimated at thousands of dollars. In response to inquiry our correspondent sent additional specimens of larvæ, together with moths and bean pods, showing the work of this species, and further stated that no other insect was concerned in this injury, and that the boll worm was destroying the bean crop of the entire Gulf coast.

The Fall Webworm (*Hyphantria cunea* Dru.).—During the years 1899 and 1900 this species was frequently observed on beans, and in one instance destroyed quite a number of vines of pea. In another case a larva was observed eating into the ripe fruit of tomato September 18.

The Garden Flea-hopper (*Halticus uhleri* Giard).—Prof. F. M. Webster has stated that he obtained newly hatched nymphs in the field May 8, showing, he believes, that the species winters over in the egg, as no adults were to be found. In Entomological News for April, 1900, the same gentleman states that there are probably not less than five generations of this species at Wooster, Ohio, annually.

In May and June, 1900, this insect was observed in some numbers on beans in different localities, and some leaves were found to have been

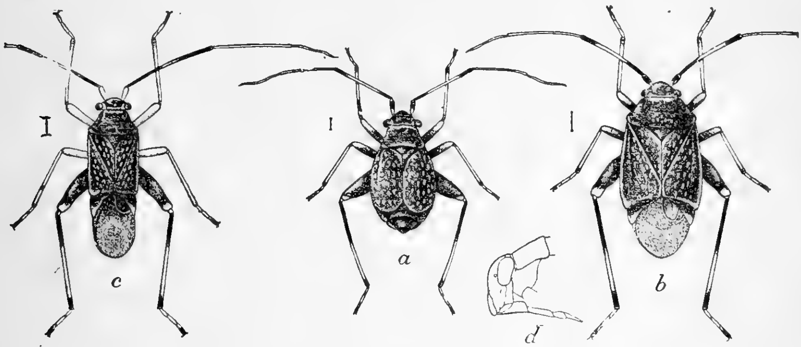

FIG. 25.—*Halticus uhleri: a*, brachypterous female; *b*, full-winged female; *c*, male; *d*, head of male in outline—*a*, *b*, *c* much enlarged, *d* more enlarged (author's illustration).

killed by its attacks. Beets and cabbage were also affected, but injury was less noticeable to these crops.

In 1901 the writer noticed severe injury to ornamental morning-glory in the city of Washington.

Acanthocerus galeator Fab.—This plant-bug, better known in literature and in collections generally as *Euthoctha galeator*, has been often seen on garden beans during recent years. September 8, 1900, Mr. F. C. Pratt observed an adult with its beak sunk in the stalk of a bean plant, so there can be no doubt of this host plant, although injury has as yet not been reported.

So little is definitely known of the true food habits of this species that it may be well to mention some of the reports concerning it:

It first came under observation at this office May 27, 1879, when Mr. Theodore Pergande observed a specimen sucking the sap from the petiole of a leaf of a terminal shoot of raspberry, the result being that the petiole became black and the leaflets wilted.

July 5, 1895, Mr. D. B. Story, Darwin, Ohio, reported that this insect did much damage to nursery stock, particularly yearling apple trees, by stinging and blighting the tender tips.

June 8, 1899, Mr. Pergande observed one of these bugs sucking young shoots of plum, which were afterwards observed to wilt and turn black as in the observation made on raspberry; and during September, 1900, he obtained a number of ymphs mostly in the last stage, attacking common ragweed (*Ambrosia artemisiæfolia*), this latter being, therefore, undoubtedly a natural food plant.

An account was given of this species by the late H. G. Hubbard in "Insects affecting the orange," which includes a figure of the adult and brief description of the eggs and the young nymphs. He states (p. 163), "It is a very common and often a very destructive insect," presumably to orange in Florida.

In a recently published account of this species by Messrs. Forbes and Hart (Bul. 60, Univ. Ill. Agric. Ex. Sta., p. 445) some additional notes are given, it being stated among other things that the authors found it on blackberry and raspberry, and on forest undergrowth in Illinois. It is stated on the authority of Bruner to occur on beets and on wild cucumber.

Alydus eurinus Say and **A. pilosulus** H.-S.—During January, 1901, Mr. F. E. Brooks, French Creek, W. Va., wrote of an insect which is described as somewhat resembling the squash bug, and which he stated was injuring his Lima beans and late cowpeas.

January 15, he sent specimens found among dead bean vines, which there was no trouble in identifying as the above species. Specimens of bean pods accompanied this letter, and both pods and beans plainly showed punctures of a sucking insect, the beans being quite disfigured by the numerous discolorations formed about the punctured spots.

In continuation of observations conducted in 1901, Mr. Brooks also sent additional specimens of this species of the variety *ater* Dall., as also of *Alydus pilosulus* H.-S., with information that they appeared to be responsible for the diseased condition of cowpea. October 28, 1901, Mr. Brooks wrote that these insects occurred again in considerable numbers, but the early frost killed the vines of cowpea, as also the pods, and rendered it impossible to determine to what extent the insects were responsible for the spread of the disease in the beans and cowpeas. Our correspondent, however, was still of the opinion that under favorable conditions these insects transmitted the disease from one pod to another and that they may prove at times a serious pest. He had observed them at the date of writing collected upon the dry pods of cowpea. They thrust their beaks quite easily through the dry pods and appeared to be feeding on something within for one or two minutes, when they removed their beaks and inserted them in another place. He could not determine whether the puncture extended to the seeds within or not. Our correspondent's opinion is of value, as he was perfectly able to distinguish the two species of Alydus, noticing also that copulation took place only with the insect's own kind and not with the associated species. The two species occurred in about equal numbers, their habits being the same.

Leaf-hoppers (Tettigoniidæ and Jassidæ).—Various species of leaf-hoppers of the families Tettignoiidæ and Jassidæ were under observation during the past three years on experimental plats of the Department of Agriculture on cowpea and beans. They occurred in all stages, feeding on the under surface of the leaves, but were not present in really injurious numbers.

The crafty leaf-hopper (*Diedrocephala versuta* Say) was the most conspicuous species, on account of its larger size and brighter colors, although numerically less than the smaller Empoascas, with which it

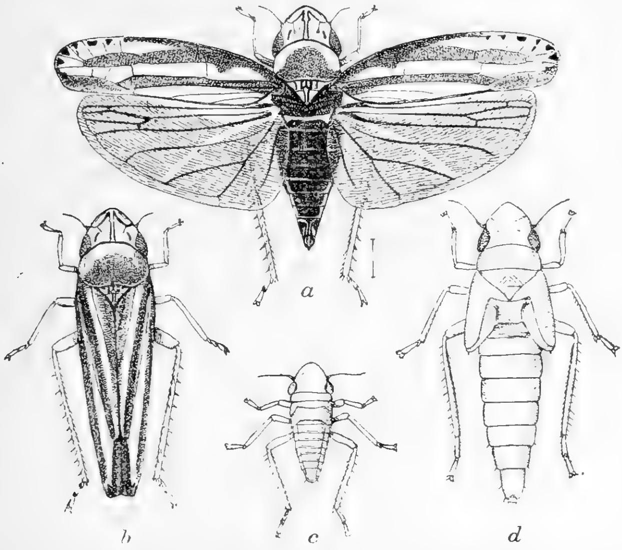

FIG. 26.—*Diedrocephala versuta*: *a*, male with expanded wings; *b*, same with wings folded; *c*, young nymph; *d*, last stage of nymph—all much enlarged (original).

was sometimes associated. Adults were present from June to September. This, like many other leaf-hoppers, probably lives largely on grasses, but cowpea is also greatly relished. Without doubt it agrees rather closely in habits with the better-known red-banded leaf-hopper (*Diedrocephala coccinea* Forst.), to which it is closely related. The latter, according to Messrs. Osborn and Ball, is double-brooded (Bul. 34, Iowa Agr. Coll. Exp. Sta., p. 615, 1897). From the latter, *versuta* differs chiefly in its smaller size and by having the vertex with the black markings nearly parallel with the anterior margin, which is usually black-lined. There is often a pair of approximate median lines on the disk. *D. coccinea* is reddish, with green stripes on the pronotum and elytra, while in *versuta* yellowish or greenish predominates, with occasionally reddish on the upper surface. A mature male of this leaf-hopper is shown in figure 26 at *a*, with wings spread as in life, while at *b* the same is illustrated with wings folded in the natural position which it assumes when feeding or at rest. From the nature of its markings this is a rather attractive species, and the yellow of the common form found in the District of Columbia is variegated above with green and bluish, forming stripes on the wing-covers, as shown. A young nymph or larva is illustrated at *c*, and *d* shows the nymph in the last or pupal stage just previous to molting.

This species, as defined by Prof. E. D. Ball (Proc. Iowa Acad. Sci., Vol. VIII, 1901, p. 30; Ser. 5, No. 21, Ohio St. Univ. Bul., p. 31), is evidently more abundant in the South. Its name does not appear in any lists of New York or New Jersey species at present available, although it has been recorded from Ohio and Illinois. It extends from central Mexico and the Gulf States northward to Maryland, Virginia, and the District of Columbia, and westward as far as Illinois. What are considered varieties of this species, however, have been described from South America and the Pacific coast.

As a result of the investigations of Messrs. Osborn and Ball (l. c.), some generalizations as to the life habits of these two families of leaf-hoppers have been drawn. The species under observation in Iowa showed, as a rule, a decided limitation as to the food plant, holding to one species while in the immature stage, but feeding more indiscriminately in more mature stages, in which respect these insects resemble larger forms of Hemiptera, such as the harlequin cabbage bug and squash bugs, which subsist normally on single orders of plants. The species observed deposit eggs upon the stems under the leaf sheaths or in the leaves of the food plant. There is a wide divergence as regards life histories, some species producing one generation; the majority of the grass-feeding forms, which includes a very considerable percentage of these insects, two generations; and some having three in a season. Save in the case of hibernation in the adult stage, the life of a generation of adults does not exceed two months, while that of the individual rarely exceeds one. Males appear a week or ten days earlier than the females, and their disappearance is much earlier. There is so little overlapping of generation that one of adults disappears before the nymphs of the next have matured, so that individuals observed at any time may be referred to the generation to which they belong. The eggs for each generation are deposited within a limited time, so that a period may be defined when all eggs of a given species will have been laid, and during which measures for their destruction may be applied.

As a further result of these studies of the life economy of leaf-hoppers, it was ascertained that simply cutting the grass (and perhaps other plants affected) and leaving it in the field would prevent hatching, as in no case did eggs observed hatch from stems that had been cut while green. The drying of the stems results in the crushing and distortion of the eggs, due to the shrinkage of the plant tissues and to the curling of the edges of the sheaths.

Stictocephala festina Say.—Another leaf-hopper, was sent in abundance to this office by Mr. Thos. I. Todd, Athens, Ga., October 2, 1899, with the accompanying statement that they were affecting Lima beans, and that they were not noticed before August of that year. Our correspondent stated that this insect caused the vines which it infested to shed their leaves, after which the stems dried, the vine finally being killed. The method of injury by suction was noticed.

The species is one of wide distribution, but little appears to have been published concerning its habits. There is at least one record of injury, however, that published in Insect Life in 1888 (p. 50), which has reference to damage to young tomato plants at Wilmington Island, Ga., in April and May, 1887. Injury is described as being due to the insect "ringing" the stem, causing the plant to wilt. The recorded distribution includes territory from Connecticut in the North and East to Florida and Texas in the South, and in the West to Colorado and Montana.

The Bean Aphis (*Aphis rumicis* Linn.)—This well-known species, which is common to this country and to Europe, having evidently been introduced from the Old World, has been noticed during the past four years in most patches or fields of bean and cowpea examined, being especially abundant upon the latter crop plant.

During 1899 and 1900 it was present on Lima bean, in sufficient numbers to attract rather general notice particularly at Marshall Hall and Cabin John, Md., and St. Elmo and Alexandria, Va. It is particularly noticeable on the last-mentioned plant from its habit of congregating on the terminal leaves and flower heads and about the stems of the pods.

The species has been the subject of considerable study by different economic writers, including Fitch, who has given it extended notice in his thirteenth report on noxious and beneficial insects of New York (1869, pp. 495–512), and Messrs. Osborn and Sirrine (Bul. No. 23, Ia. Agr. Coll. Expt. Sta., 1893, pp. 901–905). In the article last cited, which is entitled "Life history of a common plant-louse (*Aphis rumicis* L.)," a good account of the life cycle of the species is given as observed at Ames, Ia., and, as this locality is not particularly different, zoologically and geographically speaking, from the District of Columbia, no special study has been given the species by the writer.

Wireworms.—Leguminous crops do not appear to be much affected by wireworms. No doubt the insects are frequently present, but injury is seldom apparent. There is one, however, that has been identified with attack on bean. This is a common species, particularly southward, and known as *Monocrepidius vespertinus* Fab.

Numerous individuals of this click-beetle were observed by the writer during the first two weeks of July at Colonial Beach, Va. (which is about 45 miles south of Washington, D. C.), in beds of beans where no other plants grew. Search was made for the larvæ, but it was evidently not the season for them, as none were found. There can be no doubt of their infesting beans, as at this time the species in question was the most abundant of all insects observed in that field. The larva and beetle are shown in figure 27.

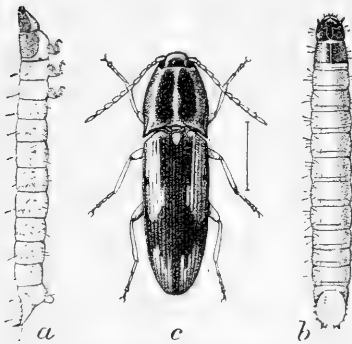

FIG. 27.—*Monocrepidius vespertinus*: *a*, larva, side view; *b*, larva, dorsal view; *c*, beetle—all three times natural size (original).

NOTES ON FLEA-BEETLES.

Among other injurious forms of insect life that were noticeable by their numbers during the season of 1900, flea-beetles of several species occupied an important place. Some of the injurious forms which were attached to special plants and some of the more striking instances of injury by species of omnivorous tendencies will be mentioned in connection with other observations that were made concerning them. During 1901 some species were injurious, but, as a rule, not so abundant and troublesome as in the preceding year.

The Pale-striped Flea-beetle (*Systena blanda* Mels.).—The pale-striped flea-beetle was one of the most abundant and troublesome forms during the year 1900. In the latter half of May and early June it was noticed by the writer and others in greater abundance in Maryland and Virginia near Washington than in any previous year, and was concerned in inj ıry to beans in several localities. It was reported to be troublesome to the same crop at Woodside, Md., and St. Elmo, Va., by Messrs. Olds and Pratt of this Department, respectively. The latter reported that during June it did great damage to pole and bush Lima beans, while the ordinary field or garden beans were scarcely touched. In some cases replanting was necessary. The occurrence of the beetles in considerable numbers on other cultivated plants as well as upon weeds was noticed, but damage was observable only to beans in the localities mentioned. Beets were also the subject of attack, as observed by the writer, and reports of injury to beets reached us from different regions. This crop, however, was not severely injured, the beetles seeming to prefer the leaves of bean when they were obtainable to any other food crop. In other more distant localities it will be noticed that beans and peas were also much injured and beets suffered considerably in Michigan and Colorado, as reported.

June 18, 1900, we received specimens of this species together with

S. hudsonias, with report that they were injurious to pole beans, as will be mentioned more in detail in consideration of the latter species, at Milo Center, Yates County, N. Y.

Mr. Edward C. Post, Dundee, Mich., who sent specimens of this beetle in 1889 from Monroe, Mich., wrote June 21, 1900, transmitting specimens taken from four different fields of sugar beet some 5 miles apart and about 18 miles from Monroe. In two of these fields the beetles did considerable damage.

August 8, 1900, Mr. Carroll Fowler, of the Agricultural Experiment station, University of California, at Berkeley, Cal., sent specimens of this beetle with the information that they had been received from Mr. W. Winterhalter, Rockyford, Colo., where they were doing considerable damage to sugar beet. Mr. Winterhalter describes the work of this beetle as follows:

It bores the leaves from the upper side, boring regular holes clear through the leaves, and, as it appears in swarms of millions, it practically kills the plants which are two or three weeks above the ground. These flies have destroyed quite a few acres in our Pueblo district. They are doing likewise with cockleburs, sand burs, and other weeds. The beets are badly injured and their growth is checked considerably, but this fly is too small to destroy old plants completely. The specimens were collected June 19, 1900.

During the summer of 1899 imagos were reared July 22 and 23. In 1900 imagos of the new generation were observed August 25, over a month later.

May 18, 1901, Mr. W. J. Langston, Sixmile, Ala., sent specimens of beetles and cotton leaves, the latter showing severe injury by this insect. The beetles had been seen at work only two days.

May 21, Mr. B. M. Moose, also sent specimens with leaves of cotton showing similar injury. He stated that the beetles were very numerous on his farm at Simpsonville, S. C., having made their appearance two days earlier. Beets were also injured.

June 20, Mr. A. L. Beals, Deming, Ind., sent numerous specimens of this beetle with report that, although the species had been in his garden only about three days, it had done great damage, especially to radish, beet, bean, melon, and cucumber.

The Red-headed Flea-beetle (*Systena frontalis* Fab.).—One of the injurious occurrences of the year 1899 was that of the so-called red-headed flea-beetle, *Systena frontalis* Fab., at Syracuse, N. Y., reported by Smiths & Powell Company, August 3, as injurious to sugar beet. Although this is the only case of damage reported from there during that year, it is possible that there was an outbreak of the species in that portion of the United States and perhaps Canada, as this insect is known to be periodically troublesome in that latitude.

Systena frontalis was first reported by Mr. William Saunders as injurious in the year 1882 (Can. Ent., Vol. XIV, p. 147; 13th Rept.

Ent. Soc. Ont. for 1882 [1883], p. 10), having been noticed at Oakville, Ontario, Canada, where it was damaging the leaves of grape. The beetles were described as being very abundant and destructive, eating the green tissue of leaves on the upper side, causing them to wither.

After a lapse of five years this species was observed, together with *S. blanda*, attacking potato at Wea, Ind. (Webster, Rept. Dept. Agr., 1887, p. 151), and was again troublesome in Canada, this time as a pest in the shrubbery and on the seed beds of the botanical garden of the experimental farm at Ottawa (reported by Dr. James Fletcher, in his report as entomologist and botanist of the Dominion of Canada for 1889 [1890], pp. 87, 88). Young plants and low shrubs of a great many botanical orders were attacked, ravages being particularly noticeable upon some species of Althæa, Hibiscus, and Weigelia, as also upon young grape vines. Injury was all done by the perfect beetles, few plants appearing to come amiss to them.

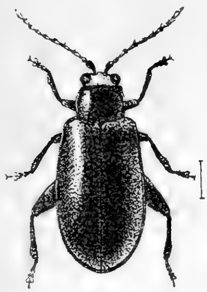

Fig. 28.—*Systena frontalis*—much enlarged (original).

In 1891 we received specimens, August 11, from Smiths & Powell Company, Syracuse, N. Y., with the information that the beetles were doing damage to pear by eating the soft leaves. A remedy was requested, as it was feared that, if the beetles were left undisturbed, that they would become a nuisance (Insect Life, Vol. IV, p. 135).

The same year we reported this insect as feeding upon beet leaves at Lincoln, Nebr., and on the leaves of *Hibiscus militaris* at Westpoint, Nebr., at which places the insect was observed by Mr. Lawrence Bruner in 1890 (Bul. 23 [old series], Div. Ent., 1891, p. 15).

The writer has been familiar with this species for a great many years, having first observed it at Ithaca, N. Y., in company with the commoner but less troublesome *Systena hudsonias*, on smartweed, pigweed (*Chenopodium album*), and other weeds in August and September (Proc. Ent. Soc. Wash., Vol. II, p. 266).

In the late Dr. Lintner's report as State entomologist of New York for 1892 (p. 343), he records the occurrence of this Chrysomelid in injurious numbers on the foliage of gooseberry at Geneva, N. Y., during the latter part of July and early August of that year.

In 1893 this flea-beetle was again troublesome in Canada, and was mentioned by Dr. Fletcher in his report for that year (1894, p. 28). It attacked a great variety of plants, including potato, horse bean, many kinds of deciduous shrubs, and young grapevines, having been especially injurious to grape at Ottawa. Its attacks were worse on those varieties which belonged to the thin-leaved grapes derived from *Vitis riparia*, the greatest damage having been done to young seedlings which were not trained on trellises and which had not been sprayed with fungicides.

In 1896 Mr. W. S. Blatchley mentioned this flea-beetle in connection with its occurrence at Indianapolis, Ind., stating that it occurred commonly in June on the leaves of the great ragweed, *Ambrosia trifida*, and that it had once been taken under bark in February (Psyche, Vol. VII, p. 437).

In 1900 Messrs. Forbes and Hart (Bul. 60, Univ. Ill. Agr. Exp. Station, 1900, p. 468) made brief mention of this species as an enemy of the sugar beet, introducing an original illustration of the adult.

The red-headed flea-beetle, as its scientific name shows, is congeneric with the pale-striped flea-beetle (*Systena blanda*), which has been treated in preceding pages and more in detail in an article by the writer in Bulletin No. 23 of the present series (pp. 22–29). It is of very similar form, a little more elongate and considerably larger, and differs, moreover, in being shining black throughout, except for the greater portion of the head, which is red. It is not likely to be confused with any other flea-beetle, and is nearest related to *Systena hudsonias*, which is entirely black and a little smaller. Apart from the color of the head, *frontalis* may also be distinguished from *hudsonias* by its somewhat broader form, the elytral punctation being less coarse, but rather more dense. It is shown five times enlarged at figure 28. The immature stages seem not to have been recognized.

The habitat of this species has been outlined by Mr. H. F. Wickham so as to include the entire region east of the Rocky Mountains (Proc. Davenport Acad. Nat. Sci., 1896, p. 162). From a statement made by Dr. Horn concerning it (Trans. Amer. Ent. Soc., Vol. XVI, 1889, p. 270), it might be inferred that its range extends from the Canadian region to the Southern States. Judging from reports of injury this species may be said to be a Transition form, extending southward through the Upper into the Lower Austral region. The list of localities in which it is known to occur includes: Vermont; Springfield, Mass.; Buffalo, Ithaca, Syracuse, Geneva, and New York, N. Y.; New Jersey, generally distributed (Smith); Iowa City, Iowa; Michigan; Westpoint and Lincoln, Nebr.; Columbus, Tex. (June 16); Florida; Ottawa and Oakville, Ontario, Canada.

The Smartweed Flea-beetle (*Systena hudsonias* Forst.).—July 26, 1899, Mr. George G. Atwood, Geneva, N. Y., transmitted specimens of this flea-beetle with the report that it was destructive to sugar beet in that vicinity. There is an earlier unpublished Divisional record of attack made to this office May 23, 1896, by Mr. B. F. Ferris, Sunman, Ind., who sent beetles with *S. blanda*, and the report that they were injuring corn in his neighborhood. It is only in recent years that this species has attracted any attention as a pest, the first record of injury known to the writer having been published in 1887 (Report Dept. Agr., 1887, p. 151). In that year Mr. F. M. Webster observed damage by this insect to potato at Wea, Ind., attack being shared, as in the preceding case, with *S. blanda.* August 17 1892, we received from Mr. Geo. Lamoreux, North Hector, N. Y., specimens of this beetle, with the statement that it fed on the leaves of grape and was noticed also on potato tops and on Canada thistle. June 18, 1900, we again received specimens of beetles together with *S. blanda*, with report that they were injurious to several acres of white pole beans at Milo Center, N. Y. Our correspondent, Mr. A. H. Ansley, stated that nearly one-fourth of the plants above ground at the time of writing were riddled by the insects. Attack was first noticed June 16, when only an occasional plant was being eaten, but at the date of writing many more of the beetles were seen, and the first plants infested were dried and crisp except a young center leaf just budding out. Sweet corn and other plants in the vicinity appeared to be exempt from attack.

This flea-beetle is shining black throughout and may be distinguished from *frontalis*, to which it is nearly allied, by the characters given in the consideration of that species (fig. 28).

According to Horn, the distribution of *S. frontalis* in the United States extends "over the entire region east of the Rocky Mountains."

Early in the past decade the writer had occasion to observe this flea-beetle in great numbers at work on a variety of weeds growing in the vicinity of the District of Columbia. From an account published in the Proceedings of the Entomological Society of Washington in June, 1892 (Vol. II, p. 266), the following list of observed food plants of the beetles with other notes is taken:

> Smartweed (*Polygonum hydropiper*), dock (*Rumex* spp.), daisy (*Chrysanthemum leucanthemum*), flea-bane (*Erigeron canadensis* and *philadelphicus*), plantain (*Plantago major* and *lanceolata*), ragweed (*Ambrosia artemisiæfolia* and *trifida*), golden rod (*Solidago* spp.), catnip (*Nepeta cataria*), *Brunella vulgaris*, and species of vervain (*Verbena* spp.). When found upon the smartweed the little insects had riddled the leaves with holes. On dock they were also numerous. They choose by preference the tenderest leaves of young plants, those of only a few days' growth being frequently attacked, but they infest as well plants that are more mature. Their work varies according to the plant attacked, but in general they eat out little holes here and there after the manner of other flea-beetles. On warm days they are quite active and voracious. The beetles abound throughout the summer months and occur on a number of other weeds, particularly of the Compositæ, besides those mentioned.

This species is given brief consideration by Messrs. Forbes and Hart (Bul. 60, Univ. Ill. Agr. Exp. Sta., 1900, p. 467), reference to its occurrence on sugar beet at Urbana, Ill., and in New York being noted. An original illustration of the adult is also furnished. The name of smartweed flea-beetle has been proposed, and this name has been adopted in the present article.

The Toothed Flea-beetle (*Chætocnema denticulata* Ill.).—This insect occurred in unusual numbers in 1900, making its first appearance during the first week of April on grasses. May 14 the writer's attention was called to the work of the beetles on sweet corn near Cabin

John, Md., and a visit to the infested garden showed that the plants, which were only from an inch to 2 or 3 inches in height, were very badly infested. A dozen or more beetles were often found on a single plant, many *in copula*, and sometimes so many would be crowded into a single rolled blade as to make the interior look black. This was the third planting of corn which had been made in this plat.

It was not possible to make a second visit to this garden until about a month later, and then the beetles had practically disappeared. Little additional injury had been done, and it seems probable that the beetles left the plants within a week after their first being noticed.

Search was made for the larvæ at the roots of corn and grasses, but without success.

Earlier mention of this species and its attack upon millet and allied grasses was made by the writer in Bulletins 9 (n. s., p. 22) and 17 (p. 85).

It has also been mentioned by different writers as an enemy to corn and to beets. On the former plant it sometimes occurs in abundance, and does conspicuous injury by making minute holes or elongate slits and white streaks on the leaves. It has been found injuring beets to some noticeable extent in Nebraska and Illinois, and in the latter State, according to Forbes and Hart (Bul. 60, Univ. Ill. Agr. Exp. Sta., 1900, p. 466), it has been noticed in abundance on coarse grasses near Elizabeth, Ill. Like most of the Chrysomelidæ, it hibernates as an adult, and eggs have been obtained early in July. Otherwise its life history appears to be unknown.

FIG. 29.—*Chaetocnema pulicaria*: beetle—for size see line at right (original).

This flea-beetle resembles the species which will next be figured, and with which it is congeneric in general structure as well as in habits. It is, however, much larger, measuring fully twice as long, or about one-tenth of an inch, is more robust, somewhat irregularly oval, and the entire surface is uniformly brightly bronzed and slightly brassy.

It is broadly distributed from the New England States southward to Florida and Texas and westward to California. It apparently occurs nearly everywhere east of the Rocky Mountains, and westward has also been recorded from Utah and Montana.

The Brassy Flea-beetle (*Chætocnema pulicaria* Mels.).—Injury to sweet corn by the toothed flea-beetle, as above reported, was complicated by the presence of this second species, which, however, occurred in much smaller numbers.

This species (fig. 29) is the more abundant of the two in most localities, and considerably smaller. It is probable that it is usually the cause of the trouble attributed to it. This flea-beetle measures less than one-twentieth of an inch, and is of oval, slightly oblong, convex form, with shining surface, having a faint greenish-bronze luster. The legs are usually brownish testaceous, but somewhat variable. The thorax is nearly opaque, *i. e.*, it bears little trace of polish.

It is known to occur in Pennsylvania, Maryland, Virginia, District of Columbia, North Carolina, Texas, and Colorado.

The Spinach Flea-beetle (*Disonycha xanthomelæna* Dalm.).—This species occurred in greater abundance during the spring of 1900 than in previous years when it was under observation, and was found during the latter days of May and the first part of June to have attacked and practically destroyed, while in the larval condition, whole rows of beets. The beets in one instance were not otherwise in condition, but other cause of injury was not observable. This appears to be the first instance of observed injury by this insect in the East. Observations subsequently made showed that beets were generally affected in this vicinity by this insect, injury being due both to adults and larvæ. A new genus of food plants was observed during the year, as also a new insect enemy of this flea-beetle.

It was noticed of the full-grown larvæ that had fed upon beets that all were of a brilliant purple hue never before seen in this species in its occurrence on its wild (green) food plants.

Upon the occasion of a visit to Brookland, D. C., June 13, very noticeable injury was observed to beets, particularly on the edges of fields near weeds. Many plants, it was obvious at this time, would produce no taproots, and examination of numbers of them showed that this portion of the plant was entirely undeveloped. The owner of one of these gardens, Mr. E. Heitmuller, was informed of the injury and he stated to the writer that he was quite familiar with the insect and its work, and said that at least an acre of seed beets had been totally destroyed for him the previous year. He also stated that the pests went below the surface of the ground and attacked the roots. Upon digging about the infested plants larvæ and beetles were found, as well as upon the foliage, and this in spite of the fact that the day was very dark, the sun not having been visible for about two hours. There seems to be no doubt whatever that our informant is correct in his conclusions. Both larvæ and beetles, at times if not habitually, conceal themselves in the earth about the plants. It has already been shown that the larvæ travel very slowly, and hence after devouring the leaves of one bunch of plants they attack the roots instead of migrating to other plants, a feat which they are nearly incapable of performing.

In instances of insect attack to beets which have come under notice, this species has been associated with the twelve-spotted cucumber beetle, *Diabrotica 12-punctata*, and the pale-striped flea-beetle, *Systena blanda*, both of which feed more freely exposed than the Disonycha larvæ and beetles, and would attract attention when the others would be apt to be missed. The cucumber beetle mentioned cuts holes of the same character in the leaves, and can be seen in broad daylight feeding on the upper surface. The pale-striped flea-beetle also feeds freely on the upper surface, while the beetles of Disonycha are generally found under the plants on the ground during the heat of the day and usually drop off the plants at the first sign of disturbance. At other times, the larvæ on the under surface of the leaves would not be noticed by the average observer. It will thus readily be seen that the year 1900 was not necessarily an exceptional one as regards attack by this flea-beetle in the East, as much of the injury that has been attributed to other species mentioned may often in reality be due, at least partially, to the spinach flea-beetle.

Fig. 30.—*Epitrix fuscula*, greatly enlarged (original).

August 16, 1900, the writer observed numerous beetles of this species, dead and living, under plants of saltbush belonging to different species of Atriplex, growing on the experimental plats on the Department grounds. Under these plants the ground was fairly strewn with living and dead beetles, and larvæ were found, though somewhat sparingly at this time, on the foliage. The species of Atriplex upon which this flea-beetle was observed include *A. semibaccatum*, *A. holocarpa*, *A. velutinella*, and an undetermined form—all cultivated varieties, and useful as forage plants.

Numerous nymphs of the wheel bug (*Prionidus cristatus*) were observed during the early part of June on beets infested with this flea-beetle. Such as were seen feeding had the larvæ of the beetle impaled on their beaks.

The Eggplant Flea-beetle (*Epitrix fuscula* Cr.).—Injury by this flea-beetle (fig. 30) which has been treated somewhat fully in Bulletin 19, n. s. (pp. 87–89), was very serious to early potatoes near Cabin John, Md., in 1900. When the infested fields were visited May 14, every plant was seen to be covered with the beetles. They were described to the writer as having burrowed beneath the surface of the earth in search of the potato sprouts.

The common cucumber flea-beetle, *Epitrix cucumeris*, occurred upon the same plants in less numbers, as did also the Colorado potato beetle, *Doryphora 10-lineata*. Injury was also due in part to cutworms, and to extreme heat and drought, which had lasted for several days.

O

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY—BULLETIN NO. 34, NEW SERIES.

L. O. HOWARD, Entomologist.

Principal Insects Liable to be Distributed on Nursery Stock.

Prepared Under the Direction of the Entomologist,

BY

NATHAN BANKS,

Assistant Entomologist.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1902.

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Artist: Miss L. Sullivan.

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY—BULLETIN NO. 34, NEW SERIES.

L. O. HOWARD, Entomologist.

PRINCIPAL INSECTS LIABLE TO BE DISTRIBUTED ON NURSERY STOCK.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., April 29, 1902.

Sir: I have the honor to transmit for publication a manuscript prepared by Mr. Nathan Banks, of this office, in which are considered the principal insects liable to be distributed upon nursery stock. The inspection of nursery stock under State laws has become so general throughout the United States that the desirability of some publication of this sort has become very evident. I had the matter in mind last autumn, and at a conference of the official horticultural inspectors for the United States, held at Washington October 11–13, 1901, a resolution was unanimously passed requesting this Department to prepare and publish an article on those nursery pests of the country which are capable of transmission on nursery stock to the injury of the purchasers. Since it is desirable that this manuscript shall be put in available shape for distribution to all horticultural inspectors and to all nurserymen and others immediately interested, I recommend that it be issued as Bulletin No. 34, new series, of this Division.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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THE PRINCIPAL INSECTS LIABLE TO BE DISTRIBUTED ON NURSERY STOCK.

INTRODUCTION.

In preparing this descriptive catalogue of the insects liable to be transported upon nursery stock, it has appeared that there is a great disparity of views as to what insects should be included. To include only such as are known to be very destructive would exclude a great many species that will be found by anyone who examines a tree in the fall or early spring. To include all the species that are known to be found in any stage upon fruit trees in winter would make the list too bulky. Therefore, all species known to be of more than local interest have been treated. Notes on the species infesting fruits are added at the end. The insects have been arranged according to their natural orders, and in the Hemiptera (bugs, scale insects, plant-lice) according to the families. In the Coleoptera (beetles, weevils) and Lepidoptera (butterflies and moths), such an arrangement did not seem desirable. No account of the remedies to be recommended or used is given, as these differ greatly, according to locality and conditions, and the various State laws specify certain treatments.

It will be a great help to those interested in the growth and sale of young fruit trees to be able to recognize the appearance of the various insect pests during the winter; therefore, much attention has been paid to this phase of the subject.

In using this bulletin one should remember that, besides the insects here treated, there may be upon a tree other insects of less importance.

TABULAR STATEMENT OF INSECTS UPON THE TREE IN WINTER.

Insects upon the roots:
- Forming swellings on apple roots.................................Woolly aphis.
- On peach and plum roots.................................Black peach aphis.

Insects upon the bark of trunk or branches:
- Plant-lice or aphids.................................Woolly aphis.
- Small brown clear-winged insect in the crevices of bark.............Pear psylla.
- Scale insects or bark-lice.................................See Coccidae.
- Caterpillars in cases or cocoons.................Fall webworm, bud moth, apple Bucculatrix, codling moth, pistol-case and cigar-case bearers.
- In nests or bunches of shriveled leaves attached to branches.....Leaf-crumpler, and brown-tail moth.

Insects upon the bark of trunk or branches—Continued.

In a case or bag hanging from twigs .... Bagworm.

Clusters of eggs on bark .... Cankerworms, tussock moth, and gipsy moth.

A belt of eggs around twigs .... Apple-tree tent caterpillar.

Single small blackish eggs often in groups on twigs or branches...... Plant-lice.

Smaller reddish eggs... Clover mite.

Insects beneath the bark:

Tiny holes usually near a crotch, each covered by a bit of frass .... Peach twig-borer.

Small brown beetle within the twig........................ Apple twig-borer.

Small holes in bark of trunk or larger branches.......... Fruit-tree bark-beetle.

A gummy exudation of sap at base of tree .... Peach tree-borer.

Discolored spots or cracks and evidences of frass............ Round-headed and flat-headed apple tree-borers, and sinuate pear borer.

TABULAR STATEMENT OF INSECTS FEEDING ON THE BUDS AND YOUNG LEAVES IN EARLY SPRING.

Feeding on the buds or young shoots.... Bud worm, peach twig-borer, leaf-crumpler, brown-tail moth, pistol-case and cigar-case bearers.

Feeding upon the leaves:

Plant-lice.................. Apple plant-lice, plum plant-louse, and cherry aphis.

Caterpillars in tents .... Apple-tree tent caterpillar.

Hairy caterpillars................ Tussock moth, brown-tail moth, gipsy moth.

Bare caterpillars .... Canker worms.

A blister or gall upon leaves .... Pear-leaf blister-mite.

Small caterpillars within little cases........ Pistol-case bearer, cigar-case bearer, leaf-crumpler, and bagworm.

HEMIPTERA (BUGS, SCALE INSECTS, AND PLANT-LICE).

The members of this order obtain their food (which is liquid) by sucking it up a slender tube into the mouth cavity. This tube or beak is composed of several needle-like pieces so shaped and arranged that they inclose a minute channel up which the liquid food is drawn. The beak is inserted in the plant often to some distance beneath the surface. The members of this order do not pass through a pupal or chrysalis stage like the butterflies and moths, but there is an approach to it in the males of the scale insects. The insects of this order to be treated are arranged in four families, which may be separated, for our purposes, as follows:

The insect from above apparently without legs, antennæ, or wings, and fixed to the host plant; the adult male (not often seen) usually has two wings...... Coccidæ. (scale insects).

The insect shows distinct legs and antennæ, and often four wings.

Most of the specimens wingless, and provided with two small tubes or cornicles (see fig. 16) near tip of body; not hopping when disturbed .... Aphididæ (plant-lice).

Adult always winged, without the cornicles; hopping when disturbed.

The prothorax not enlarged, with hyaline wings.................. Psyllidæ.

The prothorax greatly enlarged; wings obscured............. Membracidæ.

FAMILY COCCIDÆ (SCALE INSECTS).

The scale insects, or bark-lice, are readily known from most insects in that the stages commonly seen are immovably fixed to the bark or leaf, and show no outward sign of legs or other structures. For a short time after birth they are active, crawling creatures, and distribute themselves over the surface of the plant. Having selected a location, they push their long and thread-like beaks deep into the tree and proceed to suck up the sap. As they grow the protected or covered bark-lice secrete a waxy substance that hardens and forms the scale. When the insect molts the old skin or exuvium remains attached to the scale. The shape, color, and position of this exuvium is of great value in identifying the species.

Their small size and similarity of appearance makes their determination difficult, and it is rarely safe to determine the species by a few individuals, but on a moderately infested branch one is apt to find some specimens that are quite characteristic of the species.

The unprotected bark-lice, such as the Lecaniums, secrete no covering scale.

TABLE OF SCALE INSECTS.

1. Soft scales, without a shield-like covering, very convex, on peach or plum. *Lecanium nigrofasciatum.*
2. Armored scales, with a shield-like covering and showing an exuvial spot, much less convex than Lecanium .... 3.
3. The exuvium shows as a circular spot situated near the center or at least remote from the edge of the scale; the adult female scale more or less circular, rarely whitish in color........ *Aspidiotus.*
4. The exuvium showing as a more or less ribbed, elliptical spot at the end or close to one edge of the scale; scales usually whitish in color; if not, then of an oyster-shell shape .... 5.
5. Scale brownish; the female of an oyster-shell shape, male ovate. *Mytilaspis pomorum.*
6. The scale whitish, female not oyster-shell shaped, male scale elongate........ 7.
7. The female scale plainly ovate, much longer than broad; the male scale having three longitudinal keels (see fig. 4, *d*)........ *Chionaspis furfurus.*
8. The female scale is irregularly circular, but little longer than broad; the male scale with one median keel .... 9.
9. Exuvium orange or bright yellowish; on fruit trees; male with keel rather indistinct .... *Diaspis pentagona.*
10. Exuvium pale or dull yellowish; on raspberry and blackberry; male with distinct keel........ *Aulacaspis rosæ.*

THE PEACH LECANIUM.

(*Lecanium nigrofasciatum* Perg.— fig. 1.)

This insect, formerly known as *L. persicæ*, is one of the largest of the scale insects, being about one-fifth of an inch long and two thirds as wide. It is elliptical in outline and strongly convex. It is usually of a dull greenish-brown color, sometimes distinctly marked with darker bands. It is found upon the branches of peach and plum, more rarely on apple, and commonly occurs on the under side of the branch, the upper side of which is covered with a black fungus that grows on the honey-dew dropped by the Lecaniums from the branch above. The females pass the winter in the adult condition. The eggs are developed by the latter part of May. The young hatch early in June and continue for fully a month (June 10 to July 15). The young larvæ are flat, uniformly pale yellow, and with a thin marginal rim. They become stationary in a few weeks. By the middle of July the male pupæ are developed, and by the 22d the first winged males appear. There is but one brood a year, and the best time for treatment will be during July.

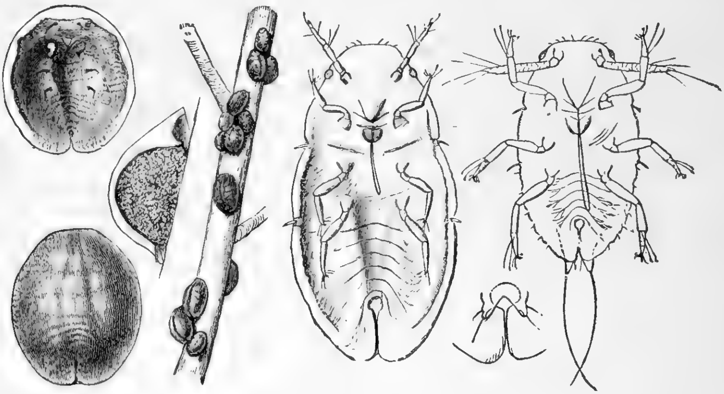


FIG. 1.—*Lecanium nigrofasciatum* Perg.: adults at left, young at right. (Howard).

There is another species of Lecanium (*L. prunastri*), less commonly found on plum. The female is much like that of the peach Lecanium, but the insect passes the winter in the larval state, not maturing till May. The young hatch in July, migrate to the leaves, and in the early fall return to the branches, where they pass the winter. It has rarely been found in this country outside of New York State.

THE OYSTER-SHELL BARK-LOUSE.

(*Mytilaspis pomorum* Linn.—figs. 2 and 3.)

The oyster-shell bark-louse is one of the best known enemies of the orchardist. It is a dark, slightly convex scale, elongate and usually curved in outline, much resembling a miniature oyster shell. When crowded upon the tree they are apt to be less curved and often quite straight. The elongate exuvium is situated at the small end. Its elongate shape and dark color at once separate it from all other common orchard scales. The eggs, which are whitish in color, are deposited in late summer, and occupy the posterior two-thirds of the scale. The female dies, but the scale remains to protect the eggs during the winter. The young hatch in May or early June, crawl out upon the

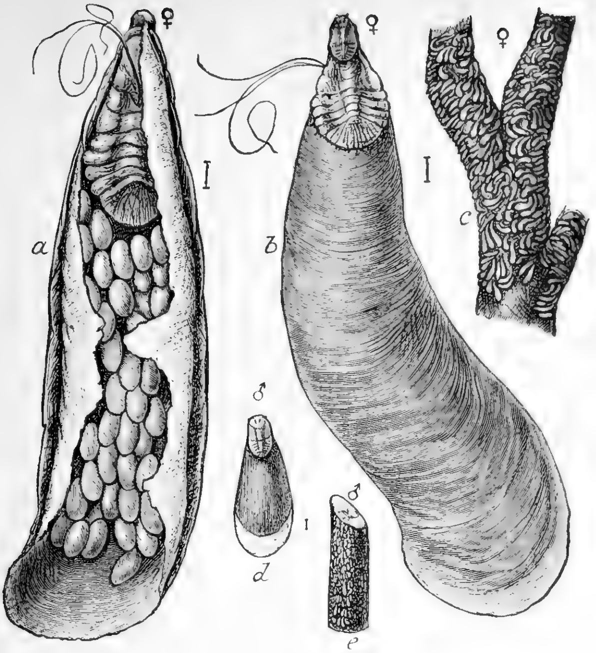


FIG. 2.—*Mytilaspis pomorum:* *a*, *b*, females; *c*, scales on twig; *d*, male scale. (Howard.)

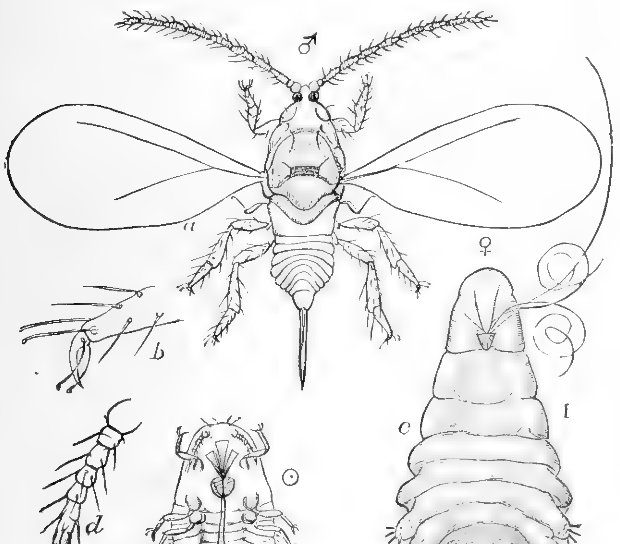


FIG. 3.—*Mytilaspis pomorum:* *a*, male; *c*, larva; *c*, female; *b* and *d*, details. (Howard.)

twigs and small branches, and locate there permanently. In a day or two they begin the formation of the scale. The male scale is much smaller than the female, elongate, wider behind than in front, and little, if any, curved. It is uncommon on apple, but often found on other food plants. The winged male insect appears in midsummer. There is but one brood a year in the North, but in parts of the South there are apparently two broods; the second one hatching about September 1. The oyster-shell bark-louse is widely distributed and attacks a great variety of trees, but is especially partial to apple.

THE SCURFY BARK-LOUSE.

(*Chionaspis furfurus* Fitch—fig. 4.)

This common orchard scale is readily known by its whitish color and ovate form. The adult female scale is rather flat, irregularly ovate in outline, with the yellowish exuvium at the apex. The life history is similar to that of the oyster-shell bark-louse. The eggs are laid in the early fall and occupy the greater part of the scale. The mother dies and the scale remains on the tree during the winter to protect the eggs. The young hatch during the latter part of May or early in June. The male scale, which is often very abundant, is much smaller than the female, snow-white in color, and fully twice as long as broad, with nearly parallel sides and three keels or ridges. The winged male insects issue in September. There is but one brood in the North, but probably two or even three in the South. The scurfy bark-louse is widely distributed and occurs on most orchard trees, but chiefly on apple and pear.

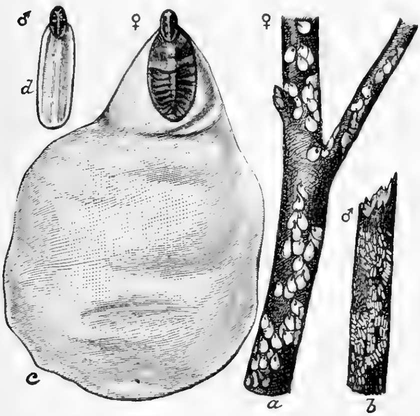


FIG. 4.—*Chionaspis furfurus*: *a*, *b*, infested twigs; *c*, female; *d*, male. (Howard.)

ASPIDIOTUS (CIRCULAR OR ROUND SCALES).

To this genus belongs the most destructive known species, the San Jose scale. The other species, however, often cause much damage. There is a considerable resemblance among the various species, so that it is difficult for any inexperienced person to determine them. The final characters that separate species are based on the structure of the pygidial plate of the adult female scale. To observe this it is necessary that a specimen be boiled in caustic potash and mounted in balsam on a glass slide. When this is examined under a microscope the lobes, spines, hairs, and sinuations of the margin of the plate appear quite distinctly. Thus, the characters that may be used in the field are not final and only comparative, and great care must be exercised, especially when only a small amount of material is available, and any doubt can be settled only by sending the material to some competent authority who can mount and microscopically examine the species.

TABLE OF ASPIDIOTUS.

1. Scale of adult female circular, with exuvium central, dark-colored, the exuvium pale yellowish when dark waxy outer covering is rubbed off; scale not very convex, about 2^{mm} in diameter; half-grown scales are nearly black and show a central nipple surrounded by one or two depressed rings.....*perniciosus* Comst.
   Scale of adult female not circular, the exuvial spot at one side of the center; the half-grown scales usually paler and without the central nipple surrounded by depressed ring..2.
2. Adult female scale dark-colored, about 2^{mm} in diameter; exuvial spot orange or reddish colored........................*A. forbesi*, *ancylus*, and *ostreæformis*.
   Adult female scale paler, or larger, or with white center........................3.
3. Scale of adult female about 2^{mm} in diameter, yellowish or pale brownish, with a white center, quite flat; on grape................................*uvæ* Comst.
   Scale of the adult female very convex, about $2\frac{1}{2}^{mm}$ in diameter, of a uniform drab or yellowish-brown color, the exuvial spot showing reddish, but not commonly exposed ....*rapax* Comst.
   Scale of the adult female large, nearly 3^{mm} in diameter, flat, and pale-grayish in color; the exuvium reddish or orange ....*juglans-regiæ* Comst.

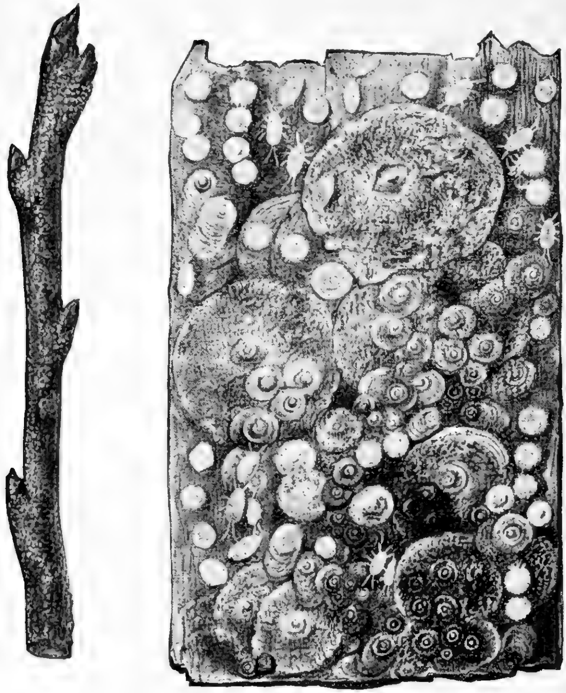
In identifying scale insects by means of the above table, scales should be examined from bark or fruit as clean as possible, and where the scales are not crowded and have room to normally develop. When thickly massed they lose their characteristic shape and appearance, and on sooty or dirty bark they are discolored and abnormal.

THE SAN JOSE SCALE.

(*Aspidiotus perniciosus* Comstock—figs. 5, 6, and 7.)

The San Jose scale is known to every orchardist by hearsay, but few, however, can distinguish it from allied scales, such as *ancylus*, *forbesi*, and *ostreæformis*. On badly infested trees the scale presents the appearance of dark gray, scurfy patches. The individual scale is about 2^{mm} in diameter, usually nearly circular in outline, of a grayish color, with the central darker nipple surrounded by one or more quite distinct yellowish or pale grayish rings. When the scales are crowded the outline is more or less distorted. In none of the allied forms is the adult female scale as nearly circular as in the San Jose scale. When on fruit or young twigs there is often a reddish discoloration around the scale. Putnam's scale and the cherry scale have a brighter colored exuvium, situate one side of the center. The cherry scale is often much paler than the San Jose scale. The European fruit scale has an exuvium similar to the San Jose, but lacks the darker nipple;

moreover, the exuvium is plainly not at the center of the scale. The male of the San Jose scale is about two times as long as broad; broader at one end than at the other, with a large, dark exuvium, showing a central nipple. It is situated toward the small end of the scale. The male of the European fruit scale is not so elongate, and the exuvium is but little darker than the scale and nearer to the small end than in the San Jose scale. The male of Putnam's scale is as elongate as that of San Jose, but has an orange exuvium. The male of the cherry scale is in shape much like that of the San Jose scale, but the exuvium is of a brighter yellow, the scale usually being paler than the San Jose.



a *b*

FIG. 5.—*Aspidiotus perniciosus*: *a*, infested twig; *b*, view of infested bark magnified. (Howard and Marlatt.)

In general the adult female of the San Jose scale may be distinguished from its allies by the more circular scale, with yellow exuvium, when exposed, more centrally located, otherwise with dark nipple; the male by similar characteristics of exuvium and nipple. But the San Jose scale is most easily recognized by its immature scales, which are almost black, circular, and with a central nipple surrounded by one or two depressed circular rings. Such a character is not found in any other of the allied scales.

The San Jose scale attacks all of our orchard trees, but appears to be most destructive to pear and peach. The insect is represented in winter by partly grown specimens whose development was stopped by the cold weather. They resume growth in the early spring; the males soon appear, mate with the females, and the latter give birth to living young. At Washington, D. C., this time is about the middle of May, and the young continue to appear for about six weeks. The larva crawls off a little way, settles, and within two days begins the

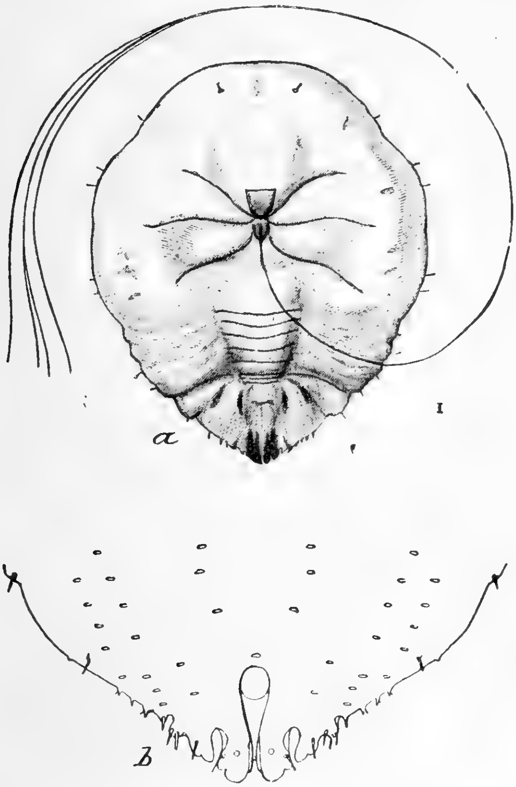


FIG. 6.—*Aspidiotus perniciosus: a*, female; *b*, margin of pygidium magnified. (Howard and Marlatt.)

secretion of its scale. This young scale is at first white with a swelling in the center. If it is situated on green tissue it is apt to produce a redness. In a few days the pale scale becomes nearly black, with a central nipple surrounded by one or two depressed rings. This form is very characteristic of the species. In about twenty-five days another brood of males appears, and in thirty days the females become adult. At about thirty-five or forty days of age the females begin to give birth to living young. Since one of these mother scales may have been born six weeks before another, it results that there is a confusion of generations throughout the summer, breeding constantly going on until late fall. The number of broods will thus depend upon the length of the season.

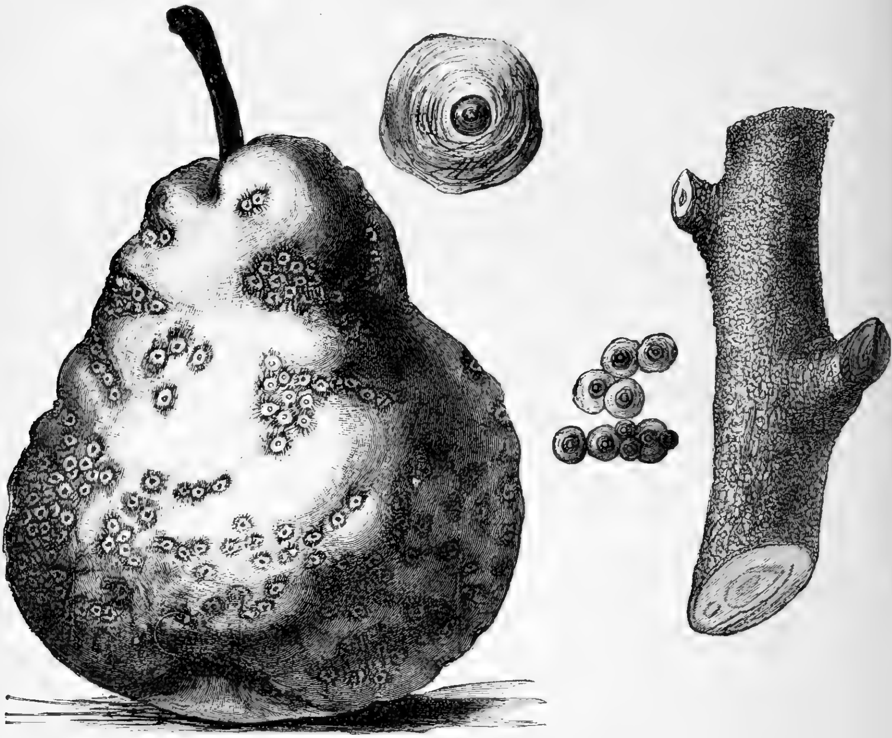


FIG. 7.—*Aspidiotus perniciosus:* Infested fruit and branch, and enlarged scales. (Howard.)

THE EUROPEAN FRUIT SCALE.

(*Aspidiotus ostreæformis* Curtis—fig. 8.)

This species can usually be readily separated from the San Jose scale by the characters mentioned under that species, but it is practically impossible, without making a microscopic mount, to distinguish it from Putnam's scale and the cherry scale. The cherry scale, especially when on cherry, is more shining and often shows a grayish margin. The European fruit scale occurs on all orchard trees, but only, so far as known, in certain Northern States. The winter is passed by the partly grown specimens, which become mature toward the last of June, and soon begin to give birth to living young. The young continue to appear for several weeks. There appears to be but one brood a year, at least in the Northern States.

PUTNAM'S SCALE.

(*Aspidiotus ancylus* Putnam.)

This scale is widely distributed and attacks all orchard trees. In general appearance it is like the San Jose scale, but at once known by the exposed orange exuvium, the less circular scale, and by the half-grown young having no depressed ring around the nipple. It can be separated from the European fruit scale and from the cherry scale only by a microscopic examination of mounted specimens. It is usually much darker than the cherry scale, the exuvium usually a brighter orange, and the scale more conical than that species. Specimens vary, however, a great deal in these points. The insect winters in a nearly full-grown condition. The males appear in April, soon pair with the females, and the latter deposit eggs in the late spring or early summer. The young begin to hatch early in July and continue during the month. There is but one brood a year.

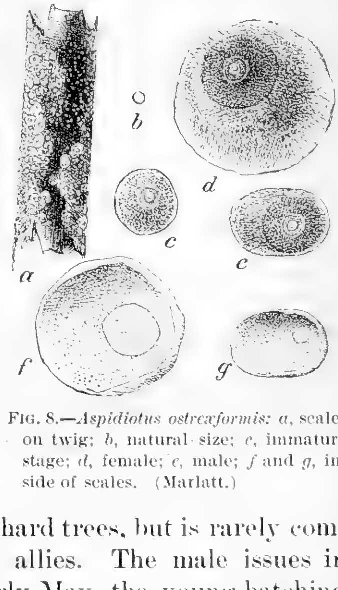


FIG. 8.—*Aspidiotus ostreæformis: a*, scales on twig; *b*, natural size; *c*, immature stage; *d*, female; *e*, male; *f* and *g*, inside of scales. (Marlatt.)

THE CHERRY SCALE.

(*Aspidiotus forbesi* Johnson.)

This scale is similar to Putnam's and to the European fruit scale, but sometimes, especially on cherry, it is more shining, and presents a gray rim around the scale, which is commonly flatter than the allied species. It attacks all orchard trees, but is rarely common. It winters partly grown, like its allies. The male issues in April. The eggs are laid in April or early May, the young hatching during May and part of June. There appears to be two broods a year, the males of the second brood issuing during the latter part of July and the young during August and September.

THE WALNUT SCALE.

(*Aspidiotus juglans-regiæ* Comstock—fig. 9.)

This insect is at once recognized by the large size of the adult female scale, it being the largest of our species of the genus, the scale often being 3^{mm} in diameter (one-twelfth inch), while the San Jose scale is scarcely 2^{mm} in diameter. The adult female scale is irregularly circular in outline, quite flat, and of a pale grayish or dirty-white color. The exuvial spot is reddish or orange and situated one side of the center. The scale often appears to be less closely attached to the bark than with the other species of this genus. The male scale is elliptical and much smaller than the female. The adult female scale hibernates, and deposits eggs in early spring. The males from them issue early in June. Eggs are deposited again in June, so that there appears to be two or possibly three broods in the South. This species is not abundant, but liable to be found on almost any orchard tree.

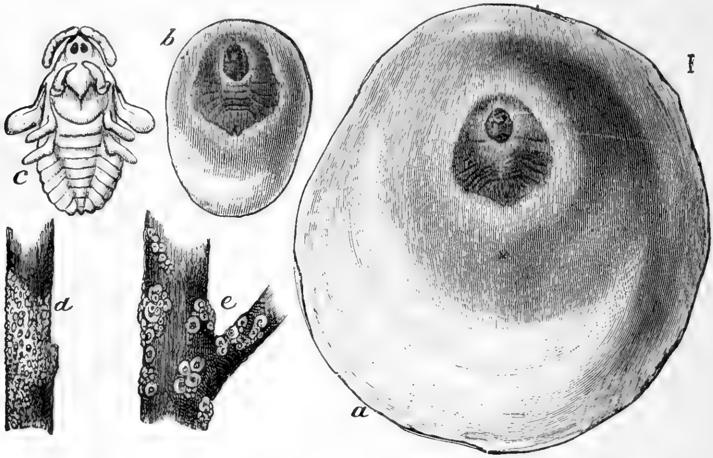


FIG. 9.—*Aspidiotus juglans-regiæ: a*, female; *b*, male; *c*, pupa; *d*, *e*, infested twigs. (Howard.)

THE GREEDY SCALE.

(*Aspidiotus rapax* Comstock—fig. 10.)

This is quite a large species, readily distinguished from the others we have treated by its very convex scale and uniform drab or yellowish-brown color, except for the dark brown exuvium which often shows near the center. The adult female scale is less circular than most of the other species, and does not always show the exuvial spot, which is at one side and covered with a film of secretion. The male scale is much smaller, and elliptical in outline. The young are nearly circular, with a central nipple often surrounded by a pale gray ring. This scale is very abundant in California and has spread somewhat eastward, especially in the South. It attacks various orchard trees, but more commonly the orange. It is a scale that is liable to be found more commonly in the future, and orchardists should be on the lookout for it. The greedy scale, in California, winters in all stages.

THE GRAPE SCALE.

(*Aspidiotus uvæ* Comstock.)

This is a more or less elliptical scale, with the exuvium rather nearer one end. It has a yellowish or pale brownish color, with a whitish center near the exuvium, the latter of a pale yellow. The scales are often found in a longitudinal row, and rarely infest both sides of the same branch. It winters in the egg stage. The young hatch in May; the males issue in the summer. There is but one brood a year. It is practically confined to the grape, but has been found on a few other plants, and may spread to fruit trees.

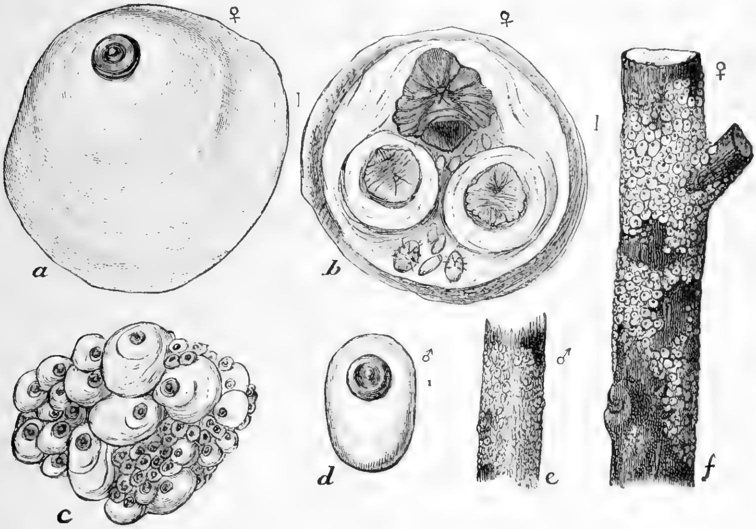


FIG. 10.—*Aspidiotus rapax.* Scales on twigs, and enlarged. (Howard.)

THE PEACH SCALE.

(*Diaspis pentagona* Targ. Tozz.—fig. 11.)

The peach scale, sometimes known as the "whitewash scale," is of a grayish white color, rather flat and irregularly circular or slightly

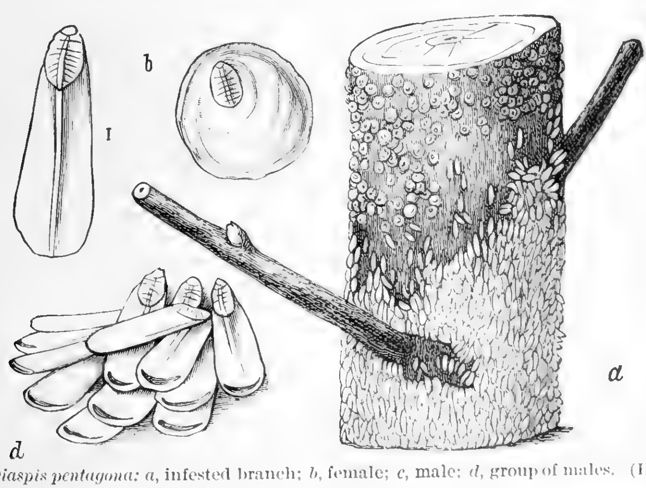


FIG. 11.—*Diaspis pentagona: a*, infested branch; *b*, female; *c*, male; *d*, group of males. (Howard.)

ovate in outline, never as elongate as the scurfy bark-louse. The exuvium is often a little way from the margin, and is yellowish or orange in color. Its pale color and elongate exuvium will readily separate it from all other scales on orchard trees. The insect passes the winter with the mature females and the male scales. The males hatch in early spring. The eggs are laid early in May, and the larvæ hatch in about ten days. The males again commence to issue by the middle of June, and the females begin egg-laying by the end of June. The second generation is full grown by the middle of August, and these in time soon begin to lay eggs for the brood that will winter as mature females and undeveloped males.

FIG. 12.—*Aulacaspis rosæ; 1*, infested branch; *1a*, female; *1b*, male. (Comstock.)

The male scale (fig. 11, *c*, *d*) is elongate, about three times as long as broad, slightly wider behind than in front, with a median keel, and snow white in color. The male scales appear to be most numerous on the lower parts of the branches and near the base of the trunk and often so matted as to make the trunk or lower branches absolutely snow white. The peach scale is becoming common in many of the Southern States and as far north as Pennsylvania. It infests plum, cherry, and peach, and less commonly other plants.

THE ROSE SCALE.

(*Aulacaspis rosæ* Sandberg—fig. 12.)

This species is similar to the peach scale, and, indeed, the easiest way to distinguish between them is by their host plants. The peach scale does not affect the host plants of the rose scale, which are roses, raspberry, and blackberry. The scale covering is much more thin and delicate and the exuvium is usually of a paler or duller yellow than in the case of the peach scale. The keel or ridge of the male is more distinct. The life history of this species does not appear to be well known in this country. It winters, as a rule, in the egg as far north as New Jersey; but mature females and immature females and males may be found in winter. In the early spring one often finds the female scales surrounded by a radiate row of male scales. It is probable that there is more than one brood in a year, at least in the South.

FAMILY APHIDÆ (PLANT-LICE).

The plant-lice are small, sluggish insects found on the under surface of leaves or on the bark and roots. Most of the individuals have no wings, but at times one finds some specimens with delicate transparent wings laid roof-like over the body. They all have distinct legs, a pair of moderately long antennæ, and usually quite prominent eyes. They occur in colonies, and by their numbers often do a considerable amount of damage. The eggs are found on trees in winter situated near the base of twigs and buds. (See fig. 13.) They are minute, oval, or elliptical shining black objects. During the warm part of the year the females produce living young, so that one individual may, in a few months, be the parent of a large colony. Many of the species secrete a sweetish liquid from two pre-apical tubes or cornicles. This liquid is known as honey-dew, and attracts other insects, especially ants.

Fig. 13.—Eggs of a plant-louse on twig. (Original.)

TABLE OF PLANT-LICE.

A. Plant-lice on the bark or roots:
- With a whitish, woolly, or cottony covering................*Schizoneura lanigera.*
- Without such covering...*Aphis persicæ-niger.*

B. Plant-lice on the leaves:
- With bluish-white mealy powder; on plum..................*Hyalopterus pruni.*
- Dark brown; on cherry...*Myzus cerasi.*
- Green, or faintly reddish; on apple..........................*Aphis mali* and *A. sorbi.*

THE WOOLLY APPLE APHIS.

(*Schizoneura lanigera* Hausmann—figs. 14 and 15.)

One often notices on the trunk or larger branches of the apple

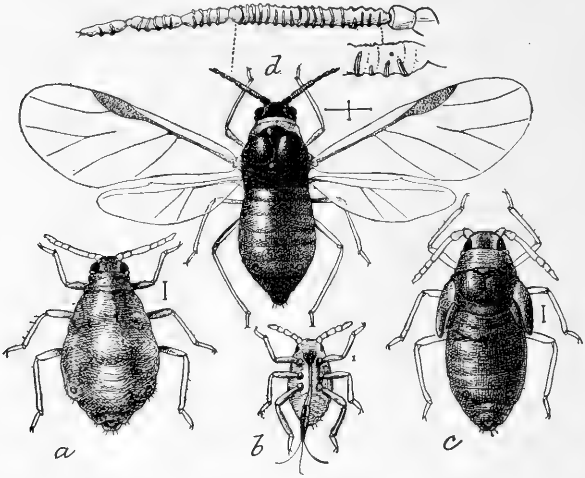


FIG. 14.—*Schizoneura lanigera; a*, agamic female; *b*, larva; *c*, pupa; *d*, winged female. (Marlatt.)

small, bluish-white, flocculent patches of a woolly substance, which indicate the presence of this insect. This cottony substance is a wax-like excretion clinging to the posterior parts of a small, reddish-brown wingless aphis. It is not, however, this form on the trunks that causes injury. This aerial form is but the indication that there are other specimens, under the ground and feeding on the roots of the tree. It is the latter form that seriously affects the vitality of the tree. Upon the trunk the lice often cause a roughening of the bark, especially on the new growth around scars made by pruning. On the roots the lice cause hard and large knots, which eventually produce a "club-footed" condition of the roots. Such trees usually show their weakness by the fewer and duller colored leaves.

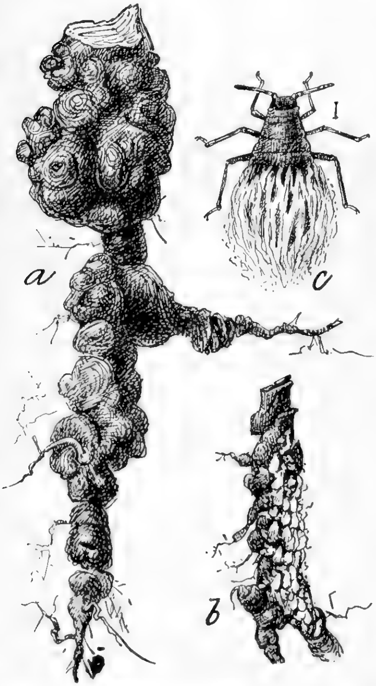


FIG. 15.—*Schizoneura lanigera; a, b*, work on roots; *c*, a louse. (Marlatt.)

The woolly aphis is practically confined to the apple, but there are a few varieties, such as the Northern Spy, that appear to be immune against its attacks. The lice commonly found on the trunk and roots in summer are the wingless, agamic females. They give birth to living young, and continue to do so, possibly for several years. In spring some of the root-lice will crawl up the trunk and continue to breed there till fall. The colonies of lice on the trunk give rise to winged and migratory females. These, when they locate, give birth to wingless male and female lice, and each female deposits a single winter egg in a crevice of the bark. This egg will, in the spring, hatch into a female which will start a new colony of wingless lice on the trunk. Some of these will, in the summer, crawl down upon the roots and continue to breed there. In the north the colonies on the trunk are apt to be killed out by the severe cold weather, but in warmer latitudes many of them live through the winter, particularly if they are protected by a piece of bark.

THE BLACK PEACH APHIS.

(*Aphis persicæ-niger* E. F. Smith—fig. 16.)

This insect, like the woolly apple aphis, does its great injury underground. Its ravages on the roots of peach give a sickly appearance to the foliage of the affected tree, the leaves often being light green or

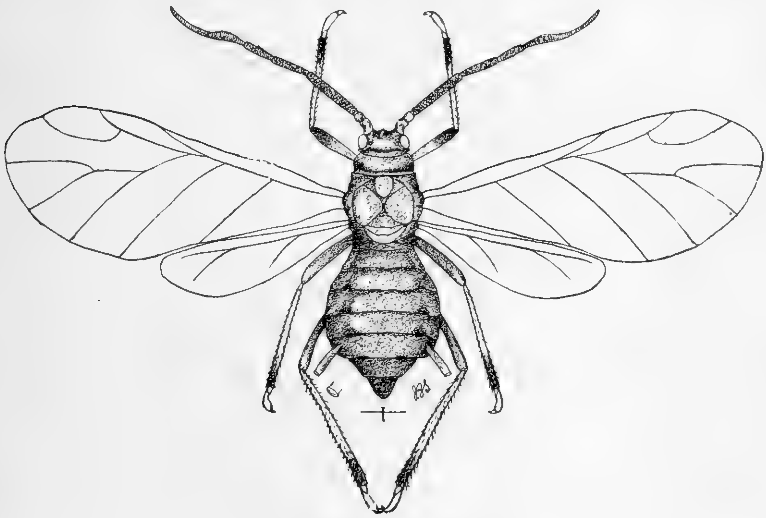


FIG. 16.—*Aphis persicæ-niger;* winged specimen. (J. B. Smith.)

yellowish in color, and their edges somewhat rolled. The wingless lice on the roots are of a dark-brown color. They breed there continuously without producing males or eggs. Early in the spring some of the root-lice crawl up the trunk of the tree and locate on the young twigs. Here the winged form develops and migrates to other trees to found other colonies. The winged insect is of a shining black or very dark brown color, the tibiæ of the legs being mostly yellowish.

Toward midsummer many of the lice on the twigs crawl down into the ground and locate upon the roots.

APPLE PLANT-LICE.

The foliage of apple trees, particularly of young trees, often appears curled, and sometimes discolored. This curling is produced by colonies of plant-lice. These lice secrete a sticky liquid known as honey-dew, which falls on the leaves below. A black fungus grows upon the leaves covered by the honey-dew, and this checks their growth. There are several of these plant-lice that attack the leaves of apple; two of them are greenish in color, another has a reddish tinge.

The commoner of the two green species is known as *Aphis mali* Fitch. (probably *Aphis annuæ* Oest). Its life history is about as follows: The eggs are laid on the tree in the fall, partly hidden in crevices of the bark; the young hatch from these eggs in early spring, and grow into wingless and sexless lice, known as "stem-mothers," which produce living young; these young become winged, and, in the early summer, migrate to grasses, where they increase during the summer. In the fall they develop a set of winged, sexless lice, which migrate back to the apple and give birth to sexed individuals; these pair, and the female lays her eggs.

The other green species is *Aphis mali* Koch. It passes its entire life history upon the apple. The eggs are laid in the late fall. They are black, and occur generally on the trunk and branches. In early spring the young hatch from these and grow into stem-mothers. These produce living young for a number of generations. Many of these of the first two generations become winged, fly to other apple trees, and there start colonies. In October sexed specimens are produced, and the female lays the eggs that are destined to pass the winter.

The other apple plant-louse is *A. sorbi* Kalt. It is distinctly tinged with red, and the wingless forms have a whitish powdering on the body. This species has a life history similar to that of *Aphis mali* Fitch., but it is not known what plants serve as its summer hosts.

THE PLUM PLANT-LOUSE.

(*Hyalopterus pruni* Fabr.)

This insect winters in the egg state. The young on hatching in spring go to the under surface of the leaf and there multiply rapidly. Their bodies are covered by a bluish-white mealy powder. Winged specimens are occasionally developed which migrate to other trees. They feed on the plum all summer, but some specimens are said to migrate to grass in early summer. In the fall the winter egg is attached to a plum twig, usually at the base of a bud. At times they do considerable damage to young plum stock.

THE CHERRY APHIS.

(*Myzus cerasi* Fabr.)

This aphis often causes the leaves of the cherry to become crumpled and rolled, and on young trees sometimes does serious damage. The winged and wingless insects are both of a dark brown color, and look much like the black peach aphis. The eggs are laid in the fall on the branches at the base of buds and in crevices of the bark. The young hatch from them in the spring when the buds begin to swell, crawl out upon the buds and growing leaves, and develop into stem-mothers, which give birth to living young. This is kept up all summer until the fall, when the sexes appear and the female deposits her eggs. A number of winged migrants are developed in the spring generations, which serve to spread the species. The insects usually become very abundant by June, but in midsummer they are not as common.

FAMILY PSYLLIDÆ.

THE PEAR-TREE PSYLLA.

(*Psylla pyricola* Forster—fig. 17.)

This insect is closely related to the plant-lice, but readily known by its longer antennæ and its ability to hop. Its color is reddish, with

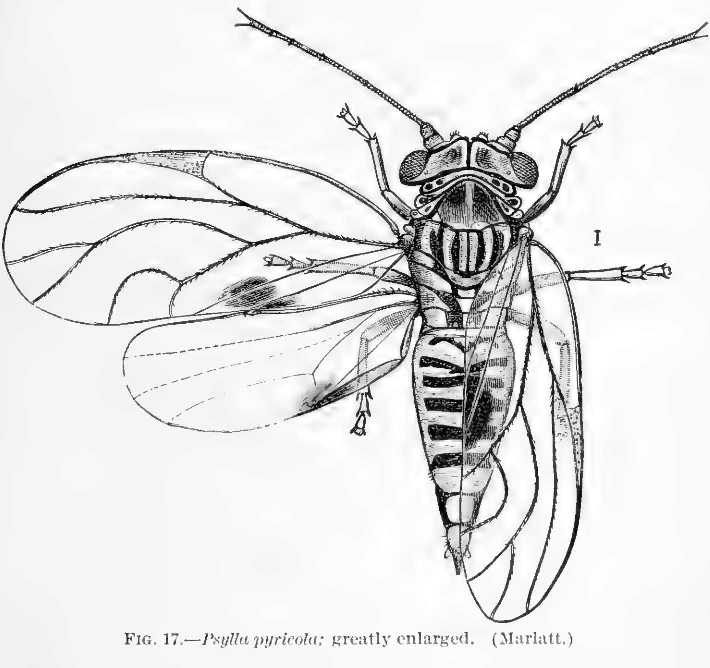


FIG. 17.—*Psylla pyricola;* greatly enlarged. (Marlatt.)

some black markings, and with clear wings laid roof-like over the body. When disturbed, it hops and flies away.

The insect is widely distributed in the East, but usually is not abundant enough to seriously injure the tree. When they become excessively abundant they cause the leaves and fruit to dry and fall. The adult insect hibernates in crevices of the bark. These overwintering specimens are brownish-black in color, with bronzy eyes. They emerge from their hiding places in the early spring, mate, and the female begins to lay eggs before the leaves are out. The eggs are placed singly or in groups in crevices of the bark of the twigs or in old leaf scars, and, when the leaves have unfolded, upon the leaves themselves. The larvæ hatch in about two weeks and begin to suck the juices from the leaves and petioles. They at once commence to excrete honey-dew, and when the insects are extremely numerous the amount of liquid secreted is enormous and fairly rains from the tree. A black fungus grows on the honey-infested leaves and tree, so that the whole soon has a smoked appearance. In about thirty days the larva becomes adult. Development continues all through the summer, and there may be as many a five broods if the season be long enough. It is only known to attack the pear.

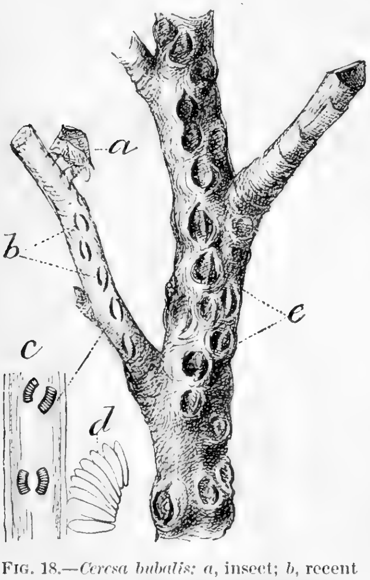


FIG. 18.—*Ceresa bubalis*; *a*, insect; *b*, recent punctures; *c*, eggs; *e*, old scars. (Marlatt.)

FAMILY MEMBRACIDÆ.

THE BUFFALO TREE-HOPPER.

(*Ceresa bubalus* Say—fig. 18.)

Upon young fruit trees, particularly the apple, one sometimes sees a series of oval or elliptical scars that disfigure and weaken the branches and render them liable to other insect attack. These scars are the results of the work of a curious insect, the buffalo tree-hopper. It is a grass-green, triangular insect that hops and flies away when disturbed. The pronotum of the thorax is enlarged, as with others of this family, to cover the head and most of the abdomen. The anterior corners of the pronotum project laterally into acute angles. In August and September the adult insects may be found on the trees engaged in oviposition. The female cuts the bark with her ovipositor in two nearly opposite curved slits, so that the bark between is cut loose. Beneath each slit she deposits a series of from 6 to 12 eggs. These eggs hatch in the spring. The dead piece of bark falls out and leaves the elliptical scar, which enlarges with the subsequent growth of the twigs and becomes an inviting point for the attack of other insects. There is but one brood each year.

LEPIDOPTERA (BUTTERFLIES AND MOTHS).

The caterpillars and cocoons of these insects are known to all. The caterpillars differ from the grubs of beetles in that they have on the under side two rows of prolegs—fleshy, wart-like structures that serve to support the posterior part of the body. The injuries caused by these insects are made by the caterpillar. These have biting mouth-parts that nip out tiny pieces of the leaf or wood, which is then chewed and swallowed. The more injurious forms that are liable to be transported on nursery stock may be arranged as follows:

1. Feeding within the trunk..Peach-tree borer.
   Feeding within the twigs or leaf-shoots......................Peach twig-borer.
   Feeding upon the leaves.. 2.
2. The insect covered by a case.........Bagworm, leaf-crumpler, pistol-case bearer, cigar-case bearer.
   The insect not covered by a case.. 3.
3. Making tents or nests...........Apple-tree tent caterpillar, fall webworm, brown-tail moth, leaf-crumpler, and bud moth.
   Without tents.. 4.
4. Hairy caterpillars ....Tussock moth, gipsy moth.
   Bare caterpillars ....Cankerworms.

THE APPLE-TREE TENT CATERPILLAR.

(*Clisiocampa americana* Harr—fig. 19.)

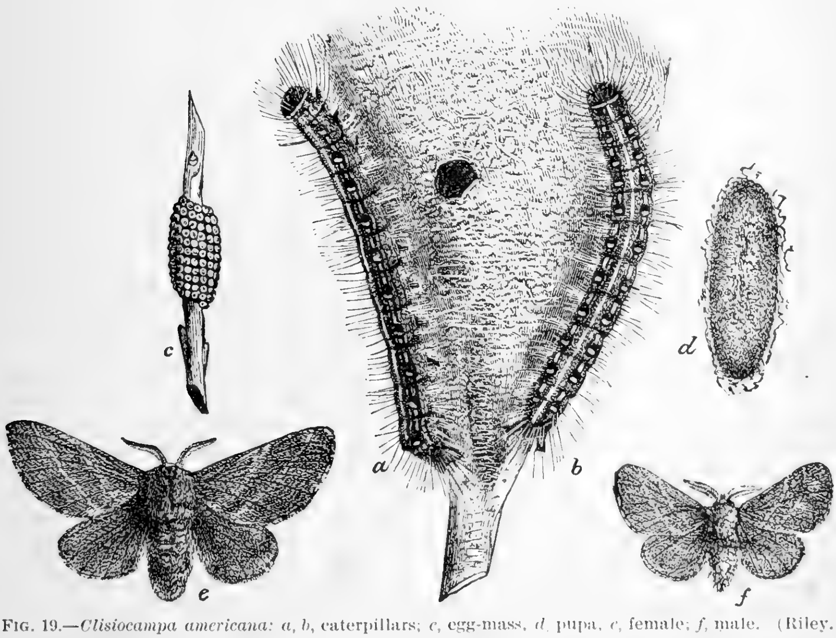


FIG. 19.—*Clisiocampa americana: a, b*, caterpillars; *c*, egg-mass, *d*, pupa, *e*, female; *f*, male. (Riley.)

The webs or tents of this caterpillar are frequently found on orchard and nursery trees in May and June. The caterpillars use this tent as a common home, where they retire at night and remain during cloudy days. Each clear morning, at about 8 o'clock, they go out along the branches to the leaves for feeding. The amount of damage done will depend a great deal upon the number of tents upon the tree. The eggs are laid in masses of 200 or 300 arranged in a broad belt around the twig. (See fig. 19, *c*.) Each end of this belt tapers off to the twig, which character serves to distinguish it from similar egg-clusters of certain other moths. Each mass is covered with a glistening substance that protects it from the rain. The young caterpillars hatch during the latter part of April or early in May, at about the time when the leaves are expanding. They immediately begin to feed on the leaves near by and to unite them into their tent, which is enlarged as the caterpillars grow. The full-grown larva is nearly 2 inches long, hairy and black, with a white stripe along the back. On each side of this is a row of short, yellow streaks; there are also pale lines on the sides of the body. The under side is nearly black. When ready to pupate the caterpillar seeks some protected spot and there spins its yellowish cocoon, and soon changes to a brown chrysalis. The moth, which is brown, with oblique white bands across the forewings, emerges in a week or so and deposits her egg-mass and dies. There is but one brood a year.

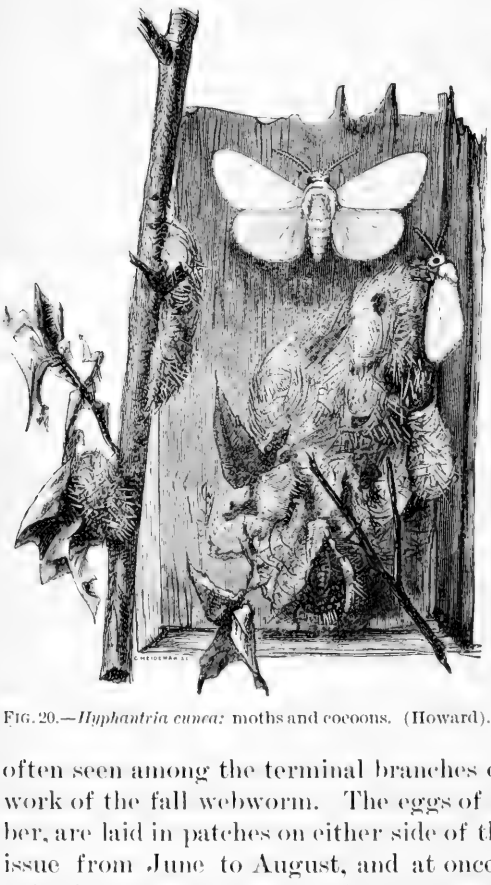


FIG. 20.—*Hyphantria cunea:* moths and cocoons. (Howard).

THE FALL WEBWORM.

(*Hyphantria cunea* Dru.—fig. 20.)

During the summer and early fall webs or tents similar to those of the apple-tree tent caterpillar are often seen among the terminal branches of fruit trees. These are the work of the fall webworm. The eggs of this moth, 300 to 500 in number, are laid in patches on either side of the leaves in June. The larvæ issue from June to August, and at once begin their web. They eat only the upper surface of the leaf, leaving the veins and the under surface untouched. The young caterpillar is pale yellowish, with dark spots along the sides and covered with scattered hairs. The full-grown caterpillar is velvety black above, the sides have two yellow stripes, and between them are many blackish patches and dots. The yellowish or brownish hairs are mostly in tufts which arise from tubercles or warts. Some specimens are quite pale; others very dark. In September or October the caterpillar is ready to pupate, and descends to the main branches or trunk of the tree. Here it makes a delicate cocoon, within which it changes to a chrysalis. The insect passes the winter in this stage, and the moth emerges the following spring. The latter has white, sometimes spotted wings, and expands about an inch and a half. There is but one brood each year in the North, but from New York city south there are two broods, the caterpillars of the second making their appearance in August.

THE BROWN-TAIL MOTH.

(*Euproctis chrysorrhea* Linn.—fig. 21.)

This insect, at present confined to certain parts of eastern Massachusetts, is such a dangerous pest that all interested in nursery trade

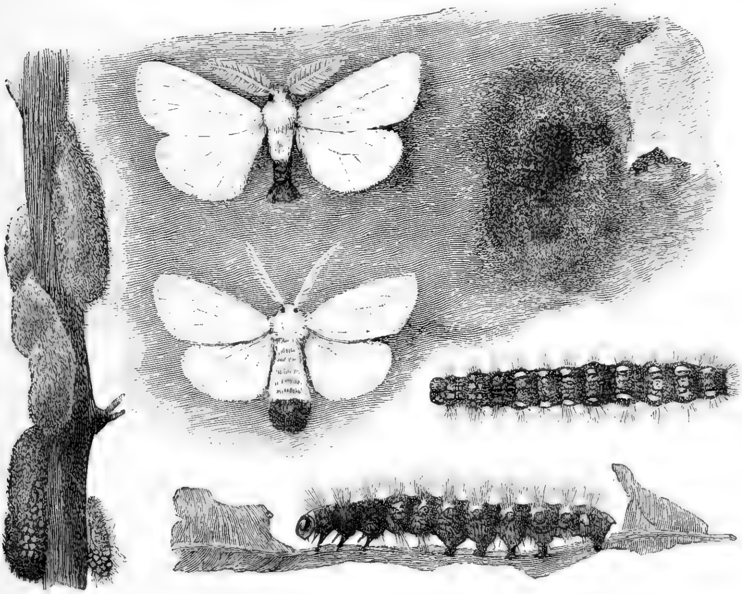


FIG. 21.—*Euproctis chrysorrhea.* Moths, larvæ, and cocoons. (Howard.)

should be able to recognize it. During winter their small but very compact webs or nests attached to the terminal twigs are very prominent objects and will aid in distinguishing the species. In midsummer the eggs may be found in patches of two or three hundred attached to the under side of a leaf near the tip of a branch. The egg mass is covered by a dense layer of brown hairs from the tip of the abdomen of the female. The young hatch in August and eat the surface of the leaf. As soon as it is devoured they draw another leaf to it, until in the fall they have quite a tent. On the approach of winter they strengthen their tent and use it to shelter them during the winter. In spring they come out, eat the unfolding buds and tender leaves, and thus do great damage. The full-grown caterpillar is about 1½ inches long, dark brown, mottled, and spotted with orange, and clothed with reddish-brown hairs and two rows of dense tufts of white hair along the upper side of the body. By the middle of June the caterpillars are ready to pupate, and each makes a cocoon attached to a terminal branch, or sometimes elsewhere on the tree, or even on some other object. These cocoons are often close to each other, so as to form quite a mass. The moths emerge in a few weeks. They have white wings, and the females a brown tip to the abdomen. There is but one brood each year.

THE LEAF-CRUMPLER.

(*Mineola indiginella* Zell.)

The presence of this insect is easily recognized in winter by the clusters of brown, shriveled, and partly eaten leaves fastened together and to the twigs by silken threads. Within each cluster of leaves is a curved tube, usually sinuate at the small end, and within this tube is the small, brownish caterpillar of this moth. This caterpillar is but half grown. In early spring the larva cuts loose from its fastenings, crawls with its case out upon the branches, and attacks the developing buds and young leaves, thus causing a great deal of injury. The caterpillar becomes full fed by the middle of May, and is then of a greenish color. It pupates in the larval nest, and the moths issue in June or early July. The eggs are deposited in July, singly on the leaves. The young larva, upon hatching, starts to make a little case for itself, which it enlarges when necessary. They feed on all fruit trees, but are partial to apple, and there is but one brood annually.

THE WHITE-MARKED TUSSOCK MOTH.

(*Orgyia leucostigma* S. & A.—fig, 22.)

The caterpillar of this moth, which does great damage to shade trees in cities, sometimes attacks apple and other fruit trees. The adult insect is a light-grayish moth, the female wingless, the male with ash-gray wings, expanding about 1¼ inches, and the antennæ are feathered. The eggs, 300 to 500 in number, are laid by the wingless female in the fall within a frothy substance, which on drying becomes hard and brittle. The whole is a very prominent whitish mass, often situated partly or wholly upon the old cocoon. In May the young larvæ hatch and begin eating the foliage. The larvæ are full-grown in July, and spin their slight silken cocoons, attached to any convenient spot. The full-grown caterpillar is a very handsome insect, about 1½ inches in length, yellowish, with three blackish stripes along the body, and a bright-red head. It is clothed with long, scattered hairs, four white

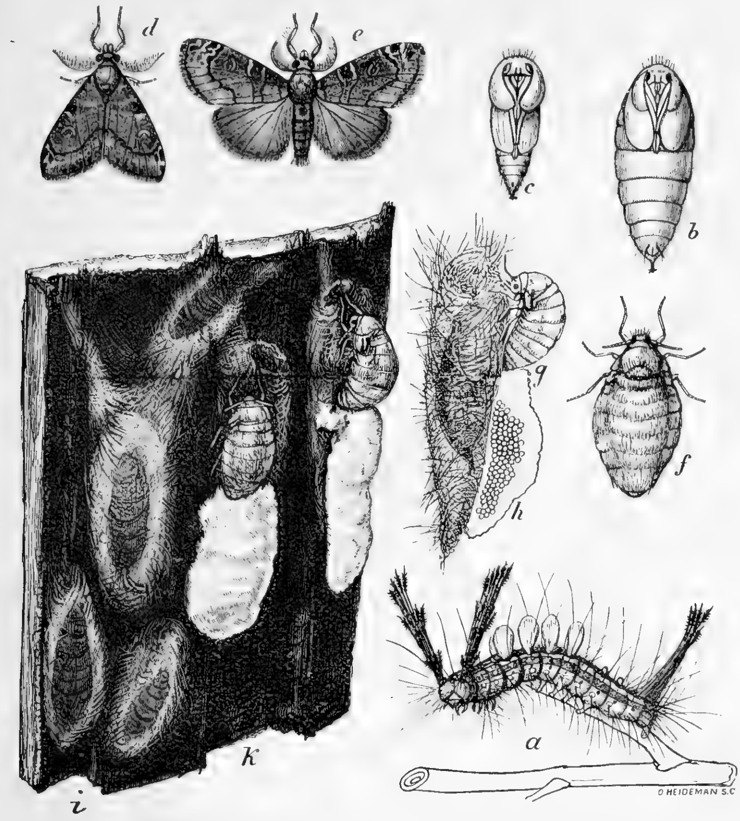


FIG. 22.—*Orgyia leucostigma.* Various stages; eggs at *h* and *k*. (Howard.)

tufts on the anterior part of the body, and three long black plumes, two in front and one at the tip of the body. In the North there is but one brood a year, but from New York city south there are usually two broods, the caterpillars of the second appearing in early August.

FIG. 23.—*Porthetria dispar:* female moth. (Howard.)

THE GIPSY MOTH.

(*Porthetria dispar* Linn—figs. 23, 24, and 25.)

Although practically confined to certain parts of Massachusetts, this insect is quite liable to spread, and all interested in orchards and nurseries should be able to recognize this caterpillar.

The eggs to the number of 400 to 500 are deposited in clusters attached to trees, fences, etc. Each cluster is covered with yellow hairs from the body of the female, which causes the mass to resemble a piece of sponge. The caterpillars hatch from April to June, and feed voraciously on the leaves, mostly at night. The full-grown caterpillar is about 2 inches long, of a grayish, mottled appearance, with the tubercles on the anterior part of the body blue, and those on the hinder part of the body red, all giving rise to long yellow and black hairs. When the caterpillars are about half grown they begin to crawl down the tree to the ground in early morning, and ascend again for feeding in the evening. By July they are ready to pupate in a thin cocoon fastened to the trunk of the tree, to a fence, or other convenient object. The pupal period is about ten days, and the moths issue in August. The female moth has whitish wings with several black spots, notably around the outer margin. The male is brownish, with darker undulate lines and spots. The gipsy moth attacks almost every sort of tree, and there is but one brood a year.

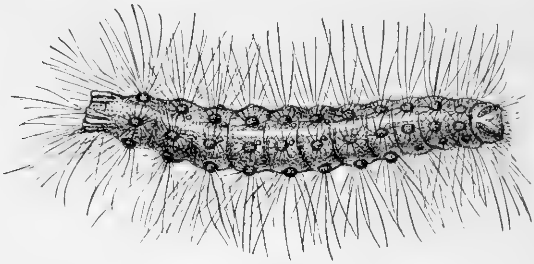


FIG. 24.—*Porthetria dispar.* Larva. (Howard.)

FIG. 25.—*Porthetria dispar.* Chrysalis. (Howard.)

CANKERWORMS.

(Figs. 26, 27, 28, and 29.)

These slender, bare caterpillars appear on apple and other fruit trees in early spring and eat holes in the leaves. As they crawl they loop up the body, and are thus called "measuring worms" or "inch worms." There are two species of the cankerworms, their habits, however, being similar. The eggs are laid in clusters on the tree in the fall and early winter, with the fall species (*Alsophila pometaria* Harr.); in March or April with the spring species (*Paleacrita vernata* Peck). The eggs of the former are flattened on top; those of the latter are rounded. The larvæ hatch in early spring and at once feed on the leaves. When full grown they descend to the ground and pupate therein, the moths issuing in late fall or very early spring. The females are wingless, and obliged to crawl up the tree to deposit eggs. The males have large, thin, gray wings. There is but one brood each year.

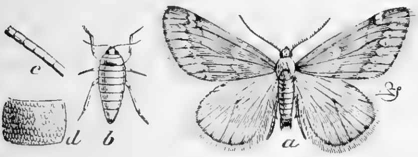


FIG. 26.—*Alsophila pometaria*: *a*, male; *b*, female. *c*, *d*, details. (Riley.)

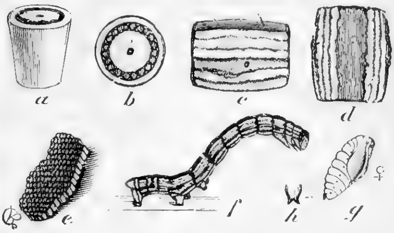


FIG. 27.—*Alsophila pometaria*: *a*, *b*, *c*, eggs; *f*, larva; *c*, *d*, segments of same; *g*, pupa. (Riley.)

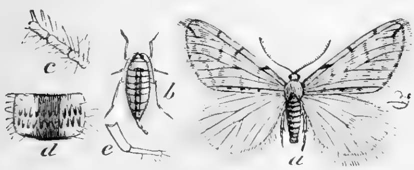


FIG. 28.—*Paleacrita vernata*: *a*, male; *b*, female, *c*, *d*, *e*, details. (Riley.)

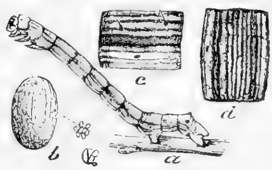


FIG. 29.—*Paleacrita vernata*: *a*, caterpillar; *b*, egg; *c*, *d*, segment of caterpillar. (Riley.)

THE PEACH-TREE BORER.

(*Sanninoidea exitiosa* Say—fig. 30.)

This destructive insect is readily discerned by the presence of a gummy exudation mixed with frass and excrement at or near the base of the tree. The parent moth lays the eggs singly (from May to July, according to latitude) on the bark of the tree, usually near the base. The young larva burrows into the bark and mines between it and the sapwood during the summer and fall. It is quiescent during the winter, but resumes feeding in the early spring, reaching full growth by May or June. The caterpillar is then a little over 1 inch in length, soft, and pale yellowish in color, with a shining, dark-brown head. It transforms to a chrysalis within an elongate cocoon just beneath or sometimes outside of the bark. The moths emerge in May

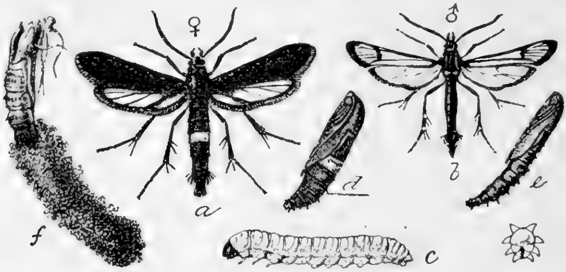


FIG. 30.—*Sanninoidea exitiosa:* *a*, female; *b*, male; *c*, larva; *d*, *e*, female and male pupæ; *f*, cocoon. (Marlatt.)

or June. The female has dark-blue fore-wings; the male has clear ones. It primarily attacks peach, but sometimes cherry and plum. There is but one brood each year.

THE PEACH TWIG-BORER.

(*Anarsia lineatella* Zell.—fig 31.)

The presence of this insect in the winter is quite readily known by bits of frass attached to the bark, often at the crotches of branches or twigs. Each bit of frass covers the entrance to a small burrow lined with silk, within which the young larva of this insect passes the winter. It is now of a yellowish color, with the head and thoracic segments, as well as the last segment, almost black. Early in spring, when the leaves are coming out, the larvæ abandon their burrows and attack the tender leaf shoots, boring into them from a point a little below the apex, and when one shoot commences to dry the larva leaves it and attacks another. In about two weeks the larva is full grown, and pupates in a slight open cocoon attached to the bark or among the shriveled leaves. The tiny, grayish moth issues in May. Two broods follow this, the larvæ boring in the young twigs

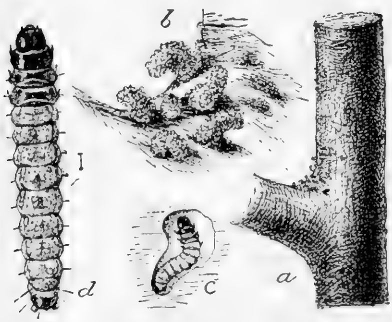


FIG. 31.—*Anarsia lineatella:* *a*, infested twig; *b*, same enlarged; *c*, larva in case, *d*, larva enlarged. (Marlatt.)

or sometimes in the immature fruit. The larva from the second brood makes the little burrows in the bark in which the insect passes the winter. The peach twig-borer feeds on all stone fruits.

THE BAGWORM.

(*Thyridopteryx ephemeræformis* Haw.—figs. 32 and 33.)

The winter cases or bags of this insect, 1½ to 2 inches long, are often seen hanging from the branches of shade trees, particularly arbor-

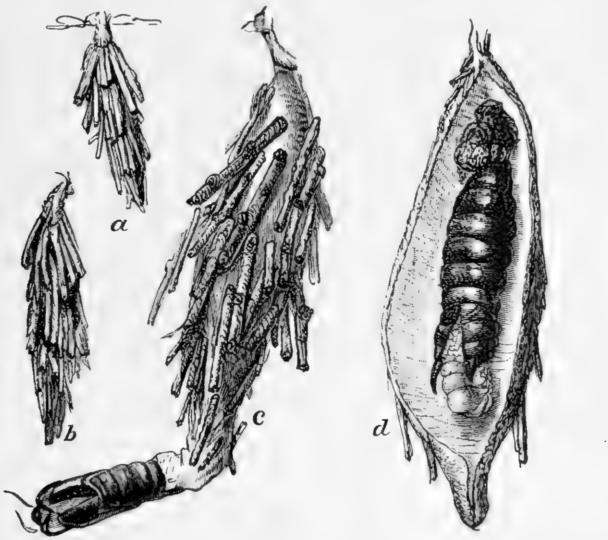


FIG. 32.—*Thyridopteryx ephemeræformis*. Cases; *d*, one cut open. (Howard.)

vitæ, locust, and basswood, but are not so common on fruit trees. The adult insect is a moth; the female wingless; the male with four

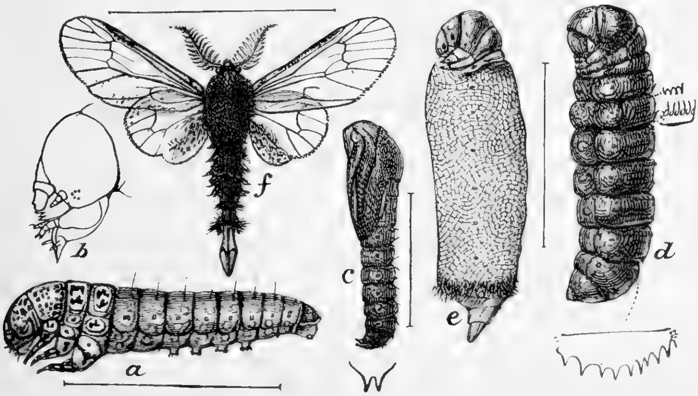


FIG. 33.—*Thyridopteryx ephemeræformis*: *a*, larva; *b*, head of same; *c*, male pupa; *d*, female pupa, *e*, adult female; *f*, adult male—all enlarged. (Howard.)

transparent wings and a black body. The female never leaves her case alive, but in the fall deposits her eggs therein, drops out and dies, the case remaining attached to the tree all winter. In May the young hatch, and at once start to make little cases for themselves, which they enlarge as they grow. When ready to pupate, the caterpillar fastens its case to a twig and transforms to the chrysalis. The male moth appears in August. There is but one brood a year.

OTHER CATERPILLARS.

On the apple tree in winter one may find several other caterpillars in various stages of development. One of them, the pistol-case bearer (*Coleophora malivorella* Riley), is a small larva with a dark head. It carries with it a case the tip of which is curved over, the whole about one-eighth inch long. It feeds on the buds and leaves in spring. In the fall it fastens itself securely to the twig, and thus passes the winter in an immature condition.

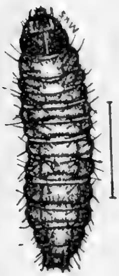


FIG. 34.—Larva of bud-moth. (Slingerland.)

Another is the cigar-case bearer (*Coleophora fletcherella* Fern.). It has a life history similar to the preceding, but its case is straight, not curved. Both feed on the pear and quince.

Small, elongate, white, ribbed cocoons, nearly one-fourth of an inch long, often in clusters, are sometimes seen on apple bark in winter. They indicate the presence of the apple-leaf bucculatrix (*B. pomifoliella* Clem.). In spring the tiny, delicate moths issue from the cases. The larvæ mine the leaves. There are two broods annually.

FIG. 35.—Work of bud-moth larvæ in opening twigs. (Slingerland.)

Small, inconspicuous cases, covered with particles of dirt and bark, are, at times, found on the bark of the apple and pear. These contain the half-grown larva of the bud-moth (*Tmetocera ocellana* Schif., figs. 34 and 35). In spring the larva feeds on the buds and young leaves, webbing the leaves in a bunch or nest. They pupate within this nest. The moth issues in July, and is a grayish insect with a creamy white patch on each fore-wing. During the summer the young larvæ partially skeletonize the leaves, feeding beneath a thin silken web. As winter approaches they migrate to the twigs and form their hibernating cases. There is but one brood a year.

COLEOPTERA (BEETLES, WEEVILS).

Beetles are easily known by the hard, coriaceous fore-wings that cover and protect the back of the abdomen. Both in the larval and the mature conditions they have biting mouth-parts, and injury is sometimes done by both the grub and the beetle. The grubs, to reach the adult condition, pass through a complete change or metamorphosis, like caterpillars, but do not spin a silken cocoon. The grubs do not have the prolegs that are found in caterpillars. The forms to be noticed below may be arranged as follows:

1. Boring in the twigs .... Apple twig-borer.
   Boring in the trunk or larger branches .... 2.
2. Making tiny circular holes in the bark .... Fruit-tree bark-beetle.
   Making a sinuate crack or depression .... Sinuate pear borer.
   Discolored spots on the bark ...... Round-head and flat-head apple-tree borers.

THE ROUND-HEADED APPLE-TREE BORER.

(*Saperda candida* Fab.—fig. 36.)

Discolored places on the bark near the base of the trunk may indicate the presence of this borer. Sometimes the bark cracks over the burrow and allows the frass or "sawdust" to drop out, and often there

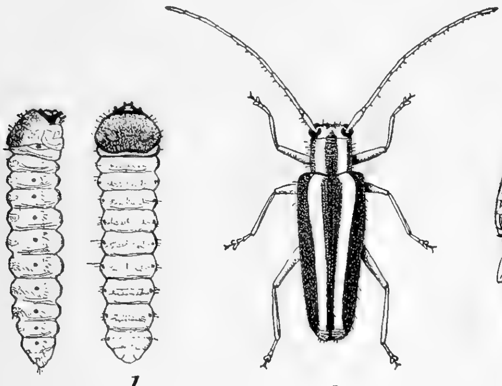


FIG. 36.—*Saperda candida*: *a*, *b*, larva; *c*, beetle; *d*, pupa, enlarged. (Chittenden.)

is some exudation of sap. Every unnatural-looking spot near the base of the tree should be examined. The adult of this borer is a grayish, long-horned beetle with two white stripes along its back. They appear in June and July, and lay their eggs in little slits in the bark made by the beetle near the base of the trunk. The larvæ or grubs soon hatch and bore beneath the bark, feeding on the sapwood and inner bark, and making flat, shallow cavities, partially filled with frass. The grubs are nearly cylindrical, pale yellowish in color, and when full-grown about an inch long. On the approach of winter they work downward, often below the surface of the ground. In spring they begin to feed again, boring upward. In this manner they feed all summer until cold weather, when they again hibernate. In the spring they resume work, but now they bore more irregularly and further into the tree. In early fall they bore close to the surface, work back a little, and then pupate. Winter is passed in this condition, and in June the beetles cut *circular* holes in the bark and escape. It thus takes three years to reach maturity. This borer also infests pear and quince, but not so frequently as the apple.

THE FLAT-HEADED APPLE-TREE BORER.

(*Chrysobothris femorata* Fab.—fig. 37.)

Discolored spots like those caused by the round-headed borer may indicate the presence of this insect. They are, however, often found farther up the trunk, and even on the larger branches. The adult is a dark, metallic beetle, rather flat, and about one-half inch in length. The female deposits her eggs in crevices of the bark on the south side of the tree, usually during June and July, but sometimes later. They apparently prefer trees that are weak or dying, but also attack healthy ones. The young larva upon hatching eats through the bark and bores beneath the surface, leaving a flattened burrow filled with its frass. Sometimes, when more mature, they bore deeper into the sapwood. The full-grown larva is nearly an inch in length, pale yellowish in color, with the segment next to the head greatly enlarged and flattened.

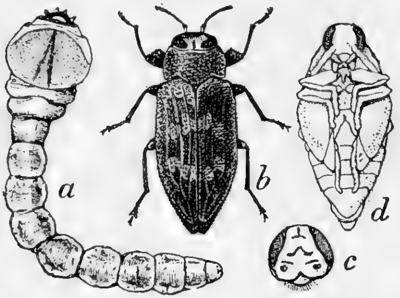


FIG. 37.—*Chrysobothris femorata: a*, larva; *b*, beetle; *c*, head of male; *d*, pupa, enlarged. (Chittenden.)

In the spring it bores out nearly through the bark, then moves back a little and pupates. In about three weeks the beetle cuts an *elliptical* hole in the bark and escapes. There is one brood each year. It attacks apple, pear, cherry, plum, and quince.

THE SINUATE PEAR BORER.

(*Agrilus sinuatus* Oliv.—figs. 38 and 39.)

The larva of this insect bores long, sinuate galleries beneath the bark and sapwood of pear, killing the wood and causing the bark above to crack. The elongate bronzy beetle makes its appearance in May or early June, and lays its eggs in crevices of the bark. The slender, whitish larva burrows beneath the bark, always downward. In the fall the larva becomes dormant, and is then about 1 inch long, quite flat, whitish or yellowish in color,

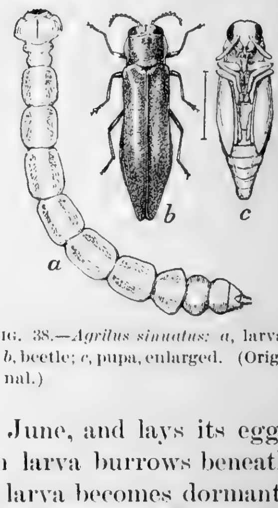


FIG. 38.—*Agrilus sinuatus: a*, larva; *b*, beetle; *c*, pupa, enlarged. (Original.)

with a brown head, and the segment next to the head much enlarged. In spring the larva resumes feeding and makes broader burrows than in the first year. In late summer or early fall, when full fed, it bores about one-fourth inch into the wood, and there forms an elon-

Fig. 39.—Work of *Agrilus sinuatus*, reduced. (Smith.)

gate cell parallel with the bark and connected to the outside by an exit hole. Within this cell it winters, pupates in April, and the beetle issues in May or June. It thus takes about two years to reach maturity.

THE FRUIT-TREE BARK-BEETLE.

(*Scolytus rugulosus* Ratz.—fig. 40.)

Small circular holes in the bark of fruit trees indicate this insect, known also as the "peach bark-borer" or "shot-hole borer." The

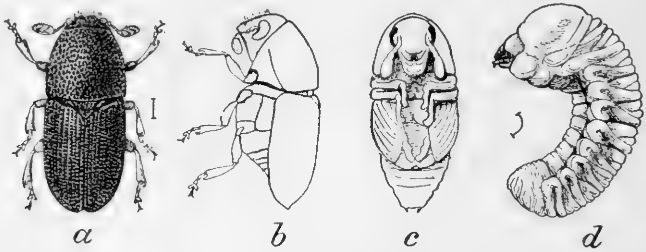


FIG. 40.—*Scolytus rugulosus*: *a*, *b*, beetle; *c*, pupa; *d*, larva; all enlarged. (Chittenden.)

adult insect, a tiny black beetle, appears in the latter part of March to the middle of May, and burrows through the bark. Between the bark and sapwood the female makes a burrow and lays her eggs along each

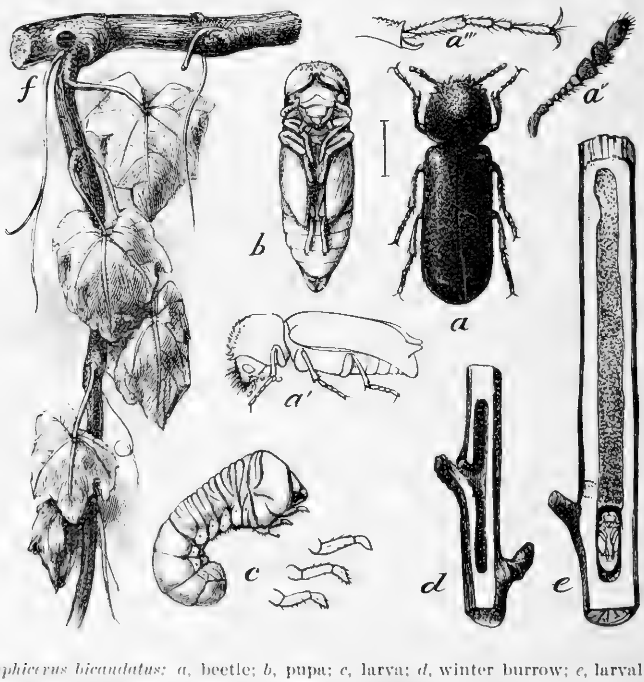


FIG. 41.—*Amphicerus bicaudatus*: *a*, beetle; *b*, pupa; *c*, larva; *d*, winter burrow; *e*, larval gallery; *f*, work in grape. (Marlatt.)

side. The young upon hatching bore away from the parental burrow, and in about three weeks are ready to pupate at the end of the gallery.

In about a week the beetles bore out from their burrows. The result is that the bark is loosened and sometimes the tree girdled. When they attack peach there is a great exudation of sap and a consequent weakening of the tree. There are two and probably three broods a year, but as they start at different times the broods become mixed. It attacks all kinds of fruit trees, and prefers trees that are dying, diseased, or weakened by other insects, but healthy trees are not exempt.

THE APPLE TWIG-BORER.

(*Amphicerus bicaudatus* Say—fig. 41.)

In the fall and winter the adults of this insect bore into twigs of apple and other fruits, as indicated in fig. 41, *d*. Cutting back from this hole one will find this borer in the adult state—a cylindrical brown beetle about one-third of an inch long. These holes are their hibernating quarters. In the spring the insect works in grape canes, causing the withering of new shoots, as indicated at fig. 41, *f*. In the spring the beetles emerge and insert their eggs in diseased or dying twigs of grape, maple, or other plants; the larva bores through the center of the twig until fall, when it pupates. The beetle issues in late fall, and there is but one brood a year. It attacks chiefly apple, pear, peach, plum, and grape.

ACARINA (MITES).

The mites are not insects, although related to them. They are recognized by lacking the distinction between the head and thorax and by the absence of antennæ. There are usually four pairs of legs, but in the pear-leaf blister-mite and its allies there are but two pairs. Besides the pear-leaf blister-mite, which is treated below, there are often found upon fruit trees in winter numbers of tiny, roundish, red eggs. These belong to a mite known as the clover mite (*Bryobia pratensis* Gar.). They rarely do damage to fruit trees in the East, but feed on clover and similar plants.

THE PEAR-LEAF BLISTER-MITE.

(*Eriophyes pyri* Scheut.)

This is a microscopic mite about one one-hundred and fiftieth of an inch long, with a slender body provided with two pairs of legs near the head end. Although each mite is so small as to do little damage of itself, it may become the parent of a vast assemblage capable of doing a great amount of injury. During the winter the mites remain hidden between the bud scales. Early in spring the mites move to the young unfolding leaves, eat through the under surface, and feed on the interior substance of the leaf. Here the mites increase a thousandfold. Some of these mites move out to form new galls, until a

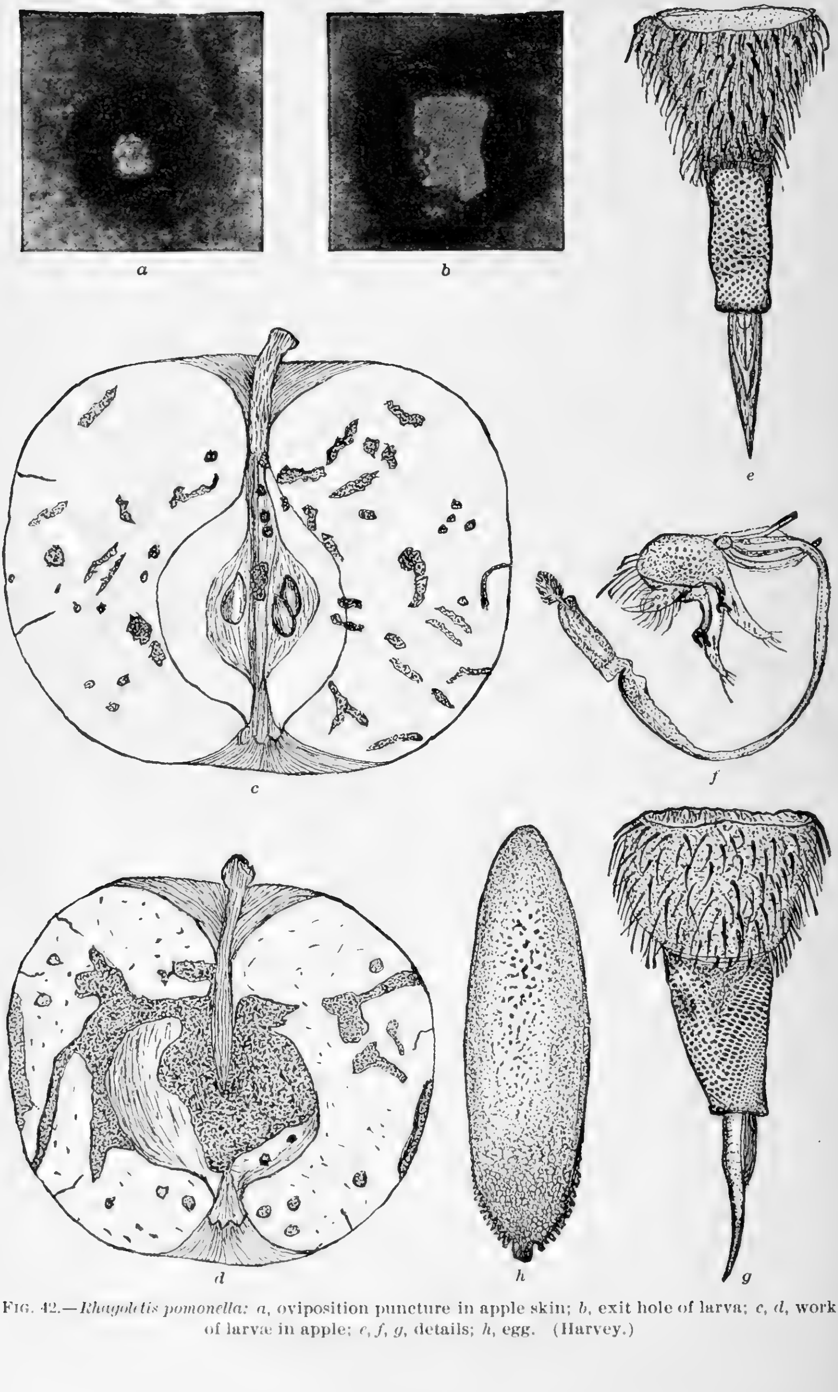


FIG. 42.—*Rhagoletis pomonella:* *a*, oviposition puncture in apple skin; *b*, exit hole of larva; *c*, *d*, work of larvæ in apple; *e*, *f*, *g*, details; *h*, egg. (Harvey.)

leaf becomes thickly spotted with them. Their feeding causes a thickening of the leaf at that spot, commonly called a blister or gall. This blister is at first of a reddish color, but it gradually turns brown, and finally black. In early fall, when the leaves ripen, the mites leave their galls and take refuge in the buds for the winter.

INSECTS INFESTING FRUITS.

Although few of the insects infesting fruit are liable to be transported upon nursery stock, several of them are such destructive pests as to merit the attention of all interested in horticulture.

* * * * * * *

The codling moth (*Carpocapsa pomonella* Linn.) passes the winter as a caterpillar in a cocoon in crevices or under loose pieces of the bark. However, they are not apt to occur on nursery trees. The cocoon is made of whitish silk and partially covered with bits of bark so that it is not easily seen. In early spring they pupate, and the moths issue to lay their eggs on young apples. The larva bores into the apple, usually from the blossom end, mines to the core, and then, when about full-fed, bores to the surface. It leaves the apple to pupate on the trunk or larger branches of the tree. Some issue in late June or July and again lay eggs on the apple, making a second brood. In the Northeastern States there is but one brood a year. The codling moth also attacks pears and quinces.

Fig. 43.—*Rhagoletis cingulata.* (Slingerland).

The apple maggot (*Rhagoletis pomonella* Walsh, fig. 42) is a two-winged fly that appears in June and lays its eggs just beneath the skin of apples. The white maggots, upon hatching, burrow throughout the apple in various directions. When full-fed the maggot drops to the ground, under which it pupates and emerges as a fly the next spring.

The cherry fruit-fly (*Rhagoletis cingulata* Loew, fig. 43) infests cherry in much the same manner as the apple maggot infests apples, and has a similar life history.

The plum curculio (*Conotrachelus nenuphar* Herbst.) is a small, grayish weevil that passes the winter under the bark of a tree or among rubbish. In spring it deposits eggs within the plum (peach or cherry) and then cuts a crescentic slit in the skin near by. The larva or grub soon hatches and feeds in the fruit, causing it to ripen prematurely and fall. The grub, when full-grown, passes into the ground and there pupates, the beetle issuing in the fall. The beetle has a peculiar habit of dropping from the tree when disturbed.

The quince curculio (*Conotrachelus cratægi* Walsh.) is a very similar insect to the plum curculio. It is the cause of knotty or wormy quinces. The weevil lays her eggs in little pits of the quince eaten by the parent for that purpose. The grubs feed in the quince till the early fall, when they leave it and burrow beneath the ground. Here they pass the winter, pupating in early spring.

The pear midge (*Diplosis pyrivora* Riley) is a tiny, two-winged fly much like the Hessian fly, that appears in the spring and lays its eggs in young pears. The larvæ feed near the core, causing the fruit to shrivel and drop. When full-fed they leave the fruit and pupate about an inch or so beneath the surface of the ground. The winter is passed in this condition, and the flies emerge the following spring.

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U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY—BULLETIN NO. 35, NEW SERIES.

L. O. HOWARD, Entomologist.

REPORT ON CODLING-MOTH INVESTIGATIONS IN THE NORTHWEST DURING 1901.

BY

C. B. SIMPSON,

Investigator.

WASHINGTON:

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Division of Entomology,
Washington, D. C., May 19, 1902.

Sir: I have the honor to transmit herewith the manuscript of a report on the codling-moth investigation in the Northwest during 1901, conducted by Mr. C. B. Simpson, a special agent of this Division, and prepared by him for publication. Fruit growers in the Northwest, and especially in the States of Idaho, Washington, and Oregon, have complained that conditions in that part of the country must be very different from those which hold in the Eastern apple-growing sections, inasmuch as the remedial treatment which is found satisfactory in the East does not give equally good results in the Northwest. Therefore, under a special appropriation from Congress, some work was begun by this office in the late summer of 1900, Mr. Simpson being appointed to carry out the investigation and experiments. A report upon the work which he did in the season of 1900 was published in Bulletin 30 (new series) of this Office (pp. 51–63). In 1901 he was able to make a somewhat earlier start, and the results were therefore more satisfactory. This work is described in the accompanying bulletin. The present summer (1902) Mr. Simpson started for the field early in May, and it is hoped that at the close of the season the investigation will have arrived at such a point as to enable the publication of a full and satisfactory bulletin covering the whole problem. I recommend this bulletin to be published as No. 35 (new series).

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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REPORT ON CODLING-MOTH INVESTIGATIONS IN THE NORTHWEST DURING 1901.

ITINERARY.

In accordance with the authorization of the Secretary of Agriculture and the instructions of the Entomologist, the following report is submitted upon the investigations of the codling moth in the Pacific Northwest for 1901.

I left Ithaca, N. Y., June 15, for Idaho, arriving at Salt Lake City, Utah, June 19. The Utah Agricultural College was visited and conferences were held with the authorities in regard to the codling moth. From Logan I went to Pocatello, Idaho, and thence to Market Lake, Idaho, to look over a grasshopper outbreak. At that place I found Professor Aldrich and with him looked over the infested section. A report of the results of this work has already been submitted. June 24 I left Market Lake and was accompanied by Professor Aldrich to Shoshone, Idaho, from which place I went to Shoshone Falls and Blue Lakes. Mr. Perrine's orchard at Blue Lakes was examined closely and remedial measures were advised. The 28th and 29th I spent in observing conditions about Mountainhome, arriving at Boise the 29th, where I spent a few days in looking over the orchards in that vicinity. A trip was then made to Nampa, Caldwell, Payette, and Weiser, Idaho, with return to Boise the 13th of July. Many trips were made to orchards about Boise. August 14 another trip was made, which included Nampa, Caldwell, Payette, Weiser and Emmett. Returning to Boise August 25, I remained there two days and then was in Mountainhome from the 27th to the 30th. In September several trips were made to Beatty, Nampa, and Meridian, and one to Payette.

October 4 I went to Portland, Oreg., for the purpose of attending the fruit fair and conferring with the Oregon people. I had a long talk with Professor Cordley and others of the Oregon Agricultural College and from there went to southern Oregon. From southern Oregon I returned to Portland and from there went to Moscow, Idaho. In company with the Entomologist and Professor Aldrich, I left Moscow October 18. After spending several days at Boise, I started for Washington, D. C., October 22 and arrived there on the 26th.

WORK DONE FROM ITHACA, N. Y.

Not being able to begin work in the field early enough to make observations during the blossoming period, circular letters were sent to prominent growers in Idaho asking them to conduct observations and begin experiments.

Letter No. 1 asked for observations in regard to the times of blooming, etc., and on life of the insect during that period. Several rendered valuable aid by making excellent observations.

Letter No. 2 asked several growers to begin cooperative experiments, which the writer would complete when he arrived upon the field. In every case the freeze of June 5 left no apples upon the trees which were selected for the experiments. Much work had been done by some growers in starting these tests.

Letter No. 3 was sent to 60 growers in different parts of the State asking that band records be kept. The fruit growers responded well to this request, and over 40 replies were received. Many valuable records were obtained.

TEACHERS' INSTITUTES.

During the summer the writer addressed four teachers' institutes upon the subject of the codling moth, the aggregate number of teachers present being about 180.

In each of these talks the damage caused by the insect and the importance of the subject were dwelt upon. A brief but fundamental sketch of the life history was given, fully illustrated by photographs and specimens of the insect's work. The most approved methods of control were explained and the results obtained by the same were given. The teachers were told how they might introduce the subject into their school work as a nature-study topic. Directions were given as to the method of presenting the work and collection of specimens. In these talks the writer took great pains to interest the teachers and has been rewarded by knowing that, in a great number of instances, the teachers put the suggestions into practice.

On account of the small fruit crop no summer meeting of the State horticultural society was held. Two farmers' meetings were addressed—one at Caldwell and another at Mountainhome. The attendance was poor, but the interest shown amply repaid the efforts exerted.

STATUS OF THE FRUIT CROP FOR 1901.

Early in the spring the fruit crop of 1901 promised to be large. A sudden freeze June 5, at which time apples were about the size of marbles, practically ruined all prospect for a good crop. About Boise prunes and peaches were all killed, and in some orchards no apples were left, while in others considerably over half a crop remained. In other sections conditions were about the same. Mr. McPherson estimates that there was only about 10 per cent of an apple crop in Idaho in 1901, and his estimate is probably not far from correct.

On account of this short crop the price of apples was high and those who could save a large part of what crop they had made good profits.

INJURY DUE TO CODLING MOTH IN 1901.

On account of the small crop it is impossible to give an estimate that is of any value in regard to the damage by the insect in 1901. It was certainly much greater than in 1900.

In orchards with but little fruit the apples were all wormy, many of them containing from 5 to 10 holes. The writer counted the remains of 23 eggs on one apple and 17 on another.

The number of the insects was decreased but little by the freeze, while the number of fruits they had to work upon was greatly lessened. Consequently, in the orchards that were well cared for a large percentage of the fruits was wormy in spite of spraying and banding. The following are estimates of injury by the codling moth in individual orchards and in localities:

M. A. Kurtz, at Nampa, had over half a crop of apples. Many of them were undersized. Spraying and banding were well done. The loss for the whole orchard was about 20 per cent.

Mr. C. Hinze, Payette, had about half a crop of Jonathans. About 50 per cent was saved from this insect. Spraying alone was used.

Hon. Edgar Wilson had a small crop of Ben Davis and Jonathans. Early sprayings were made and bands were used. Less than 40 per cent of these were saved.

Mr. John McGlinchey had nearly a full crop at Payette. Early sprays were made but banding was neglected. Not over 20 per cent was saved.

Mr. Seth Heath, 9 miles from Mountainhome, thinks he saved 80 per cent of his apples and pears. Spraying and banding and other measures were used.

Mr. W. S. Whitehead, of Boise, saved only about 20 per cent by spraying and no banding.

Many orchards were noted in various localities where all the fruit was wormy.

Professor Aldrich has found that the damage in and about Moscow was about 5 per cent.

It was reported that about Walla Walla, Wash., and in the valley of the upper Columbia River the conditions were about as they were in the Boise Valley.

In the Willamette Valley the writer has been told that the injuries where no measures were used varied from 30 to 80 per cent.

In southern Oregon the writer found orchards near Central Point in which the injury did not exceed 5 per cent. In an untreated orchard 20 per cent of the apples were estimated to be damaged. Growers said that this orchard showed much less injury than many others in that locality.

FRUITS INFESTED BY THE CODLING MOTH.

The apple is by far the most subject to the attacks of this pest, and practically all of the work has been directed against the insect in this fruit.

In 1900 it was noted that some varieties of apples were more subject to the attacks of this moth than others, and a list was prepared in order of injury. In 1901 but little revision of the list was necessary.

The following is the revised list:

Pewaukee (always badly infested).
Red Astrakan.
Bellflower varieties.
Spitzenberg.
Grimes Golden, Northern Spy, Gravenstein.
Wealthy.
Baldwin.
Ben Davis (very variable).
Rome Beauty (variable).
Jonathan.
Winesap (always least infested).

This list was made from observations in many orchards and is a composite of the conditions in these orchards. Local conditions are to a great extent the cause of the variability.

Pears are but little infested when compared with apples. In the very worst localities the injury sustained rarely if ever reaches 20 per cent, and, when remedial measures are used, injury varies from 5 to 15 per cent.

Many quinces were examined, but not a single case of infestation was noted.

Having in mind Professor Bruner's observations when he found larvæ which he took to be those of the codling moth feeding in seed pods of roses, the writer examined hundreds of these pods without finding any larvæ or eggs.

It has often been reported that the codling moth larvæ were attacking peaches, prunes, and plums. Upon investigation it was found in every case that the attack was made by the larva of the peach-twig borer.

INTRODUCTION AND SPREAD OF THE CODLING MOTH IN THE NORTHWEST.

Dr. C. V. Riley, in his Sixth Missouri Report (1874), mentions this insect as working in Utah, where it had evidently been introduced a year or two previous.

The Scientific American of November 14, 1882, mentions that the codling moth made its appearance in California in 1874.

Prof. J. M. Aldrich states that this insect has been known in the Clearwater Valley since 1887, and in southern Idaho nearly as long. By many orchardists in southern Idaho the writer was told that the above date is approximately correct. Many stories are told of how the insect reached Idaho, one being to the effect that the insect was introduced in dried prunes. Without doubt the insect was introduced in apples shipped either from Utah, Oregon, or Washington. When once introduced it can be readily understood how the insect spread over the apple-growing area by the shipping of fruit from one section to another. The spread is found to be along the lines of transportation. It was retarded in a great measure by the fact that many orchards were isolated. A well-marked case of immunity resulting from isolation is shown in the case of Mr. Perrine's orchard at Blue Lakes. This orchard was free from the insect until two or three years ago, and is now but little infested. Mr. Perrine thinks the moth was introduced into his orchard in old boxes. The spread from orchard to orchard by the flight of the moths has been comparatively slow, and usually follows a river valley.

LIFE ZONES AND PRESENT DISTRIBUTION.

The status of the insect has been studied as far as the data at hand would permit. The life zones found in Idaho (fig. 1.) may be described as follows:

The Boreal zone comprises that part of the State known as the Panhandle, a strip along the northeastern side of the State and a large area in the central part of the State which is connected with the eastern strip.

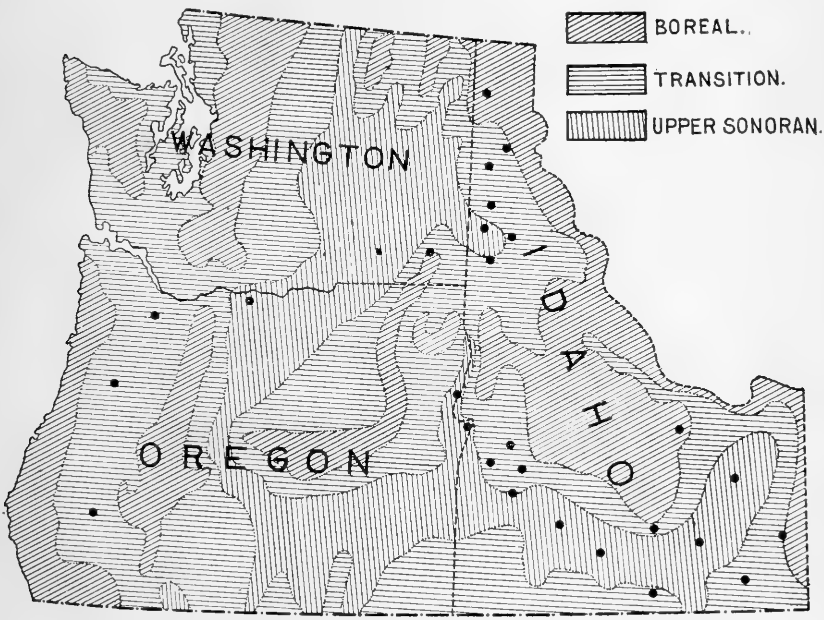

FIG. 1.—Map of the Pacific Northwest, showing life zones—locaities infested by codling moth indicated by dots.

The Transition zone is limited to an irregular area in the north and a fringe around the Boreal in the south. The southwestern and southeastern parts of the State are also in this zone. The Transition area in the northern part of the State is somewhat different from that of the southern part, on account of the larger amount of rainfall.

The Upper Sonoran comprises the area about the Snake River Valley. This area is continuous with the same zone in Oregon on the west and Utah on the south. An arm extends down the Snake River Valley on the western border. A small area of this zone is present in the valleys of the Snake and Clearwater rivers at Lewiston. At this point several of the Lower Sonoran fruits are grown.

The relations of the codling moth to these zones are as follows:

Boreal.—As no apples can be grown in this zone, this insect does not occur.

Transition.—The insect occurs in this zone, but is never greatly injurious. At Moscow the injuries for the past three years have been 21, 10, and 5 per cent, respectively. Many fruit growers have told the writer that the insect has its ups and downs, varying from practically no injury to 25 per cent. Correspondents at Almo, Cassia County; Lakeview, Laclede, and Rathdrum, Kootenai County; and Paris, Bear Lake County, state that they can find no indications of the insect at those places. The observations of those in the best position to know indicate that these locations are not well fitted for the growing of apples. The northern part of this zone, however, is evidently more suitable for apples than the southern part.

The Upper Sonoran.—From 80 to 90 per cent of the fruit raised in Idaho is grown in this zone. Some varieties of apples reach perfection. The codling moth reaches its maximum of numbers and destructiveness in this zone. and here the greater part of the investigation has been made.

LIFE HISTORY OF THE CODLING MOTH.

Many important variations in the life history of this insect were noted in 1901.

THE EGG.

As in 1900, many eggs were observed. In orchards where there were but few apples eggs were found in enormous numbers. On one apple the number of eggs or remains of eggs was found to be 23 (Pl. I, *D*); on another 17. It was difficult to ascertain the time of hatching of the eggs, but the times of hatching of eight were found with reasonable accuracy. These hatched in from three to eight days, with an average of about five days.

THE LARVA.

In a day or so after the egg is laid, a horseshoe-shaped band, which is the embryonic larva, may be seen. Later the form of the larva may be easily distinguished. In about five days the fully formed larva breaks its way through the shell and immediately seeks to enter an apple. The writer has many times attempted to observe the hatching of an egg and the entering of the apple, but has failed, although a few times the attempt was almost successful. The young larva of the first generation has been observed to spend some time upon the fruit and then to enter the calyx by squeezing its way in between the calyx lobes.

In 1900 the earlier countings showed that about 60 per cent entered the calyx end. Without doubt this low percentage was caused by including the early individuals of the second generation. In 1901, by numerous countings, the average was found to be 83 per cent, with a minimum of 79 per cent. In one counting of 130 apples, 106 had entered the calyx and 24 the side. About half of those that entered by the side entered where the apples touched. In 12 apples there were two worms each. Three larvæ were killed by fungi or bacteria. Of those which had left the apples, 13 had left by the calyx and 17 by the side.

By far the larger number of the larvæ of the later generation enter the apple at other places than the calyx—in some cases, from 90 to 100 per cent. They enter at the sides (Pl. I), at the stem, and particularly where the apples touch. In badly infested orchards it is a rare exception to find apples which touch without finding also the entrance place of a codling-moth larva.

A few larvæ of the second generation were taken out of their burrows a few hours after they had entered and were placed upon apples in order to see what they would do. All immediately commenced searching for a place to enter. They would try to bite through the smooth skin, but their jaws would make but little impression. One of them entered at the stem, another found a broken place in the skin, and another succeeded in piercing the smooth skin. As has been noted by other observers, I found that the larvæ while entering eat but little, if any, of the skin or flesh of the fruit, but push the particles out behind them. They seem intent upon getting away from the light. Professor Cordley states that he has seen them spin silk over the mouths of the holes as soon as they have fully entered.

A few authors have advanced the opinion that those larvæ which hatch on the leaves eat sparingly of the leaves before they find the apples. In spite of many attempts to throw light upon this point, the writer can offer no evidence; but he believes that many perish on account of this habit, as they get any poison that may be on the leaves. In the field a large majority of newly hatched larvæ never reach an apple, but perish. This was especially true in 1901 on account of the scarcity of apples. The apples which had 23 and 17 eggs had only 5 and 4 worm holes, respectively.

When entering by way of the calyx, the larva eats its first few meals at the surface before commencing its burrow into the fruit. On entering at the side, the larva eats out a circular mine immediately under the skin, which can be easily distinguished by its lighter color. In about three to five days the larva, after making its burrow funnel-shaped, starts toward the central portion of the fruit. When the calyx is entered a large amount of castings is thrown out (Pl. I, *D*), but when the side is entered but a small amount is thrown out (Pl. I, *A*, *B*, *C*). When the central portion of the fruit is reached the larva eats out an irregular cavity which is found filled with pellets of excrement bound together with silk. Data as to how long it takes the larva to become full grown were secured. However, the number of experiments and the number of larvæ were small and more work must be done before a good average can be given. The shortest time was fourteen days and the longest twenty-five, with twenty-one days as an average. When the larva is full grown it eats its way to the outside of the apple, but remains within, plugging the hole with frass. In a day or so this obstruction is pushed out, and the larva crawls out and immediately seeks a place in which to spin its cocoon and complete its transformation.

The effect of this insect on the apples and pears is such that they ripen prematurely and fall from the tree, being worthless for commercial purposes.

The larva makes its way from the apple to the place of spinning its cocoon in one of three ways. Most commonly it simply crawls from the apple to a twig, thence to branch, and thence to the trunk of a tree. Experiments conducted by Professor Aldrich upon trees with 5 bands show that twice as many larvæ spin their cocoons under the top band as under any intermediate band, and the next highest number was found under the bottom band. In case of windfalls, the larvæ leave the apple and crawl to a suitable place along the ground. In a few cases the larvæ drop from the tree to the ground by a silken thread. Many of these threads have been noted by the writer.

The larvæ spin their cocoons in a variety of places. Those noted are as follows: Under loose pieces of bark (Pl. III, fig. 2) on rough trees; in the cracks in the crotches of trees; in cracks or holes in the tree trunks; under splinters on fence posts (Pl. II, and fig. 1 of Pl. III); in the rough bark of adjacent trees (Pl. III, fig. 2); in any kind of rubbish about the trees; under anything lying against or upon the trees; in cracks in the dry earth about the trees; and, in some few cases, in dried fallen apples. The place of first choice under normal conditions is under the loose bark, in the crotches, or in the holes or cracks in the tree. When the tree is smooth and the earth is dry we sometimes find a considerable number of cocoons in the cracks in the earth.

In general the larva selects a dry, tight place, and it may gnaw out a hole in the bark and incorporate the pieces in the cocoon. Many times a silk tube 2 or 3 inches in length is found with a cocoon at one end. Evidently the larva did not find a place tight enough and continued spinning until such a place was made. In these cases a cap of silk is found. Cloth bands furnish a place for spinning cocoons most acceptable to the larvæ.

The larva spins its cocoon in about two days. The cocoon is composed of a single thread of silk, a product of the silk glands common

ENTRANCE HOLES OF LARVÆ.

FIG. 1.—BANDED TREE AND NEAR-BY FENCE.

FIG. 2.—POST OF FENCE SHOWN ABOVE, WITH SPLINTERS REMOVED.

FIG. 1.—PORTION OF FENCE POST, SHOWING OLD PUPA SKINS.

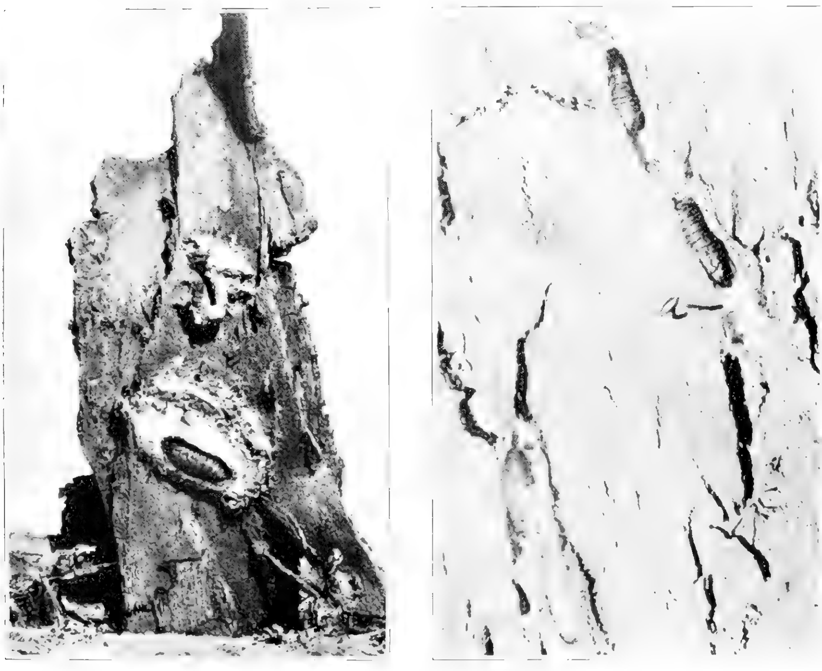

FIG. 2.—COCOONS IN CRACKS IN BARK.

to the larvæ of this order of insects. The cocoons of the early generation are fragile and not so heavy or well made as those of the later generation, in which the larva passes the winter.

THE PUPA.

The larva when spinning its cocoon is bent upon itself, but when the spinning is completed it straightens and becomes shorter and thicker. In about five days it sheds its last larval skin and becomes a pupa. One can always find this skin in a pellet at the caudal end of the pupa. The pupa is about half an inch long and at first is a pale yellow color, later becoming brown. The last day before the moth emerges it assumes a bronze color. The antennæ, mouth-parts, legs, and wings of the moth may be clearly seen, all soldered together in an immovable mass. The segments of the abdomen are movable and are armed on their caudal edge with spines which point backward.

Some time after the beginning of warm weather in the spring, or twenty-one or twenty-two days after commencing the spinning of the cocoon, in the summer, the moth emerges. The pupa pushes itself through the wall of the cocoon and out free from any obstruction. This is accomplished by rapid movement of the abdomen, aided by the spines which point backward. Pupæ were observed to have moved themselves fully an inch before a suitable place for emergence was found. They sometimes thrust themselves through muslin or burlap when such is used for bands and neglected. Soon after the pupa is free from the cocoon the pupa skin splits down the back and the moth slowly crawls out. Many experiments were carried out to determine the time elapsing between the spinning of the cocoon and the emergence of the moth. The shortest time was twelve days, and the longest during the summer was twenty-eight days, with an average of twenty-two. Only a very small percentage emerge the twelfth day.

THE MOTH.

Upon emerging the wings of the moth are small, the legs weak, and the body soft. The moth clings to the bark head up (Pl. IV, fig. 1), the wings gradually expand, and the legs and body harden and get stronger. Later the moth holds its wings for a few minutes above its back, like a butterfly. The wings are then replaced and the moth is ready for flight. During all these proceedings the moth carefully avoids the sunlight. After the wings are fully expanded and dry the moth frequently changes its position by running rapidly up the tree. In from ten to thirty minutes after emerging the moth usually flies to the lower branches of the tree and is lost as far as further observation is concerned. Quick, somewhat erratic flight is characteristic, the flight being so rapid that the eye can not follow it.

It is generally stated by writers on this insect that the adult is but rarely seen in orchards. During the summer of 1900 the writer saw only about half a dozen moths in the field. During the summer of 1901 from one to three were seen every day spent in orchards. These were usually on the fruit or on the upper surfaces of the leaves. On being disturbed they would flit away and be lost to sight.

But few fruit growers are familiar with the adult form of this insect. On this account many mistakes are made as to its identity. Anyone can easily confine larvæ or pupæ and in a short time settle the question of identity. The moth is quite variable in size, but never expands more than an inch. The wings at a glance have the appearance of watered silk, but upon closer examination one finds them crossed by numerous rows of gray and brown scales, which give the appearance of the plumage of a bird. Behind the tip of the forewing there is a large dark-brown spot which bears rows of bronze and gold-colored scales. The hind wings are of a light grayish color, darker toward the margin.

The sexes may be readily distinguished by the fact that the males bear a black pencil of hairs on the upper surface of the hind wing and a black spot on the under surface of the forewing.

Mr. Hitt, of Weiser, found in 1896 that of 50 moths but 7 were males. The writer found the females exceeding the males in number, but can give no figures.

During the summer of 1900 the writer found a moth on the trunk of a tree that had all the appearance of a codling moth except the color, which was buff and gold throughout, the bronze spot being much the same as in the codling moth. During the summer of 1901, 4 well preserved and 8 badly worn specimens having the same color were secured, and 2 others were observed in the field. Mr. Hitt, of Weiser, found 7 of these moths among 50 moths bred in 1896. Mr. McPherson has also noted this buff-colored moth. Whether this is a variety of *Carpocapsa pomonella* or another species has not yet been determined.

According to many observers the codling moth has been seen to feed upon the juice of ripe apples. Many fruit growers tell me that they have seen many moths about cider mills and have seen them feed on cider.

The conclusion arrived at by all investigators of this insect is that it is but little attracted to lights such as are used in trap lanterns. The writer finds, however, that moths will seek a window when they have emerged in a dark room or cellar.

In cages the egg laying begins the second day after emergence and has been observed to continue until the fourth day. In the field some eggs were observed to have been laid in the late afternoon and early evening.

The moths lay practically all of the eggs of the first generation upon the fruit, while those of the later generation are laid both upon the fruit and leaves. From many observations the writer is led to believe that there is no general rule as regards the eggs of the second generation. In some orchards the majority were found upon the fruit, and in others upon the leaves.

In cages the moths rarely live over a week.

GENERATIONS OF THE INSECT.

From the economic standpoint the number of generations is an important feature, as that is the chief factor in determining the amount of damage. In the Eastern States the generations vary from one and a partial second to two and a partial third. In California, Oregon, New Mexico, and Alabama, various investigators have published the statement that three generations occur. Professor Gillette has recently come to the conclusion that there are only two generations in Colorado. Professor Cordley says that there are only two at Corvallis, Oreg. In south Idaho, both Mr. McPherson and Mr. Hitt have advanced the idea that there are three full generations, and sometimes a partial fourth.

The writer has regarded this as one of the most essential points to be determined in the investigation of this insect. In 1900 an attempt was made to solve the problem. At the end of the season, though but little data had been secured, the conclusion was reached that there are three generations. The writer was not at all satisfied with this conclusion, and in 1901 considerable time was spent in studying this point.

Examination of the records of worms caught under bands showed that at certain periods greater numbers of worms went under bands than during the intervals between these times. By collecting and studying all available records it was found that these periods were quite constant, and this appears to be the best and most accurate way of determining the limits and number of generations.

In June, 1901, circular letters were sent to 60 fruit growers in different parts of the State of Idaho asking that records be kept of the larvæ killed under bands. But very few growers failed to answer. Among those who responded, a few stated that apples were not grown in their sections; others banded and found no larvæ or wormy apples; and still others could send no record on account of crop failure; but a large number sent in valuable records. These records were tabulated and curves have been drawn on cross-section paper.[a]

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[a] It was the author's intention to include in the present report a number of charts showing these curves; but owing to incompleteness of preparation, and other circumstances, these charts have been reserved for publication in a later report.

L. O. H.

A summary of the more important records is here given:

Records of capture of codling-moth larvæ under bands.

Year.	Locality.	Observer or source of record.	Number of trees.	First maximum.	Second maximum.	Days between maxima.	Total number of worms.	Time between removal of bands.	Average per tree.
1897	Boise	Mr. Ayers	140	July 17	Sept. 1	46	12,247	Weekly	87.48
1898	do	do	140	July 10	Sept. 10	62	20,909	do	149.35
1899	Juliaetta	Prof. J. M. Aldrich.	40	July 20	Sept. 24	66	8,620	do	215.50
1901	Nampa	H. G. Gibson	4	July 26	Aug. 11	46	467	Daily	116.75
1901	Payette	J. Shearer	3	July 18	Aug. 17	60	215	Weekly	71.66
1901	do	do	80	July 1	Aug. 30	61	3,554	do	44.42
1901	do	do	128	July 5	do	56	1,690	do	13.2
1901	Provo, Utah	Utah Agricultural College.	23	do	Sept. 2	59	4,141	do	180
1901	do	do	26	July 13	Aug. 27	45	2,829	do	108.2
1901	do	do	34	July 5	Sept. 2	50	2,880	do	84.7
1901	Hagerman	R. E. Conner	27	July 12	Sept. 4	54	194	do	8.2
1901	Lewiston	S. G. Iasman	4	do	Sept. 10	60	666	6 per mo.	166.6
1901	Caldwell	Wm. C. George.	10	June 25	Aug. 13	49	640	2–5 days	64
	Total and average		659			55			

All of the records here given show plainly that there are but two maxima of larvæ entering bands. There are many sources of error in obtaining the figures. A maximum lasts from six to eight days. Weekly records are much more liable to error on account of the length of the intervals. The average length of time between maxima, fifty-five days, is undoubtedly too high, as the records of Mr. Gibson and Mr. George show the time to be forty-six and forty-nine days, respectively.

The writer has secured many other records, but they can not be relied upon for determining the number of generations, as some of them were taken on too few trees, and others commenced too late or stopped too early in the season.

The intervals between the maxima may be approximated in another way. From one maximum of larvæ entering bands to another should be the length of the life cycle of the insect. The length of the stages in the life of this insect vary greatly, and averages can be accurately determined only by a great number of experiments. The observations of the writer upon the length of the different stages are not so complete as could be wished, but will serve to show the averages approximately. The egg stage was found to vary from three to eight days, with an average of about five days. The life of the larva outside of the cocoon is from fourteen days to twenty-five days, averaging about twenty-one days. The time spent in the cocoon was found to be from twelve to twenty-eight days, averaging about twenty-two days. The egg-laying period was observed to begin the second day after the emergence of the moth and continue till the fourth day. Three days would probably be a good average. The total of these averages is fifty-one days, which time compares favorably with the interval between the maxima of larvæ entering bands.

FIG. 1.—PIECE OF BARK, SHOWING MOTH JUST EMERGED, AND OLD PUPA SKINS.

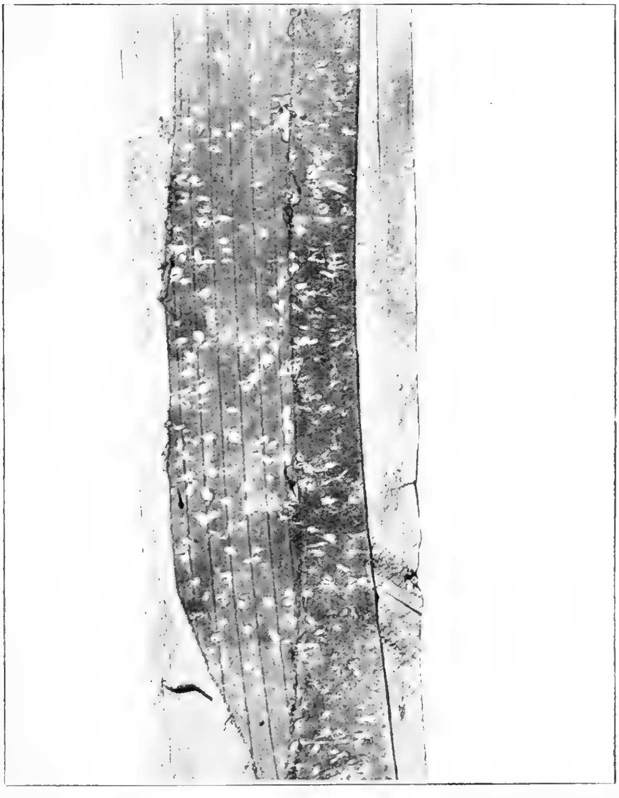

FIG. 2.—BAND ON WHICH THE REMAINS OF 330 COCOONS WERE COUNTED.

By adding fifty-five days to August 27 (the average time in 1901 of the maxima for the second generation), we should expect the maximum of the third generation entering bands. At that date (October 19) no such maximum appears upon the various records. It was noted in 1901 that none of the larvæ which spun cocoons after September 1 transformed, but all wintered as larvæ. In 1900 the corresponding date was September 7.

Mr. McPherson observed the period of the greatest number of eggs of the first generation to be from May 10 to May 25. The writer observed the same period of the second generation to be from about July 13 to August 4. But when the time came for the egg period of the third generation very few eggs were seen.

Observations were made daily in the orchards and the courses of these generations were watched as carefully as possible. On account of the variability of location of orchards and the overlapping of generations, observation is very liable to lead to error and can not be taken as proof except in so far as corroborated by other evidence.

It has been often noted that many young larvæ enter the apples in September. Whether these are the last of the second or the first of the third generation is a question which has puzzled the writer. But few of these new entrance holes were observed at Boise last September and October, and the writer is inclined to believe that the larvæ were the last of the second generation. If there was ever a full third generation, or a partial one, it should have occurred in 1901 by reason of the earliness of the season.

Professor Gillette's article on the generations of this insect has been carefully read. In general the writer's conclusions are the same, but they are based on data of a very different kind. The writer can not agree with Professor Gillette when he says that it is impossible for a partial third generation to be produced. A study of the life zones will show that we should expect some differences between the life history of the insect in Colorado and the same in Idaho.

The writer confesses that on many points there is a lack of data, and on this account does not wish to make the sweeping assertion that there are only two generations of the codling moth in southern Idaho. Whether or not there may be a partial third generation is still an open question and one which can be solved only by careful and accurate work. This much, however, is reasonably certain: The third generation is of little or no importance, whereas in the past it has been regarded as a full brood.

All future work will be based upon the assumption that there are two generations. It is hoped that next season's work will throw more light upon these doubtful points and fully establish the facts.

With the knowledge that there is no fourth brood and no full third brood, the question of the control becomes easier for the Idaho fruit growers.

OVERLAPPING OF GENERATIONS.

The overlapping of the generations is one of the conditions which makes the control of the insect most difficult. In 1900, from July 7 to about September 7, the writer could find all stages of the insect. In 1901 about the same conditions were noted.

According to Mr. Hitt's experiments, the moths in the spring of 1896 emerged during twenty-three days.

The overlapping renders the spraying less effective than it would be if all the insects were in the same stage at the same time.

This overlapping is accounted for by the fact that some of the insects, being in favorable situations, grow more rapidly, and others, in unfavorable places, lag behind.

CAUSES AND CONDITIONS WHICH AFFECT THE NUMBERS OF THIS INSECT.

There are many natural conditions which tend to decrease the numbers of this insect in the Pacific northwest. Comparatively few of the eggs hatch. Infertility, excessive dryness, and the heat of the sun seem to be the causes of this. In 1901 thousands of the young larvæ must have starved on account of not having apples to feed upon.

No insect parasites were noted in 1901. A bird belonging to the creepers was noted at Payette. This bird was very active in hunting food on the apple trees, and without doubt destroyed many codling-moth larvæ. Growers in this locality say that the bird is increasing in numbers. Many pupæ were found to be dried and shrunken, evidently killed by excessive dryness. In more humid sections bacterial and fungus diseases kill many. But if these unfavorable conditions and natural enemies alone are relied upon, almost every apple in an orchard in badly infested localities will be wormy.

There are many reasons which may be assigned for the large number and the great destructiveness of the codling moth in Idaho. The first and probably the most important fact in this connection is that the second generation is more numerous than the first, and does a larger part of the injury. This is doubtless due to the climate. It is also more difficult to combat this second generation with sprays than it is the first. The overlapping of the generation is another fact that makes the spraying more difficult.

One reason for the great destructiveness of the codling moth in Idaho may be found in the life history of the insect. A great many of the fruit growers have used remedies which are absurd. When the proper remedies were used they were not used in the proper manner, and hence failure resulted.

Fig. 1.

Fig. 2.

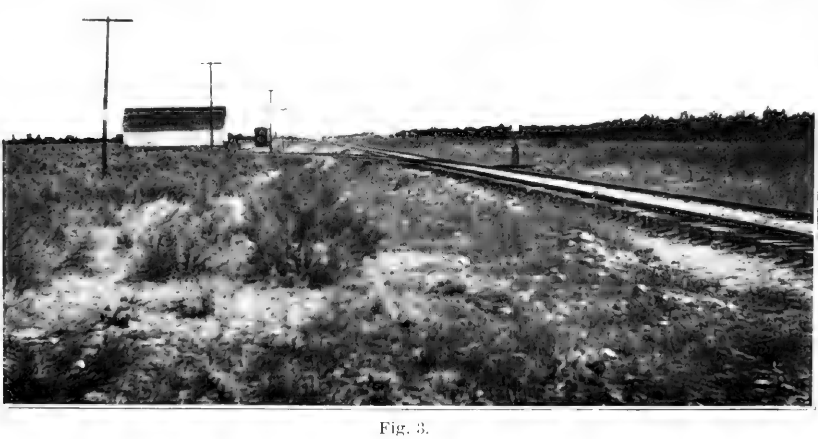

Fig. 3.

VIEWS IN ORCHARD OF HON. EDGAR WILSON, SHOWING LOCATION OF APPLE HOUSE IN RELATION TO ORCHARD.

The absence of remedial measures, use of improper ones, and improper use of suitable remedies have resulted in the abundance of the insect, and have caused many to be discouraged and to have the firm belief that the insect can not be controlled.

The presence of old, neglected orchards is a source of constant supply of the insect, and these orchards render control more difficult.

PREVENTATIVE MEASURES EMPLOYED AGAINST THE CODLING MOTH.

There has been in the past an idea prevalent among the fruit growers of the Pacific northwest that the codling moth can be exterminated. That idea is at present held by only a few. The writer has always said that he believed it impracticable to entirely eradicate this insect from a large area. In an isolated orchard there are strong hopes that it can be done. Next season an attempt will be made to exterminate the insect in I. B. Perrine's orchard at Blue Lakes. This orchard is practically isolated and all methods will be used.

The very best general result that can be expected in Idaho is to control the insect so that its ravages will not exceed 10 per cent.

There are some localities in Idaho where the moth has not yet appeared. By keeping all infested fruit and old apple boxes away from these localities, immunity may be secured. In other localities at high altitudes sudden freezes will sometimes reduce the numbers of the insect to such an extent that it takes two or three years for it to again become injurious. Fruit growers in these localities should use the utmost vigilance, and, at the first appearance of the insect, remedies should be applied and the insect exterminated if possible.

When the wormy fruit is picked in the fall, it always contains larvæ in different stages. This fruit is stored and the insects complete their growth and spin their cocoons in the angles of the boxes and in cracks in the building. In the spring, immediately after emerging, the moths seek the nearest orchard. Where apples are stored in great quantity the fruit on the nearest trees is all damaged. Two well-marked cases of the results of storing apples were noted in Idaho in 1900. In both cases the apples growing nearest the apple house (Pl. V) were all wormy. In one case they were evidently infested in this way for about 5 rows toward the center and about 15 rows along the side of the orchard. In 1901 this place was still the place of worst infestation in one orchard. These conditions may easily be prevented by shipping the apples immediately after picking, and destroying the culls. If the fruit must be stored, the windows and holes of the storehouse should be screened. The moths will collect at these screens and may easily be crushed, or, if the house is so tight that they can not escape, they may be left to die.

Many fruit growers have committed a grave error in regard to the crops of young orchards. The first crop is always small, and many do not think it worth while to use means against the moth for that season. The next season's crop is usually larger and always has a large percentage of wormy apples. If, however, the grower had destroyed most of the worms the previous season, the second crop would have suffered but little loss.

It has often been observed in Idaho that the apples in orchards in which the trees were irrigated by flooding were less wormy than those in orchards which are irrigated by ditches. Single trees or blocks of trees in ground that is continually moist bear less wormy fruit than those which are irrigated only occasionally. The only explanation offered for these facts is that the larva will not spin its cocoon in a moist place, and that moisture favors the diseases of the insect.

Whenever possible, the writer advises that the ground immediately around the trees be kept moist, especially when the larvæ are spinning their cocoons in greatest numbers. Care must be taken in doing this, as too much water will eventually either seriously injure or kill the trees.

The writer has noted many old, neglected orchards in various localities where no attempt was made to keep the insect in check. It needs no explanation that these orchards furnish a constant supply of moths to adjoining orchards, and in that way the loss in the orchard which is well cared for is greater than it would be if both received good care.

In towns and cities many people have in their lawns apple trees which also furnish a constant supply of the insects. These people wish the trees for shade only and have no desire to raise fruit. The writer has approached these people many times when the opportunity presented itself, and showed them what they could do to lessen the difficulty. The people who desire apple trees for shade only could easily destroy all the apples early in the season, and thus no damage would be done.

REMEDIAL MEASURES EMPLOYED AGAINST THE CODLING MOTH.

To intelligently apply remedial measures necessitates as a first essential an accurate knowledge of the life history of the insect. With this as a basis, any fruit grower may adapt the measures employed to his circumstances. It will readily be seen that there are certain periods in the life of this insect when it is vulnerable, and others when it is comparatively safe.

The few experiments which have been made against the insect show that it is impracticable to undertake the destruction of the eggs.

MEASURES AGAINST THE LARVÆ.

A large majority of all the remedial measures that have been used are against the insect in this stage.

Spraying.

Against the young larvæ entering the fruit, spraying with arsenical poisons is most generally used. The object is to place the poison in such places that when the young larvæ enter the apple they will get some of the poison with the first few meals.

EARLY SPRAYINGS.

The best time to spray is immediately after the blossoms fall and before the lobes of the calyx are closed. By spraying at this time the open calyx forms an excellent place to catch the poison, and by the closing of the lobes it is retained for some time. As before stated, from 80 to 85 per cent of the larvæ of the first generation enter by the calyx. Many cases might be cited showing the efficiency of this first spraying. One example will suffice: In the spring of 1901 the writer examined two orchards, separated only by a road. One had been sprayed thoroughly and other measures had been used; the other had not been sprayed, and no other measures had been used. From the first generation about 10 per cent of the apples in the sprayed orchard were wormy; in the unsprayed orchard 25 to 30 per cent were wormy. By count it was determined that in the unsprayed orchard 83 per cent of the wormy apples had been entered through the calyx, while in the sprayed orchard only about 10 per cent of the larvæ which entered by the calyx had escaped the poison.

On account of not being able to commence this work in the early spring, the writer was unable to make observations upon the hatching of the eggs of the first generation. Mr. Hitt furnishes the following data: In 1896 the first moths appeared May 5, and they continued to emerge until May 25. He also noted that the apple trees were in full bloom May 1. In 1901 the moths developed in advance of the blooming period.

Mr. McPherson noted the appearance of the first moths April 23, in 1901, and the first eggs May 10, which was about the time that the blossoms fell from the Winesap, Jonathan, Golden and Ben Davis varieties.

Investigators in different parts of the country have found that the poison stays in the calyx and is effective for at least a week; hence, the lateness of the moth offers no difficulty. Exactly what the moths do between the time of emerging and egg laying still remains to be studied in this locality. Professor Cordley has noted the same state of affairs in Oregon, and thinks that the cool nights prevent the moths from ovipositing.

The second spraying should be done about a week or ten days after the first. This spraying is intended for late larvæ of the first generation.

In cases of very bad infestation, or if extermination is aimed at, the writer would recommend a third spraying in this connection.

The writer has neglected no opportunity to impress upon the fruit growers of the Pacific Northwest that the first spraying is by far the most important remedial measure against this insect, and has gone so far as to state as his belief that one good spraying when the calyx is open saves more apples than all of the other remedial measures together.

LATER SPRAYINGS.

The question of late sprayings is one of the points now under discussion among entomologists and horticulturists. The facts gleaned from publications, letters, and conversations with those in the best position to know are as follows:

Professor Gillette, of Colorado, writes that in Colorado there are some fruit growers who advocate 9 or 10 sprayings, while others say that they obtain just as good results with 2 or 3. Professor Gillette says he has two cases in mind where as good results as one could wish were obtained with only 2 sprayings. He says he can hardly see how more than a slight benefit can be obtained by any spraying after the second.

Professor Card, in his Nebraska bulletin, rather discourages later sprayings.

Prof. M. V. Slingerland, in his bulletin upon this subject, states that he can not see how the larvæ get any of the poison from the side of the fruit.

Professor Washburn, of the Oregon station, concludes that 2 or 3 sprayings will save from 70 to 80 per cent of the early apples, and that 6 sprayings will save from 65 to 70 per cent of the winter apples.

Professor Cordley says that now he can obtain a much higher efficiency.

The writer visited the orchard of Olwell Bros., Centralpoint, Oreg., and estimated their loss in 1901 to be 5 per cent from the codling moth, and Mr. James Olwell told him that the loss was greater than in 1900. Many other apple growers in southern Oregon are obtaining similar results every year.

Mr. Gus Goeldner, of Boise, Idaho, writes that by spraying he saved 98 per cent of his apples, and Mr. C. Hinze, of Payette, Idaho, reported to the writer in 1900 that by spraying he had saved 95 per cent of his apples. Instances of such results, however, must be regarded as exceptional and may be deceptive, as account is probably not taken of the amount of fallen, wormy apples. It still remains to be proved exactly what percentage of apples can be saved by spraying alone in badly infested localities.

This question of later spraying has become one of the most important features of the control of this insect. The writer has made many observations as to the efficiency of the spray. It is a common thing in sprayed orchards to find places on the apples where larvæ had entered and, a day or two after entering, had died. This condition was found to be much more frequent in sprayed orchards than in those which were unsprayed. Without doubt these larvæ were killed by the spraying. Exactly how and when the larvæ get the poison is a question. As has been stated before, the larvæ eat but little of the skin or flesh of the apple while entering. The cavities in which they are found dead are usually of such size that it would take the larvæ a day or two to make them. Particles of lime are sometimes found in these cavities. While seeking a place of entrance the larva may get some of the poison, and it may live a day or so after getting the fatal dose. Some of the spray may get into the entrance hole and be eaten.

Soon after dying, the larvæ become dry and shrunken and can be distinguished only by the presence of the head.

The writer once noted a case where 70 cent of the larvæ entering in the course of two or three days were found dead. It is extremely probable that a considerable part of them died naturall7. Many other observations were made, but never was such efficiency noted again.

In many orchards that had been well sprayed, hundreds of these spots were noted which had been caused by the larvæ and upon examination no larvæ were found.

In 1901 the writer found a larva which had begun an entrance hole and had just died.

On account of these observations and the general results obtained by spraying and banding, the writer has no hesitancy in recommending these later sprayings. Without doubt the efficiency is much less than in case of the first spraying, but the writer believes them well worth the expense.

The writer has found that many growers spray when they have time and do not take into consideration the stage the insects are in. Some spray every three weeks and others spray when they see the number of entrance holes increasing. As already shown, the larvæ are entering more or less all summer; but at two certain periods of the season there are many more entering than at other times. One can easily see that the theoretically perfect time for spraying would be when the larvæ are entering the fruit in greatest numbers. It is therefore essential to recommend simple, practical methods for determining this period of greatest entrance. The writer advises every one who wishes to spray for the codling moth to keep a daily band record on about 4 trees. By a study of this record the maximum can be easily found. In the summer this maximum will be found sometimes between June 25 and July 15. By experiment we have found that the maximum of egg hatching should occur twenty-nine days after the time when the greatest number of the preceding generation entered the bands. In the record made by Mr. Gibson it will be noted that the first maximum occurred June 26, and that by adding twenty-nine days we get the date of July 26. As the maximum of egg hatching extends over some time, spraying must be done before this date in order to get those which are early. In this instance the spraying should have been done between July 15 and August 4. Observation in the orchard in which the record was taken showed the period of greatest number of eggs to be between July 13 and August 4.

The writer has never had an opportunity to test this recommendation thoroughly. Many practical tests were made, and the results of these show that it is absolutely essential for highest efficiency to do the spraying when the largest number of larvæ are entering. The writer would advise two thorough sprayings during this period. Another may be made if infestation is bad.

MATERIAL FOR THE SPRAY.

It is recommended in every case that arsenical sprays be used for this work. Paris green is most used in the proportions of 1 pound to 160 gallons of water with 2 pounds of lime. By the use of this solution excellent results are secured, but on account of its cost and liability to settle many are abandoning it for the white arsenic compounds.

London purple is rarely used alone. Mr. Tiner, of Boise, and Olwell Brothers, of Centralpoint, Oreg., are using a combination of Paris green and London purple. Olwell Brothers use the following proportion: Water, 120 gallons; Paris green and London purple, 9 ounces each; and lime, 2 pounds. Mr. Tiner believes that in this way the poisons are kept in suspension better. Such good results are obtained that these growers are loth to adopt other compounds. White arsenic compounds are being used more and more with results just as good as those obtained with other arsenicals. Dr. H. P. Ustick, of Boise, and Mr. C. Hinze, of Payette, have used them successfully. Information as to the methods of making these sprays have been published in Idaho and the fruit growers are familiar with them.

As far as the writer can learn, lead arsenate has never been used as a spray against this insect in the Pacific northwest. The writer believes that it will be found excellent, and will use it in experiments next season. There are a few fruit growers who use whale-oil soap with the sodium arsenite. Many observations were made in connection with the use of this mixture to ascertain if it caused the poison to remain on the fruit longer. Without doubt this is the case, but the soapy solution collects on the under sides of the apples and damages them materially. In one block of Jonathans fully 50 per cent of the clean apples had spots caused by the soap.

It is intended that future work will show exactly which one of these arsenites is the most effective.

EXPENSE OF SPRAYING.

From the data given by the fruit growers it is found that spraying is comparatively inexpensive. The material to spray 2,000 trees costs about $5. Orchardists always have teams and men already employed, so that the extra expense on account of spraying is very small compared with the benefit. By the use of a gasoline-power outfit the work can be done much more quickly, and, in a large orchard, with less expense in the end. When quickly done the cost should be less than 1 cent per tree per spraying. If inferior appliances are used, or the trees are larger than the average, the cost will be greater. Labor is the most expensive factor in spraying.

Picking and Destroying Wormy Fruit.

While the larvæ are feeding in the apples, these may be picked and destroyed. This is especially recommended as an effective remedy for use early in the season. As has often been shown, thinning the apples to 4 inches apart produces a finer quality of fruit and causes the tree to bear well each year. It is strongly recommended that in Idaho, between June 1 and 15, the fruit be thinned, and that in thinning all wormy apples be removed and destroyed. The writer believes it well worth while to thin apples in order to kill the codling-moth larvæ, without considering the other advantages. Picking and destroying the wormy apples during July and August is too expensive to be of any great value in a large commercial orchard.

In order to get best results, orchards should be cleared of all windfalls as promptly as possible, so that the worms contained may be destroyed. In some small orchards it is the practice to allow hogs to run in the orchard and pick up the windfalls. It would be an almost endless and expensive undertaking to pick up and destroy the windfalls in a large orchard every day or two. The writer does not think it worth the expense if the proper precautions are taken in the use of the bands.

The cheapest and most effective way to get rid of culls, windfalls, and the apples picked in thinning is to bury them. Water should be allowed to run into the holes, and not less than 10 inches or a foot of earth should cover the fruit. If the earth is in clods, it will be well to pack it. Many observations were made during the season of 1901 to ascertain the effect of burying in this way. In many cases the larvæ succumbed to diseases induced by the moisture. Most of them spun cocoons at the surface of the apples, but the moths were unable to escape. Larvæ put in the earth remain a longer time in the cocoon than they otherwise would.

Banding.

When the larvæ leave the apples and seek a place in which to spin their cocoons another point of attack may be taken advantage of by furnishing a suitable place for the spinning of the cocoons and by killing the worms after they have entered the place. This object is accomplished by placing cloth bands from 8 to 10 inches wide around the trunks of the trees. If the trees are large, each of the larger branches may also be banded. The bands may be made of any heavy fabric, such as burlap, old clothes, old carpet, etc. The band should be folded once lengthwise and placed around the trees about 1½ to 2 feet from the ground. After placing the band around the tree, a small nail should be driven through the ends firmly into the tree. The head of the nail should be nipped off. Subsequent removal and replacing of the bands may be done more quickly by this method of fastening.

The number of worms caught under these bands is sometimes astonishing. (Pl. IV, fig. 2.) It is quite common to find, during a maximum period, from 50 to 100 each week for two or three weeks under the band on a single large tree. The highest number Professor Aldrich records as caught on one tree from July 7 to October 15 is 494. Under neglected bands as many as 200 have been found at one time. It is found in orchards that have been sprayed and banded that, in September or the first part of October, the worms are very scarce, thus in a way showing the efficiency of the methods.

Apparently banding is one of the most effective methods, and there are two highly essential features that can not be emphasized too strongly: (1) All places suitable for spinning cocoons other than bands must be removed or rendered unsuitable. The loose bark should be scraped from the tree, all holes and cracks in the trees should be filled with mud or cement, and the earth around the trees should be kept moist during the periods when the worms are most numerous. (2) At regular intervals the bands must be examined and all the larvæ and pupæ killed. The interval between examinations of the bands recommended heretofore has been six or seven days. During the summer of 1901 the writer, by numerous experiments and observations, found that every ten or eleven days is often enough to kill the worms. This extension of time between the changing of the bands reduces the cost of banding considerably, as instead of 14 or 15 changes of bands there is need of only 10 or 11.

Many methods have been devised for killing the larvæ, but the most rapid and effective is either to crush them or cut them in two with a knife.

At the suggestion of Hon. Edgar Wilson the writer again experimented with Paris green in and under the bands to find whether or not the worms would get any of the poison and be killed. Five bands were thoroughly soaked in a strong solution of Paris green and a large quantity of the dry poison was dusted on 10 others. These were placed upon trees and examined every day or two. Not a single larva was found dead. Many were found to have spun their cocoons in the poison which was laying in the crotches of the trees.

Bands should be placed upon the trees not later than the middle of June and should not be finally removed until about a week after the crop has been harvested. By a close watch on a few bands one can tell when the worms begin to descend in the spring. After the first week in September it is found that very few, if any, larvæ change to pupæ and emerge. It is not advisable to let any bands stay on the trees all winter, as they rot, and the cost of bands is a considerable item in a large orchard.

Many fruit growers believe that under favorable circumstances they can save almost half their crop by banding alone.

It is strongly urged that, late in the fall, during the winter, or early in the spring, the orchard be examined, and all the larvæ found in crevices and under the bark of the trees killed.

MEASURES AGAINST THE ADULT.

TRAP LANTERNS.

Considerable effort has been made to put the facts about trap lanterns before the Idaho apple growers. The agent for a patented trap sold 240 in Boise and vicinity. He claimed that he caught 6 codling moths in one night. A majority of the growers who bought these traps found out for themselves that this method is useless. A very few still advocate its use. The writer did not think the method worthy of experiment.

BAITING THE MOTH.

One fruit grower at Mountainhome uses buckets of cider or vinegar, with which he says he catches large numbers of codling moths. Dr. Riley's experiences show that these catchings must have been accidental. The writer set out some of these cider buckets and in two weeks while the moths were flying caught but few. The notes on the experiment were misplaced, but the writer remembers that about 10 codling moths were caught and many Noctuids. At best the results of the method would in no way be commensurate with the expense.

RÉSUMÉ AND CONCLUSION.

As has been before stated, the codling moth can not be exterminated throughout the Pacific northwest. Reduction of the damage with least expense has been the object in view. The writer believes that by the intelligent use of the methods herein given the moth can be so well controlled that the injuries will be between 2 and 10 per cent. With the insect under control, it will not be necessary to use all of these measures every year.

The writer has never had the opportunity of putting all of these recommendations into practice in one orchard. This would have been done had it not been for the freeze of 1901. Advice was given many times as to the treatment of orchards and the results were noted as far as possible. Some of the successes are here given:

M. A. Kurtz, Nampa, Idaho, has an orchard of about 2,500 trees, many of which are stunted partly on account of lack of care. In 1898 there was less than a full crop, about 50 per cent being damaged; in 1899 there was a full crop, but only 100 boxes of clean apples were harvested. In 1900 there was about one-fourth of a crop, and all were wormy. In 1901 Mr. Gibson, in charge, began good cultivation, spraying, and banding. There was probably over a half crop. The trees were all sprayed with Paris green four times, and a majority of them a fifth time. Bands were well attended to. The writer visited the orchard frequently during the season, the last visit being made the latter part of September, when the fruit was estimated to be damaged as follows: Ben Davis, 5 per cent; Steele's Winter Red, 10 per cent, and Blue Pearmain, 25 per cent. A few Ben Davis trees showed 10 per cent of damage. A large amount of the fruit was undersized. The writer could not get figures after the crop was harvested, but he believes the work done against the codling moth was quite successful. The only cause of uncertainty was the fact that the crop was small the year before, and the insect might possibly have been reduced on this account.

Hon. Edgar Wilson has an orchard (Pl. V) near Boise, containing about 4,000 trees, about 2,000 of which were bearing. There was a light crop of Jonathans and about one-half crop of Ben Davis. Only the early sprayings were made, and they were well done. Bands were well attended to. The later sprayings were not made, and the bulk of the injury was done by the second generation. Not over 40 per cent of the apples in this orchard were free from worms. In 1900 from 85 to 90 per cent were saved.

Mr. Tiner, of Boise, has about 400 trees, in a badly infested locality. Spraying and banding were well done, but only about 30 per cent of the fruit was saved. In 1900, 80 per cent was the amount saved.

The losses in many other well-treated orchards with small crops varied from 20 to 80 per cent. In those orchards where the loss was higher only partial measures were used. In untreated orchards in badly infested localities the loss was always about 100 per cent. The reason of these excessive losses, even when the best measures were used, may be accounted for by the fact that the freeze killed a large percentage of the fruit, while the moths survived.

Olwell Brothers, of Oregon, spray every three weeks during the season, and the writer examined the orchard in October and estimated only 5 per cent loss from the codling moth.

The writer feels grateful to the Idaho growers for the way they have adopted his recommendations. Plans have been partially made for next season's work. In general, the plans are to select one or two typical badly infested orchards and there apply remedial and preventive measures to demonstrate exactly what can be done against the insect. The writer has no fears that the results will not substantiate all that is claimed for the remedial measures.

O

M. G. Johnson

29 - 35, 1901-02

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