REPORT OF EXPERIMENTS & STUDIES IN ENTOMOLOGY.

HERBERT OSBORN, Entomologist.

During the past season we have given especial attention to grass and clover insects, the importance of which, in this State, need not be emphasized. Other studies of insects affecting potatoes and rape have been made because of their immediate interest, those on the Potato Stalk Weevil being published in this number. Some of the insects affecting rape were mentioned in a preceding Bulletin, and it is hoped that further matter may be presented in the next number, along with some details of studies on Leaf Hoppers, the present number being already crowded.

The work on the Clover Seed Caterpillar has been so largely performed by Mr. Gossard, and that on the Potato Stalk Weevil by Mr. Sirrine, that it appears under their respective names. I have been assisted in the details of experiments with Leaf Hoppers, especially by Mr. Gossard, and am indebted to him for careful attention to the work as planned.

In previous Bulletins (13 and 14), we have urged the importance of the little leaf hoppers that are to be found so abundantly in grass, and in Bulletin 14 gave the results of experiments to increase the yield of Hay. Desiring to test more fully the plan detailed as applied to pastures, an experiment was planned for the present season. This was carried through with the co-operation of the Farm Section of the Experiment Station, and I wish to thank the officers of that section for use of pasture land and cattle for the purpose of the experiment, and also for assistance in locating the plats and selecting the animals.

AN EXPERIMENT WITH THE TAR-PAN FOR LEAF-HOPPERS ON PASTURE LAND.

Two lots of blue grass pasture, which we will call lots 1 and 2, each containing about one and three-fourths acres, were fenced June 10th. The lots adjoin, and at the time of

selection were deemed to possess about equal capacities of pasturage. Lot 1 was left to experience entirely natural conditions throughout the season.

On the 4th of June a dozer, consisting of a heavy pan of sheet iron, 8x3 feet, and coated with coal tar, applied by means of an old broom, was dragged over lot 2, every part of which was passed over once by the dozer. Leaf-Hopper larvae were taken in great numbers, also many adults of *Deltocephalus debilis*, but none of *inimicus*.

June 8th lot 2 was again cleared, the ground all being passed over twice and hundreds of thousands of Leaf-Hopper larvae were destroyed.

June 9th the treatment was repeated on lot 2, the ground being twice passed over. About half as many Leaf-Hoppers were taken as on the preceding day. We made a rough estimate at this date, based upon last year's counting, that up to this time not less than 1,000,000 Leaf-Hoppers had been captured on lot 2.

June 17, three short-horn cows, estimated to weigh about twelve hundred pounds apiece, certainly not differing more than fifty pounds from each other, and all dry and with calf, were selected for the grazing part of the experiment. One of the cows was about six years old, the other two about four. One of the younger cows was put in lot 1, the other two in lot 2. For convenience in watering, tubs were set in lot 1, and the cows in lot 2 were driven to them regularly, for water. They were not allowed to remain eating the pasture of lot 1. The cow in lot 1 had access to water at all times. All other conditions with regard to the cows were exactly the same.

June 24th lot 2 was dragged over twice with the dozer, but the day was too windy to secure good results.

On the same date the dozer was dragged 36 feet in lot 1 and one-fifth of the entire length of the pan was taken to represent the average catch for the whole pan, and the Leaf-Hoppers on it counted. Two hundred and forty were taken on this section, or 1200 were caught upon the whole pan and at this rate, 181,440 would be caught on an acre. The day was so windy that this may be regarded as far below what the catch ought to have been under favorable conditions.

June 25th we dragged lot 2 twice. The day was very favorable, the hoppers springing up actively, and there was just enough breeze to gently drive the drift of the hoppers on the pan as we worked from the leeward to the windward side of the lot. The first round on the lot captured 783 Leaf-Hoppers upon a six inch section of the pan extending its whole width, which was judged to be an average catch for the remainder of the pan. As we made about 20 rounds in covering the lot twice, something like 250,000 Leaf Hoppers were taken this afternoon. This result seems large when we take into account the previous dragging, but it must be remembered that the plat was surrounded by grass land from which hoppers could readily work in at the margins, and probably many had hatched since the last treatment.

July 7th we went over the pasture once, with the dozer, taking a comparatively small number of adults, mostly *inimicus*.

July 20th the ground of lot 2 was dragged twice for the especial purpose of capturing young grasshoppers, which were beginning to appear in great numbers. Goodly numbers of grasshoppers were taken, a great many adult *D. debilis* of the second brood, and but few *D. inimicus*, the first brood having pretty nearly disappeared by this date.

No further treatment was given to either lot during the season.

Lot 1 had a ridge running its entire length, the grass on top of which began to show some silvering at the date when the cows were turned in. The soil upon the ridge is believed to be lighter than the soil in other parts of the lots, which may account for part of the drying out of the grass, but we also think it was greatly hastened by the drains made upon it by the leaf hoppers. By last of June the pasture upon this ridge, occupying about one-fourth the area of the lot was dead, and has been worthless ever since. An equal area of sandy ridge in lot 2, which possibly had a somewhat deeper soil, remained green and vigorous until late fall, retaining, it is thought, a better vitality than the pasture just outside the lots upon the same ridge, notwithstanding the greater strain imposed upon it, in the number of animals fed from it.

By the 12th of August the pasture in lot 2 was short, but green and vigorous, and the two cows had kept their relative condition as well as their neighbor in lot 1, the only reduc-

tion, in any case, being due to flies and hot weather. The animals were all pronounced in fine flesh, and the pastures to be able to support the cows indefinitely. While lot 1 seemed capable of more than supporting the one cow, it seemed certain that it would not stand an additional cow. A great many leaf hoppers were noticed in lot 2 from this date onward, having probably entered chiefly by migration from the adjacent grass land, and this doubtless had a tendency to reduce the capacity of the plat.

August 29th the younger cow in lot 2 calved, and was at once removed from the lot. September 8th the older cow calved and was removed from the lot. Both cows had kept in good flesh up to the date of their removal, though hardly so well as the cow in lot 1.

September 15th a short-horn cow of about equal weight and condition as the cow in lot 1, and a Holstein cow weighing about 900 pounds, were turned in lot 2.

September 14th a frost occurred, which was repeated a few days after, and pastures everywhere began to fail.

September 14th the Holstein cow in lot 2 calved, and was removed. She was replaced the same evening by a Jersey cow, weighing from 700 to 800 pounds.

The pasture failed so in both lots, as in other pastures, that all the cows were removed September 28th, and the experiment was discontinued. The farm cattle had been taken from blue grass pastures some days before and turned in upon clover. At the date of removal lot 1 contained about one-half an acre of excellent pasture in which there was a liberal sprinkling of white clover located in a draw which supports a living spring. The rest of the lot was poorer than lot 2, which is favored by no draws whatever. The grass in both lots seemed to be as good, if not a little better, than the grass adjoining outside.

Summarizing our results we find that lot 1 supported one Shorthorn cow, weighing 1,200 pounds, for 103 days continuously.

Lot 2 supported two Shorthorn cows, weighing about 1,200 pounds each, for 73 days continuously, or one such cow for 146 days. It supported one of the cows 10 days longer or during the continuous period one such cow for 156 days. The lot then had seven days in which no stock was upon it.

Then a Shorthorn cow such as the others was pastured upon it for 13 days, a Holstein weighing from 800 to 900 pounds for 9 days and one Jersey weighing from 700 to 800 pounds for four days. If we call the time of the Holstein and Jersey together equal to nine days for such a cow as one of the Shorthorns, lot 2 supported one 1,200 pound Shorthorn cow for 173 days, or 70 days longer than lot 1 did. This would represent a gain of 68 per cent in the capacity of pasturage. As we have said, however, lot 1 would have stood more cropping than it was given, but the difference in the lots should also be taken into account, so that perhaps we can only say that our results confirm our previous experiments that the pasturage can be increased at least one-third to one-half by the use of the leaf hopper tar pan.

On the other hand it must be said that actual practice on a farm should give more decided results, for we had a small plat, less than two acres, for two large cows, and this plat surrounded by grass land, swarming with insects, which naturally must have worked in upon the treated portion, both to feed and deposit eggs.

To counteract this in part, and also to learn the best times for treatment, we treated the plat a greater number of times than would be considered necessary or profitable with operations on an entire pasture.

The life history of the two most injurious species now being known, it seems that the dozer may be used most effectively at three different dates throughout the year; viz: When the first brood of both species occurs as larvæ, from May 25 to June 10. Again from July 15 to 25, when second brood of *debilis* is to be taken. Again about August 10, when second brood of *inimicus* is to be taken. If more applications are desired they should be adjusted so as to catch the third brood of larvæ as they appear. Evidently thorough and successful work upon the first brood should reduce the necessity for later operations.

The experience of the present year shows that the tar pan will give the best results if used in the afternoon of a warm day (perhaps best from 3 to 6 p. m.), and when there is little or no breeze. This is necessary when grass is in bloom.

With regard to the cost incurred, it may be said that the cost of sheet iron, which will last for a long time is only a

dollar or a dollar and a half, the tar used is scarcely to be counted an expense, and the cost may be considered as limited to the labor involved. In operation two men have usually covered the plat mentioned, an acre and three-fourths in about two hours, lapping strips so that the ground is covered twice. One man working alone can cover the same ground in but little longer time, but needs a somewhat lighter sheet for rapid work.

At the first rate it cost, counting a man's services at one dollar a day, about 20 cents per acre for treatment.

On a larger scale and placing three or four such sheets in line, or using a continuous sheet, so as to cover a strip 30 or 40 feet wide at once, four men could easily cover six acres per hour at a cost of about seven cents per acre. Horse power could doubtless be used at still less expense, provided the ground was smooth enough to permit the sheet to run without catching.

THE CLOVER-SEED CATERPILLAR.

H. A. GOSSARD.

Grapholitha interstinctana, Clemens.—This insect has attracted considerable attention in recent years, in widely separated sections of country, on account of the injury it inflicts upon the forming clover seed crop. While reports of its injuries in any particular season seem to indicate that they have been somewhat local in character, the local areas from which these reports have come are situated in New York, District of Columbia, Michigan, Indiana, Iowa, Ohio, and Illinois. It also occurs in Missouri and Pennsylvania. It is probably found wherever the common red clover (*Trifolium pratense*) is grown in the eastern and central States. We have also reared it from white clover (*Trifolium repens*) in the breeding cage and found it infesting the same plant in the field. It seems probable that it does considerable damage every year over the entire territory within which it is found,

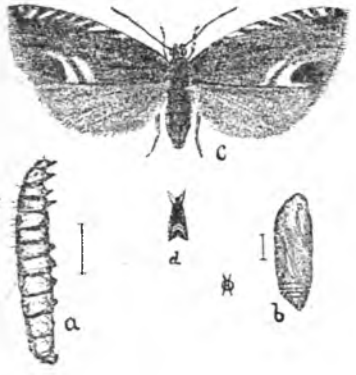

Fig. 1. *Grapholitha interstinctana*. *a*. larva, *b*. pupa, *c*. adult, all enlarged, *d*. adult, natural size. (After Osborn.)

escaping general notice except in particular places and seasons, when local causes multiply it to such a degree that a large percentage of the crop is threatened or destroyed.

Prof. Comstock noticed it, at Ithaca, New York, in July, 1874, and says that from 15 to 20 per cent. of the clover heads in that vicinity were infested with generally one, sometimes two, small, greenish-white larvae per head, from which *Grapholitha interstinctana* was reared in August. He also states that the same moths were swept from clover on the grounds of the U. S. Department of Agriculture, at Washington, D. C., in May, 1879.*

Prof. F. M. Webster writes us that he observed it quite abundantly on leaves of *Helianthus grosse-serratus*, in DeKalb county, Illinois, fully 15 years ago. He reared specimens in 1890, from clover heads sent him by Miss Cora Himlanch, of Vicksburg, Michigan, who stated that clover in that vicinity was injured 95 per cent in some fields. He noticed that adults were abundant at LaFayette, Indiana, May 25, 1891, and during May, 1892, at Columbus, Ohio. Prof. A. J. Cook says that it was quite common about Lansing, Michigan, in 1885.†

In October, 1890, Prof. C. P. Gillette found the clover about Ames severely infested by a caterpillar which he did not determine, but from his description of the insect, and its mode of attack, we have no doubt that it was *Grapholitha interstinctana*. He says: "There was scarcely a bunch of the clover that was not infested by from one to half a dozen small lepidopterous larvae, that were eating at the bases of the leaf stems, severing them and devouring the young unopened leaflets.‡ He found the same caterpillar at Champaign, Ill., in November of the same year, but not nearly so abundant as at Ames.

Prof. Herbert Osborn remembers the moths as occurring about Ames in considerable numbers, eight or nine years ago, but they were not connected at the time with any damage observed in clover fields.

Prof. C. M. Weed listed it as a clover insect in Ohio, in 1889‖ Cook states that Grote has captured it in Pennsyl-

*Report U. S. Department. Agr., 1880, p. 254.
†Beal's Grasses of N. A., Vol., I. p. 392.
‡Bulletin No. 12, Iowa Agricultural Experiment Station, p. 535.
‖Bulletin of Ohio Agr. Experiment Station, Technical Series, Vol. 1, No. 1, p. 30.

vania,* and our information that it occurs in Missouri is based upon the fact that the parasite, *Glypta leucoyonata*, Ashmead, was reared from it at Kirkwood, in that state, by Miss Mary E. Murtfeldt.

Personal observations upon the species commenced May 23, 1891. Most of the observations made during the year 1891 have been published in Bulletins No. 14 and 15, of the Iowa Agricultural Experiment Station, under joint authorship with Prof. Osborn, and portions of the original articles are used here, unchanged, without quotation marks.

SPRING BROOD OF ADULTS.

The moths when first noticed were flying in great numbers about a clover field, upon the College farm. They were resting upon the blossoms and among the leaves, and upon being disturbed would fly a few paces and then settle again.

They increased in number from the time they were first observed until, by the third of June, they seemed to reach their maximum and in the early evening, when the field lay between the observer and the sun, a perfect cloud of them could be seen hovering over the blossoms as far as the eye could reach. It was also noticed that they were pairing freely at this time. By the 24th of June this, the first brood of adults, had almost entirely disappeared, a few stragglers only being found by diligent search.

The present year, 1892, was extremely late in this section, and the first moth was taken on May 23, another May 25, and three on the 2d of June. It was not until the middle of June that the brood reached its maximum, though it disappeared but little later than the corresponding brood disappeared last year, the bulk of each going during the last week of June. One adult was observed June 30, or six days later than the last adult of the same brood was seen last year. Prof. Cook says that the moths lay their eggs in May in Michigan†, and as previously mentioned Prof. Webster writes that they were abundant at La Fayette, Indiana, May 25, 1891, and during May, 1892, at Columbus, Ohio. Prof. Comstock's

*Beal's Grasses of N. A., Vol I. p. 292.
†Beal's Grasses of N. A., Vol. I, p. 392.

record for Washington, D. C., is early May, 1879.* It may therefore be stated that the first brood ranges from early May until late June, the bulk of the brood being confined to a period of about three weeks, occupying the last week in May and the first two weeks in June in ordinary seasons in this locality, and perhaps the first three weeks in June in extremely backward springs, while the general average date for the entire territory known to be infested seems to be one or two weeks earlier than here at Ames.

DESCRIPTION AND HABITS OF THE MOTH.

The moths are very small and may be generally described as dark brown or nearly black in color. The wing expanse is from 8mm to 10mm (.31 to .39 inch). They are marked by two small, parallel, excurved, short silvery lines at the middle of the hind border of each fore wing, so that when the wings are closed the lines form a double crescent over the back (see Fig. 1 *c* and *d*). A great many specimens, otherwise bright and new, have all traces of these crescents obliterated, and at one time they were supposed by the writer to be dimorphic specimens, but later observation has convinced him that they are rubbed specimens. The rubbing may, in many instances, be done while emerging from the pupa case, since the first specimens of the brood to appear are often damaged in this manner. Eight white, silken lines are disposed along the front border of each fore wing, which in common with the hind wings are delicately fringed. The wings beneath are shining and silky and have a greenish tinge in certain lights.

The following is Grote's description, pronounced by Prof. Comstock to be much better than Clemens's which we have not seen.

Adult—"A tiny blackish silky species, resembling the European *compositella*, but with only two white lines on the internal margin of the primaries. Eight white costal marks disposed in pairs, crowded toward the apices, and becoming straighter and shorter; the first pair more oblique and divaricate. A silvery subterminal streak runs from opposite the cell over the median nervules tapering to internal angles.

*Report U. S. Dept., Agr., 1880, p. 254.

(This streak cannot be seen in some lights—J. H. Comstock.) Secondaries fuscous with pale fringes. Beneath iridescent, greenish in certain lights, with minute costal dots over the outer half of the wings. Body scales beneath whitish."

One of the peculiarities of the moth that first attracted our attention was the habit of swinging about in a circle immediately after alighting, the head being the pivot and the posterior end of the body describing the circumference. Two or three revolutions are usually performed in a spirited manner, the direction of movement being abruptly reversed before the insect settles to rest. We are unable to interpret the performance unless it be a scouting movement for discovery of spiders and other insect enemies that love to lurk about the low foliage of a clover field, or as it seems to us, it is more probably a trial circuit made to find the best position for repose.

The moth is often found in situations remote from clover fields, thus suggesting a possibility that it is not confined to clover as a food plant. The fact of its frequenting such Compostæ as *Helianthus* or wild sunflower, mentioned by Prof. Webster, has also been noticed by the writer during both the seasons of 1891 and 1892. Search for larvæ in the flowers both years was not rewarded, and while the investigation was not sufficiently thorough to justify the conclusion that these plants are not utilized for food by these insects, it was, we think, thorough enough to warrant the conclusion that the flowers, at least, are not used nearly so extensively for this purpose as the habits of the moth seem to suggest. We have often taken the moth while sweeping weed patches in the woods and found them resting on the leaves of various trees at a considerable distance from growing clover. While it may not be deemed so very surprising that a great many specimens should be found in such places when the myriads that occur in clover fields are considered, and the possible agency of the wind in scattering them is taken into account, yet the number of specimens that would constantly appear in our net from sweeping such localities, often a quarter of a mile or more from any clover whatever, and attracting our notice throughout the entire period representing the life of the

brood, leads us to question, somewhat doubtfully, if they did not issue from some place more adjacent than the nearest patches of clover.

PLACE OF DEPOSITING EGGS.

The soft, yellowish eggs are laid in the involucre of the head, or within the florets when the clover is in blossom, and in or about the crown of the plant when no blossoms are available. An examination of a great number of clover heads gave the following evidence on this point. Most of the infested heads were occupied at the base by the caterpillar, which almost always had eaten a circular opening through the base of one or more florets in immediate contact with the involucre. In a case, such as one of these, we can hold no positive opinion as to whether the egg was deposited in the involucre or within a floret, but think for reasons that we shall state presently that it is usually deposited in one of the lower florets. In one head examined, the caterpillar was found within a floret which had no orifice, except the natural one, neither was there an opening into any other floret in the head except the natural one. The caterpillar was nearly half grown, and excrement and signs of feeding outside the floret, made it appear certain that it had not developed from the egg in the floret, in which it was found. It seems highly probable that in this case the egg was laid in the involucre, and that the caterpillar had entered the floret through the natural opening after it had attained nearly one-half its growth. The possibility remains, however, that it could have hatched from an egg deposited in some other floret, which it had left through the natural opening, fed for some time outside, and then retreated to the situation where it was found, but it would seem that some evidence of feeding in the floret within which the egg was deposited would have been left, if such were the case, and no such evidence was found. Caterpillars have also been found in the upper part of the head with from one to a half dozen or more florets perforated, and without evidence of their having been at any other place about the plant. In each case of this sort, the egg must have been laid in one of the upper florets, or between them, in the higher

part of the head. In most cases where the caterpillar was found entirely outside the florets, its track could be plainly distinguished, though often few or no perforated florets could be found along short portions of it, while many times young caterpillars were found that had eaten their path directly through the bases of contiguous florets, sometimes not more than two in number, without any indications occurring of their having been elsewhere, thus strongly suggesting that in each the latter cases the egg was dropped into one of the florets, and that the caterpillar, in eating its way out of it, had eaten its way through the contiguous walls of another floret, thus having no opportunity to make an external track. We are quite sure that in one instance we pressed a newly hatched caterpillar from an unperforated floret, the egg presumably having been deposited in the place in which the caterpillar was found. The element of uncertainty in the observation, lies in the fact that the wind caught the caterpillar and carried it away, beyond recovery, before it was certainly identified. The heads of clover that is just beginning to blossom at the time when a brood of moths are flying, are much more commonly infested near the base than are heads that are older, and all of whose florets have expanded, from which we infer a preference on the part of the moth, or at least an accidental convenience to her, to drop her eggs into the fully developed florets, rather than in the immatured part of the head. Accordingly we find the first brood of caterpillars working near the bases of the heads, more commonly than the second and third broods, though in particular cases the practices of husbandry may favor the disposition of the eggs of either of these broods in the same relative situation as those of the first brood.

The different stages of growth reached by caterpillars found in the crowns of the plant can leave no doubt that the eggs are deposited here, when no blossoms are available, as is frequently the case when the moths are ovipositing for the third or winter brood of larvæ. We would not think it very surprising or at all impossible, that the eggs may be sometimes dropped upon the ground, from which the young caterpillar, if favorably located, could easily find its way to the nearest branch of clover and begin feeding. We have never

found the eggs *in situ*, our entire knowledge of them being derived from the above observations and dissections of gravid females.

DESCRIPTION AND HABITS OF LARVÆ.

The larva (Fig. 1 *a*) is a small, greenish-white caterpillar, with a dark brown head, and is about 6mm to 8mm (.25 to .30 inch) long when full grown. Many of them become tinged with red toward the hinder extremity as they approach the time of pupating. Comstock gives the following technical description:

"*Larvæ*—Length 8mm, subcylindrical, tapering slightly at each end; legs and prolegs normal. Color, dirty white, often with a greenish tinge; head dark brown, trophi, black; prothoracic shield, yellowish with a brown hind border interrupted in the middle. Body with many delicate whitish hairs. The dorsal piliferous tubercles of each segment arranged in two pairs, of which those of the anterior pair are closer together than the posterior pair."*

It seems probable that the greenish tinge possessed by the larvæ from which Prof. Comstock drew his description, and the pinkish tinge characterizing many specimens observed by the writer are both derived from the contents of the intestinal canal, consisting of greenish and reddish floret tissue in the respective cases.

The worms damage the clover by eating into the young florets, and later into the seed vessels, causing the heads to dry up and the flowers to shell from the receptacles like chaff, or, when the clover is not in blossom, by feeding in the crown, severing the leaf stems and devouring the unopened leaflets.

On the 24th and 25th of June, 1891, an examination of 177 heads of clover taken from the field where the moths were first observed showed ninety-one heads infested with the caterpillar as against eighty-six not infested. Many of the larvæ were full grown and some were spinning their cocoons. The hay was cut at this date. An examination the next day (June 25th) of forty-eight clover heads taken from the college campus showed eight, or sixteen and two-thirds per cent. of

*Report U. S. Dept. Agr., 1880, p. 255.

the whole, infested. Examining forty-two heads from a different field, cut on the 23d and 24th of June, only three were found infested. Of some larvæ of this brood put into a breeding cage, the first pupa was found July 14th, but a visit the same day to the field proved the second brood of adults to have already appeared. An examination at the time of some dried bunches of hay left on the field, disclosing some larvae in the heads which had spun their cocoons to pupate, led to the conclusion that the caterpillars could live in the cut hay for considerable time if not hampered in their movements. In the light of our subsequent discovery that the larvae commence work on the lower part of the plant after the hay is cut, we regard the correctness of this conclusion to be very doubtful. It seems more probable that the worms had fed on the green plants and had crawled into this convenient shelter to pupate. An examination of the hay from the same field stored in the barn showed all the larvae to be dead. A dead pupa was also found, but nothing living. No empty pupa cases were found to indicate that any moths had escaped from the hay thus stored. From these facts we drew the conclusion that every caterpillar and pupa subject to the pressure and heat incident to storage had been killed. We then recommended as a remedy for this pest which had caused the destruction of probably fifty per cent of the clover seed in the field observed; that the hay be cut soon after the first brood of larvae appears, or in early June; also that the hay should be carefully cleaned from the field so that the larvae may not find shelter in scattered bunches which have not been gathered up; that scattering clover growing by the roadsides and in the fence corners be carefully mown at this time, and the heads, at least, disposed of in some manner to insure the destruction of the larvae they may contain. We expressed the belief that this method could not but prove effective in reducing the second brood of moths and would at the same time operate against the clover seed midge (*C. leguminicola*) which has become a very numerous and destructive insect in Iowa within the last two or three years. While the recommendation that the loose bunches of hay should be carefully cleaned from the field was very probably based upon a misinterpretation of the facts observed as previously men-

tioned, we are still of the opinion that it should be considered a practical and important suggestion for reasons that will appear in another connection.

Prof. Comstock was the first to suggest cutting and stacking the hay containing the larvae,* though he published no observations proving the efficiency of the remedy. Prof. Cook said, in 1887: "By cutting the crop early we might destroy the larvae, but fear we should not."†

Observations during the season of 1892, upon this brood, are as follows: June 28th, eighty-seven heads of clover were selected at random, from the same field upon which observations were made last year, the clover having been cut for hay the day before, June 27th. Seventy-four heads were, and apparently had been, free from the caterpillar, two heads had been doubtfully infested, and eleven heads were infested at the time of examination. This would show that about fifteen per cent. of the heads were infested this season at the time of cutting. We believe that this was a lower percentage than the field actually averaged, and it certainly does not represent the percentage of damage that the insect inflicted upon this cutting as will be readily seen in the subsequent discussion of the habits of the third or hibernating brood of caterpillars. An examination of stored hay, made this year, confirmed last year's observation as to the fate of the caterpillars. Clover near the outside of the mass may develop worms that are nearly mature at the time of storing, and we found an empty cocoon in such a situation, suggesting, but not proving, that the moth had emerged, since the caterpillar sometimes spins a cocoon for some time before pupating, and if disturbed during the interval, will take up its abode elsewhere, leaving its cocoon empty, as was this one. Heads of clover taken from the interior of the pile, showed the dead and shrivelled caterpillars as in former observations. Spider's webs were very common in the barn, and finely woven nets were spread over the top of the hay for the purpose of entrapping emerging insects. These webs covered many square feet, and contained the remains of flies, leaf hoppers, and other insects, but not a fragment of a *Grapholitha* moth was to be found. If

*Report U. S. Dept. Agr., 1880, p. 255.
†Beal's Grasses of N. A., Vol. I., p. 393.

Grapholitha larvae had lived and matured in the stored clover like *Asopia costalis*, it seems certain that some of the myriads of moths that must have issued would have been caught in these webs. Fragments of the wings at least must have remained undevoured as witnesses of such a habit. The tendency of the moth to fly to the window when loosened in a darkened room, led us to examine with particular care, the webs that would have intercepted flight toward the door of the barn, which was nearly always open in the day time. Not a vestige of a moth was found. It is perhaps proper to mention in this place that light traps placed in the clover field to attract the moths have been found to be of no avail.

Within a day or two after the hay was removed from the field, an examination was made, resulting in the discovery that many larvae were working in the crowns of the plants very near to the ground. As the heads had wilted after cutting, it seems that many of the worms had become restless, and had either quitted their old abode for cooler quarters and fresher food, or else had crawled out of their usual retreat within a floret, and had been thrown from the hay to the ground by the Tedder, a machine that possibly may waste as much by flinging noxious insects from the hay back on to the field as it saves in other respects. Observation is needed upon this point.

Examination, July 1st, of some heads of clover left uncut along the borders of the field, revealed that the few moths living at the date of cutting, and perhaps adjacent to the edge of the field, had congregated on them for the purpose of ovipositing, as many as seven larvae being found in a single head, and ranging in size from the newly hatched caterpillar to the well matured specimen. Hardly a head could be found in this situation that was not infested with from three to five worms. We think that possibly this habit may be turned to economic account, by leaving narrow swaths of bloom uncut at regular intervals, through the field, where part of the eggs for the first brood of caterpillars, and most of the eggs for the second brood will probably be deposited and the larvae can be destroyed with comparative ease, as soon as the second brood of moths disappears.

We believe that if this is done the attack upon the mown portion of the field will be in some measure lessened.

To secure the greatest immunity for the second crop, the cutting should be done early enough to coax a considerable part of the first brood of moths to oviposit in the heads of the uncut strips.

COCOON AND PUPA.

The delicate, white silken cocoons of the insect are spun in the head among the dried florets, grass, and bits of eroded, but undevoured flowers, and are thus so covered with brown as to make them difficult of detection.

The cocoons of the larvae that feed on the green tissue near the ground, are spun in the aftermath, rotten manure, or any trash available. The pupa state lasts from about twenty to thirty days. The chrysalids work their way entirely out of their cocoons and drop to the ground before bursting their pupa cases, which may be found scattered in abundance on the ground, from which a brood has just issued.

The following is Comstock's description of the pupa:

"*Pupa:* Length, 5mm, moderately slender. Wing sheaths extend to sixth abdominal segment, antennae and posterior tarsal sheaths ending at tip of wing sheaths, the tarsal sheaths being a trifle the longer. Dorsum of each visible abdominal segment except the last with two transverse rows of backward directed teeth, those of the anterior row being strongest. Anal segment blunt at tip, with six stout blackish excurved hooks at its posterior border, two dorsal and four lateral, none ventral; also a number of very delicate hooked filaments. General color rather light-brown, darker on wing covers and dorsum of thorax."*

SECOND BROOD OF ADULTS AND LARVAE.

In 1891, the second brood of adults had disappeared by the 20th of August, and the second brood of larvae were found vigorously feeding in the heads about August 5th. This brood of larvae behaved exactly like the first brood, feeding upon the florets and seed vessels, and perhaps doing a greater amount of damage than the first brood.

The work of the first brood of larvae upon the crowns of the plants just after cutting, and the damage inflicted upon

*Rept. U. S. Dept. Agr., 1880, p. 255.

the seed crop by the second brood of larvae, and the clover seed midge (*C leguminicola*), combined with the damage inflicted upon the clover hay crop by grasshoppers, the Flavescent Clover Weevil (*Sitones flavescens*), the Clover Leaf Hopper (*Agallia sanguinolenta*), and other insects rendered the second crop of clover too worthless to pay for harvesting in some places, and some fields upon the college farm remained uncut.

In 1892 the adults of the second brood were found in the field July 21, and began appearing in our breeding jars July 22. They had probably appeared some days before they were observed, and we have no record of when they disappeared.

THIRD BROOD OF ADULTS.

In 1891 the third brood of adults appeared some little time before September 8th. September 19th, the third brood of caterpillars were found working among the bases of the leaves, near the roots.

In 1892, a few fresh moths were seen August 24th, which proved to be the pioneers of the third brood.

In 1891, we thought we found some indications of a tendency of the moth to become four brooded. We had a record of some adults, observed October 9th, which led to this inference. The observations made upon the third brood of 1891, however, were somewhat disconnected, and we now believe that if it had been continuously watched we would have found the last adults observed to be stragglers of the third brood. We are in some doubt about the accuracy of the date recorded, though we know it cannot have been in error by more than a very few days. The present season, 1892, has furnished continuous observation upon the brood, which had not wholly disappeared by September 25th. Sweepings were made October 6th, 7th and 8th, on one or two unrecorded dates, between these and on October 18th, 20th and 21st, without securing a moth. With our present knowledge we may affirm that there are three broods of the insect, and very probably not more.

HIBERNATING LARVAE—REMEDIES.

The larvae of the third brood remain feeding about the bases of the leaf stems, until frozen up in winter, their only

apparent inclination to seek shelter being shown in an effort to descend closer to the ground, or to burrow deeper into the crowns of the plants and tighter leaf-sheaths.

Observations made during the warmer days of February, 1892, showed great numbers of the worms to be apparently dead. No signs of their remains could be discovered in the spring, but the number of caterpillars to be found at this time were certainly reduced seventy-five per cent from the numbers observed in the fall.

It is possible, however, that they had left the clover plants and spun their cocoons where they were not found, as a cocoon in the after-math, or decaying manure or rubbish, is an object that is detected with much difficulty.

April 22d the larvae were found secreted beneath rubbish, particularly in barnyard manure, which had been heavily spread over some parts of the field. Most of the worms were full fed at this date and pupated in their sheltered retreats without returning to the clover plants to feed. Some were still immature and feeding in the crowns of the plants, which it seems, they had never left. The most careful and diligent searching at this date failed to find the caterpillars in any position of the field except where it was heavily manured, and this was too remote from the parts that seemed uninfested to admit of supposing that the caterpillars had migrated to it for protection. Repeated examinations of plants, made throughout the spring, failed to discover immature larvae feeding in any but the manured part of the field, where they were not uncommon. We are strongly of the opinion that the worms in the more exposed quarters of the field died during the winter. As clover, in itself, fertilizes the field richly for the crop that is to follow it, we think it wiser not to give a manure dressing to clover from which a crop of seed is expected the following year. Finely rotted manure may be applied in the spring of the year if thought to be a necessity, but it is not advisable to apply it in the fall.

It also appears probable that if the clover can be used as later pasture for cattle or sheep, so that the aftermath will be cleaned up, and the clover eaten close to the ground, and tramped a good deal, that it will enter the next year comparatively free from several species of enemies that are kept

strong in numbers by a husbandry that is misdirected when their presence is considered, however commendable it may be when they are known to be absent.

NATURAL ENEMIES.

A small, light brown, ichneumonid parasite, *Phanerotoma tibialis*, Hald., and originally described by Haldeman in the Proc. Acad. Nat. Sci. Phila., Vol. IV, p. 203, as *Sigalphus tibialis*, was reared from one of the cocoons by Prof. Comstock. It is 3.5mm long, light brown in color, with a large yellowish spot on the back of the abdomen. This insect occurs at Ames, but has not been bred from *Grapholitha interstinctana*.

Another ichneumonid parasite was reared from it at Kirkwood, Mo., by Miss Mary E. Murtfield, July 12, 1887, and was described by Ashmead in the Poc. U. S. Nat. Mus., Vol. 11, 1889, p. 449, as *Glypta leucozonata*. It is described as follows:

"*Male:* Length, 8mm, yellowish white; vertex of head and occiput, mesonotum, band on middle of collar, spot on mesonotum, two longitudinal bands on mesothorax, band across first abdominal segment, and bands at the base of the following segments, black. The first nine joints of the flagellum are ferruginous, joints 10 to 14, black, joints 15 to 25 white, the following joints black. Head smooth, thorax moderately closely punctured, the parapsidal grooves indicated anteriorly, mesothorax delicately rugulose and faintly areolated, legs yellow ferruginous, the anterior and middle coxae white; all the tarsi white, the first joint of posterior tarsi at base and the tibial spurs dusky. The abdomen is punctured, the oblique lines on the segments so characteristic of the genus become obsolete after the fifth segment. Wings hyaline, iridescent, stigma pale, veins dark brown."

This insect is not known to occur at Ames.

The most abundant parasite at Ames is *Microdus laticinctus*, Cress. From about forty *Grapholitha* caterpillars put in a breeding cage, eleven specimens of this insect emerged from the subsequent cocoons. It corresponds exactly with the moth in number of broods, a few specimens nearly always being observed before the first specimens of the moth

are seen, and they linger until after the last straggling moths of the brood has disappeared. It is described in the Can. Ent. Vol. V, p. 53, as follows:

"*Microdus laticinctus*, male.—Small, black, shining; mandibles and palpi pale, metathorax scabrous; tegulae pale honey yellow, broadly black at tips, their tarsi fuscous, abdomen shining black, first segment longitudinally striated, second yellowish, remainder polished.. Length 20 inch." Habitat Can., Mo., Ia. It has also been reared from *Tmetocera ocellana*, Schiff. on apple, at Washington (See Insect Life, Vol. 3, p. 17).

Another ichneumonid that is associated with *Grapholitha* in marked numbers, and corresponds with it very closely in time of appearing is *Bracon vernoniae*, Ashm., which has been reared from *Platynota sentana* and *Eudemis botrana* in the seed capsules of *Vernonia noveboracensis* (Insect Life, Vol. II, p. 349). It is described by Ashmead in the Proc. U. S. Nat. Mus., Vol. 11, p. 619. We are sure that the specimens at Ames do not come from the *Vernonia noveboracensis*, since this plant has never been collected in this locality, though known to occur in some other sections of the state. The *Vernonia fasciculata* found here does not occur anywhere near the clover field in which the insect has been so conspicuous, nor is it a plant sufficiently common to furnish breeding room for the great numbers of the insect that are seen. *Platynota sentana* and *Eudemis botrana* are not in our collections, and while it is possible that they occur here, the presumption is quite strong in our mind than *Bracon vernoniae* also preys upon *Grapholitha interstinctana*, although it has not yet been reared from this host.

Summarizing artificial remedies we recommend:

First: That a wise rotation of crops be practiced, clover not being allowed to occupy the same ground for more than three consecutive years in any case, and if possible at all, not more than two.

Second: That seed for new crops be sown on land as remote as may be from old and infested fields.

Third: That infested fields, from which a crop of seed is expected the following year, be pastured in the fall, so that no aftermath will remain to shelter the hibernating worms, and

if it is desired to manure the field, that this work be done in the spring and that the fertilizer contain no matter that will not have fully decayed by fall, and that it be applied lightly. Of course, it may be applied as heavily as desired if it is expected to change the crop in the fall or spring following. The larvae have not yet been observed to enter the earth for shelter or to pupate, though search was made for them here in the spring.

Fourth: If the field is badly infested in May and June, that the hay be cut as soon as possible, and carefully handled, so that the worms are not shaken from the hay to the ground. Avoid the use of the tedder on infected hay, if it can be profitably saved in any other way. Stack or shock as quickly as can be done after cutting. Leave narrow strips at intervals of six or eight rods, to the blossoms of which the moths can retreat for ovipositing, and cut these strips as soon as the moths of the second brood have disappeared, caring for the hay with the express object of destroying the caterpillars and without regard to saving the forage. Allow the remainder of the field to fill for seed if so desired.

Fifth: When the ground has been occupied by clover long enough to give the proper rotation of crops, plow under sometime in October, November, or in early spring when the third brood of larvae is found near the ground. Then harrow and roll the field so that everything is covered under. If the plowing is done in the fall it will be safest to simply harrow in the spring and not stir up the earth with a cultivator.

We believe that if the first three recommendations were heeded by clover growers in general, and if the cutting and and storing were done at the best time, as suggested in the fourth recommendation, the other suggestions might be considered as special remedies offered to meet extraordinary conditions, and also to be practiced as they may conveniently fit to the usual course of operations upon the farm.

One of our western agricultural journals suggests that the mammoth clover (*Trifolium medium*) be cultivated instead of the common red clover (*Trifolium pratense*), assigning as one of the reasons therefor, that because of maturing later it will fill with seed in the interval, between the first and second broods of the moth. We know of no observations bearing

upon the freedom of this clover from insect attack, but judge that *Grapholitha interstinctana* will do as great, if not greater, damage to it than to the common sort. It seems highly probable that the insect will attack *Trifolium medium*, since it attacks both *pratense* and *repens*. We should expect to find that the spring brood of moths would deposit their eggs about the crowns of the plants, since no heads would have developed at the time when the adults should appear, and recalling our observations on the caterpillar's work when thus situated, it may well be doubted if this is not the most vital spot in which the seed crop can be attacked. If the caterpillar is in the head, part of the seed vessels may escape, and a partial crop be secured. If the growing stem that bears the head is severed, or eaten so that it wilts, the whole head is ruined, and we suspect that this is just the sort of damage that this insect will be found to inflict upon the mammoth clover. The second brood of larvae could probably begin working in heads that had escaped the first brood, before the seed could mature, and we would thus have the two strongest broods of the insect attacking the only seed crop, a misfortune that does not befall the first crop of common clover. It must be remembered that the hibernating brood of caterpillars, doing only a comparatively small amount of feeding in the spring, the broods of adults are sharply distinguished, the larval broods being separated by very brief intervals of time, if indeed, they do not always overlap, and that their period of existence is much longer than that of the adults.

We doubt if there is any time in the year, when larvae, in some stage of growth, cannot be found working in some place about the plant. We are not prepared to express an opinion as to whether the more vigorous habit of growth, possessed by the mammoth clover over the common red species, may not prove a great advantage in enabling it to withstand insect attack, especially upon the hay crop, but a hope of immunity based upon any other quality of the plant, or upon any known fact in the economy of this insect, we should regard as ill-grounded in the extreme.

We believe that the most intelligent and effective methods of treatment will be found in the recommendations that we

have given, and that their relative importance will be found to closely follow the order in which they are arranged. We think that the great multiplication of parasites, observed in the fall of 1891, contributed in a large measure to reduce the extent of loss this season, and that perhaps we may ascribe as much to this agency as to winter exposure in reducing the number of worms living in the fall by so large a per cent in the following spring.

Our acknowledgments are due to Prof. Herbert Osborn, under whose supervision the above paper was prepared, and whose counsel and criticisms have been freely sought and freely given throughout the entire progress of the investigation, to Dr. C. V. Riley, for the determination of *Microdus laticinctus* and *Bracon vernoniae*, and to Prof. F. M. Webster for the use of some of his unpublished notes.

SYNONOMY.

Stigmonota interstinctana, Clemens, Proc. Acad. Nat. Sci., Philadelphia, 1860, p. 351.

Dicrorampha scitana, Walker, Cat. Lep., Het., p. 413.

Grapholitha distema, Grote, Bull, Buffalo Soc. Nat. Sci., Vol. 1, p. 92.

Grapholitha interstinctana, (Zeller)

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NOTES ON THE POTATO STALK-WEEVIL.

(*Trichobaris trinotata*, Say.)

F. A. SIRRINE.

Injury to potatoes by this insect was first observed in the vicinity of Ames during the fall of 1890. Undoubtedly pota-

toes were injured by them previous to this time, but the dry season of 1890, made their work conspicuous. A small amount of injury was noticeable in 1891, and the beetles were quite plenty in the stems of "Wild Ground Cherry" (*Physalis*), some larvae were also noticed in the stems of the "Horse Nettle" (*Solanum Carolinense*).

The damage done the past season was fully as great as that in the fall of '90. Estimates of the per cent of vines infested were made by examining all the vines on a square rod in the different potato fields on the College Farm. In patches of early potatoes the infested vines ran as high as 99 per cent; in later varieties as low as 60 per cent; while in late potatoes no vines were found infested. 90 per cent of the early potatoes was reported injured by the weevil in north Tama county. Early potatoes were reported as injured by what was supposed to be dry weather in Calhoun county and in north central Illinois.

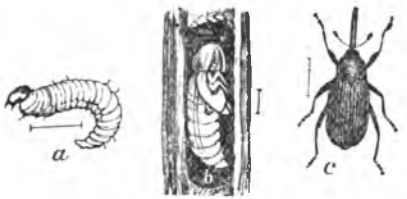

Fig. 2. *Trichobaris trinotata*, Say. *a*. Larva. *b*. Pupa. *c*. Adult. (After Riley.)

Three trips were made over different portions of Boone county. One each side of the Des Moines river and one down Beaver creek. No early potatoes were found in any of these localities that were free from the work of the weevil, and only the latest varieties apparently had escaped.

A disease (probably bacterial) injured about 50 per cent of the late potato vines on the experimental grounds, but none was observed in other localities. The disease is easily mistaken for the work of the weevil, as in both cases the leaves look as if sunburned, at least after the vines have been affected for some time. Careful examination will show that there is a difference. The work of the weevil shows first, generally, in the lower branches, though if dry, hot winds happen to prevail, the whole plant will show the effect. The leaves look as if sun-burnt, while the stems retain a little green color for a few days and never shrivel or become withy. The disease usually shows first at the ends of the top branches.

The leaves appear the same as in the work of the weevil, but the stems shrivel and collapse as the disease extends down the branches, so the vines droop and fall, while in the weevil work they always remain standing as if ripened naturally.

The Potato Stalk-Weevil was first described by Dr. Say,[1] Its life history was worked out in 1849, by Miss Margaretta H. Morris, of Germanton, Penn.[2] The habits and life history, with the addition of a figure of the adult beetle, was published by Dr. Harris.[3] Dr. C. V. Riley[4] has since published accounts of it several times, with remedies, figures of the adult, pupa and larvae, and additional observations.

In 1890 Prof. C. P. Gillette[5] published the first notice of the beetle, in this State, together with figures and remedies, adding some additional observations. As the observations made the past season differ in some respects from those made by Professor Gillette, it may be well to repeat his. He says: "The female beetle deposits one egg in a place in a slit made in the stalk of the potato, a little above the surface of the ground. The grub soon hatches, and tunnels its way down deep into the root. It works its way back again, and when fully grown changes to the pupa state, and then to the adult beetle, in the stalk just below the surface of the ground."

The eggs are deposited in the young, tender portions of the stems, or a leaf petiole, (according to Miss Morris[6] at the base of the leaf) usually on the lower branches first. In some cases more than one egg is deposited in a single branch, but not in the same slit. As soon as the egg hatches the grub commences to feed on the tender pith of the stem, always mining downward. By the time the larva is full grown it reaches the main stem where the pith is not so nutritious. Not satisfied with simply eating a channel large enough for its body, it mines out the whole pith of the main stem from where it entered, or from the point where it reaches maturity down to the root where the pith ends. It then turns and mines back up the stem nearly to the surface of the ground, or a little above, and gnaws a hole through the woody por-

[1]Entomology of North America, Thomas Say, Vol. I. p. 220.
[2]Harris's Insects Injurious to Vegetation, Flint, p. 81.
[3]Harris's Insects Injurious to Vegetation, Flint, p. 81-82.
[4]Amer. Entomologist, 1868. Vol I, Oct., p. 22-23; Insects of Mo., First Report, p. 93; Potato Pests, by C. V. Riley, p. 92.
[5]Bulletin No. 11, Iowa Exp. Station, p. 490.
[6]Harris's Insects Injurious to Vegetation, Flint, p. 82.

tion to the bark, not through it. Here the grub changes to the pupa, and finally to the adult beetle. As the outer bark rots away it makes the escape of the beetle from the vine easy. It seems probable that Prof. Gillette mistook this point of issue for the slit in which the egg is deposited, as his observations were made late in the season. The head of the beetle is always turned upward, and is close to the outer opening. The mining of all the pith in the lower portion of the stem kills the vine, so the injury is not easily noticed till after the grub has obtained its growth, at the expense of the potato plant. At the same time the mining of the first larva, to reach the main stem, deprives many of the immature grubs of their food supply and they perish. The latter is only true for potato vines.

The mining out of the whole pith in the lower portion of a stem, which kills the vine and the younger larvae, may be a means of self-protection, for in examining the stalks, specimens are often found where two or more larvae have obtained their growth, and entered the main stem before the vine was killed by the first grub. The one following the first mines through the borings of the first cutting up the first one, as if it were pith. The pieces are often to be seen mixed with the borings. Again specimens have been found with two or three pupae arranged one above the other, this is especially true of those found in the stems of the Ground Cherry, where as many as a half dozen pupae will be found, arranged one above the other, with a plug of pith one-quarter to one-half an inch long between each.

Where the vines are large and the eggs are deposited in the secondary branches, the larvae attain maturity before reaching the main stem. In such cases the pith of the branch is mined out down to where it joins the main stem. Of course in such cases only the branch shows the effect.

In Bulletin No. 12, page 547, Prof. Gillette says: "I have, during the past winter, found the weevils abundant in the stems of two species of Physalis (Ground Cherry) in this vicinity. These, and perhaps others of the same genus, are undoubtedly the native food plants of this beetle."

The past season larvae have been taken from the stems of the "Horse Nettle" (*Solanum Carolinense*) and three species

of "Ground Cherry" (*Physalis Philadelphica, Physalis Virginiana var ambigua* and *Physalis lanceolata.*) Adults were obtained from all except the "Horse Nettle," which is such a detestable weed that it was cut too often by the Farm Department to let any of the larvae mature.

As Prof. Gillette says, the "Ground Cherry" is probably the native food plant of the weevil. The stem of the "Ground Cherry" has a thicker ring of woody tissue around the pith than the potato, so it does not show any injury when the pith is all mined out, at least the perennial species (*Physalis Virginiana* and *lanceolata*) do not.

The injury of the Weevil to potato vines this year was first noticed the latter part of July. The first adult was found in the stems August 7th. Larvae were found in the annual species of "Ground Cherry" (*Physalis Philadelphica*) at the same time. No injury was observed or larvae found in the stems of late potatoes. Old potato vines, examined as late as November 3d, contained a few adult beetles. Perennial species of the "Ground Cherry," examined as late as November 3d, still contained larvae, pupae and adults. Why they should continue to work so late on the "Ground Cherry" and not on late potatoes, is a question. It seems as if there must be one of two reasons. Either the "Ground Cherry" is the native, and at one time the only food plant of the weevil, and, that at present cultivation, retards its growth so that the beetles are driven to deposit their first eggs on the potato vine; or the weevil is double brooded (which seems hardly possible), the first brood feeding and maturing on early potato vines and annual "Ground Cherries," from which they issue from the middle of August to the middle of September and deposit a second brood on perennial "Ground Cherries," in the stems of which they mature and hibernate. Dr. Riley says it issues from the potato as an adult beetle, about the last of August or the first of September.

REMEDIES.

The remedies given by Dr. Riley[7] and Prof. Gillette[8] are in brief, as follows: "Pull the vines as soon as they show signs of wilting, and burn them, roots and all. If the tops

[7]Potato Pests, by C. V. Riley, p. 92.
[8]Bulletin No. 11, Iowa Exp. Station, p. 491.

are left till time to dig the potatoes, many of the beetles will have matured and escaped." Care should be taken not to pile the vines up to dry. Instead, they should be spread as much as possible, so they will dry without rotting the outer bark away and thus prevent, to a certain extent, the escape of the adult beetles before the vines have cured enough to burn. By pulling the vines and stacking them on a pile of straw or other dry rubbish, they could be burned enough to destroy the beetles. Simply pulling the vines of the early potatoes as soon as they show signs of the weevil's work, will destroy many of the immature grubs.