U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 23.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 3, 1891.

SIR: I have the honor to submit for publication Bulletin No. 23 of this Division. It comprises the reports of the field agents of the Division for the past year (1890), a summary of which has been included in your annual report.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The reports of the six permanent field agents of the Division are included in this bulletin. They are printed this year in full, but it should be understood that they are little more than summaries of the work in general performed by each one. Special reports upon specific subjects have from time to time been sent in by special direction, and these have been published in INSECT LIFE.

Mr. Lawrence Bruner, who last year reported upon the insects injurious to young trees on tree claims, has the present season devoted much of his attention to insects affecting, or liable to affect, the Sugar beet, a crop of growing importance in the State in which he is located. Although but one season's collecting has been done, some 64 species have been observed to prey upon this crop. As has been shown, nearly all of these can be readily kept in subjection by the use of the kerosene emulsion or the arsenites.

Mr. D. W. Coquillett's report is mainly devoted to methods and apparatus for the destruction of scale-insects by means of fumigation. The experiments were aimed at the Red Scale, which is one of the most difficult to treat with washes. He describes the simplified tents, the rigging which enables them to be used rapidly, and shows the advantage of excluding the actinic rays of the light. Judging from recent California newspapers the use of this method of fighting scale-insects is rapidly increasing and the comparatively expensive apparatus is already owned by a large number of fruit-growers. This improved method is the legitimate outgrowth of experiments which we instituted at Los Angeles in 1887, and possesses the advantage over spraying that it can hardly be done in a slovenly manner. If used at all its effects are nearly complete.

Mr. Albert Koebele, while reporting upon a number of interesting fruit pests, notably the Tent Caterpillars of the Pacific slope, and a Noctuid larva which destroys the buds of certain fruit trees, devotes most of his report to the description of certain tests, which I directed him to make with different resin compounds against the Grape Phylloxera in the Sonoma Valley during September and October of the past year. The results have been fully as satisfactory as we anticipated, and the economy of the process is very striking, labor being practically the only expense.

Miss Mary E. Murtfeldt reports upon the insects of the season in eastern Missouri, and also gives the results of experiments which she has made with certain insecticides submitted to her from this office for trial. She also presents descriptions of four Microlepidoptera, which are new in the rôle of feeders upon Apple.

Prof. Herbert Osborn reports upon the insects injurious to forage-crops, meadows, and pastures in his State. His report last year was mainly taken up with the consideration of the Leaf-Hoppers, to which he gives some further consideration this year, adding some notes on locusts and crickets. He presents also a series of miscellaneous observations.

Mr. F. M. Webster devotes his report mainly to the Hessian Fly, discussing the number and development of broods, the effect of the larvæ upon plants, the effect of the weather on the development of the fall brood, and preventive measures. He also gives some notes upon three of the species of Plant-lice, found commonly upon wheat.

In presenting this bulletin for publication, I desire to thank these agents for the care with which they have followed out instructions and for the intelligent manner in which they have conducted these investigations.

C. V. R.

REPORT ON NEBRASKA INSECTS.

By Lawrence Bruner.

LETTER OF SUBMITTAL.

Lincoln, Nebr., *October* 16, 1890.

Sir: Herewith is submitted a report of my work in Nebraska for the year as special field agent of the Division of Entomology of the United States Department of Agriculture.

In addition to my observations on the general insect depredations within the State, I have incidentally given some time to the study of such insects as were taken upon the sugar and other beets during the summer.

This special study was undertaken at the suggestion of our experiment station director, who was quite anxious that "beet insects" should be made the subject of a special bulletin to be issued from the station some time during the coming winter. I accordingly include herewith a brief summary of the results of this special study.

Yours truly,

Lawrence Bruner,
Field Agent.

Prof. C. V. Riley,
U. S. Entomologist.

The past summer has not been particularly noted as one in which insect depredators were especially abundant or destructive to the various crops that are raised in the State. In fact, taking the State as a whole, the injuries from this source have been rather less than is usually the case. No one species, so far as I have been informed, has been a pest during the year. The Corn Root-worm (*Diabrotica longicornis*), while it has spread some since my last report, was much less abundant than last year. Cut-worms did not appear in early summer so universally over the State, nor did they do anything near the damage they did the year past. No Army-worm depredations have been reported at the station, nor have any come to my own observation; while the Corn Ear-worm (*Heliothis armigera*) has been less destructive in most portions of the region along the Missouri River.

If any one insect has been on the increase and has caused more injury than usual, it was the almost universal Codling Moth (at least universal wherever apples are grown or eaten). But if this insect has become apparently more widespread within this region than it was formerly, it is quite consoling to know that the warfare against it has also become more general. Almost every fruit-grower has at last come to the forced conclusion that warfare against this insect, at least, has become an absolute necessity, and has accordingly instituted a rigorous fight against it. The arsenious spray is the almost universal remedy resorted to with our fruit-growers here in Nebraska, as it is in other localities. Either London purple or Paris green are the poisons used, and where applied properly always result favorably to the orchardist.

THE GREEN-STRIPED MAPLE WORM.

The Green-striped Maple-worm (*Anisota rubicunda*) appeared quite numerously again in the towns and cities of Nebraska, and has done much injury to the Soft Maples (*Acer saccharinum*) growing along their streets. Here in Lincoln, the first or spring brood of larvæ was sufficiently numerous to defoliate many of the largest trees before they had become fully matured, and in that manner proved to be quite effectual towards self-extermination. Many of the larvæ actually starved to death; while others were so weakened from starvation that they either died in the chrysalis state, or else were so exhausted when they emerged as moths that there was but little egg-laying for a second brood. Some of the neighboring cities and towns were less fortunate, and had a much more plentiful fall brood of the larvæ, and hence will be well supplied with the insect next spring unless something unforeseen prevents it.

Considerable has been done in the way of remedies by the citizens of Lincoln against the second brood. Many of the moths were gathered and destroyed before they had time to deposit their eggs and later on in the season spraying the trees with London purple and Paris green was resorted to with good results.

While a moderately dry summer usually has the tendency to increase the number of most of our injurious insects, several such years immediately following one another have the opposite effect. So it has been with the summer which has just closed. The drought was so very marked that even the more hardy insect life was sensibly affected by its severity. Such species as had been favored by the scarcity of their more frail parasites during several years of moderate drought, this year were themselves, to a certain degree, sensibly affected by its continuance and severity.

LOCUSTS OR GRASSHOPPERS.

Locusts or grasshoppers of several species were quite numerous in certain localities, especially in cities away from the destructive influence of fowls and such other predaceous animals as are always at hand in the country ready to "gobble up" various insects. These locusts did some damage, of course, but not nearly so much as was done by them last year. Whether this decrease in their numbers has been due to parasites or to disease, I can not say.

One noticeable fact in connection with the subject of insect depredations, in this particular region at least, is the growing interest which the general public is taking, and the tendency on the part of the people to help themselves against this host of insect enemies which is assailing them on all sides. Whether this interest is traceable to any particular source, or whether necessity is the awakening factor, I can not say. I trust, though, that my work in this direction has not been entirely in vain.

BEET INSECTS.

Ever since the Sugar Beet industry was first agitated here in the West, and now especially since the project has assumed such a practical form, it has become of general interest. For several years now the cultivation of the sugar beet has been a theme for much speculation, and to some extent also of experimentation. Now that a large factory has been built at Grand Island in this State, the sugar beet is to be one of our regular crops year after year. It will no longer be a plant that is grown out of mere curiosity or simply for experimentation.

It has been ascertained in connection with the culture of the sugar beet that certain insects show a tendency to attack and injure it. In this respect the beet is not any different from other cultivated plants; or, for that matter, wild or native ones also. In fact, it is too evident that certain ones of these insect enemies seem to prefer this "new" crop to any of these which have been cultivated in the same region for a considerable time.

It was therefore thought here at the experiment station, early last summer, that it might be well, as far as practicable in connection with other lines of work, to give some attention to these insect enemies of the sugar beet. Accordingly the following "press bulletin" was sent out over the State:

SUGGESTIONS IN REGARD TO THE SUGAR-BEET CULTURE.

Reports from the sub-stations established in the spring by the State Experiment Station for the purpose of determining the effect of the varying conditions of the soil and climate on the growth of and the production of sugar in the Sugar beet are in the main good.

In many places, especially in the extreme western part of the State, beets have suffered from hot weather and a lack of rain; as a rule, though, they seem to withstand these unfavorable conditions as well as corn and better than small grain.

From some points reports tell us that insect enemies have begun their ravages. * * *

As there are several kinds of insects that attack the beet, and as they have already been reported as having begun operations, it seems the proper time to begin to learn something of their appearance, habits, and the best means of meeting their advances. To this end the beets should be watched very carefully, from day to day and at different times of the day, and even in the evening, for any insect, bug, or worm that seems to have an interest in them; search the leaves, pull up the beets and search the roots and the top layer of the soil, and when any marauder is found send it to the experiment station for study and identification.

Directions for sending such specimens I copy from Bulletin XIV on "Insects Injurious to Young Trees on Tree Claims," just issued:

"Whenever possible, insects should be packed alive in some tight tin box—the tighter the better, as air-holes are not needed—along with a supply of their appropriate food sufficient to last them on the journey; otherwise they generally die on the road and shrivel up.

"Send as full an account as possible of their habits; what part of the plant they infest, time of day when they are most active, amount of damage done, etc.

"Packages should be marked with the name of the sender and should be addressed to the entomologist of the Agricultural Experiment Station, Lincoln, Nebr."

It will aid very materially in forming conclusions if all people who have planted seed this season will send from time to time reports of the conditions of their beets to the experiment station.

Address:

H. H. NICHOLSON,
Agricultural Experiment Station, Lincoln, Nebr.

The very dry summer may have had considerable to do towards influencing much of the insect injury to the beets grown within the region designated, and some species of insects may have worked upon this plant that ordinarily would not have done so. In many localities various insects were observed to congregate among the leaf stems just above the ground that could not have been there for mischief, since they were such forms as do not feed upon growing plants. Especially was this true in portions of the State where the drought was severest and where other refugees from the burning sun and parched soil were scarce or entirely wanting. In many of these localities a great variety of insect life was always sure to be found hidden away during the day-time in such places. Not only beetles but also representatives of such other orders as the Hymenoptera, Hemiptera, Neuroptera, Orthoptera, Diptera, and Lepidoptera were quite common in such localities. Even many water-inhabiting forms frequently occurred in company with the others.

Of course all of these insects that were found on or about the roots of the beets were sent in to the station both by the field agents and by the various correspondents, who took an interest in the investigations under way. To separate most of these "refugees" from such other forms as might possibly be there for mischief was, of course, quite easily done at the station by those who were accustomed to the habits of most of the insects under consideration. A few of them were, however, more difficult to single out, and required special study to decide positively, which in nearly every case was accomplished.

In the study of this subject it was quickly demonstrated that almost all of the insect enemies of the sugar beet, as well as of the common garden and other varieties, were either weed feeders or else were such as are very general feeders. It was also ascertained that nearly if not quite all of the insects of whatsoever description that attack other

Chenopodiaceous plants, as the various species of "tumble weeds," the "pig-weed," Atriplices, etc., the purslane and other juicy weeds, as also many of those that attack the various Cruciferæ and Solanaceæ, will also feed upon the beet. Not a single species of insect has thus far been reported by any of the agents of the station, or by correspondents, that is exclusively a beet feeder. Every one of them has been ascertained to attack some one or more of the other plants that are also common to the region. Only a very few species have appeared in numbers sufficiently great to be what could be termed "destructive" to the beet within the region covered by these studies or investigations; and these few are of such a nature that they can be readily combated.

In their modes of attack upon the beet these various insects, so far as they have been studied, are either leaf-feeders or root-borers, *i. e.*, they either attack the foliage which they devour or from which they suck the juices by inserting their beaks, or they bore into or gnaw the roots. Later on in our investigations we may find that there are others that will attack the seeds and seed stems. In either of the former cases the result is an injury to the beet, whether it is being cultivated for the table, for feeding to stock, or for the manufacture of sugar. Should future study reveal others that attack the seed of the beet these latter would of course be of direct injury to the seed industry since much seed will necessarily have to be raised to provide for the large crops that are required each year for sugar.

Having now become fully convinced that the cultivation of the Sugar Beet is not without its drawbacks here in the West, and that there are insects which we must contend against and overcome in raising this crop, as well as in the raising of corn, wheat, and potatoes, we see the necessity of beginning our fight at once if we would prevent much future loss. By prompt action in the beginning, when the enemies are few in numbers and less generally distributed, we will have a much easier time of it; besides, our losses from this cause will be infinitely smaller than if we neglect them and permit them to go on increasing and spreading unmolestedly.

The following list embraces all such species of insects as were either found to injure the beet here in Nebraska or else have been recorded by others as attacking this plant within the region referred to:

List of Beet Insects.

Species that attack the Leaves.

Lepidoptera.

1. *Spilosoma virginica*, Fab.—The larva of this very common insect, is one of the first noticed to injure the beet. It also infests a large number of other plants.
2. *Spilosoma isabella*, Abb.—The larva, like that of the preceding, attacks the beet and many of our common weeds.
3. *Mamestra picta*, Harr.—Larva occasionally attacks the leaves of beet and other garden plants.

4. *Eurycreon rantalis*, Guen.—The larva of this small Pyralid moth is one of our most destructive beet insects. It is the one usually known as the Garden Web-worm; and also attacks a number of other plants among which are the "Pig-weed," the tumble weed, purslane, etc.
5. *Mamestra trifolii*, Rott.—Larva quite common on beets; and sometimes doing considerable injury by gnawing away the leaves and the entire tops of small plants. Also a purslane insect.
6. *Plusia brassicæ*, Riley.—The larva occasionally attacks the beet, but more commonly the turnip, cabbage, and other Cruciferæ.
7. *Deilephila lineata*, Fab.—Larva found feeding on beet leaves in Lincoln, Nebr., by Mr. H. Marsland. A very common purslane insect.
8. *Copidryas gloveri*, G. and R.—Taken several times on the leaves of beets which it had eaten more or less. An abundant purslane moth.
9. *Agrotis*, spp.—Several species of these "cut-worms" are occasionally quite destructive to the beet while it is still small. They work more or less all summer, but are most destructive early in the year. They cut off the plant just at or a little below the surface of the ground. Some of them also work upon the leaves above the ground.
10. *Leucania unipuncta*, Haw.—The Army Worm, when it is abundant, does considerable damage to beets and other garden plants by eating their foliage.
11. *Botis pesticata*, Grt.—The larva of this moth is said to be quite destructive to a number of plants here in the West. "In 1873 we found the larvæ feeding upon Helianthus, Ambrosia, potatoes, and beets, skeletonizing and ruining the plants for miles along the Neosho Valley and throughout Kansas," writes Professor Riley in the U. S. Agricultural Report for 1883.

ORTHOPTERA.

12. *Melanoplus femur-rubrum*, DeG.—Occasionally injuring the leaves of beets and other vegetables.
13. *M. atlanis*, Riley.—When common, a general feeder, at least upon the products of the garden and farm—beets of course included.
14. *M. spretus*, Thos.—Attacks the beet during times of invasions. Sometimes entirely eating away the leaves and portions of root that protrude from the ground.
15. *M. differentialis*, Thos.—When plentiful it occasionally does some injury to the foliage of the beet and other garden plants.
16. *M. bivittatus*, Say.—Where beets are planted on low ground or are growing close to some rank vegetation, it attacks their tops, but never does much damage.
17. *Dissosteira carolina*, Lin.—Found feeding upon the tops of sugar beets during the month of July, at McCook, Nebr.
18. *Trimerotropis latifasciata*, Scudd.—Taken in company with the preceding, also feeding on sugar beets.
19. *Spharagemon æquale*, Scudd.—Several specimens were received during the summer from McCook and Ravenna, Nebr., with the accompanying statement to the effect that they fed on the sugar beet.
20. *Pezotettix olivaceus*, Scudd.—I have seen this hopper in beet fields several times under such circumstances as led me to think it feeds upon that plant. It is also quite partial to Helianthus and Chenopodium.

COLEOPTERA.

21. *Diabrotica 12-punctata*, Oliv.—Quite common on the leaves of beets, which it injures by gnawing holes in them.
22. *Disonycha triangularis*, Say.—The beetle feeds upon the leaves of beets and other Chenopodiaceous plants. Sometimes quite common here in the West.

23. *D. cervicalis*, Lec.—Has similar habits to the preceding, but is less abundant.

24. *D. xanthomelæna*, Dalm.—Common on beets and other Chenopodiaceous plants, the leaves of which it riddles with holes.

25. *D. crenicollis*, Say.—One of the 5-lined flea-beetles that occur here in moderate numbers; is also occasionally taken on beet leaves at Lincoln, Nebr.

26. *Systena frontalis*, Fab.—Found feeding upon beet leaves on the College farm, Lincoln, Nebr.; also on the leaves of *Hibiscus militaris* at West Point, Nebr.

27. *S. tæniata, var. blanda*, Melsh.—A very numerous species in all parts of the State from which beet-feeding insects have been received. It literally riddles the leaves of beets with pit-like holes, in some instances entirely destroying the leaves of quite large plants. I have also taken it upon white clover, purslane, and amaranthus. This is liable to be one of our most destructive beet insects here in the West, especially in Nebraska.

28. *Psylliodes convexior*, Lec.—Another of the flea-beetles that is very abundant on the leaves of beets in some portions of Nebraska, and which works in a somewhat similar manner to the preceding.

29. *Chætocnema denticulata*, Illig.—I found still another of our small flea-beetles at work on the beets growing on the State farm here at Lincoln, although in much fewer numbers than either of the two species preceding.

30. *Epitrix cucumeris*, Harr.—This small flea-beetle was found to be quite abundant at Ashland, Nebr., where it was taken by Mr. T. A. Williams, upon the potato, *Solanum nigrum*, and the beet, the leaves of all of which were more or less closely riddled with holes.

31. *Epicauta pennsylvanica*, DeG.—This black blister-beetle injures the leaves of quite a number of plants, prominent among which are the potato, "pigweed," and beet. It has been received at the station from central and western Nebraska as one of the most destructive insects attacking the plant.

32. *Epicauta cinerea*, Forst.—Another of these blister-beetles was found here at Lincoln by Mr. Herbert Marsland, who said it almost ruined a small bed of beets growing in his garden. I have also collected the same species from one of the wild beans and several other native plants.

33. *Epicauta maculata*, Say.—This insect has been received from Medicine Lodge, Kans., and from Grant and Neligh, Nebr., where it was found to injure the sugar beets by feeding on the leaves. It is a very common insect here in the West upon quite a number of the Chenopodiaceous plants, and especially upon the various species belonging to the genera Chenopodium and Atriplex.

34. *Epicauta vittata*, Fab.—This striped blister-beetle is also a beet insect; and has been received from Ogalalla, this State, where it was reported as doing much damage to sugar beets. It also is quite a general feeder. Among its food plants are to be mentioned the Solanaceæ, some of the Leguminosæ, and I have found it to be quite destructive to several of the Sagittariæ.

35. *Epicauta cinerea, var. marginata*.—This large black blister beetle also frequently gathers upon vegetables of different kinds in the semi-arid regions east of the Rocky Mountains, but chiefly upon beans. I have taken it on beets once or twice here in Nebraska.

36. *Cantharis nuttalli*, Say.—During the late summer and early fall of 1888 this insect was very destructive to garden plants, beets included, in the Black Hills of South Dakota. It also abounds in the western and northwestern parts of Nebraska.

37. *Colaspis brunnea*, Fab.—This small leaf beetle, which appears to be quite a general feeder, has been taken on several different occasions upon the beet both by myself and different ones of the field agents, and also by some of the correspondents.

38. *Epicærus imbricatus*, Say.—The Imbricated Snout-beetle has been known to attack the beet among the many other plants upon which it feeds. It is a general feeder.

39. *Centrinus penicillus*, Hbst.—Another of the Snout-bettles that attack the beets here in the West is the one known to the entomologist by the above name. It gnaws small holes in the leaf-stem, and when numerous does considerable harm to the plants attacked. Whether or not the insect breeds here I was unable to ascertain.
40. *C. perscitus*, Hbst.—Still a third species of weevil was found upon the beets growing on the State farm. It is a much commoner insect than *penicillus*, and works in a similar manner upon the leaf-stem.
41. *Apion*, sp.—This little Apion was taken on the leaves of beets here at Lincoln on two separate occasions.
42. *Doryphora* 10-*lineata*, Say.—The Colorado Potato-beetle was brought into my office at different times during the summer by those who reported its having been captured on the leaves of beet which it was " certainly eating."

HETEROPTERA.

43. *Blissus leucopterus*, Say.—The Chinch Bug has quite frequently been taken by me upon beet tops in company with several others of the plant bugs. Whether or not it was there only temporarily, I can not say; but suppose it was, since all of our leading economic entomologists assert that its food-plants are limited to the grasses.
44. *Piesma cinerea*, Say.—A very common bug on the beet and various others of the Chenopodiaceous plants. Sometimes doing much damage to the leaves of the former.
45. *Nysius angustatus*, Uhl.—Another bug that often gathers upon the beet and other garden plants is what is called the False Chinch-bug. When numerous it often does considerable harm to the plants which it attacks. It is also one of the weed insects that enjoys a wide range.
46. *Geocoris bullatus*, Say.—The Large-headed False Chinch-bug, or Purslane Bug, is also much addicted to infesting the beet here in Nebraska. In fact it has been received from all over the State as one of the commonest of insects infesting the beet. It is also a great weed bug.
47. *Trapezonotus nebulosus*, Fall.—This bug also frequents the beet and several other Chenopodiaceous plants. It is especially partial to the Pigweed (Chenopodium album) here in Nebraska.
48. *Emblethis arenarius*, Linn.—Taken several times on the beet in company with the preceding. This insect also is a frequenter of localities where *Chenopodium album* is growing. The species also occurs about the roots of "Stink Grass" (*Eragrostis major*).
49. *Lygus pratensis*, Linn.—Probably one of the most general feeders among the true bugs, and sometimes a very destructive enemy of the beet. It occurs throughout the entire North American continent in the temperate regions.
50. *Euthoctha galeator*, Fab.—This bug has also been taken several times on the beet in the vicinity of Lincoln, Nebr. I have collected it also from the wild cucumber (*Echinocystis lobata*).

HOMOPTERA.

51. *Agallia siccifolia*.—This little leaf-hopper, which seems to be especially partial to the different species of Amarantus and Chenopodium and allied weeds, is also equally fond of the beet, at least such would appear to be the fact, judging from the large numbers of the insect that are invariably to be found upon this plant all through the summer. It occurs in all stages.
52. *Immature forms only*.—Found in moderate numbers on the sugar beet at Grant, Nebr., a rather large leaf-hopper, which also occurs upon the Amarantus and Chenopodium.

53. *Allygus sp.*—This prettily marked leaf-hopper is very partial to *Chenopodium album,* on the under side of the leaves of which it breeds throughout the summer. This insect also attacks other species of the same genus, those of the genera Amarantus and Montilia, etc. Besides these it is very frequently found on the beet. Characteristic marks of its presence are the rather large purplish spots that are seen upon the leaves of plants that have been punctured by its beak.
54. *Erythroneura sp.*—Another small, slender, green leaf-hopper that is occasionally met with upon the beet.
55. *Athysanus (? sp.).*—Still another of these leaf-hoppers that is found upon the beet.
56. *Liburnia intertexta.*—There is still a sixth of these leaf-hoppers that has been taken on the beet here in Nebraska; and which presumably also does some injury to that plant by sucking its juices.
57. *Aphis atriplicis,* Linn.—Mr. T. A. Williams tells me that he has taken this plant-louse on the beet at Ashland, this State, where it was quite common during the year.
58. *Aphis cucumeris,* Forbes.—This past summer Mr. Williams also took what he determined to be the *Aphis cucumeris,* Forbes, breeding quite abundantly upon some beets that grew right by the side of some cucumber vines that had been infested by the same insect.
59. *Siphonophora pisi,* Kalt.—The same gentleman tells me that he has also taken the common garden aphid here at Lincoln, on the beet. He found it in the pupa and winged stages.

Species that attack the Root.

COLEOPTERA.

60. *Ligyrus gibbosus,* De G.—This beetle has been quite destructive to the sugar beet over limited areas towards the western part of the State during the present season. It attacks the root, into which the mature insect gnaws great holes, sometimes entirely imbedding itself. It worked most on old ground and where irrigation was resorted to. It worked on the roots from the surface to a considerable depth but most at about 3 or 4 inches below the surface. In some instances it reached a depth of fully 7 inches below the surface.
61. *Lachnosterna fusca,* Fröh.—Not unfrequently the common white grub attacks the roots of the beet, and does injury to the plant in that way. There are very likely several kinds of the "grub" that are concerned in these attacks, since almost every locality has its particular species of "June bug" that predominates in numbers.
62. *Wire Worms.*—Several of the larvæ of "snapping beetles," or click beetles, are also to be charged with injuring the roots of beets in some localities.
63. *Unknown larva.*—On two different occasions during the past summer I found beets that had been attacked by some unknown larva just below the surface of the ground, and from which the depredator had already escaped. The work resembled that of an insect that works in the roots of different "tumble weeds" and causes them to break off. The larvæ are rather short, thick, whitish grubs with brownish heads, about one-fourth of an inch in length, slightly largest in the middle; possibly the larva of some snout beetle.

UNCERTAIN.

64. *Silpha opaca,* Linn.—This insect has been taken several times by me in beet fields, and in gardens where beets were growing. In Europe the insect is said to be quite injurious to the beet crop, by attacking and devouring the leaves. Whether or not it has the same habit in this country I can not say.

In addition to the above list of insects that are known to actually attack one or the other varieties of beet there are several others that have been taken so frequently upon that plant, and under such peculiar circumstances, that they, too, may prove to be its enemies. Among these latter I would mention several of the Eleodes, one Collops, and several Diptera.

REMEDIES THAT CAN BE USED AGAINST BEET INSECTS.

It will be quickly seen by any one who has taken the pains to go over the foregoing list, that in nearly every case, at least so far as mentioned here, the insect enemies of the beet are identical with those that work upon our common garden weeds, or else they are such as are very general feeders. It will also be observed that most of them are leaf-feeders; *i. e.*, they nearly all attack that portion of the plant above ground. These being the facts in the case, the remedies that at once suggest themselves are simple. A spray of some kind scattered over the plants will be effectual as well as economical. The beet tops are seldom utilized for food, either for man or beast. Hence for protection against insects with gnawing mouth parts that attack them an arsenical spray can be used, whilst for such as receive their nourishment by means of a sucking mouth the kerosene emulsion will answer the purpose. This latter remedy will also be effective against No. 27, as has been demonstrated by actual experiment by at least one of our correspondents, who writes that "The kerosene emulsion which you directed me to try on my beets against the flea-beetles was a perfect success."

A direct as well as useful remedy is the careful destruction of all such weeds as furnish food for the same insects that attack the beet. Clean culture in this case becomes doubly necessary. First, to prevent the appropriation by the weeds of nourishment that should be taken by the beets, and secondly, to give less room for the propagation of injurious insects.

REPORT ON VARIOUS METHODS FOR DESTROYING SCALE INSECTS.

By D. W. Coquillett, *Special Agent.*

LETTER OF SUBMITTAL.

Los Angeles, Cal., *October* 8, 1890.

Sir: I herewith submit my annual report for the season of 1890. The Australian lady-bird (*Vedalia cardinalis* Mulsant) recently introduced by this Division, successfully survived the winter unprotected out of doors, and as early as the month of March I was able to distribute several colonies to those requesting them. Lest this species, after exterminating the Fluted or Cottony-cushion Scale (*Icerya purchasi* Maskell) should become extinct on this coast, our State Board of Horticulture, at the suggestion of its president, Hon. Ellwood Cooper, has erected two propagating houses over two large orange trees belonging to Col. J. R. Dobbins, in the San Gabriel Valley; in these houses the Vedalias are to be propagated and distributed to those requiring them. At the present writing it is no easy matter to find a single living Icerya anywhere in this part of the State, although in the early part of the season they appeared in limited numbers in a great many places; later in the season the Vedalias also appeared in considerable numbers, and by sending colonies of these to the different localities where the Iceryas had appeared, the latter were effectually held in check.

The Red Scale (*Aspidiotus aurantii* Maskell), so destructive to Citrus trees in certain localities, is rapidly reduced in numbers through the agency of the treatment with hydrocyanic acid gas, described in my previous reports. This treatment is now being largely used for the above mentioned purpose, and is giving far better results than have ever been obtained by the use of any kind of a spray; numerous instances have occurred where, upon large Citrus trees treated with this gas, neither myself nor other parties were able to find a single living Red Scale, either upon the bark, leaves, or fruit—a result which so far as I am aware has *never* been obtained by the use of any kind of a spray. The cost of treating trees with the gas is scarcely greater than that of using a spray, while the method has been so greatly simplified that trees can now be treated with the gas very nearly as rapidly as they can be sprayed. I have not as yet learned that any person, or even a single domestic animal, has ever been accidentally injured either by the gas itself or by the materials used in producing it. All of the objections which at first were urged against the use of this gas—the danger of being poisoned by it or by the chemicals used, the great expense attached to its use, and the impracticability of operating the tents—have finally been overcome, and the treatment is now in successful operation.

In my last report I gave an account of the spraying of a number of orange trees at Orange according to instructions. These trees were not again sprayed until the lapse of a little over one year. At this latter date the trees were again badly infested with the Red Scale (*Aspidiotus aurantii* Maskell), although these were not so numerous as they were at the time that I had them sprayed a little over one year previously. The oranges when gathered in the following spring were quite free from the scales, none of them having been rejected by the purchaser on account of being too badly infested with these pests. Those who depend upon spraying for ridding their trees of these scales usually spray their trees twice a year, in March or April, and again in August or September, although some growers perform these operations only in the autumn, the second spraying being given to the trees about two months after the first.

During the past season I have received numerous favors from you, especially in the matter of identifying insects, for all of which please accept thanks.

Respectfully yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
United States Entomologist.

THE GAS TREATMENT FOR THE RED SCALE.

The process of treating trees with hydrocyanic acid gas for the destruction of scale insects (Family Coccidæ) is now being extensively used in southern California, not only in the orange groves, but also in the nursery where the imported trees are subjected to this treatment for the purpose of ridding them of insect pests. In Orange County alone fully 20,000 orange and lemon trees have been subjected to this treatment the present year in order to free them from the red scale (*Aonidia aurantii* Maskell).

Since the year 1887 various accounts of this process have been published in some of the Annual Reports and Periodical Bulletins of this Department.*

But as these are somewhat scattered, and include an account of the various improvements that have been made from time to time, I have thought it desirable to give in this place a brief account of this process as at present used in actual field work, including in the account such improvements as have been made since writing up my last report upon this subject. Briefly speaking, this process consists in covering the infested tree with an air-tight tent and afterward charging the tent with hydrocyanic acid gas. The material commonly used in the construction of the tent is what is known as blue or brown drilling. A few persons have used common ducking in place of the drilling, but this is much inferior to the latter; in the ducking the threads of which it is composed extend only lengthwise and crosswise, whereas in the drilling they also extend diagonally—this belonging to the class of goods to which our merchants apply the term "twilled"—and for this reason the drilling is both stronger and closer in texture than the ducking.

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* See Annual Report United States Department of Agriculture for the year 1887, pp.123-142; and 1888, pp. 123-126. Also INSECT LIFE, vol. 1, pp. 41,42 and 286; and vol. II, p. 202-207.

After the tent is sewed up it is given a coat of black paint, as it has been ascertained that tents treated in this manner last longer than those which have been simply oiled with linseed oil. Some persons mix a small quantity of soap suds with the paint in order to render the latter more pliable when dry, and therefore less liable to crack. Instead of thus painting the tent some persons simply give it a coating made of an inferior grade of glue called "size," first dissolving this in water and then covering the tent with it, using a whitewash brush for this purpose. Sometimes a small quantity of whiting or chalk (carbonate of lime, $Ca\ Co_3$),is added to this sizing with or without the addition of lampblack. A few make use of the mucilaginous juice of the common Cactus (*Opuntia engelmanni* Salm.) for this purpose; to obtain this the Cactus leaves or stems are cut or broken up into pieces, thrown into a barrel and covered with water, after which they are allowed to soak for three or four days; the liquid portion is then drawn off and is ready for use without further preparation. Tents which I saw that had been prepared with this substance were to all appearances as air-tight and pliable as when prepared in any other manner.

A tent 26 feet tall by 60 feet in circumference—a size large enough to cover the largest orange tree now growing in this State—if made out of drilling, and either painted or sized, as described above, will cost completed about $60. Where the trees to be treated are not more than 12 feet tall the tent can be placed over them by means of poles in the hands of three persons; to accomplish this, three iron rings are sewed to the tent at equal distances around and 6 or 7 feet from the bottom of the tent; immediately under each of these rings an iron hook is attached to the lower edge of the tent. When the latter is to be placed over a tree each of the hooks is fastened into the corresponding ring above it; one end of a pole is then inserted into each of these rings and the tent raised up and placed on the tree. The hooks are then released from the rings and the lower edge of the tent allowed to drop upon the ground.

Instead of allowing the tent to rest directly on the tree some growers use an umbrella-like arrangement, the handle of which is in two pieces, which are fastened together with clamps provided with pins; this allows the handle to be lengthened or shortened according to the height of the tree. This apparatus is put up over the tree and the tent allowed to rest upon it. By the use of this simple device the danger of breaking off the small twigs on the upper part of the tree by the weight of the tent is avoided. Mr. Leslie, of Orange, used four tents and tent-rests of this kind, and he informs me that with the aid of two men he fumigated 120 trees in one night. To remove the tent from one tree, place it over another, and charge the generator required only one minute and a half. In the place of poles some persons attach a circle of gas pipe to the lower edge of the tent; then two men, each taking hold of opposite sides of this circle, throw the tent over the tree. Dr. J. H. Dunn, of Pomona, informs me that four men, using six tents like the above, fumigated 240 orange trees in one night, and that the average for each night was over 200 trees, the latter being 8 feet or less in height.

Trees over 12 feet tall will require a derrick of some kind for the purpose of putting on the tent and removing it again. For this purpose a stout mast is erected in the center of a strong framework mounted upon the running gears of a common farm wagon, the height of the mast depending upon the height of the trees to be operated upon. This mast is braced in four directions, and to the upper end of it is firmly attached a cross-piece, extending transversely to the length of the wagon, and long enough to reach from one row of trees to another. To each end of this cross-piece are attached small pulleys, through which pass ropes which are attached to the tents; by pulling down on these ropes the tents are drawn up to the cross piece after which the wagon is drawn ahead until the tents are directly over two of the trees to be treated; the ropes are then let out and the tents lowered down over the trees. The ropes are usually attached to the lower edge of the tents as well as to their apices, and when the tent is to be taken off of the tree the ropes attached to the bottom of it are first pulled downward, thus drawing the lower part of the tent up to the cross-piece first, and in a measure turning the tent inside out. But for this device it would be necessary to have the cross-piece at least twice the height of the trees to be operated upon. This apparatus is drawn between two rows of trees and the trees on each side of it treated with the gas. It is customary for the men themselves to draw the fumigator from tree to tree, thus doing away with the use of horses for this purpose. Stout planks are frequently used for the wheels of the fumigator to run upon. A fumigator of this kind, without the accompanying wagons and tents, can be built for about $15, it being the cheapest and simplest apparatus ever used for this purpose. It has not as yet been patented, and is more largely used at the present time than any other kind, operating the tents successfully even upon the largest orange trees. The first fumigator of this kind was built by Mr. O. H. Leefeld, a prominent orange-grower of Orange, and a man who has had considerable experience as a machinist.

Within the past few weeks a new kind of a fumigator has been brought out by Mr. W. H. Souther, of Covina, Los Angeles County, Cal. This, like the preceding one, is mounted upon a common farm wagon, and operates two tents, one on either side of it. At each end of this fumigator are four upright posts attached at their lower ends to the framework, which is mounted on the wagon; the outermost posts are shorter than the inner ones, and to the upper end of each is attached a long spar by a hinged joint, which allows the spar to be moved back and forth transversely to the length of the wagon. The two spars on one side of the fumigator are connected with each other near their upper ends by means of a wooden cross-piece, and are drawn back and forth by means of ropes passing through pulleys. The tents are operated by means of ropes, which pass through pulleys attached to the spars and cross-pieces described above, there being five ropes attached to each tent; one of these is attached to the apex of the tent, and passes through a pulley fastened to the middle of the above-mentioned cross-piece; two other ropes are attached to opposite sides of the tent, about midway between its apex and base, and pass through pulleys fastened to each of the spars near their upper ends; the other two ropes are attached to opposite sides of the lower edge of the tent and pass through pulleys fastened to each of the spars a few feet higher up than those above described. To the bottom of the tent is attached a wooden circle in several pieces, and the two ropes attached to the bottom of the tent are fastened to this circle; these ropes are not exactly on opposite sides of the tent, the space between them equaling about one-third of the entire circumference of the lower edge of the tent.

In taking the tent off of a tree the two ropes attached to the tent midway between its base and apex are first drawn downward until their points of attachment are slightly above the top of the tree, after which the two ropes attached to the lower edge of the tent are drawn downward until their points of attachment are drawn up against the spars at the places where the pulleys through which these ropes pass are fastened; the lower edge of the tent at this stage will be perpendicular to the surface of the ground, and these ropes are further pulled upon until the spars on this side of the wagon are perpendicular to the wagon, thus bringing the weight of the tent upon the middle of the wagon; the spars are prevented from going over backward any farther by the presence of the inner upright posts referred to at the beginning of this description. When both of the tents have thus been drawn upon the wagon the latter is moved forward until the tents are brought opposite the next two trees. Before the tents are again let down over the trees the fumigator is first braced up by means of four long braces attached to each of the four corner posts at a distance of about 8 feet from the ground; these are attached in such a manner that they may be swung out at right angles to the fumigator, or, when not in use, may be swung around and loaded upon the wagon without first detaching them. After these four braces are in position the ropes attached to one of the tents are let out and the tent allowed to fall down over the tree, a guide-rope being attached to its lower edge to aid in guiding it in its downward descent over the tree.

Mr. Souther, the inventor of this fumigator, informs me that a fumigator of this kind, without the wagon and tents, could be built for about $60. He also informs me that a patent has been granted to him upon this fumigator.

Besides the above fumigators I may also mention one which has been used in a few instances with very good results. It is an extremely simple affair, consisting of an upright post the lower end of which is attached to a framework on a wagon or sled, while to its upper end is attached a long stick of timber, the latter being attached near its middle to the top of the post, like the sweep of an old-fashioned well. The tent is then attached to one end of the sweep, and by pulling downward on the opposite end the tent is raised up, and may then be swung around and let down over a tree.

After the tent is placed over the tree the next step is to charge it with the gas. The materials used for the production of the gas consist of commercial sulphuric acid ($K_2 SO_4$), fused potassium cyanide (KCN), and water, the proportions being 1 fluid ounce of the acid, 1 ounce by weight of the dry cyanide, and 2 fluid ounces of water. The generator is placed under the tent at the base of the tree; it consists of a common open earthenware vessel. The water is first placed in the generator, then the acid, and last the cyanide, after which the operator withdraws to the outside of the tent and the bottom of the latter is fastened down by having a few shovelfuls of earth thrown upon it. The tent is allowed to remain over the tree for a period of from 15 to 30 minutes, according to the size of the tree.

It was found by experimenting that the trees were less liable to be injured by the gas when treated at night than they were when operated upon in day time, and at the same time the gas is just as fatal to the scale insects when applied at night as it would be if applied in the day time; and indeed it appears to be even more fatal when applied at night. This is accounted for by reason of the fact that in the day time the light and heat decompose the gas into other gases which, while being more hurtful to the trees, are not so fatal to insects. At night the trees are also more or less in a state of rest, and therefore are not so liable to be injured by the gas as they would be in the day time, when they are actively engaged in absorbing nourishment and replacing wasted tissue with new materials.

Of the different materials used in generating the gas, the most important is the potassium cyanide; of this there are three grades: The mining cyanide, commercial cyanide, and the C. P. (chemically pure). Of these three brands, the mining cyanide is wholly unsuitable for the production of the gas, and the C. P. is too expensive; the commercial brand (fused) is the only one that is used for producing the gas, but even this varies greatly in strength, containing all the way from 33 to 58 per cent. of pure potassium cyanide. It is, therefore, of the utmost importance that the operator should know the exact percentage of pure potassium cyanide that his cyanide contains, and when large quantities of it are purchased at one time it would be advisable to obtain one or more analyses of it by a reliable analytical chemist; or if it is not possible to submit the cyanide to such person, an analysis of it could be made by almost any person accustomed to the use of chemicals or drugs.

The only substance required for this purpose is the crystals of nitrate of silver ($AgNO_3$), which may be obtained at almost any well-stocked drug store. Dissolve the nitrate in cold water contained in a glass or earthen vessel, using one-fourth of an ounce (Troy) of the crystals to 1 pint of water; this dissolves in a few minutes, forming a whitish, semi-transparent solution. The cyanide, when dissolved in water, forms a transparent, nearly colorless solution; when a small quantity of the nitrate of silver solution is added to this it at first spreads out in a white cloud, like milk, but it soon breaks up into small, white, floccy pieces which gradually disappear upon being agitated, leaving the solution nearly as transparent as at first; when more of the nitrate of silver solution is added from time to time the above process is repeated, except toward the last, when the cyanide solution becomes somewhat milky, but it still remains semitransparent, permitting the operator to see quite clearly the bottom of the vessel containing the solution. As soon as a sufficient quantity of the nitrate of silver solution has been added to the cyanide solution the latter immediately becomes white and opaque, like milk, completely concealing from view the bottom of the vessel containing it. This completes the operation, and the quantity of nitrate of silver solution used will indicate the strength of the cyanide tested. When absolutely pure, $5\frac{3}{4}$ grains of the potassium cyanide dissolved in water will require 1 fluid ounce of the above nitrate of silver solution before the turbidity occurs, indicating that the cyanide is 100 per cent. strong; if only one-half of a fluid ounce of the nitrate of silver solution produces this turbidity, this indicates that the cyanide in only half strength, or 50 per cent. strong; if only one-fourth of a fluid ounce is required, then the cyanide is 25 per cent. strong; and so forth. The nitrate of silver solution should be added to the cyanide solution very slowly, the latter being agitated by gently shaking it each time that any of the nitrate solution is added. Wherever any of the nitrate of silver solution comes in contact with the skin or nails of the hand it produces a reddish or black stain which can easily be removed by washing the stained part in a solution of potassium cyanide and water; this will quickly remove the stain without causing any injury to the parts affected, except, of course, when the stains occur upon a sore or cut in the hand, in which case it would be very dangerous to apply the cyanide to these places.

It sometimes happens that the percentage of cyanogen (CN or Cy) is given, instead of the percentage of potassium cyanide (KCN or KCy); but in cases of this kind the percentage of cyanide can be readily ascertained by always bearing in mind that two-fifths of a given quantity of potassium cyanide is cyanogen. Thus if a certain brand of cyanide contains 24 per cent of cyanogen, this is equivalent to 60 per cent of pure potassium cyanide. Potassium cyanide when absolutely pure (equal to 100 per cent.) contains 40 per cent. of cyanogen; and, therefore, no grade of cyanide could contain a larger percentage of cyanogen than this.

The potassium cyanide used for producing the hydrocyanic acid gas is principally manufactured by two firms: Power & Weightman, of Philadelphia, Pa., and the Mallinkrodt Chemical Works, of St. Louis, Mo. That made by the first named firm is the most largely used; when purchased by the ton the price is 36 cents per pound for the grade containing about 57 per cent of pure potassium cyanide, packages and carriage extra. It is put up in tin cans holding 10 pounds each, and also in barrels holding about 400 pounds each. That in the cans is much to be preferred, since the quantity in each is so small that it will soon be used up after the can is opened; whereas, the barrel containing so large a quantity, the cyanide used toward the last will have lost much of its strength by contact with the air. It is customary to weigh out the cyanide in small paper parcels, and mark each parcel with the number of ounces of cyanide that it contains; then when the tree is to be fumigated it is an easy matter for the operator to select one of the parcels containing a sufficient quantity of the cyanide for the tree, thus saving the trouble of weighing out the cyanide as it is to be used for each tree. As the fumigating is done only at night the weighing of the cyanide is frequently done by the ladies of the house upon the day preceding its use.

The quantity of cyanide to be used on each tree will, of course, depend not only upon the size of the tree but also upon the strength of the cyanide used. The following table will aid in determining the proper quantity of each ingredient to be used on different sized citrus trees, the cyanide being about 58 per cent pure:

Height of tree.	Diameter of tree-top.	Water.	Sulphuric acid.	Potassium cyanide.
Feet.	*Feet.*	*Fluid ozs.*	*Fluid ozs.*	*Ounces.*
6	4	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
8	6	2	1	1
10	8	$4\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$
12	10	8	4	4
12	14	16	8	8
14	10	10	5	5
14	14	19	$9\frac{1}{2}$	$9\frac{1}{2}$
16	12	16	8	8
16	16	29	$14\frac{1}{2}$	$14\frac{1}{2}$
18	14	26	13	13
20	16	36	18	18
22	18	52	26	26
24	20	66	33	33

Not only is this gas fatal to the Red scale (*Aspidiotus aurantii* Maskell), but also to the San José scale (*Aspidiotus perniciosus* Comstock), and indeed to all of the armored scales. It is also fatal to the Brown scale (*Lecanium hesperidum* Linn.) and to the Black scale (*Lecanium oleæ* Bernard), but the eggs of this species are not affected by it. The common Red Spider (*Tetranychus telarius* Linn.) and the Woolly Aphis (*Schizoneura lanigera* Hausmann) are also not affected by the gas when used strong enough to destroy the Red scale, although I have known it to prove fatal to true spiders (species not determined). House-flies (*Musca domestica* Linn.), Lace-winged flies (*Chrysopa* sp.?), and certain kinds of Ichneumon flies (*Ophion macrurum* Linn.) are also destroyed by the gas. On one occasion I obtained a cluster of eggs of a species of Psocus fly (*Cæcilius aurantiacus* Hagen) that were deposited upon a leaf of a tree before the latter had been treated with the gas, and from these eggs afterwards issued a number of parasitic flies belonging to the family Proctotrupidæ and to the genus *Alaptus*; but the species is as yet undescribed. Various kinds of Lady-birds, which are in the tree when the latter is treated with the gas, become stupefied and fall to the ground, but finally recover and are to all appearance none the worse for their temporary loss of consciousness. Birds, lizards, and even barn-yard fowls sometimes refuse to leave the large orange trees while the tent is being let down over them at night, and are therefore inclosed in the tent and subjected to the gas; the latter proves fatal to all of these. The small, pale yellow mites which are frequently found on orange trees, especially beneath the dead scales, are not affected by the gas; these have a general resemblance to the young of the Red scale, and several operators, finding these mites still alive after the tree had been subjected to the gas, came to the erroneous conclusion that the gas had not been effectual, thinking that these mites were the young of the Red scale.

From the above it will be seen that the gas treatment is not a sure specific for every kind of insect pest, but for destroying Red scales on citrus trees it is far superior to any other method at present known.

THE RESIN WASH FOR THE SAN JOSÉ SCALE.

During the past winter I carried on quite a series of experiments with various kinds of washes for the destruction of the San José scale (*Aspidiotus perniciosus* Comstock) on dormant deciduous trees, kindly placed at my disposal by Mr. C. H. Richardson, the inspector of fruit pests for the Pasadena district, Mr. Richardson also aiding me in making many of these experiments. Among all of the washes tried the following gave the best results:

Resin	pounds	30
Caustic soda (70 per cent)	do	9
Fish oil	pints	4½
Water, enough to make	gallons	100

For making 100 gallons of the above wash a kettle holding 30 gallons will be required. Place all of the ingredients in the kettle and cover with water to a depth of 4 or 5 inches, boil briskly for about 2 hours, or until it will dilute evenly with water, like black coffee, which it closely resembles in color. When this stage is reached the kettle should be filled up with water, adding this very slowly at first; the contents of the kettle can then be emptied into a tank or other vessel, and a sufficient quantity of water added to make 100 gallons. Care should be taken not to chill the wash by adding large quantities of cold water at one time.

The making of this wash will be greatly accelerated if the resin and caustic soda are first pulverized before being placed in the kettle; if in large pieces, a considerable length of time will be required in which to dissolve them. If a sufficient quantity of water is not used at first the materials when dissolved will form a thick, pasty mass, which simply breaks open in places to allow the steam to escape, and pieces of the mixture will be thrown out of the boiler or against its sides or lid by the escaping steam. When this occurs, water should be added until the solution boils up in a foamy mass. Whenever there is a tendency to boil over a small quantity of cold water should be added, but not too much, or the making of the solution will be retarded; after a few trials the operator will learn how much water to add in order to prevent the solution from boiling over and yet keep it in a brisk state of ebullition. If it is not desired to add all of the water at the same time that the solution is made, then enough can be added to equal two-fifths of the quantity required; the balance of the water can then be added at any subsequent time without again heating the solution. Thus, if a sufficient quantity of the solution is boiled to make when diluted 100 gallons, this could first be diluted to make only 40 gallons, and the remaining 60 gallons of water added at any time as required. If it is desired to use it in a still more concentrated form than this, it need not be diluted at all after it has been boiled sufficiently, but in this case it will be necessary to heat it again before adding the water.

On the 11th of February, between the hours of 1:30 and 4:20 p. m. (sun shining, light breeze), I had 60 dormant deciduous fruit trees sprayed with the above solution. These consisted of peach, plum, apple, pear, and quince trees; none of them had started to leaf out except the quince, which had put forth a few leaves at the tips of some of its branches. Each of these trees was infested with the San José scale (*Aspidiotus perniciosus* Comstock) and several of them had been almost killed by the attacks of this pest. April 23 I made a careful examination of these trees and found only a very few living San José scales; all of the trees except those which were nearly dead when sprayed were now making a vigorous growth. May 12 I again examined these trees, and found living San José scales on only three of them, about half a dozen scales on each. I made another examination on the 11th day of June, and found a few San José scales on some of the pears on the above trees. All of the Black scales (*Lecanium oleæ* Bernard) which I found on these trees were dead, and their eggs were dry. July 24 I again examined these trees and found three or four living San José scales on a few pears and apples on some of the trees, but the fruit was practically clean, whereas on adjoining trees which had not been sprayed nearly all of the pears were very badly infested with these scales. There was, however, a singular exception to this: A LeConte pear tree that stood in the midst of several Bartlett and Winter Nelis pear trees, which were very badly infested with the San José scale, was, wholly free from this pest. Nor is this an isolated case, since I saw the same thing in another pear orchard located several miles from this one. Mr. Richardson informs me, however, that the fruit of this tree is almost worthless.

Wishing to test the effects of the above wash on growing trees, I sprayed a prune, peach, apricot, apple, and orange tree on the 12th day of May, between the hours of 10 and 11 a. m., sun shining, light breeze. I examined these on the 11th of June; on the prune all of the fruit had dropped off, and upon one-third of the leaves were dead brown spots, these spots not exceeding one-sixth of the entire surface of any of the leaves; on the peach all of the fruit was dead, but still clinging to the tree, and half the leaves had brown spots in them, these leaves being much more injured than were those on the prune tree; on the apricot the fruit was not injured in the least and three-fourths of the leaves were uninjured, but the remaining leaves had small brown spots in them, these spots not exceeding one-fifteenth of the surface on any of the leaves; on the apple all of the fruit had dropped off and half the leaves had large brown spots in them, these spots sometimes exceeding one-half of the entire surface of the leaf; on the orange nearly all of the fruit had dropped off (the young oranges being about half an inch in diameter), but the leaves were uninjured.

This indicates that of the different kinds of fruit thus experimented upon the apricot was the hardiest and was the least affected by the wash; next to the apricot is the orange, then the prune, after this the peach, the apple having suffered most from the effect of the wash.

The orange tree experimented upon was infested with the Yellow scale (*Aspidiotus citrinus*), and also with the Black scale (*Lecanium oleæ* Bernard), and all of these, as well as the eggs of the Black scale, were destroyed by the wash.

According to the scale of prices furnished me by the Los Angeles Soap Company of this city, the material for making 100 gallons of the above wash, when purchased in large quantities, would amount to $1.14, being but a trifle over 1 cent a gallon for the diluted wash.

The materials used in preparing the above wash are the same as those I used in spraying orange trees last season for the destruction of the Red scale (*Aspidiotus aurantii* Maskell), an account of which is given in my report to Professor Riley for last year, published in Bulletin No. 22 of the Division of Entomology (pp. 10–14); but the spray I then used was only three-fifths as strong as the one I used for the destruction of the San José scale as above described. On the 19th of December I tested the spray of the same strength that I had used for the Red scale on orange trees, but it did not prove fatal to all of the San José scales that it came in contact with.

The question as to the manner in which the above resin spray proves fatal to the scale insects—whether the caustic property imparted by the caustic soda is the destructive agent, or whether it is the suffocating effect of the resin and fish oil saponified by the caustic soda that produces this result—is a very important one. Quite a number of our fruit growers were at first inclined to believe that it is the caustic property of the wash that destroys the scale insect, and they therefore increased the quantity of this particular ingredient, only to find that the wash so constituted is not apparently more fatal to the insects, while at the same time it is very liable to injure the fruit. My own studies and experiments lead me to believe that the above sprays kill for the most part by suffocation. In the course of experimenting I found that a wash composed of the following ingredients:

Caustic soda	pounds	8
Resin	do	33
Water enough to make	gallons	100

did not prove fatal to as large a percentage of Red scale as did one consisting of:

Caustic soda	pounds	6
Resin	do	20
Fish oil	pints	3
Water enough to make	gallons	100

Now, if it is the caustic property of the wash that proves fatal to the scale insects, it is evident that the wash containing the largest amount of the caustic agent would prove fatal to the largest number of scale insects, but the reverse of this was really the case; the wash containing the smallest amount of the caustic agent, the caustic property of which was still further lessened by the addition of the oil, proved fatal to the largest number of the insects. On the other hand, the addition of the oil, while reducing the caustic property of the wash, would increase its varnishing qualities, since it is a fact well-known to painters that the addition of oil to a varnish improves its qualities. For these reasons it seems quite certain that it is the suffocating properties of the wash and not its caustic nature that cause it to prove fatal to the scale insects which have been sprayed with it.

I have seen orange trees that had been sprayed with a wash so caustic that it killed fully nine-tenths of the leaves on the trees, burnt the bark brown, and caused nearly all the oranges to drop off, and yet quite a number of the Red scale insects located on the oranges still remaining on the tree were alive. This will show the utter uselessness of attempting to destroy the Red scale on citrus trees by the use of caustic washes.

THE LIME, SALT, AND SULPHUR WASH FOR THE SAN JOSÉ SCALE.

For destroying the San José scale (*Aspidiotus perniciosus* Comstock) on dormant deciduous fruit trees many growers in this State use a wash composed of the following ingredients in the proportions here given:

Sulphur	pounds	33
Lime	do	42
Salt	do	25
Water enough to make	gallons	100

All the sulphur and half of the lime are placed in a kettle and 33 gallons of water added, after which the contents of the kettle are boiled briskly for about 1 hour; the solution will then be of a very dark brown color and having a reddish tint. All of the salt is added to the remaining 21 pounds of lime and the latter slaked, after which this slaked lime and salt are added to the above described sulphur and lime solution and the whole then diluted with a sufficient quantity of water to make 100 gallons; this is then strained, after which it is ready to be sprayed upon the trees.

This does not form a perfectly liquid solution but contains a considerable quantity of undissolved sulphur and lime, which soon settles to the bottom unless the solution is stirred almost constantly while being sprayed on the trees. It is therefore somewhat of the nature of a thin whitewash, and the trees sprayed with it have the appearance of having been whitewashed. On the 26th of November, at 12:45 p. m., sun shining, light breeze, I sprayed a pear tree with a wash made according to the above directions, the tree being very thickly infested with the San José scale. January 15 I found 14 living San José scales on this tree, and on the 23d of April I found several more; on the 11th of June I found on this tree a Black scale (*Lecanium oleæ* Bernard) containing healthy eggs.

I also tested this wash in the following proportions:

Sulphur	pounds	50
Lime	do	63
Salt	do	37
Water enough to make	gallons	100

This was applied to a pear tree at 1 p. m., November 26, sun shining, light breeze. On January 15 I found 6 living San José scales on this tree, and on the 23d I found several more.

At the time of making these tests there were several green leaves on each of these trees, but all of these were killed by the washes. The trees otherwise were not apparently injured, and in the following spring started into a vigorous growth which was continued throughout the summer. These trees were not over 10 feet tall, and were very thoroughly sprayed, so it seems quite certain that every scale insect located upon them must have been covered with the wash.

The philosophy of this wash is not at present clearly understood. It seems very probable however that the product of the lime and sulphur (bisulphide of lime, CaS_2) furnishes the insecticidal property, and the presence of the salt and slaked lime simply imparts permanency to the wash. I made quite a series of experiments with the above-named ingredients, with a view of ascertaining which of the ingredients were really insecticides, but these experiments have thus far resulted negatively. The following is a brief account of these experiments:

SALT.—Experiment 229: Table salt, 19 pounds; water, 100 gallons. I simply dissolved the salt in cold water and then sprayed the solution on a pear tree at 12:30 p. m., November 26, sun shining, light breeze. This did not kill all of the green leaves that were upon the tree. January 15 I found a great many living San José scales on this tree.

Experiment 228: Salt, 38 pounds; water, 100 gallons. Dissolved the salt in water as before and sprayed on a pear tree at noon, November 26, sun shining, light breeze. This killed all of the green leaves that were upon the tree. January 15, I found many living San José scales on this tree.

Experiment 237: Salt, 60 pounds; water, 100 gallons. Dissolved the salt as before and sprayed on a pear tree at 10 a. m., January 20, sun shining, light breeze. April 23, I found a great many living San José scales on this tree.

Salt and Lime.—Experiment 238: Salt, 25 pounds; slaked lime, 8½ pounds; water, 100 gallons. The salt and lime were added to the cold water, stirred occasionally, and strained through a piece of Swiss muslin and then sprayed upon a pear tree at 10:30 a. m., January 30, sun shining, light breeze. April 23 I found a great many living San José scales on this tree.

Salt and Sulphur.—Experiment 232: Salt, 25 pounds; sulphur, 75 pounds; water, enough to make 100 gallons. The sulphur was boiled for an hour in 75 gallons of water, after which the salt was added, and the solution diluted with a sufficient quantity of cold water to make 100 gallons. After standing for a few minutes the greater portion of the sulphur settled to the bottom, making it necessary to stir the solution almost constantly while applying it to the tree. Sprayed on a pear tree at 2:45 p. m., November 26, sun shining, light breeze; this killed all of the green leaves on the tree. January 15 I found a great many living San José scales on this tree.

Sulphur.—Experiment 233: Sulphur, 100 pounds; water, enough to make 100 gallons. Placed the sulphur in the water and boiled for 1 hour, then when cold, sprayed the solution on a pear tree at 3 p. m. November 26, sun shining, light breeze. This did not injure any of the green leaves that were on the tree. January 15 I found a great many living San José scales on this tree, a smaller proportion being killed than in either of the preceding experiments.

Lime.—Experiment 239: Slaked lime, 10 pounds; water, enough to make 100 gallons. The lime was placed in the water, stirred occasionally and in two hours the solution was strained through a piece of thin Swiss muslin and sprayed upon a pear tree at 10:45 a. m. January 20, sun shining, light breeze. April 23, I found a great many living San José scales on this tree.

Lime and Sulphur.—Experiment 240: Quicklime (CaO), 100 pounds; sulphur, 33⅓ pounds; water, enough to make 100 gallons. Placed the lime and sulphur in a copper vessel, added 30 gallons of water, and boiled for two hours, then filtered. The solution was of a deep orange-red color. After standing for a few minutes needle-like crystals somewhat resembling the down on the seeds of thistles separated out. These were composed of bisulphide of lime (CaS_2) and being freely soluble in water, were dissolved when the balance of the water was added. In this action all of the sulphur had been incorporated with the lime, since the residue when dried would not ignite. Added a sufficient quantity of water to the above solution and sprayed an apple tree with it at 10:30 a. m. March 18, sun shining, light breeze.

About 14 hours after making the above experiment it began to rain very gently and this was continued for 24 hours. April 23, I found a great many living San José scales on this tree. At the time of making the above test I also sprayed some of the solution on a branch of a peach tree in full blossom, but this did not appear to produce any injurious effect upon the blossom, since at the time of my visit on the 23d of April this branch bore as many peaches as did any of those I had not sprayed. It seems almost certain that the rain, coming on so soon after the wash was applied, rendered neutral the effect of the above solution on the scale insects sprayed with it. I have seen orange trees that had been sprayed with the resin wash on a certain day and a rain occurred during the night following the application; but the wash did not prove fatal to nearly as large a percentage of the red scales as would have been the case had no rain occurred.

On the same day that the above test was made (March 18), I also tried the above mentioned lime and sulphur solution at half strength, but it did not produce any apparent effect upon the San José scales infesting the tree sprayed with it. It was now too late in the season to make additional tests of this solution, but I hope to be able to follow up this subject during the coming winter.

From the above experiments it would appear that neither lime, salt, nor sulphur when used separately are effectual in destroying the San José scale; and the same is true in regard to any two of them when used in combination, except, perhaps, the lime and sulphur, which have not as yet been sufficiently tested. It is very probable, however, that these two ingredients give to the wash its insecticidal property, while the addition of the slaked lime and salt simply impart stability to the wash, rendering it less liable to be washed off the trees by the winter rains. Should this surmise prove correct, then the directions given at the head of this article for preparing this wash should be changed, an equal number of pounds of lime being required with the 33 pounds of sulphur, instead of only 21 pounds of lime, as at present used.

I experienced considerable difficulty in preparing and applying this wash, owing to the fact that some of the materials used are not soluble in water, necessitating an almost constant stirring of the solution while it is being sprayed upon the trees. On this account it is quite impossible to spray it uniformly upon all of the trees, and this difficulty has also been experienced by each of our fruit-growers who have used it and with whom I have conversed upon the subject, or who have written to me in regard to it. Some of the trees sprayed by this solution would be very much whitened, as if whitewashed, whereas other trees sprayed from the same tank as these would be scarcely discolored by the wash. It is, of course, the slaked lime added to the solution that causes it to give the trees the appearance of having been whitewashed, since neither the salt nor the sulphur discolor the tree to any appreciable extent, and the same is true of the bisulphite of lime, which is produced by boiling the quicklime and sulphur together.

The cost of 100 gallons of this wash according to prices furnished me by Howell & Craig, wholesale grocers, of this city, for the sulphur and salt, and by the Southern California Lumber Company, also of this city, for the lime, is as follows, the materials being purchased in large quantities:

Sulphur, 33 pounds, at $2\frac{1}{8}$ cents per pound	$0.70
Lime, 42 pounds, at $\frac{7}{9}$ of a cent per pound	.33
Salt, 25 pounds, at $\frac{9}{20}$ of a cent per pound	.11
Total	$1.14

The salt quoted above is a poor grade, such as is used for salting hides, and the price quoted is by the ton; the sulphur is in sacks, and the lime in barrels containing about 220 pounds each.

Of the two washes above described—the resin, caustic soda, and fish oil, and the lime, salt, and sulphur washes—the one containing resin is greatly to be preferred. Not only is this wash easier to prepare than the other, but it is also much easier to apply it to the trees, since it is perfectly soluble in water and therefore does not require to be stirred while being sprayed upon the trees. For this reason more uniform results will be obtained by its use than would be obtained by using the sulphur wash. Moreover, the resin wash, by being properly diluted, can also be used in the summer season, and thus only one wash need be used at any time of the year. In my own experiments better results were obtained by the use of the resin wash than were produced by the sulphur wash. The price per gallon of each of these washes is about the same. The sulphur wash should never be used on trees in leaf nor on those just starting to leaf out, and this is also true of the resin wash when made according to the formula given in the preceding article.

MISCELLANEOUS EXPERIMENTS.

CORROSIVE SUBLIMATE (also known as mercuric chloride, $HgCl_2$).—Some time ago one of the Horticultural Commissioners of San Bernardino County remarked to me that he had used a simple solution of corrosive sublimate for the purpose of destroying various kinds of scale insects on nursery trees, and had obtained very good results by the use of the same; and it was also reported in some of the San Diego papers that a gentleman living in that county had obtained better results by the use of a solution of the above kind than he had by using any other kind of insecticide for the destruction of the black scale.

Thinking the subject worthy of investigation, I made a few experiments with this substance, but the results were far from being satisfactory. I dissolved the sublimate in cold water by frequent stirring; this required about 15 minutes, and the solution was of a dark bluish-gray color. Following is a brief account of these experiments:

(224) Corrosive sublimate, $2\frac{1}{4}$ ounces; water 100 gallons. Sprayed on an orange tree infested with the red scale at 3 p. m., October 10, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(223) Corrosive sublimate, $4\frac{1}{2}$ ounces; water, 100 gallons. Sprayed on an orange tree at 2:30 p. m., October 10, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(236) Corrosive sublimate, $1\frac{1}{6}$ pounds; water, 100 gallons. Sprayed on a dormant pear tree infested with the San José scale at 10 a. m., December 31, sun shining, light breeze. February 3, found a great many living San José scales on this tree.

The price in this city of the corrosive sublimate in 10-pound lots is at the rate of $1.40 per pound; at this rate the strongest solution I used (experiment 236) would cost about $1.63 per 100 gallons. I did not test a stronger solution than this, since its cost alone would prevent its being extensively used.

GLUE.—For the purpose of testing this substance as an insecticide for the destruction of the red scale on citrus trees I made a few experiments with it, but with very unsatisfactory results. The grade I used is of a light brown color, not the white, nor yet the poorest grade, but such as is used by cabinet-makers. To dissolve the glue I simply boiled it in water, and it dissolved in about 10 minutes. Following is a brief account of these experiments:

(227) Glue, $4\frac{1}{2}$ pounds; water 100 gallons. Sprayed on an orange tree infested with the red scale at 4:30 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(226) Glue, 8.1 pounds; water 100 gallons. Sprayed on an orange tree at 4 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(225) Glue $12\frac{1}{4}$ pounds; water 100 gallons. Sprayed on an orange tree at 3:30 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

In this city (Los Angeles) the price of glue of the above grade in 10-pound lots is at the rate of 50 cents per pound; at this rate the strongest solution I used (experiment 225) will cost $6.25 per 100 gallons. This, of course, is much too expensive for ordinary use as an insecticide, and for this reason I did not test a stronger solution.

Aloes.—Dr. M. F. Bishop, of Alameda, the owner of a large orchard of deciduous fruit trees in the vicinity of San José, in the northern part of the State, gave me a package of aloes, with the request to test it on the scale insects infesting citrus trees. Accordingly I made a few tests with it, simply dissolving the aloes in cold water, straining the solution through a piece of Swiss muslin, and then spraying it upon the tree. The aloes is not readily soluble in cold water, and 4 days were required for it to dissolve, being occasionally stirred during this time. The experiments are as follows:

(243) Aloes, 12½ pounds; water, 100 gallons. Sprayed on an orange tree infested with the yellow scale (*Aspidiotus citrinus*) at 10:30 a. m., March 22, sun shining, light breeze. April 23, leaves and fruit uninjured; found many living yellow scales on this tree.

(242) Aloes, 25 pounds; water, 100 gallons. Sprayed on an orange tree at 10 a. m., March 22, sun shining, light breeze. April 23, leaves and fruit uninjured; found several living yellow scales both on the leaves and fruit of this tree.

The price of the aloes in large quantities is at the rate of 16 cents per pound; at this rate the strongest solution I used (experiment 242) would cost $4 per 100 gallons. At this strength (25 pounds of aloes to 100 gallons water) it proved fatal to a large percentage of the scale insects, and doubtless if it had been used one-half stronger it would have been entirely effectual; but the high price of a solution of the latter strength would prevent its being used on a large scale.

REPORT OF EXPERIMENTS WITH RESIN COMPOUNDS ON PHYLLOXERA, AND GENERAL NOTES ON CALIFORNIA INSECTS.

By Albert Koebele.

LETTER OF SUBMITTAL.

Alameda, Cal., *October* 20, 1890.

Sir: I herewith submit report upon experiments, chiefly with resin compounds, on *Phylloxera vastatrix*, and observations made during the year.

Very respectfully,

Albert Koebele,
Field Agent.

Prof. C. V. Riley,
U. S. Entomologist.

By your direction a series of experiments was carried on, chiefly with resin compounds, upon the *Phylloxera* in Sonoma Valley during September and the beginning of October.

In preparing the compounds the following were used: Bicarbonate of soda, sal soda, and Greenbank's caustic soda, 98 per cent. Three pounds are required of the former to dissolve 4 pounds of resin properly, or, in other words, to make a resin soap; 1 pound of the latter is sufficient to dissolve 10 pounds of resin or even 11, but I did not succeed in dissolving 12 pounds, as parts of the resin would always remain. In repeated and careful trials this could not be overcome.

The results showed somewhat in favor of the bicarbonate of soda as far as to destruction of the insects, but the price has to be considered. Next to this seems to be the emulsion prepared with caustic soda, but it is a difficult matter to decide which will work best without carrying on an extensive series of trials. It is safe to say, however, that the results will not vary greatly.

One pound of resin was used to each 10 pints of compound, and this again was diluted with water at a strength of 1 pound of resin in 2½ gallons of water, up to 1 pound in 37½ gallons of water—one part of compound in thirty parts of water. This compound will, as has been previously stated, do effective work on unprotected Aphids, *i. e.*, such as are not covered with cottony or mealy exudations, at one part in fifteen parts of water, or 1 pound of resin in about 16 gallons of water. (The former mixtures were somewhat stronger; 1 pound of resin in 9 pints of liquid.) The action upon the Phylloxera is much more marked and with a mixture of one part of compound in thirty parts of water the insects, if immersed for a few seconds only and left exposed, will die, notwithstanding this solution will not adhere to parts of the roots, not having at this strength the required penetrating power which a sufficiently strong solution, say about 1 pound resin in 15 gallons of water, has, and more so than any other insecticide I know of. The experiments were made on 25-year-old Tokay vines (the only ones remaining that have withstood the ravages of the Phylloxera), in loamy soil, which was completely dry and hard at this time of the year, no moisture being noticeable until a depth of from 10 to 12 inches below the surface was reached.

In all cases the ground was removed to a depth of about 6 inches, forming a hole 4 feet in diameter. Ten gallons of the solution, it was observed, penetrated here to 12 inches in depth around the roots where the hole was deepest, or about 18 inches from original surface of ground, and most of the insects were destroyed to about 16 inches in depth, if the 10 gallons contained 4 pints of compound. In the later experiments these holes were made only about 2 feet in diameter, and nearly if not the same results were obtained with only half the amount or 5 gallons of the mixture. This is more practical, as the chief roots only are reached and the solution can be used so much stronger. The less solution required the better, providing it will do the work, for at 10 gallons to each plant this would mean 7,000 gallons or over per acre. If the solution is applied at another time of the year, say early spring, when rain is still expected, the results undoubtedly will be still more favorable. I have had excellent results with solutions prepared with caustic soda by using 4 pints of this to 16 pints of water only and applying 5 gallons of water soon after and 5 gallons the following day. This destroyed the Phylloxera to nearly the depth the fluid reached. Thus it will be seen if a small amount of the mixture, sufficiently strong, be applied in early spring the following rains will do the rest. As it was, with the dry soil, the 4 pints of compound in 10 gallons of diluent did better work than the same amount of compound in only 5 gallons, for the simple reason that it penetrated farther and thus reached more of the insects in sufficient strength to kill. It must also be remembered that a completely dry soil will take up a large amount of the liquid, whereas in a moist soil this is not the case.

The compounds were prepared as formerly, sal soda 3 pounds, resin 4 pounds, dissolved together with 1 quart of water, and water added slowly while boiling to make 40 pints. The caustic soda, which comes in 10-pound tin cans, is dissolved in 4 gallons of water, after which 4 gallons more should be added. This lye will dissolve 100 pounds of resin and make 125 gallons of compound, sufficient for 250 plants, and costing at wholesale in San Francisco (T. W. Jackson & Co., No. 104 Market street) $2.50. This is sufficiently strong, and to use more is unnecessary, as it was found that even 3 pints of the emulsion to the plant would do the work.

I will give here a receipt for preparing the cheapest compound. This is with common caustic soda, such as is sold at wholesale at about 5 cents per pound:

Caustic soda, 77 per cent	pounds	5
Resin	do	40
Water to make	gallons	50

First the soda should be dissolved over fire with 4 gallons of water, then the resin added and dissolved properly, after which the required water can be given slowly while boiling to make the 50 gallons of compound. This will make 500 gallons of the diluent, sufficient for 100 plants, and costing about 84 cents.

While a much weaker solution would kill the Phylloxera, this is recommended, as it also destroys their eggs effectively. Below are given the results of some of the experiments to show the effects of various strengths. Most of these have been duplicated or tried upon several plants. A small mite (*Tyroglyphus* sp.), always very abundant among the Phylloxera, and, as a rule, feeding upon the sap of the roots, yet from numerous empty skins appearing to feed also upon the lice, was in no case injured by these resin washes.

Compound No. 1.—*Bicarbonate of soda*, 3 *pounds; resin*, 4 *pounds, and water to make* 40 *pints, costing* 15 *cents.*

Compound, 1 gallon; water, 6 gallons; in holes 4 feet in diameter. Destroyed insects to about 12 inches in depth from original surface, as well as the eggs of the same, which became dark in color.

Compound, one-half gallon; water, 4 gallons. Destroyed all insects where they were reached (occasionally a living one running about).

Compound, 1 part; water, 10 parts; about 10 gallons of the fluid used. This will destroy all lice and their eggs completely to 12 inches from original surface, but not deeper.

Compound, 1 part; water, 12 parts; 9¾ gallons used. Twenty-four hours after application some of the solution remained still on top, and on examining 6 days later it was found that it had penetrated the ground to 12 inches from original surface. Much of the solution had evaporated and left a brown scum (dry soap) on top. It will also destroy most, if not all, of the eggs.

Compound, 1 part; water, 14 parts. Three and three-fourths gallons of the diluent in holes 2 feet in diameter killed the insects to 8 inches in depth, or 14 inches from original surface.

Compound, 1 part; water, 16 parts; 8½ gallons diluent. Occasionally a living insect found and large numbers of mites on the nearly dead vines.

Compound, 1 part; water, 18 parts; $9\frac{1}{2}$ gallons diluent; examined 5 days after. Nearly all the insects dead to 14 inches in depth, but most of the eggs looked bright yellow and no doubt will hatch. Behind the thick bark near the top, where apparently the solution did not penetrate, a number of young lice were found alive.

Compound, 1 part; water, 20 parts; $10\frac{1}{2}$ gallons diluent; in holes 4 feet in diameter. An examination 5 days later showed the fluid had penetrated the ground on plants $15\frac{1}{2}$ or 20 inches from original surface. All the insects were destroyed 13 inches in depth and but very few living 3 inches deeper. This solution seems to work best of all this series, but it is doubtful if the eggs will be affected by it.

COMPOUND NO. 2.—*Caustic soda,* 98 *per cent.,* 1 *pound ; resin,* 10 *pounds ; water to make* $12\frac{1}{2}$ *gallons ; compound costing* 25 *cents.*

Compound, 4 pints; water, 4 pints; in hole 4 feet in diameter; 5 gallons of water added 1 hour later and the same quantity next day. Very few dead insects were found upon this plant, and none living. Not sufficient to show proper result.

Compound, 4 pints; water, 2 gallons; 5 gallons of water added 1 hour after and 5 gallons the following day. Examined plants 7 days later; result very satisfactory, hardly any living phylloxera as far as the fluid reached. After examination 5 gallons more water were added and again examined a week later, when no living insects could be found to a depth of 18 inches.

Compound, 4 pints; water, 10 gallons. Destroyed insects to about 8 inches in depth and but few below this.

Holes only 2 feet in diameter; 5 gallons of water in same first, and solution 1 hour later in the four succeeding experiments.

Compound, 4 pints; water, $4\frac{1}{2}$ gallons; examined 13 days later. Destroyed insects and eggs as well, which had become very dark. Occasionally a live specimen running about.

Compound, 3 pints; water, $4\frac{1}{2}$ gallons. Examined 13 days later and found all insects dead that had been reached.

Compound, $2\frac{1}{2}$ pints; water, $37\frac{1}{2}$ pints. Examined 13 days later. A piece of root about 10 inches deep one-half inch in diameter by 6 inches long and completely covered with phylloxera showed but one single living young, probably hatched from egg after application.

Compound, 2 pints; water, $4\frac{1}{2}$ gallons; also examined at the end of 13 days. All insects to 8 inches below ground or 14 inches below original surface were destroyed, as well as a large part of the eggs. Occasionally a living young was found wandering about.

Four other experiments were made with this compound, using 1, 2, 3, and 4 pints in 20 of the solution, the ground having 4 hours previously been saturated with 5 gallons of water in each case. Examined 12 days after; results were not good with 1 pint but were progressively better with the other three. Applied 4 gallons more water on plants where 3 and 4 pints had been used, and found 2 days later that this additional water still increased the effect.

In addition to this a number of plants were treated with this compound to note the results next spring. The holes were made 2 feet in diameter, and after the solution had disappeared the wet ground from the outside was placed around the plant and the hole closed again. The experiments were: Five pints of compound in 5 gallons of the solution, four plants; 4 pints of compound in 5 gallons of the solution, eight plants; 3 pints of compound in 5 gallons of the solution, ten plants; and 2 pints of compound in 5 gallons of the solution, ten plants.

COMPOUND NO. 3.—*Caustic soda,* 98 *per cent,* 1 *pound; resin,* 8 *pounds; and water to make* 10 *gallons of compound, costing* 22 *cents.*

Compound, 4 pints; water, 7½ gallons. Examined 6 days later; result good.

Compound, 4 pints; water, 10 gallons. Examined 6 days later and found result favorable.

Compound, 3 pints; water, 75 pints. Found only part of insects destroyed 6 days later.

Compound, 3 pints; water, 90 pints. There were not enough insects upon this plant to deduce fair results, which would no doubt be very poor.

COMPOUND NO. 4.—*Sal soda,* 3 *pounds; resin,* 4 *pounds; and water to make* 5 *gallons of compound; costing* 11 *cents.*

Compound, 4 pints; water, 7½ gallons. Examined 5 days later and found all insects killed except a few living on a plant under thick bark, where solution apparently did not penetrate.

Compound, 4 pints; water, 10 gallons. Examined 5 days later and found insects dead to 12 inches in depth from original surface, with only occasionally a live one walking about.

Compound, 3 pints; water, 75 pints. On examining, 5 days later, only the insects near surface were found dead.

Compound, 4 pints; water, 15 gallons. This destroyed only partly the lice near the top.

The following four experiments were made with this compound, the ground having been previously soaked with 4 gallons of water:

Compound, 3 pints; water, 21 pints. Examined 12 days later. Did not show good results, as part of the insects were found alive. Twice the amount of water with the same quantity of compound will do much better work.

Compound, 3 pints; water, 33 pints. Examined 12 days later and found results fairly good. Only a few living ones were running about.

Compound, 2 pints; water, 30 pints. On examination numerous live insects were found, but more than half were killed.

Compound, 2 pints; water 38 pints. Result about the same as in preceding experiment.

These four experiments were repeated and the water added (3 gallons) 2 hours after instead of before application of emulsion. The results in this case were much more satisfactory, destroying most of the eggs in the two first experiments and nearly all of the phylloxera in the two last to a depth of about 10 inches.

GENERAL NOTES.

It was probably owing to the unusually heavy rainfall during last winter that insects were comparatively scarce in the early part of the season. At least no complaint was noticed or heard during this time. While a large number would undoubtedly be destroyed by weeks of excessive rains and floods, yet there are such as are not or only slightly affected by this element. I may cite here, for instance, such species the eggs of which are found upon trees and shrubs during the winter months as well as the eggs of locusts usually deposited on dry hillsides. On a visit to Sonoma county during May, the larvæ of *Clisiocampa* were extremely abundant. Two species were found, namely, *C. constricta* and *C. thoracica.* The first species predominated in numbers, and while usually feeding upon deciduous oaks was also found upon Live Oak and *Quercus agrifolia* as well as various shrubs. In confinement these larvæ were furnished with food consisting of leaves of Plum and Cherry, but for three days they would not feed upon these and readily attacked the leaves of Live Oak which were given them, and upon these they were raised. *C. thoracica*, which is the species defoliating various fruit trees, was found chiefly upon willows, but also upon oaks, and here again usually upon White Oak, upon which its eggs were found in October. This species was bred upon leaves of Prune and Cherry.

At the end of May of the present year, I received from Mr. F. L. Washburn, entomologist of the experiment station at Corvallis, Oregon, a few *Clisiocampa* larvæ new to me. He said they were found feeding upon a species of *Cratægus* and were sent with leaves of apple, upon which I reared them. On my visit to Washington these larvæ were met with at Tacoma, on June 8, within webs upon Alder (*Alnus rubra*), and again at Easton, during July, upon Willow. Near Tacoma I also found what I took to be the larvæ of *C. thoracica* very abundant upon *Cratægus*, Alder, Hazel, and various other shrubs. Two of the larvæ were taken to Easton, and one pupated and to my surprise produced not the expected *C. thoracica*, but *C. erosa* Stretch.

About 10 miles along the railroad in southern Oregon, about the beginning of June, larvæ and webs of one of these moths were seen in large quantities on dry hillsides upon *Purshia tridentata* DC., *Ceanothus* sp., and also Wild Cherry. While crossing the Columbia River on steamer, June 8, at which time the water was very high, large numbers of these larvæ were observed floating upon the swift current and as many as a dozen could be seen at one time, but of all the hundreds seen very few were dead. They were usually in a half circle and completely dry above and were carried off to be distributed safely along the shores. In both cases I had no opportunity to obtain specimens for identification.

As to the parasites, so far two species of a small Chalcid were bred from 37 egg masses of *C. constricta* found within three hours while collecting Cynipid galls in Sonoma County during October. This species is preyed upon by Tachina flies, which are or have been, the present season, the chief agent in destroying them. From about two hundred grown larvæ collected but very few moths were obtained, the Tachina maggots issuing from the dying and spun-up larvæ in large numbers. No ground for their reception had been furnished in breeding cases and they pupated among the leaves and excrement. At least 80 per cent of these larvæ were parasitized and but one of the flies has issued up to date. I also obtained one large cocoon of an Ichneumonid from larvæ in confinement and others were still found in nature during September.

C. thoracica was also infested by Tachina larvæ, but only about 30 per cent. were destroyed by these maggots. Two species of the flies have come out so far. *C. californica* was noticed full of eggs of these flies and some had previously been bred. An Ichneumonid was obtained from young larvæ the present year. Professor Rivers, of Berkeley, informed me the end of April that he had previously observed one of these larvæ at Bay View upon Willow, and accordingly a trip was made to that locality and this species was found as well as its tents, not alone upon Willow, but also on the scrubby Live Oaks growing there, Hazel, Wild Currant, *Rhamnus californica*, Blackberry, and other plants, showing that this species is not confined to Live Oak alone.

No Tachina has yet been obtained from the species in Santa Cruz Mountains, nor have I observed any eggs, but larvæ of this species placed upon Cherry and Prune at Alameda were badly attacked. The same species of Ichneumonid bred from larvæ of *C. californica* has also been obtained from this. This species was observed upon Plum, Prune, Willow, *Ceanothus* and *Cercocarpus*.

Two species of Ichneumonids were bred from the new species of the north, one from larvæ found at Tacoma, and the second from those found at Easton.

I may mention one Noctuid larva as very destructive to buds, young fruit, and foliage of fruit trees, chiefly Apple, Pear, Plum, and Prune. This is *Tæniocampa*, and I have full proof that the destruction of a large share of the buds and young fruit, so universally, yet incorrectly, attributed to birds on this coast, is due to this larvæ. In the very early spring, often in February, these moths make their appearance from hibernated chrysalids and copulate, and the female deposits her eggs, from two to three hundred or more, in crevices of bark. I found them in large numbers together, thrust deep into a place where one of the branches had broken off. The young larvæ soon made their appearance and in want of leaves began to feed upon buds and blossoms, and later on, as I have repeatedly observed on apple trees, upon the young fruit also. Within about 24 days these larvæ become full grown and enter the ground for pupation to remain in this state for nearly 11 months. If only one or two early broods occur upon a single ordinary tree, they will, in some cases, destroy most if not all the fruit buds before any leaves appear. The light green, white, variegated, and striped larvæ at rest on the under side of leaves during the daytime are not, especially by an untrained eye, very readily discovered, and hence are overlooked and the more innocent bird is made responsible for the damage done.

During April, 1888, when I had a brood of these larvæ in confinement at Alameda, a common titmouse, *Lophophanes inornatus* Gamb., was noticed flying constantly to an old apple tree and carrying off dozens of these very larvæ to a hollow tree not far distant, within which it had a nest with six young. These birds are quite plentiful at this time of the year and are the only enemy of this larva as yet observed. None of the numerous larvæ collected the present year appear to be parasitized.

By jarring the trees in the early morning these larvæ, especially the larger, will fall to the ground, and can readily be collected and destroyed. If the tree be only slightly shaken, all the mature larvæ will drop.

Caloptenus devastator, so well remembered since its outbreak in 1885, has again been on the increase the present season and is quite abundant in Sonoma County as well as around Alameda, where *Camnula pellucida* was equally as numerous. Aside from complaints in Sonoma County others were heard of in Yolo County. I quote from the Woodland Democrat of September 11, 1890:

> For the past few weeks our farmers have been watching their alfalfa crops very closely. The Army Worm and the Grasshopper are both here, although not in such quantities as in the early days. In some cases the crops in young vineyards have been entirely destroyed by them. C. Eakle lost all his grapes by the grasshoppers, and others have shared a like fate. In other cases the alfalfa crops have fared badly from the effects of the worm and the hopper. Mrs. P. Hannum had saved some alfalfa for seed, but the worm attacked it, and she was obliged to cut it for hay in order to save any of it. Mr. Hopkins, we understand, was caught in the same predicament, while the pastures of those who have lately irrigated and where the clover is just beginning to grow nice and green are full of the hoppers, and the worms have also attacked many others.

As yet no specimens from the above locality can be obtained, but it is more than likely that the injury was caused by several species and the Devastating Locust among them. One favorable season, however, should no parasites appear, would again show a marked increase in destructive numbers, and local outbreaks may be expected the coming summer.

ENTOMOLOGICAL NOTES FOR THE SEASON OF 1890.

By Mary E. Murtfeldt.

LETTER OF SUBMITTAL.

Kirkwood, St. Louis County, Mo.,
October 31, 1890.

Sir: Inclosed please find summary of my notes on injurious insects for the present year, as observed throughout the season in St. Louis County, and as compiled from correspondence with and occasional visits to other sections of the State. As in preceding years, many thanks are due you for various determinations and helpful suggestions.

Respectfully, yours,

Mary E. Murtfeldt.

Prof. C. V. Riley,
U. S. Entomologist.

GENERAL OBSERVATIONS.

The season of 1890 throughout the Mississippi Valley has been in many respects unusual. The winter months were characterized by a temperature much above the normal, by occasional very heavy rains, and, after the middle of January, by a prevalence of clouds and excessive moisture. Many shrubs, for example Forsythia, Cydonia, and Lilac bloomed in the open air about the holidays, while the buds of all fruit trees were much swollen, and peaches and apricots opened their blossoms in sheltered situations in February. During early March the mercury for the first time in the year dropped to the neighborhood of zero, and on the last day of the month occurred a phenomenal fall of snow. April also was cold and damp, and similar weather prevailed until the middle of May, the soil, except where drainage was exceptionally good, being in poor condition for planting. With the first of June excessive heat set in, and for seven consecutive weeks the mercury was seldom below 90° F. at midday, and usually approached or exceeded 100°. This extreme heat was accompanied by an equally severe drought for the same length of time, scarcely mitigated by two or three very slight and very local showers.

That the effects of such a season should be plainly marked on insect life is not surprising. The following memoranda show considerable deviation from the records of preceding years.

Chinch Bugs were not reported as injurious in any part of the State, and scarcely a specimen could be found during midsummer and early autumn.

Canker Worms.—Very few, and found mostly in orchards or on trees standing somewhat above the general level. The male moths were flying every month during winter, and an occasional female was also seen in January and February. Probably the severe cold of March destroyed a large proportion of the very young larvæ, more perhaps by retarding the development of the apple leaves than by the direct effects of the cold.

Of the few worms that were found later in the season taking their noonday siesta on the trunks and larger branches of the trees, quite a number were seen which had evidently been attacked by some Carabid or other predaceous species, the skin having been punctured and the fluids oozing out with every motion. All injured worms perished, but what the assailant was I was not able to discover.

Cutworms (*Agrotis* and *Hadena*).—Vegetable gardens in the spring enjoyed an immunity from these pests that was most welcome to the gardener. This was probably due to the fact that some of the most destructive species hibernate in the larva state, and the degree of cold not being sufficient to reduce them to complete dormancy they perished of starvation and dampness or fell victims to the birds, which remained with us in greater numbers than is usually the case. My memoranda show that very few Noctuid moths of any kind were taken at light previous to the middle of August. To this scarcity of Noctuid pests there were, however, two notable exceptions—that of *Gortyna nitela* and *Heliothis armigera*, which have seldom committed so great injuries to certain crops as during the present year. About the middle of June many samples of young corn and potato stalks were sent me that were being bored by the first-named larva, and it was then reported from some localities—among others from Kidder, Missouri—as having destroyed fully one-half the crop of potatoes. Its injuries to young corn were also extensive, but I have no data for making an estimate. It was also found in considerable numbers, when very small, in small grain. In this it could scarcely reach maturity, and probably migrated to the stalks of such more succulent plants as were conveniently near. In the case of the attack on potatoes a treatment with Paris green and flour was recommended, on the probability that in passing from one stalk to another the worm would obtain a sufficient quantity of the poison to destroy it. Of the success of this experiment, if tried, I have not been informed. It did not occur in any noticeable numbers in the vicinity of Kirkwood.

Heliothis armigera was very destructive on both early and late corn, especially on the latter. In the southern part of the State it injured the tomato crop to a considerable extent. Spraying with Paris green and with other arsenical compounds was tried with considerable success previous to the ripening of the fruit, but there is considerable danger in its use and it is best to thoroughly drench the plants that have been treated with clear water a day or two after the use of the insecticide. Experiment on a limited scale shows that it can be kept from corn by the same remedies, but how far this would be practicable in the field has not yet been demonstrated.

The Striped Flea-beetles (*Phyllotreta vittata* and *P. sinuata*) did not appear at all on early Crucifers, nor have they been observed in any considerable numbers in this vicinity at any time during the growing season. Whether this notable riddance was due to atmospheric conditions or to the scarcity of the fostering weeds, *Lepidium* and *Arabis*, I am not able to decide.

The Corn Flea-beetle (*Chætocnema pulicaria*) was reported to me from various localities as unusually numerous and injurious. Mr. Falcon, of St. Clair County, feared that he should lose his first planting from its attacks, but from later accounts the plants recovered more rapidly than he had expected.

The Plum Curculio was much reduced in numbers during winter, and as there was in this section, and indeed throughout the State, an almost entire failure of stone fruit crops, with the exception of the sour cherries, which the insect rarely attacks, there was very little of the work of the latter observed. A small proportion of the few early peaches that set were punctured, but that the midsummer drought prevented the development of the larvæ was indicated by the fact that such late peaches as there were did not show a single one of the food punctures which commonly so disfigure them. On one tree which the previous year had suffered so much in this way that the fruit was absolutely worthless, was a single peach that reached perfection without one stroke from the beak of a curculio; and similar observations were made on other trees on which a very little fruit ripened. Nor was I able to find *Conotrachelus* breeding in apples, although during June and July I examined nearly six hundred specimens of fruit, a few of which showed punctures that might have been made for food. Should other conditions be favorable, I think, so far as this insect is concerned, we may predict for 1891 fine crops of stone fruits.

Plant lice, always quite abundant in the spring, amounted this year almost to a scourge. Trees, shrubs, and herbs alike suffered, and for many plants there was no after-recovery. The species causing the most appreciable loss was probably the Grain Aphis (*Siphonophora avenæ*). It occurred throughout the State on all small grain, even on rye, causing, undoubtedly, some shrinkage of that crop as well as of wheat, but its most disastrous attacks were on oats. About the middle of May farmers began to be alarmed for the safety of this crop, and subsequent developments proved their fears to be well grounded. Letters of inquiry and packages of specimens came to me from all directions, and during a trip about the first of June, to Butler County, on the southern boundary of the State, I was able to observe for myself the dwarfed and sickly appearance of small grain everywhere along the railroad, attributable in all cases to the attacks of this insect. Shortly afterward the outfields in St. Louis County and in many other localities were plowed up and replanted to corn, which, owing to the drought and to its own insect enemies, was, in its turn, a poor crop. The unusual prevalence and unparalleled multiplication of *Aphididæ* was undoubtedly due to to the scarcity of their natural enemies, both parasitic and predaceous. It was not until the middle of June that the larvæ of *Syrphidæ*, *Coccinellidæ*, and *Chrysopa* became numerous, and, reënforced by parasites of the genera *Aphidius* and *Trioxys*, finally brought relief from the pests; too late, however, to prevent irreparable injury to many herbaceous crops, young fruit trees, and various sorts of shrubbery.

A somewhat remarkable development of the season was the appearance in unusual numbers of many insects not often accounted noxious, and the reappearance of some species not observed in this locality for many years.

Among the former may be mentioned the great abundance and variety of "stinging" larvæ, principally *Limacodes.* For the first time in my experience the beautiful larvæ of *Parasa chloris* were so abundant on some young apricot trees in the orchard of one of our neighbors as to do great damage to the foliage. When full grown, three-fourths or more of an inch in length, thick, oblong, sub-cylindrical, gaily striped longitudinally in carmine red, purple, and bright yellow, the stinging spines concealed in the two rows of deflected bright yellow plumes that adorn the back, gliding with slow, graceful motion over the leaves, they were almost too ornamental to doom to destruction. As they were very voracious, however, the latter was a necessity of the case. Those that were preserved were fed to maturity on the leaves of Chickasaw plum, to which they were transferred without difficulty.

Euclea querceti H. S., of the same form and size as *P. chloris*, but much less brilliantly colored, being of a dull, mottled green, with two or four dark purple-red spots on each side of the dorsum, and having the plumose spines pale green, appeared on Plum, Cherry, and Apple in the orchard, as well as on Sycamore, Post Oak, and Wild Cherry in the forest. It was not, however, in any destructive numbers on any fruit tree.

So far as coloration is concerned this larva varies greatly. The crimson sub-dorsal spots, usually quite large when there are but two, are in some examples smaller and less conspicuous and are followed posteriorly by a second pair. The longitudinal ridges on which these are situated, and from which also proceed the larger urticating spines, vary in hue from pale pea green to yellow and bright orange. A second variety was so distinct as to be described, previous to breeding, as another species. This is entirely of a pearly, translucent white color, with fine, wavy, purple lines, one on each side of medio-dorsal space and two others lower down on each side inclosing the second row of spines, which, like the general surface, are translucent white. There is a large purple spot a little back of the middle on each side of the dorsum. I have found this variety only on pear, and it is rather rare. The cocoon is spun among the leaves and does not differ in color, form, or texture from those of other *Limacodes.* The moth bred from this pale larva does not differ from those of typical *querceti,* being of a rich fustic brown, with bright green and velvety black ornamentation. In the size of the green and black spots and in general intensity of color a series of moths of this species also exhibit considerable variation.

The almost equally beautiful and even more strikingly marked Saddle-back Caterpillar (*Empretia stimulea*) occurred in very unusual numbers on Plum, Pear, Chestnut, Maple, and Wisteria vine, doing considerable damage—especially during the semi-gregarious period, which continues to the third molt—to the foliage of the fruit trees attacked.

Phobetron pithecium and *Limacodes scapha* were other species of this group observed.

Lagoa crispata was quite numerous on White Oak and Chestnut, and colonies of *Saturnia io* appeared on Corn and Sassafras and defoliated several rose bushes in our garden before we discovered the authors of the mischief. Altogether there was quite an array of "urticators," and gloves were very necessary to preserve the hands of the collector in taking them and also in caring for them in the rearing cage. They seem to dispense stinging points all over the foliage over which they crawl and all about the cage in which they are confined. I have often had my hands smart for hours after changing the leaves and cleaning the cage in which these larvæ had been reared, long after they were inclosed in their cocoons.

There was throughout this and contiguous States a notable outbreak of *Datana* both *D. angusii* and *D. ministra,* but especially the former. This species appeared on the Walnut in June, and the second brood again in August, and from the excessive and repeated defoliations it is probable that many fine trees have been destroyed.

During a journey taken about the 1st of September, numbers of trees were noticed bearing what would have been a heavy crop of nuts, but absolutely leafless, while the trunks were almost covered with larval exuviæ. The nuts were, of course, small and imperfect, the shrunken husks clinging to the seed. Several collections of the walnut-feeding larvæ were sent me, but not having a supply of walnut leaves convenient, I was not able to rear any of them, as they refused to accept as a substitute the leaves of hickory or of *Rhus glabra* or *copalina,* although some years ago I bred them from the latter.

During September the black-necked larvæ of what I suppose will prove to be *D. ministra*, Drury, appeared on post oaks in Kirkwood and vicinity, defoliating portions of the trees infested. From their gregarious habit and their susceptibility to poison they were easily routed. Even a stream of water turned upon them from the spraying pump would dislodge and bring them to the ground, where they were easily killed.

Orgyia leucostigma, a species formerly abundant in this locality, but which I had not observed for ten or twelve years, was found on Sycamore (*Platanus*), on which, strange to say, it would not feed after the second molt, and consequently all caterpillars left on the tree perished before attaining half their growth. The question suggested by this observation was how the young larvæ came to be upon this tree which so evidently did not suit them for food. I could not find either cocoon or egg mass of the mother insect, nor were any of the larvæ discovered in the adjacent orchard.

Ichthyura inclusa, another species not observed here for many years, appeared on willows in great numbers in September, but coming so late in the season the defoliations did no serious damage.

In concluding these notes I wish to mention an insect that will probably prove most efficient in ridding the country of the pest of the Web Worm (*Hyphantria cunea*). This is the larva of a small and inconspicuous Carabid of the genus *Plochionus*, bearing the appropriate specific name *timidus*. I had observed during the month of June that the greater number of the webs of the caterpillar were unusually small and incomplete and seemed to have been deserted much sooner than usual.

Before I had time to investigate the matter, I received from Mr. J. C. Duffey, horticulturist at the Shaw Botanical Garden, a colony of the worms, interspersed among which were numerous small active Carabid larvæ, which Mr. Duffey informed me were preying upon the former. The collection was placed in a cage and arranged for convenient observation, and I very shortly had ocular demonstration of the correctness of Mr. Duffey's assertion. Many interesting observations were made upon these small but ferocious larvæ before they changed to pupæ, and the appearance of the perfect insect was awaited with much interest. The first beetle developed about the middle of July and proved to be the species named.

Comparatively few webs of the second brood of *Hyphantria* were seen in and around Kirkwood in August, and extensive examination revealed the fact that fully three-fourths of these also contained larvæ of *Plochionus*, which were busily engaged in reducing the numbers of the rightful inhabitants. Nor is the beetle confined in its diet to the web worm. I found the larvæ repeatedly during the present autumn in the masses of leaves webbed together by the somewhat gregarious larvæ of a Tortrix (*Cacœcia fervidana*) and between the two leaves webbed by various Tineids, especially *Cryptolechia nubeculosa* and *C. schlegerella*. (I doubt not I may have occasion to deprecate its work in the future in these groups.) That this *Plochionus* had not appeared this season much to the east of St. Louis was evinced by the much webbed and defoliated orchard and forest trees noticed in Illinois and Indiana in August and September.

As Mr. Duffey proposes soon to publish a history of the insect, with detailed descriptions of its various stages, I defer offering my own notes upon its habits and forms until after the appearance of his paper.

A FEW MORE INJURIOUS MICROS ON APPLE.

A very considerable number of Microlepidoptera, including *Pyralidæ*, *Phycitidæ*, *Tortricidæ*, and *Tineidæ*, have already been characterized and catalogued among the more or less injurious insects of the orchard and garden; but the observations of almost every year add to this list, and I propose here to briefly describe a few which have not as yet been placed on the roll, but which in this locality are annually so numerous as to commit appreciable injury.

PENTHINA CHIONOSEMA, Zell.—The larvæ of this beautiful species were, last year, uncommonly abundant during the month of May on the leaves of apple, particularly in young orchards. They fold the leaves at the midrib, or sometimes one edge over to the midrib, fastening the edges all around firmly and feeding upon the inclosed upper surface.

Larva.—The larva is not especially characteristic, being of a pale opaque green color, without maculation, except the rather inconspicuous glassy piliferous plates. Head pale yellow, tinged with green, legs similarly colored; length from 16 to 17^{mm}; diameter, 3^{mm}. Form subcylindrical, tapering but slightly either way from middle.

When full grown it incloses itself under a rolled edge of the leaf, lining and strengthening the tube thus formed with a white silken web. The moth appears early in June, and I have no record of a later brood, although there may be one.

The original description, by Professor Zeller, is not accessible to me at present, but it will suffice to note the following characters:

Palpi and tuft of the head rich ferruginous, antennæ scarcely half the length of the wing, fine, gray brown. Thoracic tuft dark brown. Wing expanse from 15 to 16 ^{mm}—rather more than a half-inch. Ground color of primaries somewhat mottled dark brown, with a slight suffusion of olive, diversified by three broad, indistinct, irregular, obliquely transverse bands of purplish gray, having a somewhat metallic reflection; these transverse bands broaden toward the inner margin, where they almost coalesce. On the costal edge is a large, milk-white, rounded triangular or nearly semicircular patch, extending along the costa from the middle third, inclusive, almost to the apex, constituting a most distinguishing and ornamental character. Cilia purplish gray. Secondaries, silky, pale brown with lighter fringes. Abdomen and legs pale brown. Under side of wings pale, rosy brown, the large costal spots on this side inclining to orange.

PROTEOPTERYX SPOLIANA Clem.—The larva folds and webs into clusters the young leaves of apple during the month of May, appearing, preferably, on the shoots of small trees.

Larva.—When full grown it measures 10^{mm} in length by $2\frac{1}{2}^{mm}$ in diameter, the form being rather thick cylindrical; color translucent white, tinged with yellowish green; surface velvety; piliferous plates small, glassy, giving rise to short, fine, light hairs. Head and cervical collar same color as general surface or a little deeper in shade, inclining to amber. The head is broad and flat, with red-brown trophi, and a very large dark brown spot on each side. Legs and prolegs same color as general surface.

When full grown it forms a tough, oval cocoon, thickly covered with particles of soil, on the surface of the ground, occasionally just beneath it. It is but single-brooded, and is very difficult to rear in confinement, as it must be kept through the heat of summer and the cold of winter, and if a little too damp it molds, while if moisture is withheld it dries up. From almost innumerable larvæ collected during several years I have only been successful in rearing two or three specimens, enough, however, to determine the species, and, as the moths are always abundant early in the spring on the trunks of orchard and forest trees, there need be no scarcity of specimens for the cabinet.

Adult.—The moth expands 15^{mm}, wings rather narrow. In color it closely simulates the bark of the trees on which it naturally rests. The vestiture of the head is brown interspersed with gray; palpi and antennæ cinereous; thorax and abdomen pale brown. Primaries brown, with a series of oblique double silvery streaks all along the costal edge, extending about one-fourth across the wing; a large silvery spot of irregular outline, inclosing a patch of dark brown, is situated near the outer edge of the wing, and a less distinct patch of silvery scales occurs on the inner edge near the middle, while a shading of the same color modifies the brown tint on other portions of the wing. Cilia pale brown and cinereous intermixed. Secondaries cinereous, shading on costal edge to pale brown; cilia dingy white. There is some variation in distinctness of the markings and depth of coloring.

STEGANOPTYCHA PYRICOLANA Riley MS.—This is somewhat similar to the above in coloring, but smaller and proportionally broader winged. This bores the shoots of the second growth of apple in August and September, occasionally on recently planted trees, inflicting serious damage. The larva spins scarcely any web, but bores downward through the terminal bud, entering the stem for from half an inch to an inch, sometimes blackening all the growing points of a young tree.

Larva.—When full grown it is 8^{mm} long by $1\frac{1}{2}^{mm}$ in diameter, slender, subcylindrical, tapering slightly in both directions from middle segments; surface smooth; incisions deep; color, pale cream yellow, somewhat translucent; the dorsal surface beautifully mottled with rose red. Piliferous warts and hairs only discernible with a lens. Ventral surface pale, slightly concave, and much wrinkled. Head elongate, cordate, pale brown, shading to dark brown on the middle of each lobe; trophi prominent, dark brown, with two or three long light hairs on each side. Supra-anal plate oblong, large, dark, smoky brown. Legs and prolegs rather unusually developed.

I failed to rear the first specimens collected, most of them wandering around in the jar until they died. Subsequently, by supplying them with bits of pith or bark in which to bore, I succeeded in getting three or four imagos between the last of September and the first of October.

The moth expands 10^{mm}. The head, thorax, and abdomen are densely covered with long hair-like scales, of a dull gray-brown color with bluish reflections. Basal half of primaries of similar color, but with more intermingling of blue and brown scales. About the middle the wing is crossed by a broad, irregularly outlined band of rich brown, sparsely intermingled with silvery scales, and the terminal third is quite evenly mottled in brown and leaden gray, the costal edge of this portion being ornamented with alternate oblique light and dark streaks extending about one-fourth across the wing; cilia bluish gray; secondaries lustrous pale brown, shading to cinereous on costal edge; cilia dingy white.

Professor Fernald, to whom a specimen was shown, considers it identical with Clemens's *S. salicicolana*, which I believe breeds in willow galls, but Dr. Riley pronounces it distinct, and he has types of Clemens's species.

GELECHIA INTERMEDIELLA ? Chambers.—This pretty Tineid appears in its larval form on the tender leaves of apple early in May and again in September. It gnaws the parenchyma from the upper surface, giving the leaves a burned and eroded appearance.

Larva.—8^{mm} in length when mature, slender, cylindrical, tapering slightly in both directions from middle; incisions deep, giving it a submoniliform appearance. General color bluish green, acquiring a purple hue at maturity, with faint longitudinal stripes of cream white. Head pale brown with a tinge of green, ornamented with cream-colored markings on each side and a row of graduated cream-colored dots down the middle of the face. First segment narrow, without perceptible shield. Thoracic legs long, whitish, proceeding from papillated projections on the ventral surface.

This larva covers the leaves with fine web, in which it moves with great agility, and in which it rests suspended, without touching the surface of the leaf, except when feeding. It is semigregarious and very irregular in its development, some clusters of the leaves showing very recently hatched young, while on other clusters they will be full grown. It pupates on surface of the leaf under a little round cover of dense web, similar to those under which some spiders protect their eggs. The moths emerge in about 3 weeks after pupation and hibernate in the perfect state.

Adult.—A beautiful species, expanding 12 or 13^{mm}. Head and thorax dark gray, more or less suffused with crimson; palpi dark gray, annulated with rosy white or pale pink. Ground color of primaries leaden gray and rosy white; scales about evenly intermixed. Three very irregular and variable, often interrupted, bands of rich olive brown cross the wing, intermingled with some light golden brown or ochreous scales; near the base and center of the wing these form quite distinct patches. The apical third of the wing is margined with alternate dark brown and rosy patches; cilia gray. Secondaries cinereous, with paler cilia. This species is closely allied to both *roseosuffusella* Clem., and *rubensella* Cham., resembling in coloration the latter and in size the former. Mr. Chambers says of it: "Intermediate between *roseosuffusella* Clem., and *rubensella* Cham., with one or the other of which it has hitherto been confounded. The third joint of the palpi is longer and more acute than in *rubensella,* more like that of *roseosuffusella,* but the fore wings are much less roseate than in either of the two other species, frequently showing no tinge of the roseate hue. * * * As in *rubensella* (and sometimes in *roseosuffusella*), the first dark band does not cover the base of the wing. The second band is like that of *roseosuffusella,* but the third extends across the wing, the dorsal portion being, however, paler than the costal, and the costo-apical part of the wing is ochreo-fuscous.

This description, or rather these distinctions, of Mr. Chambers apply to some examples, while to others they do not. Many specimens are very roseate and richly colored, while a few appear almost plain black and dull white. The three species are best distinguished in the larva state, in which there are very decided differences. *G. roseosuffusella* feeds on Clover, *G. rubensella* on Oak, while the species under consideration, so far as my observations show, is confined to Apple. The larval characters are also very diverse in the three species.

EXPERIMENTS WITH INSECTICIDES.

During the great prevalence of *Aphididæ* in the spring I made much use of pyrethrum and of the X. O. dust. Of the value of the former as a remedy for these pests, except in the case of one or two species, I have no occasion to change the favorable opinions already repeatedly published. The X. O. dust was thoroughly tested on the following Aphids: *Aphis mali* and *Schizoneura lanigera* on Apple; *Aphis prunifolii* on Plum; *Siphonophora rosæ* on Rose; *Myzus persicæ* on Peach; *Aphis brassicæ* on Cabbage; *Aphis* sp.? on Cucumbers and Squash; *Siphonophora* sp.? on Lettuce; *S. cratægi* on Thorns; *S. rudbeckiæ* on Solidago; *Aphis ambrosiæ* on *Ambrosia trifida*, and *Aphis chrysanthemi?* on Chrysanthemum. With its effects on all of these I was well satisfied, although in some cases it took several dustings to thoroughly clear a plant. When applied with a powder bellows it causes the insects to drop to the ground at once, where they may be pressed into the soil with the foot or patted down with a trowel. The more delicate species succumb to a single thorough dusting and never recover from the effects of contact with the powder. This preparation will also destroy *Siphonophora avenæ*, but whether it could in any way be applied to a field of infested grain has not been demonstrated.

The Black Chrysanthemum Aphis is one of the greatest pests of the flower garden and gives much trouble to both amateurs and professional florists. It hibernates on the plant and attacks the stolons as soon as they appear in the spring, and unless great care is taken to eradicate it, it is more or less numerous on the plants throughout the summer, dwarfing and deforming them by its punctures and by the loss of sap which it appropriates. As soon as the buds are formed it seems to develop with four-fold fecundity and requires assiduous attention to keep in check. The Buhach or pyrethrum powder is utterly useless against this species, probably because the plant from which it is made is so close an ally of the Chrysanthemum. The X. O. dust, composed of creosote and tobacco, is the best remedy within my knowledge, killing the Aphis without the slightest injury to the plant. I have found it best to apply during the middle of the day when the dew is off. A few minutes after dusting the plants, I pass along the rows or among the pots, and give each branch a smart shake or a blast of air from the empty puff, and every Aphis that has not previously dropped is dislodged, and "to make assurance doubly sure," it is stamped into the earth. On most of the insect foes of the plant lice the dust produced no disastrous effect, but the larvæ of Syrphidæ would, in some cases, not recover from the pungent coating.

Arsenites of ammonia.—This new preparation, for which F. J. Andres, 25 Pearl street, New York, is the agent, was sent to me for experiment, in accordance with directions from the entomologist of the Department of Agriculture. It did not reach me until about the 1st of June, too late for use on a number of insects. It is a clear solution of arsenic in aqua ammonia, and apparently does not differ much from a preparation of my own devising, as reported on two years ago, and with the effects of which on vegetation I was not entirely satisfied. The directions accompanying each of the gallon bottles, in which it is put up, are to use one tablespoonful of the liquid to a gallon of water.

June 7.—Weather clear and hot. Prepared a quantity of the fluid as directed and had it applied to the following plants: To potatoes, on which were a few *Doryphora* larvæ; to rose bushes, on which still lingered a few larvæ of *Selandria rosæ*, *Characlea angulata*, and *Amphipyra pyramidoides;* to cabbage, covered with full-grown and young larvæ of *Pieris rapæ;* to cucumbers and squash infested with *Diabrotica.* It was too late in the season to test it thoroughly on apple for the Codling Moth, and as there were scarcely any peaches or plums or curculios, its effect on the latter insect can not be reported upon. Portions of the trees as well as of cherry were sprayed to discover its effect upon the foliage.

June 9.—Made the rounds of all plants sprayed and noted results as follows:

Potato plants slightly scorched, edges of the leaves curled, larvæ of *Doryphora* mostly on the ground dead, beetles sickly.

Rose bushes uninjured, or very slightly burned where the leaves were very tender; all larvæ killed.

Cabbage uninjured; all *Pieris* and other larvæ killed. Cucumbers much injured, squash less so; striped beetles killed or vanished.

Peach and cherry foliage badly scorched, turned yellow. Plum and apple only slightly injured. Other experiments later in the season made with one tablespoonful of the poison to one and one-half gallons of water were not injurious to any except the most delicate foliage, while in most cases it sufficed to kill *Sphinx quinquemaculata* and *Heliothis armigera* on tomato, *Darapsa myron*, *Cidaria diversilineata*, *Psychomorpha epimenis*, and *De mia maculalis* on grape, with but slight damage to the foliage. The fruit being "bagged" was not touched by it. *Empretia stimulea* on plum and pear and *Datana ministra* on oak also speedily died from eating leaves that had been dampened with it.

I do not consider these experiments conclusive, as with the heat and drought, vegetation was not by any means in a vigorous condition, and therefore more liable to injury from poisonous applications. It is a most convenient preparation and leaves no sediment to disfigure the foliage, and will, I trust, be found, by more thorough experiment, efficient as an insecticide when used of a strength that will preclude injury to foliage.

Late in the summer a preparation of petroleum sludge with soap was sent me from the New York Chemical Works for trial, but there were very few insects at that time on which to test it, while its almost intolerable and persistent odor is really a serious objection to its use, especially in small gardens.

In making my experiments, I have used the Lewis Combination Force Pump and Syringe, and consider them well adapted for use in small orchards and vineyards, and especially adapted for purposes of experimentation, where the larger and heavier appliances are not necessary.

REPORT ON WORK OF THE SEASON.

By HERBERT OSBORN.

LETTER OF SUBMITTAL.

AMES, IOWA, *October*, 1890.

SIR: I transmit herewith a report upon the work of the season, including mention of certain insects that have been observed during the season and notes regarding certain others, observations on which are in progress, with the expectation of giving more detailed accounts of their life histories and habits.

There is much yet to be done on the insects affecting grass before anything like a full report can be made upon them, but I shall hope to bring the work of the present season into shape for submission at the end of the year.

The work on the parasites of domestic animals has been continued and a part is already submitted for printing, while a considerable amount of other matter is in form to be presented at an early date.

Very respectfully,

HERBERT OSBORN.

Prof. C. V. RILEY,
U. S. Entomologist.

During the past summer there has been no great depredation by any single insect pest in the State, but a number of the common species of insects have been working with their accustomed energy, and the losses from this source in the State have probably been up to the average of ordinary seasons.

The observations on insects affecting grass crops have been continued, and I am only the more strongly impressed with the importance of the insects affecting these crops in this State, and believe that the estimates given in my last year's report as to the probable loss from this source to have been by no means overstated.

Judging by the reports of the correspondents of the Iowa Weather and Crop Service, who represent every section of the State, the insects that have caused most extensive injury are those infesting meadows and pastures and sod land planted to corn. Not only are there numerous reports of injury by insects to timothy, to pastures, and to corn planted on land previously in grass, but numerous mention of poor condition in meadows and pastures, shortage in grass and hay crop, etc., which, to any one familiar with the great number of insects now infesting grass land in this region, tell a certain story as to at least one of the great sources of loss.

Frequent mention is made of the Cutworms, Grubworms, Wireworms, etc., and it is evident that a very great variety of species are included in this list; but while I am certain that many species of Cutworms belonging to the common species of Noctuidæ are included in this list, I believe that much of this injury is due to the species of Crambus treated in detail in my report for 1887, the Dried Crambus (*Crambus exsiccatus*), or as called in the larval stage, the Sodworm or Turf Webworm. This has been very plentiful here in the adult form the present season, though by no means so abundant as in 1887, and I have no doubt that it has been as abundant in other parts of the State. The work of this species in meadows, however, would not be readily distinguished from that of Cutworms by those unfamiliar with the habits of insects, and even in corn the effect on the plants is not easily to be distinguished from the effects of Cutworms, Wireworms, or other forms of insects attacking the stalks at or near the surface of the ground.

LEAF HOPPERS IN GRASS.

In my report of last season I mentioned a number of species of leaf hoppers (*Jassidæ*) that are destructive in grass land. Further observation and collection in this same line has served to strengthen my opinion as to the great amount of injury to be attributed to these minute insects. A number of species particularly of the genus *Deltocephalus* occur in immense numbers in grass land, and among the most common of those observed here are the *Deltocephalus* (*Jassus*) *inimicus* Say, treated of in last year's report, but associated with these are *D. debilis* Uhler., *D. Sayi* Fitch, *D. Melsheimeri* Fitch, and a number of species apparently as yet undescribed. A fuller report upon these I hope to make a little later when material on hand can be more fully examined and a more complete statement of results given, but it may be in place to mention as one of the results of this study that I have been convinced that these insects are a very important factor in the production of "silver-top" in grass, this being one of the effects produced by their suction of the juices of the plant and resulting when they penetrate the succulent portion of the stem at the base of the terminal node. That other insects may and do cause this same form of withering and injury to grass I do not deny, but in a great number of examinations of injured stems I have in the great majority of cases found no insect within the sheath of the injured part, and feel positive that for these the injury could not have been produced by Thrips or Meromyza or any insect working within the stem while the presence of immense numbers of the leaf hopper on the affected plants and the presence of punctures show clearly the possibility of the injury being due to them.

This question has been more fully discussed in a paper read with your consent before the Association for the Promotion of Agricultural Science at the Indianapolis meeting. In that paper I have referred to different explanations for the silver-topped condition of grass and presented the grounds for my own opinion that for this locality and in blue grass the injury must be referred mainly to these Jassidæ. From the fact that these Jassidæ are exposed to the application of remedies that would not affect insects protected in the sheath it is evident that the adoption of measures to destroy these, as suggested in my last year's report, should result in a decrease of the "silver-top."

GRASSHOPPERS AND CRICKETS IN GRASS.

The common species of grasshoppers or locusts have been as usual very plentiful, *Melanoplus femur-rubrum* probably heading the list for abundance, but several other species, as *M. differentialis*, *Dissosteira carolina*, *Tomonotus sulphureus*, and *Arphia sordida* form a very conspicuous part of the grass-eating species. For the present season also there has been a very great abundance of the little field cricket, *Nemobius vittatus*. This was noticed as especially abundant on sunny hillsides in pastures and in many places aggregated in such numbers as to completely cover the surface of the ground. While this species has been rather frequently mentioned among the species common throughout the country and its herbivorous habits accepted, so far as I know by all, there has been apparently little attention to it as a destructive species or one worthy of particular attention on account of the injury it may cause in pastures.

It is quite evident, however, that when occurring in anything like the abundance in which it has been observed here this season it must be the cause of no little loss, and it may very well be associated with the more frequently mentioned locusts in the category of destructive meadow insects.

MISCELLANEOUS NOTES.

The Apple Leaf Skeletonizer (*Pempelia hammondii*) has been sent me this season from near Des Moines, where it was reported as doing considerable damage. This insect has been comparatively rare in the State for a number of years, but from the account received of its appearance this year it must have been in such numbers as to cause no little damage, and it is to be hoped that prompt measures will be adopted by the fruit-growers of that locality to prevent its spread.

The Turnus Butterfly (*Papilio turnus*) has been noticed as more than ordinarily abundant, the larvæ occurring in considerable numbers on various trees, especially on plum trees in this vicinity. While the species has seldom assumed an economic importance, in this State at least, it may be that it will require occasional attention, and it will of course readily succumb to the treatment by spraying, so efficacious for leaf-eating larvæ.

The Cherry Slug (*Selandria cerasi*) has also been quite plentiful and damaging cherry and plum trees. It would appear that this insect has been rather more than usually common in a considerable territory the present season, as I have heard of it from various localities. It is generally the case, however, that it does little damage for more than one or two seasons in succession, so that it seems hardly necessary to take any great amount of trouble in dealing with it unless it is working destructively upon particular trees, when the usual poisonous sprays suffice to rid the trees of its presence.

The Handmaid Moth (*Datana ministra*) has been on the increase apparently for a number of years past and for the last two years has succeeded in defoliating quite a number of trees in the vicinity, especially hickories and black walnuts. As mentioned in another place, the arsenite of ammonia was used in treating it this fall and proved very efficient in destroying the insects. Previously, we have used London purple for this purpose, and there is apparently little choice, unless there be sufficient difference in price to render one cheaper than the other. It is important in using any of the poisonous solutions for this species to spray the whole tree or as much of it as possible, since when only the part where the worms may be working at any particular time is sprayed, they are very likely in their next move to occupy some part where there is no poison to affect them, and they may in this way escape until they have caused considerable damage to the tree.

Abbot's White Pine Worm (*Lophyrus abbotii*) has appeared in the State, and so far as I am aware it is the first time that this destructive insect has been brought to notice in Iowa. It was sent to me from Farley and with the report that the evergreen trees were suffering severely from its attacks.

The Corn Root Worm (*Diabrotica longicornis*) is evidently on the increase and gradually extending throughout such localities as it has not hitherto occupied. Here, it appears very abundantly in the adult stage, and in fall, collecting in great numbers on flowers. So far as I know there has not as yet been any very great injury to the corn in the vicinity, but probably the worms occur in considerable numbers scattered through the various fields, and it is probable that in a short time they will multiply to such an extent that in fields kept long in corn they will cause serious loss.

The species of *Diabrotica* infesting squashes, melons, etc., *D. vittata* and 12-*punctata*, have been very abundant the past season, though perhaps not more so than is common for them, but the crops they infest have required attention in order to prevent serious loss.

The Potato Stalk Weevil (*Trichobaris trinotatus*) was observed this season for the first time and occurred in such numbers as to cause considerable damage. It was first noticed by Mr. F. A. Sirrine, a special student in entomology, at present assisting in the botanical work in the Experiment Station. It is quite likely that the insect has been present in previous seasons in small numbers, but it has not been taken even in the adult form, in this locality till this summer, so that it seems more likely that it has been introduced in some way quite recently.

TESTS OF ARSENITE OF AMMONIA.

During the month of May I received instructions from Mr. Howard to make tests of an insecticide put on the market by Fr. Jac. Andres, of 25 Pearl street, New York, under the name of arsenite of ammonia, as agent for the Caspar Schneider Chemical Works. In due time the samples came from the New York firm and I proceeded to make such tests as were possible to determine both the effects upon various kinds of plants and its effectiveness in killing insects.

On the morning of May 30, 1890, between 9 and 10 o'clock of a hot, sunny day, I sprayed the following plants with a view to giving a thorough test of the effect on foliage:

Squash vines infested with *Diabrotica vittata.*

Cucumber vines infested with *Diabrotica vittata.*

Potato vines infested with *Epitrix cucumeris.*

Plum, Cherry, Box-elder, Willow, Elæagnus, Elm, Mountain Ash, Birch, Apple, Raspberry, beans, grass, and clover.

The results were watched closely for a number of days but the record of June 2 gives the results for the entire set. On that day a careful examination was made of all the plants that had been treated and it was found that in no case could there be found any injury to the foliage, except possibly a slight injury to the elm and the beans, but the injury was so slight, if any, in these cases that it could hardly be charged with certainty against the arsenite. The solution in this case was as given in the directions, a tablespoonful to an ordinary pailful of water, and the conclusion was that with this strength it could be applied without danger to any of the above-named plants.

On the squash vines and cucumber vines the beetles seemed much less abundant, but I was unable to find any dead insects around the vines. The hills treated, however, remained quite free from further trouble from these insects, while others in the vicinity were seriously affected. The failure to find dead beetles under the treated plants might easily result from the insects flying away after eating the poison to places of shelter and dying there. The same was true of the flea-beetle affecting potatoes. The beetles seemed much less abundant, but no dead ones could be found under the treated vines.

While it was so late in the season that it was not expected that this test would give any definite results as to the effect on the codling moth, it is worthy of mention that the branches of the apple tree sprayed with the arsenite were loaded with apples, while the other portions of the tree were much less fully loaded.

The apples also of this portion were quite free from worms, though in the late fall they were of course exposed to the action of the second brood and a portion of the fruit was found infested. While this is not given as a good example of the effect of spraying, it seems strong enough certainly to warrant the conclusion that the arsenite of ammonia will prove as effectual as any other form of the poison against this pest.

There were none of the Colorado Potato Beetles to be found in the vicinity, so the poison could not be tested with them, a test that would have been of course more satisfactory, especially with the larvæ, because of the fact that the dead insects can afterward be found readily around the treated vines.

I was able, however, to give a thorough trial of the insecticide properties of the substance later in the season on the common Handmaid Moth (*Datana ministra*), which was very plentiful on some of the hickory and black walnut trees in the vicinity. A single application of the poison was found to kill the caterpillars in large numbers, evidently affecting all that fed upon the leaves that had been reached by the poison. Dead caterpillars began to be found in 24 hours from time of application, and for two or three days afterward the caterpillars were dying off rapidly. The application was in this case made a little stronger than in the first trials, and in a few days the trees showed some injury from the effects of the arsenite, so it seems quite evident that the strength for these trees must be kept within the limits indicated by the directions. The liquid is very convenient to mix with water, and forms probably a very uniform mixture, so that it seems to possess some points of superiority ver the arsenites in solid form.

REPORT ON SOME OF THE INSECTS AFFECTING CEREAL CROPS.

By F. M. WEBSTER.

LETTER OF SUBMITTAL.

LA FAYETTE, IND., *October* 22, 1890.

SIR: I herewith submit my annual report of observations on some of the insects affecting cereal grains. For assistance in carrying on the experiments connected with the studies of the Hessian Fly, I am greatly indebted to the following gentlemen: Hon. Samuel Hargrave, Princeton; Mr. W. S. Ratliff, Richmond; Mr. Miles Martin, Marshall; Hon. W. Banks, La Porte, and Hon. J. N. Lakta, Hawpatch; to Purdue University, and later the experiment station. I am also under obligations for use of land, seed, and labor in carrying out my own experiments here at La Fayette.

To yourself especially, and others of the division, I am under many obligations for the determination of specimens and other numberless favors.

Respectfully submitted.

F. M. WEBSTER.

Dr. C. V. RILEY,
U. S. Entomologist.

THE HESSIAN FLY.

Number and Development of Broods.

My experiments, notes, and observations upon this insect extend over a period of a little over six years, and while it received little more attention than was given other wheat-destroying species, a considerable number of facts have accumulated which, while not by any means clearing up all of the mysteries of the pest, will nevertheless serve to throw some light on several obscure points. Unless otherwise stated, all of my observations and experiments herein recorded relate to the State of Indiana, extending from latitude 37° 50′ to about 41° 45′ N. The exact latitude of many places of observation is given, not so much for the American reader or investigator as for those of other countries, notably England and Russia.

My experiments and observations have been carried on almost exclusively out of doors and very largely in the fields, as I consider indoor and breeding-cage observations on this species, except for the purpose of securing specimens and parasites, of very doubtful value from an economic standpoint or as indicating its normal habits. The observations have many of them been once and often twice substantiated.

In ordinary seasons and throughout the area above indicated the statement made long ago by Dr. Fitch that the Hessian Fly is double brooded is true. While in the southern portion of the State the fall brood of adults seem to appear some weeks later than in the northern part, nevertheless I have found but two destructive broods. Between these two broods, however, is a considerable mass of fluctuating individuals, the true position of which is rather anomalous.*

At LaFayette, Ind., latitude 40° 27′, wheat plants were transferred from the fields to the breeding cages April 5, 1890, and kept out of doors. The seed producing these plants had been sown the preceding September 3. On April 17 a female emerged, and a male appearing soon after, these, on April 22, were both placed together on young growing wheat planted in a breeding cage, out of doors. From these adults were secured June 8. The attempt was made to follow the offspring of these, but failed on account of the wheat being killed by rust. On June 7, and also on the 14th, 1888, in the same locality, adults were observed ovipositing, the eggs being placed on the youngest and most tender shoots, and there was every evidence that these eggs developed through the larval to the flaxseed stage by early July. Besides, I have observed in the same locality late-growing shoots literally overrun with very young larvæ on the 26th of June, and found larvæ as late as the 10th of July.

On October 16, 1887, Mr. W. S. Ratliff, who made a great number of experiments for me, near Richmond, Ind. (latitude 30° 51′), secured adults from a small plot of wheat plants which appeared above the ground September 4. From a plant from this same plat that had been transplanted indoors, he secured an adult female 11 days earlier. In either of these cases with favorable weather the female could have sent her offspring into the winter in the flaxseed state. Mr. Ratliff also observed adults on July 10, 1887. At La Fayette, Ind., the same autumn, I saw females ovipositing on November 3, in a temperature of 64° F., among the plants. From a plat sown August 13, and which came up on the 17th, I obtained adults of both sexes on October 1, 44 days after the plants appeared and 48 days after sowing. That larvæ, even though quite immature when winter begins, may survive till spring has been demonstrated again and again, and was especially true of the exceedingly mild winter of 1889–'90. In fact, by a series of sowings all

* Dr. Fitch states that the eggs of the fall brood are deposited in the State of New York early in September, and also that "the deposit is doubtless made later to the south of us than it is here in New York." (*Seventh Report.*) Mr. Edward Tilghman observed oviposition in Queen Anne's County, Maryland, about latitude 39° to 39° 30′, during the second week in October, and mentions it as of usual occurrence. (*The Cultivator, May,* 1841.)

stages of the insect can be produced continually from April to October, and by keeping a cage indoors I have produced adults in abundance in January.

As Dr. Lindeman has well stated, the puparia are greatly influenced by environment, temperature, etc., and this is probably true of the other stages, larvæ of different ages being, for all we know, influenced to a different degree. To these facts must be added another of considerable moment, viz, while nominally two brooded, flaxseeds collected by me in the spring of one year have lived over to the spring of the following year. This is also true of at least one of the parasites of the species. How far the number of these interlopers is augmented by a retarded development of greater or less extent it is impossible to say, but that there is an accession through this means there can be no doubt. In fact, it would appear as though nature had in this way provided against the extinction of the species.

Now, is it proper for us, from these scattering individuals, to attempt to construct distinct broods? It seems to me not. I have several times sown wheat at La Fayette early in July and never had it seriously infested by Hessian fly until late in August or early in September. Very young larvæ were exceedingly abundant early in October of this year in a field of early-sown wheat near La Fayette.

It is true that observations during a single season, in a single locality, might produce apparently good evidence of a third brood, but a continued close study of the species in such locality will probably show it unfounded. That these aberrant individuals may, under favorable conditions, collect or "bunch" together in certain fields is probably true, but my own experience has been that the following year this irregularity will have disappeared or have been reduced to a minimum by the effect of the weather during midsummer and winter. On June 24, 1887, near Princeton, Indiana, latitude 38° 23′ N., I found a field of wheat, sown about the first of the preceding November, literally alive with larvæ from one-fourth to nearly or quite full grown. There were no pupæ to speak of in this field at the time, but in other fields in the vicinity these were abundant, but here there was no larvæ to be found. At this date wheat harvest was at its height. The late-sown field had evidently attracted the late-appearing adults of the fall before, and their progeny, living over in this field, as delayed larvæ, emerged correspondingly late in the spring, giving rise to the generation of larvæ observed by me. My reason for taking this view is that I have several times tried to draw off the spring brood of flies by offering them young plants on which to oviposit, but have always failed, as they seemed to prefer tender shoots of older plants to the young plants themselves. In the fall this characteristic seems to be somewhat the reverse, although even then, if attacked after tillering, the tillers will be chosen instead of the main stem. The fall brood of adults is probably the migratory brood, and their power of detecting wheat plants is almost phenomenal.

I have drawn them to a small plat of wheat sown in a secluded corner of my garden, in the midst of town, fully half a mile from any wheat fields. But, be this as it may, a second brood of larvæ in June would be rather difficult to sustain, as the puparia of the earlier part of the month are known to remain in that stage until September. Neither have I been able to secure any better evidence of a brood originating in volunteer wheat during July and August. Puparia are to be found every year from one end of the State to the other in this volunteer wheat, but here in Indiana I have never found these sufficiently numerous to imply a distinct brood. Professor Forbes and his assistants, working in Illinois, appear to have a greater confidence in this extra brood than myself, although, as will appear farther on, our experiments were carried on the one perfectly independent of the other, though only a few miles apart.

My attention has been called to the condition of this field near Princeton, by Honorable Samuel Hargrove, member of the board of trustees of Purdue University, and also a member of the State Board of Agriculture, who willingly agreed to further aid in the investigations by sowing for me plats of wheat at intervals of about 2 weeks, beginning as soon as possible after harvest. Being detained in Louisiana myself until nearly the 1st of August, and the weather being exceedingly dry, no plats were sown until August 4, 1887, followed by another on August 22, and a third September 5. These were sown on one of Mr. Hargrove's farms, about 10 miles northeast of Princeton.

The first two sowings, owing to the drought, came up sparingly and about the same time. The third was also affected by drought, and did not come up until about the 1st of October. These plats were sown along the lower edge of a high, rolling stubble field, which had been too dry to plow, and in which I had found an abundance of flaxseeds the preceding June.

These plats were examined by me on October 8. The two earlier-sown plats had thrown up a good growth of plants, which had tillered finely, being along a low ravine. On these plats I found a number of larvæ, which were nearly or quite grown, and a less number of flaxseeds, one of which was empty. Besides these, the plants were literally alive with very young larvæ, so young, in fact, that they had not yet lost their reddish tint. The third plat had sent up the normal number of plants, which were now in the second leaf. These plants had not appeared in time for the earlier deposited eggs, but were even more seriously infested by young larvæ than the plants of the two earlier plats. One of the plants from the last plat is before me, and contains twenty-six young larvæ, all of which must have hatched from the eggs only a few days prior to my observations. Now, from whence did the progenitors of these young larvæ originate? Most assuredly not from volunteer wheat, because there was none. Not from my earlier-sown plats, else these would have shown the effect. There are, it seems to me, but two other sources from which they could have come, viz, the stubble, which I know to have been infested, and grasses, which we have no knowledge of the species affecting.

These plats were plowed up soon after examination, as I was afraid to allow them to stand thus, a menace to the adjoining fields the following spring, though the plants would have probably been destroyed before even a small portion of the larvæ matured.

From all the information that I am able to gather, the usual time of appearance of the fall brood of adult flies in southern Indiana is the last portion of September, or some years the first days of October. This is, I believe, the opinion of the most observing farmers, including Hon. J. Q. A. Seig, of Corydon, Harrison County, who is as familiar with the earlier stages of the pest and its effect upon fall wheat as I am myself. Mr. J. P. Londen, of Sharp's Mills, same county, stated that wheat sown on October 1, 1886, was damaged 50 per cent., while that sown on the 6th was injured only 15 per cent. Mr. J. A. Burton, writing from Mitchell, Lawrence County, November 24, 1887, gave the results of his examination of wheatfields as follows: Fields sown September 8, about one plant in 8 infested; sown September 15, about one plant in 12; sown September 22, about one plant in 50, and sown October 1, seemingly free from injury. The observations of these gentlemen also coincide with my own, made in November, 1888, in Harrison and Posey Counties. Therefore, from all the information which I have been able to gain, the best season for wheat sowing, to avoid the attacks of the Hessian fly in extreme southern Indiana, is soon after the 1st of October. Exactly how far northward this advice will apply I am unable to say, but am inclined to think it would cover territory laying between latitude 38° and 39°, and possibly 39° 30′, although near the northern limit it would probably be safe during ordinary years to sow soon after September 25.

During the years 1887 and 1888 Mr. W. S. Ratliff made a large number of very careful observations, and sowed a series of plats of wheat on different dates near Richmond, Ind. In 1887 plats were sown August 5 and 29, September 12 and 26. All of these plats were attacked and more or less injured except the last, which as late as December 19 showed not the least injury by the Hessian fly. Up to May 31, 1888, there was very little injury to this plat, and even on the above date there were very few larvæ as compared with the number on the others. From this date on till July 11 the plats were all injured by black and red rusts, Chinch bugs, and the Wheat Stem maggot, the greater injury appearing to fall upon this, so that at harvest, July 11, the last was the poorest of all in yield, that sown August 15 being the best. The sowings of 1888 were as follows: September 6, 20; October 4, 22; November 1. On November 14 the first plat was found to be infested by larvæ of the Hessian fly. During June, 1889, Chinch bugs again attacked the plants growing on these plats, and the grain aphis seriously injured the later sown plats, so that at harvest, July 5, these latter were the poorest of all, the other three averaging about alike. All of these plats during both years had been sown in narrow strips among corn along one side, the remainder of the field being corn, and later also sown to wheat, thus bringing the latest-sown plats between those sown earliest and the entire field itself, as appeared to me, the severest test to which I could subject the several plats. The results, while not conclusive or even entirely satisfactory, indicate that in that latitude about September 25 is, generally speaking, a good time to sow wheat to escape fall attacks of the fly and winter killing. A series of plats sown for me by Mr. Miles Martin, of Marshall, Parke County, Ind., in very near the same latitude as Richmond, but nearer the western border of the State, gave rather more conclusive results, the sowings of September 22 being almost entirely exempt from the attack of the Hessian fly, while earlier plats were infested.

In regard to my own experiments here on the Experiment Station grounds at Lafayette, I may state that I have never been able to provoke a disastrous attack of the pest, though there has been nothing left undone which could possibly induce the adult flies to oviposit at any time between March and December; and there is probably not a month between these dates during which the insect could not have been found in all of its stages. The two destructive broods, however, invariably appear in May and September; in the latter case usually before the 20th.

My own experimental showings were rather more elaborate and extensive than those of any of my correspondents, comprising a number of varieties and extending over several months. Without going into details, the experiments and results may be summarized as follows: 1887, plats comprising the varieties Michigan Amber, Clawson and Velvet Chaff, each one width of a grain drill twenty rods in length, were sown on the following dates: August 13, 27; September 10, 24; October 8, 27; November 5, 19. The autumn was very dry, and the plants of the first six plats went into winter in poor condition, being very small, while the last two sowings did not come up until the following spring. The severe winter destroyed the plants so generally, that only the first three produced sufficient grain to pay for harvesting. These were also the only ones to suffer from the fall attack of the fly, the first producing adults October 1. Plat 8 was attacked on the following June, and on the 26th was badly infested with young larvæ, full-grown larvæ and puparia, the latter, the most numerous, were found on the 16th of July. The plats harvested produced a poor crop, but the Michigan Amber ranked first, Velvet Chaff second, and Clawson the poorest of all.

The condition of the Hessian fly in these three plats, at the time of harvest, July 10, 1888, may be inferred from the result of examinations made on this date.

Empty flaxseeds	15
Containing healthy pupæ or parasites	69
Larvæ	16
Total	100

August 3, the state of the insect in these same plats was as follows:

Empty flaxseeds	53
Containing healthy pupæ and parasites	47
Total	100

The condition of the insect on September 1, as shown by examination of the stubble, is indicated below:

Empty flaxseeds	55
Healthy flaxseeds	28
Parasitized flaxseeds	17
Total	100

Notwithstanding the per cent of healthy puparia passing the summer was small, there is little probability that many adult flies emerged. A plat of the same dimensions was sown July 16, along one side of the first three sown the previous fall, the plants of this last sowing coming up ten days later. This plat was closely watched. After July 17 only an occasional larva was found. By August 4 plants had been destroyed by the combined influences of chinch bugs and dry weather, but a second plat has been sown adjoining, and the plants of this appeared above ground on August 6. On September 4, 200 plants were examined and but two larvæ were found thereon. A second examination of the same number of plants from this plat, on September 15, revealed a small number of young larvæ. A third examination of this plat on October 6 showed about 1 per cent of the plants to be infested. Stubble from the three original plats, kept in breeding cages, out of doors, did not give adults until the 17th of September, although it is quite probable that some few were abroad before that date. It will be seen, however, that no great number could have emerged from the stubble, and the increase in the number of empty flaxseeds between July 10 and September 1 is doubtless to be attributed to parasites. This appears all the more probable, as I have repeatedly observed these parasites during July and August emerge in breeding cages, and at once begin to oviposit in flaxseed in the stubble from which they had themselves emerged. The percentage of healthy puparia reaching September in safety, however, was probably unusally small, as experiments on the same ground the following year did not suffer near so much from either fall or spring attacks. Another feature of these experiments is, that it strongly indicates that the larger per cent of the parasites emerge prior to the 1st of August. Indeed, stubble from the entire length of the State, collected in June and placed in breeding out of doors here at La Fayette, has indicated the truth of this.

The sowings of 1888 were made on August 30, September 18, October 3, 6. Of these, only the first sown were attacked in the fall, that sown on September 18 being in the best condition the following July. During May, 1889, the plants of these plats were found to be much less infested than some fields a considerable distance away, although such fields had been sown on oats stubble, while the ground on which my experiments were located was the same that had been used for this purpose the previous year.

The sowings of 1889 were continued on the same grounds, the plats being sown September 3–20, October 4–18, November 4. The autumn attack was the most severe on the first plat, but the extremely mild fall and winter was so favorable to the development of the flies that the spring attack was unusually severe, and appeared to fall upon the three earlier sown plats with about equal force. The later sown plats, though the plants were much the younger, did not suffer so much, but these were very seriously affected by the weather during early spring.

These experiments appeared to indicate that, in this latitude, while wheat sown as early as the last of August may under favorable conditions and during particular seasons produce as good or even a better crop than when sown at a later date, yet such cases are the exception and not the rule; but that wheat sown as soon as possible after the 20th of September stands the best chance of evading the attacks of the fly and withstanding the unfavorable weather, the regular operations of the University farm during the last seven years certainly substantiate. It is the custom with the experiment farm, each year, to sow the regular field crop at this time, and in no case has severe injury been sustained from attacks of the Hessian fly. Fields on adjoining farms sown at earlier dates have frequently been seriously injured, although this has not invariably followed.

Another series of experimental sowings was carried on for me by Hon. W. A. Banks, near La Porte, Ind., about latitude 41° 35′. The first series of these sowings was begun in August of 1887. The sowings of 1888 were not carried on under Mr. Banks's immediate supervision, and were of little value. No experiments were made in 1889, but a well planned and carefully executed series were sown in the fall of 1890. The series of 1887, each of which comprised two widths of a grain drill, extended along one side of the field about 60 rods in length, the first of which was sown on August 13, the plants appearing above ground within a few days. The second sowing was on August 23, a third on September 2, the fourth September 12, the fifth September 22, the sixth and last on October 7. These plats were visited by me on October 14, and their condition found to be as follows: The first was found to be infested by great numbers of larvæ and puparia, some of the shells of the latter being empty, and the plants were seriously damaged. The second plat was even worse injured than the first, and the third much worse than either of the others. The fourth appeared to be almost as badly infested as the third, but it had only partly tillered, and hence there was a better prospect for it to throw up unaffected shoots. The fifth had not tillered, and was only very slightly infested, with very young larvæ, while the sixth was not yet up.

On April 12, 1888, the plats were visited again. About 25 per cent of the plants on the first three plats appeared to have survived. The fourth was apparently 50 per cent better, the fifth was in almost as good shape as the fourth, while the sixth was backward, the plants being small and thin on the ground.

The estimate yield, made by Mr. Banks at time of harvest, on the basis of 20 bushels per acre as an average yield, was as follows: First plat, 50 per cent; second, 50 per cent; third, 65 per cent; fourth, 90 per cent; fifth, 70 per cent. The remainder of the field was sown on September 2, and shared in the destruction in common with plat 3. Another field at some distance from this was sown about September 20 and sustained no material injury.

It will be observed that the first three plats were sown almost at the same time as the first three at La Fayette, yet stubble from the first three plats at La Porte, collected on September 2 and placed in a breeding cage beside another containing stubble from the first three at La Fayette, gave adult flies nearly a week earlier. In other words, the majority of the adults from Mr. Banks's plats emerged prior to September 15, while those from my own did not reach their maximum numbers until after the 15th, and from then on till the 25th. In both cases, however, a few stragglers emerged occasionally until early in October. As previously stated, the plats of 1888 were not properly sown, Mr. Banks not being able to attend to them himself; but a visit to the locality on November 8 revealed but very little injury to wheat which had been sown after the middle of September.

The experiment plats of 1890 were sown September 1, 10, 20, 30. These were examined late in October and fully substantiated the experiments of previous years. The sowing of September 1 was considerably injured, while that of the 10th was very seriously affected, as was also a large field adjoining sown but a day or two later. The sowing of September 20 was comparatively free from attack, while that sown September 30 appeared to have almost entirely escaped injury.

The sixth and last series of experiments were made for me by Hon. J. N. Latta, at Haw Patch, Lagrange County, in about the same latitude as La Porte. The sowings were made in 1887, the first being drilled on July 28, but owing to drought the plants did not appear above ground until about the 28th of August. The second plat was sown on August 15, but came up the same time as the first; the third, sown September 1, came up September 6; the fourth, sown September 12, came up September 21; the fifth, sown September 24, came up the

28; while the sixth and last was sown October 12, and did not come up until about the 20th. These plats were examined by me on October 17; the first three and the last sown were very poor, the fourth and fifth promising a fair yield. A field adjoining, sown on the same day as plat 5, did not suffer from the fly and produced nearly an average yield of 20 bushels per acre.

The results of these meager experiments have, as a rule, proven correct in the fields of the farmers. I have not only observed this myself, but it has become well known in the locality that wheat sown before September 15 and after the 30th of the same month seldom produces a good crop, while that sown between the 15th and the 25th is the most likely to escape the attack of the Hessian fly, and, as a general thing winters, as well as that sown earlier.

In summing up the results of this entire system of experiments, it seems that while no exact date can be laid down for the appearing of the fall brood of fly in any precise locality, there is, notwithstanding, a gradual delay in its appearance as we go from the north southward. In other words, there is here a characteristic element in the life history of the species which may be utilized by the farmer to his advantage. Fruit-growers, I believe, estimate that in spring the season advances northward at the rate of about 12 miles per day. This would be a trifle less than 6 days per degree of latitude. If farmers in extreme northern Indiana and southern Michigan can sow their wheat with safety about the 12th to the 15th of September (and we have demonstrated that the fall brood emerges largely prior to the 15th), and farmers in extreme southern Indiana must delay sowing until after the first days of October, there must be a general system of retardation, which, if understood, may be used to advantage throughout the intervening territory.

Starting in southern Michigan on the 12th to 15th and passing 4 degrees south to the vicinity of Evansville, Ind., we should expect about the same condition of the Hessian fly during the first week of October. That is, if we pass the danger line about the second week of September in southern Michigan, we should expect to encounter it again in southern Indiana in the first or second week of October. A considerable correspondence and my own experiments indicate that this is usually true. It is not to be supposed, however, that it is possible for me to give precise dates for given localities, as there is another element which is likely to figure in these calculations, viz, elevation. It has been stated upon reliable authority that "an elevation of 350 feet is equal to 1 degree of cold in the mean annual temperature, or 60 miles on the surface northward."* While we can hardly expect this to influence comparatively level countries like the State of Indiana at least to any marked degree, extensive areas of high table-

* Draper's Intellectual Development of Europe, Harper Bros., New York, revised edition, vol. 1, p. 29.

lands would be apt to show its effect more distinctly. There may also be some obscure influence peculiar to the natures of the different soils.

It will be seen, therefore, that the experiments have fallen far short of settling the whole problem, yet it seems to me that they have been carried as far as profitable, and the matter is now in proper state to be taken up by the intelligent farmer, whose experimental plats are his fields. And it may be added that this is done with a feeling on my part that whatever of truth there may be in the matter will stand as a nucleus about which others may build, while whatever there may be of error will as surely disappear.

THE EFFECT OF THE LARVÆ ON THE PLANTS.

The effect of the larvæ, especially on the young plants, does not appear to be generally understood, and I have myself been able to verify either the figures or descriptions of Fitch and Packard only in exceptional cases. The swollen bulb just above the roots in Fitch's figures gives but a vague idea of the true appearance, while Packard's figure represents plants which have very evidently sprung from seeds only slightly covered by the soil. Besides, the former figure only represents the condition of the plants long after the larvæ have done their work, and the latter, aside from the shoot being shorter, gives no idea of the appearance of an infested stem, as found in nature, growing in the fields. The yellow color of the foliage—there is usually more brown than yellow about it—appears later, after the larvæ are full-fed, and then it is largely, at least, confined to the younger leaves, the older ones, under whose sheaths the larvæ occur, are killed by the freezing weather of winter. In Circular No. 2 of the Agricultural Experiment Station of Purdue University I have given a representation of an infested plant fresh from the field drawn from nature. The plant had been attacked soon after its appearance above ground and had not tillered. The leaves under these conditions are broader, darker green, more vertical and bunchy. The youngest leaf on a healthy plant as it unfolds and pushes upward is of a tubular form and spindle-shaped, somewhat as represented in Packard's figure of a healthy plant. In the case of an affected plant, the stem having been destroyed below ground, the spindle-shaped central leaf is always absent. The difference between a healthy and infested plant is shown by a comparison of figures. If a plant has already tillered, each of the identical laterals, as they are attacked, will begin to take on the form and color above described. It is, therefore, not only possible to detect an infected plant without removing it from the ground, but also to determine the individual tiller infested. Now, while this feature of infested plants is so very clearly marked, at least after the larvæ are one-third grown, and from an economic standpoint of so much importance that it is surprising that it should have been overlooked, yet I can not myself lay claim to the fact by right of discovery, as it was pointed out to me by a farmer in the autumn of 1884, and was the outcome of circular No. 1, issued in October, 1884, from Purdue University. It was only after testing the stability of this feature in various fields, under widely different conditions, that I placed full reliance upon its permanency. An illustrated circular of inquiry, No. 2, issued by myself from Purdue University during the fall of 1887, brought also a great number of replies, from among which I have selected the two following, because of their widely separated localities and the well-known ability of the writers:

CLYDE, N. Y., *December* 9, 1887.

DEAR SIR: In regard to the appearance of wheat plants infested with Hessian fly, and as illustrated and explained by Fig. 3 of circular, I believe that it is correct in the main, especially the darker color possessed by infected plants over healthy plants, and this is, as you say, quite different from the information given by Fitch and Packard; and you have published this quite constant and true form and condition for the first time, I believe. I had noticed this somewhat a year ago, and in bringing up the destruction done by the Hessian fly in a Grange meeting, I found that a number of farmers reported this very condition, viz: when fields or parts of fields looked extra dark colored and healthy, damage from the fly was to be apprehended there. Still, the yellow color came after a while, especially with early-sown winter wheat in a long autumn or the following spring. I think the spring brood are apt to select tillers.

Truly,

W. L. DEVEREAUX.

Prof. F. M. WEBSTER,
La Fayette, Ind.

UNIVERSITY OF CALIFORNIA, COLLEGE OF AGRICULTURE,
Berkeley, December 15, 1887.

DEAR SIR: Your favor of November 28, with circular relating to appearance of grain infested with Hessian fly, received. The appearances you describe are quite characteristic of fly-infested grain here, but it is not seen in the fall, for we do not have any grain above ground at that time. The districts in which the fly is found in this State are of narrow area comparatively near the coast. In these parts it is not usual to sow grain until after the winter rains have wet the ground enough for plowing, and sowing can some years be made as late as the last of February, and still do well. It is better, however, both for the growth of the grain and baffling of the fly, to sow in January if the soil is in proper condition. For these reasons we do not find the flaxseeds until about the first of March, and then it is that the grain assumes the feature you describe. It is a very bunchy growth, with very few yellow leaves and exceedingly few seed stems thrown out. On some of our plats there will not be a single stem, but the grain will remain bunchy and low for weeks, and then will turn yellow and die as the dry season comes on. On other plats there will be a seed stem thrown out here and there, and a few heads will ripen.

Such is my recollection of the appearance of past crops. We do not intend to sow wheat and barley this year on our fly-infested ground, but the pest may follow our sowing on another part of the grounds, and if it will be of interest to you, I will watch the plants and send you specimens.

Yours very truly,

E. J. WICKSON.

Prof. F. M. WEBSTER.

If the soil is rich and the plants are attacked before they have tillered, these last will be thrown out from the roots which are not injured. These, if the fall be very favorable, and the winter does not commence too early, will often winter through and produce stem-bearing heads the following harvest. On the other hand, if the autumn be dry, or the ground be frozen early in the season, the crop will probably prove a failure. This is the reason why some fields will present a much better appearance the following June, and give a much better yield than could have been anticipated from appearances during the fall. The practical value of knowing how to detect the infested plants readily is in that the destruction may be observed and the damage estimated long before the foliage turns brown or yellow, and the fields be plowed up and resown or allowed to remain, as the owner judges best. If resown, it would seem best to replow also. Mr. W. A. Oliphant, of Pike County, southern Indiana, writing me in the fall of 1884, in reply to circular No. 1, stated that of 300 acres he had resown 200 acres after replowing, and 100 acres without plowing. The first yielded him 27½ and the last 11 bushels per acre.

The popular notion in regard to the effect of larvæ on the straw is, so far as I know, usually correct. This year, however, has been an exception, at least so far as southern and central Indiana is concerned. As far north at least as La Fayette the larvæ of the spring brood were located just above the roots, and the straw did not break at the lower joints, as is usually the case, but either fell or was blown over from the roots, the culm usually being uninjured elsewhere. I observed this to a very limited extent at Oxford, Indiana, in 1881. In fields about La Porte, in the northern part of the State, none of this lower attack of the plant was noticed, the larvæ and later the puparia being invariably found just above some of the lower joints. Mr. James Fletcher, Dominion entomologist of Canada, reported at the meeting of the Entomological Club of the American Association for the Advancement of Science at Indianapolis that the wheat about Ottawa, Canada, had this year suffered from the attacks of larvæ of the spring brood in precisely the same manner as I had observed at La Fayette and southward. Quite a percentage of the pupæ in the fields about La Porte were located so high up the stem as to render it probable that they would be carried away with the straw. As yet I have not found a good reason for this difference, but have a vague idea that the killing down of the plants during the preceding March might have had something to do with it, as this was less severe in the northern part of the State.

THE EFFECT OF THE WEATHER ON THE DEVELOPMENT OF THE FALL BROOD.

It is quite probable that some autumns are more favorable for the development of the insect than others, but just what the favorable influences are is not well understood. Mr. Ratliff, at Richmond, saw an adult emerge from the pupa on October 16; the wheat which it infested appeared above ground on September 4. Between these two dates, Mr. Ratliff's notes give the following record of minimum temperatures through which the insect must have necessarily passed.

September 23 (frost)	26°
October 6 (light frost)	26°
October 11 (light frost)	34°
October 12 (light frost)	26°
October 14 (heavy frost)	24°
October 15 (frost)	26°
October 16 (light frost).	29°

Rains on September 11, 26, October 10. Total precipitation during September and October, 2.50 inches.

At La Fayette, the same year, I found adults ovipositing on November 3, but of the origin of these flies of course nothing was known. The temperature through which these must have passed, supposing the eggs from which they evolved were deposited after September 1, was as follows:

	Min. temp.
September 23	39°
September 24 (first frost)	29°
October 11	39°
October 12 (frost)	29°
October 14 (frost)	33°
October 15 (frost)	31°
October 16	38°
October 19 (frost)	31°
October 20 (light snow)	37°
October 21	29°
October 22	21°
October 25 (frost)	19°
October 26 (frost)	21°
October 27 (frost)	21o
October 28 (frost)	28°
October 29	33°
October 30 (frost)	19°
October 31	28°
November 1 (frost)	28°
November 2 (frost)	36°
November 3 (frost)	32°

Rains on September 7, 13, 14, 22, 27, 28, 29, 30, October 3, 9, 10, 12, 23. Total rainfall, 4.64 inches.

From this it will be observed that the adult flies may emerge and oviposit under what we suppose to be very adverse circumstances. To what extent the eggs and young larvæ are able to withstand such weather I have no facilities at present for demonstrating. The major portion of the small brood of flies, however, emerge during a more favorable period, and for meteorological aid against these we can only look to the dry, hot weather of July and August, though to the south a portion of September might be included. But the straggling individuals, which, as I have proved, may originate from stubble, volunteer, or even early sown grain, and which I myself can find no satisfactory reason for not considering either the retarded or accelerated individuals of either one or the other or both broods, have it in their power to reproduce a considerable progeny, which, though of themselves not a serious menace to the crop, yet, added to that of the remainder of the brood, greatly increase the probabilities of serious damage. For these a long, mild autumn, extending into December, would appear to be exceedingly favorable, as it would enable their progeny to enter winter in a comparatively hardy state, and probably produce late appearing larvæ the following year simultaneously with or but little in advance of the progeny of the earlier appearing adults of spring. In other words, the one winters as advanced puparia or unemerged adults, the other as advanced larvæ or newly formed puparia. It thus appears that while the autumn usually has little effect on the major portion of the fall brood, a mild October and November may emphasize the destructiveness of the pest. So far as observed by me, a damp spring, even though a cold one, is also favorable to the development of the insect, while dry, hot summers are as unfavorable, and cause serious mortality to the earlier stages of the fall brood of adults.

PREVENTIVE MEASURES.

These may be noticed as follows: Sowing at the proper time; burning the stubble; rotation of crops; sowing long, narrow plats in late summer as baits; applying quick-acting fertilizers to seriously infested fields in the fall in order to encourage attacked plants to throw up fresh tillers, and to increase the vigor of these that they may make sufficient growth to withstand the winter.

None of the measures are original with me, and in fact the most of them are as old as the history of the species itself. There is certainly much to be gained by the farmer in timing his sowing so as to avoid the larger part of the fall injury, and if all farmers of a neighborhood would sow about the same time even a serious outbreak would be so diffused as to lessen its injury.

The burning of the stubble after harvest, when it is practical to do so, is usually recommended by the majority of writers. The plan is criticised by some authors on the plea that the parasites are also destroyed, which, if allowed to continue, would themselves overcome the fly. This idea has always appeared to me to be both theoretically and practically wrong. If only the normal number of wheat plants allowed by nature to spring up under a perfectly natural environment were produced, then the theory would be correct, because nature would then be working out her plans from the beginning. As the facts exist hundreds of thousands of plants are produced where nature intended but one. Her domain is invaded and her law defied at the beginning. The Hessian Fly is itself a parasite, the wheat plant being its host, and what we term its parasites are practically only secondaries. In the Hessian Fly nature has an efficient servant in controlling the wheat plant, and the parasites of the former seem to be on guard to see that the duty is not overdone. Now we outrage nature and expect that she will uphold us by destroying these servants and permitting the indignity to go on.

With this state of affairs the American farmer has found that the Hessian Fly will be overcome by its parasites only temporarily, and then at the expense of a larger per cent of at least one crop. By burning the stubble we destroy all of the pest and also numerous other enemies which are to be found in the fields at the time. The present season, however, many of the flaxseeds were so situated that it is doubtful if enough heat would have reached them to have destroyed them.

In a rotation of crop the adults are obliged to travel about in search of the fields, and there is a greater chance of their being destroyed while thus engaged. This, however, has its exceptions, as we observed at New Castle, about 30 miles northwest of Richmond, Indiana, on November 17, 1888. The whole field had been sown in standing corn, a portion of it about the 5th of September and the remainder considerably later. The early sown portion had been seriously attacked and at least 85 per cent destroyed; the later sown portion was only slightly injured, as was late sown wheat generally in the community. Here at the Indiana Experiment Station the plan of rotation is as follows: Corn one year, followed by oats one year, wheat one year, clover and grass two years. The wheat fields are never seriously affected by the ravages of the Hessian Fly.

Sowing narrow strips about the fields, early in the fall, as decoys, was long ago strongly advocated by Dr. Fitch, but the advice has been, so far as I have observed, totally ignored by the farmer. While it is hardly possible to thus entrap the major part of the fall brood of larvæ, it is certainly possible to entice to these plats the stragglers and interlopers, which we have shown to be capable of considerable injury. In this way the farmer can, in a measure, continue the influences of summer and winter in sharply separating and defining the two broods. In other words, while he can not eradicate the pest in this way, he can weaken its power to commit serious injury. It is very doubtful if the volunteer wheat, springing up after the wheat has been plowed, can be used as decoys, and if allowed to stand until the date of sowing the fields, these volunteer plants should, by all means, be plowed under as deeply as practicable, or grazed off by pasturing. Simply killing the plants will not do, as has been illustrated by the experience of Mr. Oliphant, previously cited, and by the observations of Professor Forbes in Illinois.* If volunteer wheat is allowed to stand at all, it should not be for over a fortnight. The proper time for sowing these decoys will probably vary with the latitude. For northern Indiana they should be sown during the latter part of August, and in the southern part of the State not later than the first week in September. To the north and south of this I have, as previously stated, no definite information as to the date of appearance of the fall brood of flies, and hence can not undertake to settle the date of sowing. These decoys should not be permitted to stand over four weeks at the farthest, and should be *plowed*

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* Bulletin 3, State Ent., Ill., p. 48, 1887.

very soon after the crop is sown, turning the infested plants under and thoroughly covering them. Simple cultivation, whereby the plants are only killed, would probably only destroy a portion of the insects, the full-grown larvæ very likely going through the remainder of their transformations.

The application of fertilizers is, I believe, here in this State confined to the poorer soils, and there more for its general effect on the crops than as against the effects of insects. The idea in late sowing is to retard the plants so that they do not appear until after the greater part of the fall brood of flies have appeared and died, then to overcome the effect of this delay by aiding the plants to make the greatest possible growth before winter closes in, which will the better enable them to withstand its rigors. In this direction, it would seem that the application of proper commercial fertilizers would pay by the effect upon the growing plants, even though the land itself was not in actual want of such treatment. The application to a field which has previously been seriously damaged, with a view of encouraging the throwing out of fresh tillers, is for practically the same purpose; and if there is a tendency to throw out the later shoots freely, if not too late in the season, many may be enabled to secure sufficient vigor to sustain them until spring. Whether it would be more profitable to plow and resow than to try to secure a crop from the infested field by the aid of fertilizers is, of course, a question which each farmer must decide for himself in accordance with the time of year and extent of injury already done.

These measures are all of them practical and entail little if any unusual expense. In fact, good farming presupposes that the most of them will be carried out as among the essential elements of the business. Where clover is to follow wheat it of course precludes the burning of stubble or the destruction of volunteer plants, but it necessitates the rotation of crop, and decoys can be sown and the seeding delayed. It is hardly possible for a farmer to become so situated that he can not carry out some of these measures, and if this were done generally, and every year, the Hessian fly would, in all probability, become of so little importance that it would cease to enter seriously into the problem of successful wheat growing.

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