neglected meadows where the insect has opportunity to multiply unnoticed by man and undisturbed by cattle.

Connection of wet and dry Seasons with Army Worm Increase.—The past history of Army Worm years shows conclusively that dry seasons are favorable to the multiplication of the insect. Fitch's theory that such excessive multiplication occurred only during a wet season following the dry ones, required that the Spring of the present year should be a wet one, whereas, throughout the Atlantic States where the worm has been destructive, the exceptional drought has been proverbial. We must, therefore, believe that the Army Worm is most likely to appear in destructive numbers after dry seasons, regardless of the wetness of the season in which it does so appear; though moist cloudy weather, rather than hot dry weather, is without doubt favorable to the development of the species.

Some recent practical Results of the Cotton Worm Inquiry by the U. S. Entomological Commission. By C. V. Riley, of Washington, D. C.

The Cotton Worm (*Aletia argillacea* Hübn.[1]) has already formed the subject of two papers read at recent meetings of the Association. A year ago I presented some of the facts and conclusions regarding the habits and natural history of the insect, that had up to that time grown out of the investigation begun by me three years ago under the Department of Agriculture and continued under the auspices of the U. S. Entomological Commission. It is my purpose in the present short paper to present a few of the more practical results obtained up to the present time.

PRINCIPLES ESTABLISHED.

While experience and methods must vary, there are certain underlying facts and principles which we have fully established, and which should everywhere guide, since they obtain all over the cotton belt. Among the more important of these that have a practical bearing are the following:

[1] *Anomis xylina*, Say.

1. The first worms appear in small numbers, much earlier than has been hitherto or is usually supposed, and generally in the same particular spots year after year, in hibernating centres or regions where the parent moth survives the winter; for this fact of survival in the imago state in the southern portion of the belt is now established upon substantial evidence.

2. These first worms appear much earlier than the so-called "first crop," which attracts the attention of the planter, and they may be looked for early in May, or even during the last days of April. While young their presence is most readily detected by the pale, translucent spots they make on the leaves, which spots are a sure indication either that the worm is present or that it has been; for these early worms are frequently swept entirely off by their enemies.

3. The eggs in early summer are laid on the underside of the leaves, and very uniformly on the older leaves about the middle or the lower third of the main stem, and the young worms feed there for a few days, producing the spots above described, before ascending to the more tender leaves.

4. The parent moths, while fond of all sorts of sweet exudations, the nectar from flowers and the juices of fruits, obtain their chief nourishment in early summer from the glands which occur on the underside of these leaves and on the involucre, and which exude a sweet liquid. They are able to suck up solid particles, and may be killed by poisoning the sweets upon which they feed.

5. The eggs of the Boll Worm are, also, mostly laid in similar situations and rarely on the squares or the bolls, and the young Boll Worms likewise feed upon the leaves for some days before entering the squares or the bolls.

From the above well-proved truths it follows that poisons applied to the under surface of the leaves will accomplish more good than when thrown on the upper surface, as is the common custom. They will thus more surely kill these young worms before these do any damage; they will tend to kill the moths, and they will likewise kill the young Boll Worms.

My efforts the present season have, therefore, been principally directed: 1. To discovering feasible means of thus poisoning; 2. To improving present methods by diminishing the quantity necessary to an acre and the labor necessary to apply it; 3. To the discovery of cheaper, safer and more satisfactory substances.

THE BEST POISONS.

The experience of the year has so far given us nothing superior to the substances previously tested. We have over five tons of extracts and decoctions of various native plants centered at Selma, Ala., made either by Professor R. W. Jones, of the University of Mississippi, or by Mr. James Roane of Georgetown, D. C., agents of the Commission. But two or three, so far, give any promise, and these not much. Yeast ferment or beer mash, which Dr. Hagen, of Cambridge, so strongly recommended, has proved entirely useless. Of the various arsenical poisons, Paris green still proves the best, so far as efficacy and harmlessness to the plant are concerned, but the use of this and of different preparations of white arsenic is to-day so well understood that they need no further mention.

LONDON PURPLE.

Of this arsenical refuse from the manufacture of aniline dyes, which I introduced a year ago with a good deal of hope as a cheap substitute for Paris green, it will be well, however, to say a few words. The testimony in regard to it is very generally favorable the present year, as I anticipated would be the case from the experiments we made a year ago. But some reports are less favorable, and such mostly come from parties who have not understood how properly to mix and use it. Pound for pound, it should be made to go twice as far as Paris green, *i. e.*, a pound of the purple is sufficient to eighty or even one hundred gallons of water, and if used dry should be in proportion of one to forty parts of the diluent.

It should be borne in mind that great care is necessary in mixing it in water to prevent its forming lumps, and that it acts more slowly than Paris green. To this last fact is due most of the unfavorable experience and judgment. If a rain follow too soon after an application, the purple kills comparatively few worms. Its good effects are fully seen only under favorable circumstances on the second or third day, while the green shows its good effects a few hours after application, and particularly the day following. In the early use of the green the same diversified experience was had, and from defective methods or adulterated material unfavorable results were quite frequent. One source of failure with both these materials in liquid is the lack of provision to keep them

stirred up and well suspended; another, in not bearing in mind that the poison has greater specific gravity than the water in which it is carried; so that in poisoning many rows at a time the finer spray falls on the furthermost rows with little or no poison.

London purple is exceedingly fine and sifts through the slightest crevice. This is an advantage to the planter who uses it on his cotton, but necessitates great care in shipping. The manufacturers have shipped it for the most part in barrels, which have permitted it to leak and stain other goods, as well as the vehicles of transport, thus doing more or less injury and prejudicing freight agents against it. This defect should be remedied. Some of the unfavorable results with this purple, I am constrained to believe, have resulted from adulteration. Experience would indicate that it is less dangerous to use than the green.

PYRETHRUM.

This powder, of which, since last year's experiments, I have had great hopes, fully warrants them. No other vegetable substance approaches it. Last year while it was found by Prof. E. W. Hilgard, of California, that an alcoholic extract of any part of the plant possessed the insecticide property, I had serious doubts whether it could ever be successfully used in the cotton field because of its cost. The simple powder, mixed with flour as a diluent, could then be made to go over more ground than the alcoholic extract. The present year we have found that a simple fluid extract, made after the ordinary formula of the pharmacopœia will go much farther, and that the extract from a pound kills all the young worms when diluted in 120 gallons of water! Nay, more, one of the most important discoveries is that it acts equally well or even better when simply mixed with water, and even one pound to 150 gallons is effective, and one pound to 200 gallons will cause the destruction of most young worms. Its action is really marvellous; but as it kills by contact, its effects are not lasting as in the case of arsenical poisons, which act through the stomach. It produces convulsions and paralysis; so that all young worms in contact with it soon writhe to the ground. Larger worms are less easily affected, but they soon writhe to the ground, from which they rarely recover, even if the pyrethrum fails in the end to kill; for once on the ground and enfeebled, a host of enemies are ever ready to finish the work begun by the powder. This insecticide

acts quite differently on different insects, but Aletia is one of the most susceptible to it. It acts equally as well in rainy weather, and I have not a doubt that when the plant is grown in this country so that the cost of the powder will be nominal, Pyrethrum will be extensively employed by planters, and to this end I have taken steps to have it introduced and cultivated. Its harmlessness to man, the small quantity necessary, and the fact that it may be grown by the planter himself, will offset the greater permanency of arsenical powders.

OILS.

Nothing is more deadly to the insect in all stages than kerosene or oils of any kind, and they are the only substance with which we may hope to destroy the eggs. In this connection the difficulty of diluting them from the fact that they do not mix with water has been solved by first combining them with milk, either fresh or spoiled, to form an emulsion, which is easily effected, while this in turn, like milk alone, may be diluted to any extent by water, the particles of oil being held homogeneously in suspension. Thus the question of applying oils in any desired dilution is settled, and something practicable from them may be looked for.

IMPROVED APPLIANCES.

Planters will apply poisons either in liquid or in powder according to circumstances and conveniences. The wet method, according to present practices, is the more expeditious, and the safer so far as injury to man and stock is concerned. It acts less favorably in wet weather, the first outlay in appliances is greater, and they are often useless where the soil is heavy and wet. The dry method can be most advantageously used in wet weather, and the application is most persistent: the cost of diluents has heretofore been great; there is more danger to the operator, and an acre is poisoned less quickly.

Important advances have been made the present year in both methods. The perforated sprinkling nozzles have given way wherever they have come into competition with those which spray by obstruction against an inclined plate or by pressing the water through a crescent-shaped slit. The simplest and cheapest nozzle, and that which least clogs, will give most satisfaction, for which reason one which I introduced the present summer, and which is

known as the Riley sprinkler, has been largely used. It is a simple, semicircular piece of metal, about three inches in diameter, with a narrow strip of the straight edge bent upward at an angle of about 45°, and the nozzle so adjusted that the jet strikes the angle of the bend at its middle.

Experiment shows that there is a limit to the subdivision of the liquid beyond which it cannot practically be carried, both on account of the greater tendency of the nozzle to clog and of the greater specific gravity of the poison compared to water in fine spray; so that in attempting to throw a fine spray over ten or twelve rows, the outer rows, as already stated, receive no poison. This last obstacle applies less to pyrethrum, which has least specific gravity. Nevertheless, experiment has demonstrated that forty gallons of poison may be successfully made to go over three acres of cotton instead of one, which is a great gain. In using the poisons dry, it does not seem possible to advantageously diminish the amount per acre by any present appliances, but I have reason to believe that a diluent of simple earth well dried and pulverized may be used with as much advantage as any more costly.

POISONING FROM BELOW.

Now the throwing of the poison from below will enable us to diminish much further the quantity to be thrown on the plant in either method, and one of the ideas originated and now being tested by the Commission is to throw the poison upon the plants by means of rotating brushes. This method promises full success and is probably the simplest and cheapest by which the principles mentioned in the beginning of this paper can be satisfactorily applied. It has these further advantages: the amount of the poison is easily regulated; it is uniformly applied; it remains longer and is not so easily washed off by rains, and finally, the plan does away with pumping and stirring. The brush is made to revolve in a box or trough, which is supplied with fluid poison on the principle used in automatic inkstands, or with powder from a hopper having slits from which the bristles brush out the powder. The spray may be produced by the centrifugal force from rapid rotation, in which case the box is only open on the side from which the spray is desired, while the slow turning of a very stiff brush against an edge will throw either a spray or a cloud of powder by the elasticity of the bristles as they spring out from

under the edge. It is useless to go into details, and we have not yet decided whether steel, whalebone, bristle or broom corn, or some other material will prove best. Prof. W. S. Barnard, of Ithaca, N. Y., is now working out the details of the gearing, and will continue to experiment with different devices and on different principles. He has already made some very important discoveries which will be duly recorded in the next report of the Commission on the subject. Another simple plan now being tried, for applying wet poison to both sides of the leaves, without involving machinery, is by a long, heavy fringe upon which the poison-fluid drips, and from which it is wiped off by the leaves as they are pulled through its pendent parts, which hang down among the branches while it is carried over the row. Another principle will be practically applied and worked out, if possible, by Mr. J. D. Cross, of Alabama. It is to throw the powder behind a cultivator by means of a revolving fan, worked by a spring to be wound up at intervals, so that the plant may be poisoned without extra labor when it is being for the last time cultivated or laid by. It is unnecessary to allude here to experiments that have given no practical results.

EARLY POISONING.

The importance of poisoning early, or when the very first appearance of the worm is manifest, cannot be too strongly insisted on. Wherever it has been done early and judiciously the crop has been saved, and the contrast between the poisoned fields and those not poisoned is most marked. The latter have been defoliated over a month, and will yield, on an average, but one-third as much cotton as the former, and that of an inferior quality.

WEATHER: CONCLUSION.

The weather throughout most of the cotton belt has been unfavorably wet, and, indeed, the persistent rains have greatly interfered with the experiments and the work of the Commission. Yet we have reached a stage in the management of the worm when there is no longer any excuse for loss by its ravages, and with the results of this year's labors of the Commission, I feel that I have measurably accomplished what I set out to do three years ago, viz.: to get thorough and accurate knowledge of the habits of the principal insects injuriously affecting the cotton plant — a knowledge

which did not then exist — and to learn best how to control them. The Caterpillar and the Boll-worm, the two worst of these enemies, will soon cease to be a cause of anxiety to intelligent and enterprising planters. How best to overcome in this connection the negligence and indisposition of the more careless and ignorant of the cultivators, of whom there are so many among the freedmen, is a question which I may consider at some future time.

THE HITHERTO UNKNOWN LIFE-HABITS OF TWO GENERA OF BEE-FLIES (*Bombyliidæ*) By C. V. RILEY, of Washington, D. C.

[ABSTRACT.]

THE paper gives the life-history of *Systœchus oreas* O. S. and of *Triodites mus* O. S. and shows that their larvæ have the same habit of preying on locust eggs. It calls attention to the parallelism in the life-history of the Bee-flies and of the Blister-beetles. The Bombyliidæ (accepting the more recent expansion of the family), so far as their habits have been hitherto recorded, were known to prey parasitically in the larva state upon the larva either of burrowing bees (genera *Anthophora*, *Andrena*, *Halictus*, *Colletes*, etc.), of mud-daubing wasps (*Trypoxylon*, etc.), or on the pupæ of certain Lepidoptera (*e. g.*, *Limacodes*). Yet certain genera develop in the egg-masses of the Acrididæ, feeding upon the eggs. So the habit of the Meloïdæ, so far as known up to the year 1877, was to live parasitically in the cells of either burrowing bees or mason bees, though certain genera, *e. g.*: *Epicauta* and *Macrobasis*, were then shown to prey on locust eggs. (See Proc. of the Association for 1878, B., p. 18.) The abundance of both the Bombyliidæ and Meloïdæ in the western country is referred to as directly connected with the prevalence of locusts there, and the facts of retarded development in the early stages of both families are recorded and explained as a characteristic beneficial to the species which must depend on such uncertain food as the eggs of insects like the migratory locusts, which in some years prevail in great abundance and in others become scarce or are not found at all, in given localities.