THE INSECT PESTS OF COTTON IN INDIA.

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The cotton plant, like all other crop plants, has its pests, insects which lessen the yield and quality of the lint and seed, insects which destroy the plant and very materially affect the gross yield from every acre. In the United States and Egypt these pests have been studied, and, especially in the States, vigorous measures have been adopted to check them. This has not yet been done in India; the results of investigation up to date are accordingly set forth in the following pages, with a view to drawing attention to these pests and to the best lines of experiment in checking them.

The annual value of cotton grown in India is stated to be in the neighbourhood of twenty million pounds sterling. The efforts that are now being made to improve the quality of the lint, to extend the area in cotton and to increase the yield per acre, are based upon improvements in the varieties grown, in the methods of cultivation and manuring, and in the quality of the seed. Less effort has been directed towards measures based upon checking the pests that now infest cotton throughout India, though it is probable that an improved quality of cotton, as well as a much larger yield, will be obtained when more attention is directed to this object. It is difficult to estimate the aggregate loss in the value of this crop from insect pests; the cotton grown in South Gujrat, Khandeish, and the Central Provinces is probably at least 10, and more nearly 20 per cent., below the yield that would be obtained were the plants free of pests; nor is this all, for the cotton that is picked is of poorer quality, and frequently stained by insect pests.

There is a further important point in which the work of insects has been hitherto neglected; many trials are being made of new varieties; exotic cottons are being introduced and acclimatised; hybrids are being produced; this work is done principally on experiment farms where insect pests are, from the nature of the farm, especially numerous. The results of these experiments and of these efforts at acclimatisation, are very seriously affected by insect pests, that is, by a factor that has up to now been somewhat neglected. It is

possible to find two plants of the same variety of cotton growing within a hundred yards, the one a fine vigorous plant yielding freely, the other a tall, straggling unhealthy bush that never yields and eventually dies ; this is often the work of insect pests, which seriously affects such experiments. The efforts made to introduce cotton into Behar in recent years have been very materially affected by the insect pests, and this is a factor that must be reckoned with if such attempts are to be a success.

The field study of cotton pests has not as yet extended into many cotton areas of India, but the enquiries have shown that the more important pests have a wide distribution in India, and in some cases in Ceylon and the Straits Settlements.

A total of sixteen insects are now known which are pests of cotton, but we may eliminate ten, as not seriously affecting the cotton crop. Every crop has minor and occasional pests which have to be watched, as they may at any time become important ; these need not concern us here, and we may consider only the really important species.

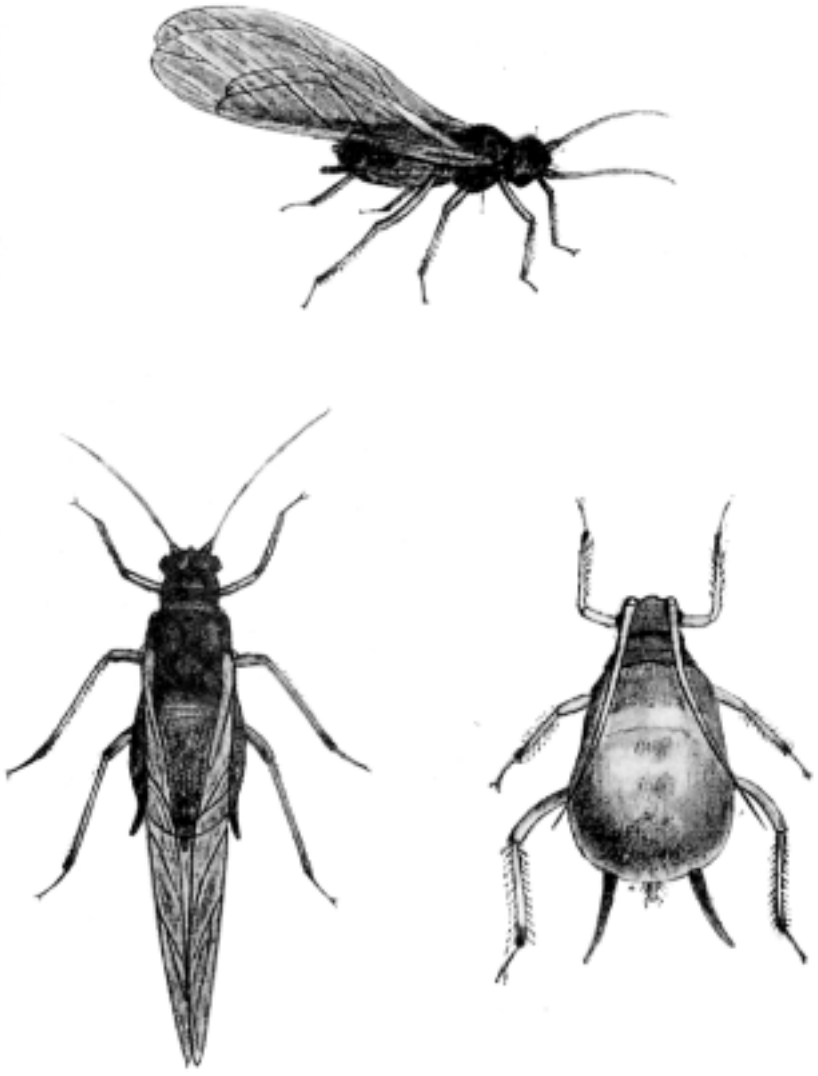
We may designate these pests by names similar to those in use elsewhere ; the cotton aphis differs in no essential from other aphides which attack crops throughout the world, and is clearly the equivalent of the same pest in cotton in the United States. So also are the bollworms ; in India there are three species of bollworm, which we may designate as the spotted bollworms, and (2) the pink bollworm ; these represent the notorious bollworm of the States which, though common in India, does not attack cotton. There is also the Red Cotton Bug, not the same species as the American Cotton Stainer, but similar in its effect on cotton. The cotton leaf caterpillar of the States is unknown in India, and that of Egypt is a species which in India attacks tobacco or other crops ; these are represented by an insect not of sufficient importance for inclusion here. Nor is the Texas boll weevil represented in India ; in its place we have the Stem Borer and the Stem Weevil, two pests whose importance is less than that of the notorious boll weevil, but which may still play an important part in cotton-growing in India.

THE COTTON APHIS. (*Plate VI.*)

Whatever be the species or the plant attacked, aphis is generally familiar ; multitudes of small dark insects, each no larger than a small seed, grouped in myriads on the leaf and stalk ; they move but little, generally remaining motionless, the beak buried in the tissues ; from each there drops a liquid which, falling on the leaves below, produces a shiny gummy layer ; in England they are known as green fly ; in India as *tela*, *mowha*, *mewa*, *mahu*, and the like. Looked at with a magnifying glass, one sees the legs,

PLATE VI.

COTTON APHIS.



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the rounded body, the head with feelers, and, projecting from the hinder end, a pair of short straight syphons. Some are winged, some are wingless. There are many points of interest in their lives. In the warm climate of India, they are commonly viviparous, young being born alive and all females. Whether winged or wingless, the ordinary colony that multiplies so fast is composed wholly of females, producing young parthenogenetically at a rapid rate. The young is active and able to look after itself. In a few days it produces young and as all are females, the reproduction is amazingly large. When the colony is small and food plentiful, wingless females alone are produced; as the colony increases, winged ones are formed, ordinary young ones, which develop wings and presently fly off to a new plant to found a new colony. If all goes well, the small colony of to-day has in ten days covered several plants, and is daily spreading further over the field. The drain on the plants is very great and further growth becomes difficult. Instead of a healthy vigorous plant, we find a stunted growth unable to produce a full crop of good cotton. The net result is a small crop of poor cotton. But for natural checks on the pest, its increase during the favourable months would destroy the cotton; natural checks there are in the form of Ladybird beetles, lacewing flies, the syrphus flies and the aphis parasite. As the colony grows large, these come and feed upon the aphis. They breed among the colonies, and as they increase, so the aphis diminishes; it becomes a fight in which slowly but surely the enemies of the aphis win. Having devoured the aphis in one place, they move in search of fresh colonies. We cannot overestimate the beneficial effect of these useful insects, and we can only wonder that the aphis ever becomes a pest. But it does not always happen that the beneficial insects come in time or in sufficient number. In spite of its enemies the aphis often becomes a most serious pest, especially under certain conditions. The cultivator says that "Mahua" is a disease produced by cloudy weather; two causes appear to lie at the root of this fact; in cloudy weather the plant is apparently a more easy prey to the aphis, possibly because in the absence of sun the transpiration has become checked and the plant is turgid, possibly because the general vitality of the plant is simply lowered; also in damp and cloudy weather the aphis itself thrives; the winged aphis spread over the field and scatter; their enemies do not find them, and these flying individuals found colonies over a very large area; each colony separately does not afford food for the increase of the useful insects, and in a short time there are numberless small colonies, the progeny of these flying females. Very soon these become large and extensive, when the Ladybird beetles and other insects come. The aphis has by this time got so good a start that its rate

of increase is beyond the feeding capacity of the various enemies, and it is some time before the latter increase sufficiently to overtake the aphis. This struggle occurs frequently, circumstances sometimes favouring the aphis, at others increasing the numbers of the various insects that prey upon it. If we could assist these useful insects, or bring them upon the scene in time, nature alone would do the work, but we cannot at present assist nature in this respect. (*See Plate VII.*)

The significant factor is the healthy plant ; not only will a vigorous plant not succumb, but it will be less easily attacked. The moral is to grow only such cottons as are healthy enough to resist aphis. Most exotic cottons, and many Indian cottons growing in new localities, require to be acclimatised ; a cotton acclimatised to one district in India is not necessarily proof against aphis in the next district, and in seasons of unfavourable climatic conditions no cotton is immune. When new cottons are to be introduced, it should be done only where artificial remedies can be applied to check the aphis. There is but one sound artificial remedy, spraying, and this must be relied on to keep down the aphis that will otherwise attack exotic cottons that are not fully healthy. The time may come when the cultivator will buy and use a two-rupee sprayer, but that time has not yet arrived ; till then it is necessary to acclimatise the cotton by the free use of the sprayer; at present no experimental cultivation of cotton should be done unless a sprayer can be used, and this remedy should be as much a part of routine work on an experimental farm as weeding or any other agricultural operation.

THE RED COTTON BUG (*Plate VIII.*)

Under the euphonious title, *Dysdercus cingulatus*, we have the common cotton stainer, a near relative of the American insect, *Dysdercus suturellus*. This insect may be found on the cotton at all times, most abundantly when the bolls are forming and the crop is ripening. It is a common insect throughout the plains, feeding on many malvaceous plants and originating in the jungle. Under favourable circumstances it is abundant in the cotton fields and multiplies rapidly.

The perfectly developed insect is a vivid red, with a black diamond mark on the wings and some white lines on the lower surface. It is known as *Jhanga* or as *Lalkiri*, but does not seem to have generally impressed itself on the cultivator. The female lays a mass of little round yellow eggs on the soil or on the cotton boll. From these come small active red insects which run about the plant, and cluster on leaves or bolls, sucking out the juice. They are readily found in open bolls or on green bolls, and, if there are no bolls, on the leaves. With plentiful food they develop rapidly, the

PLATE VII.

APHIS ENEMIES.

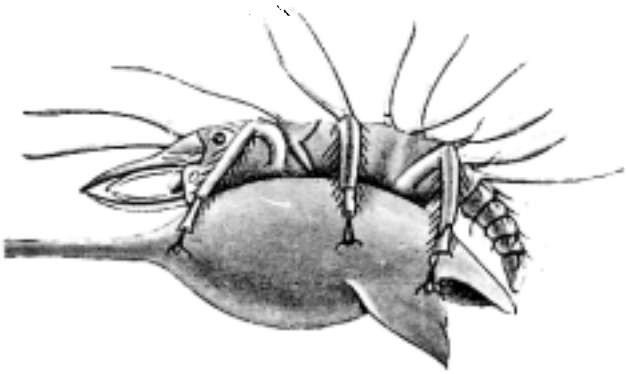
Lady Bird Beetle.

Syrphus Grub.

Lacewing Fly.

Syrphus Grub.

Eggs of Lacewing.



Lacewing Grub just hatched.

Full grown Lacewing Grub.

wings appearing as small black lobes on the back after the third moult, and attaining their full development after the last. The full-grown insect rarely flies, but runs actively. Food is obtained by the long suctorial beak, which is capable of entering the green boll and sucking out the seeds. This insect is rarely abundant enough to injure the cotton plant, and the damage it causes passes unnoticed. To all appearance it is an unimportant pretty insect which lives in the cotton and does not harm it. The damage it causes becomes apparent only when the cotton is picked, and this damage is certainly not assigned by the cultivator to its right cause. If we pick and gin the cotton from an infested field, we find (1) a large proportion of light seeds, which have been sucked out by the red bug; (2) a large proportion of bad lint, produced from bolls sucked out when young by the red bug; (3) a quantity of lint stained by the excreta of the insect; and (4) a quantity of lint stained by the small red bugs crushed in the gin.

Cotton from a field moderately infested with red bug has been found to yield about one-third of bad lint, stained or spoilt by the bug, and after the removal of this, one-third of the remaining seeds are light and without germinating power. The net result is a loss of one-third of the lint and of half the seeds.

There is, unfortunately, nothing to connect, in the mind of the cultivator, the damage the insect causes with the insect itself. The cotton is picked after the insect has done its work, and when such young insects as there are, are hiding among the lint of the open bolls. The insect works when the bolls are green, and is probably hibernating in shelter by the time the cotton-picking commences. The cultivator does not realise that the red insect which was in his fields a month before, is responsible for the bad quality of his cotton; it is doubtful if he ever saw the insect; still more doubtful if he realises that his cotton could be better.

There is no difficulty in checking the pest; give the ordinary coolie a flat basket and an empty kerosene tin or pot, having a little kerosene and water at the bottom; let him shake the red bugs off the plants into the basket, and tip them at once into the kerosene and water; he will, in a very short time, clear his cotton of bug at the expense only of a little kerosene and labour. If kerosene is not forthcoming, water heated over a fire, and occasionally warmed up again, is all that is required.

The difficulty is to get the cultivator to realise that the bug must be killed; in many places, it breeds also on the bhinda (*Hibiscus esculentus*), on the ornamental Hibiscus, and on other malvaceous plants. If he realised the importance of this pest, he could check it breeding on bhinda when there is no cotton, as it does in so many places. This difficulty should not

exist on experimental farms ; red bug should be checked systematically, and unless there is much jungle near the farm, thoroughly destroying the pest once will prevent its becoming established. A far greater amount of harm is done by this bug, than mere inspection of the growing cotton shows, and it is only when we examine the ginned seed, that we can estimate the loss. A seed that has been sucked out shows no mark, looks normal, and can be distinguished only when cut open. Such a seed will not germinate, yields no oil, and is valueless.

THE BOLLWORMS. (*Plate VIII, IX.*)

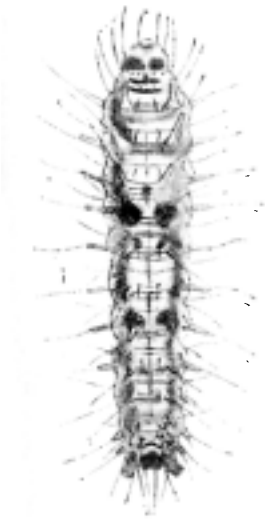
By far the most important insect enemies to cotton are the bollworms. An account of these pests is being published elsewhere, and we need here touch on salient points only. Bollworms hatch from eggs laid by the parent moths, on the bolls of cotton ; they are tiny caterpillars when they first emerge, and feed on the bracts or flower buds before eating their way into the cotton boll ; when the caterpillar has grown a little, it eats straight through the green rind of the boll, through the developing lint, and goes into the seed ; having eaten out one seed, it attacks another and so on till it is full-fed ; then it comes out of the boll, makes a cocoon in a sheltered spot and turns to the chrysalis, from which after a few days comes the moth that lays eggs and starts the fresh brood.

The details vary a little in different localities ; the cocoon may be in the soil or in the bracts of the boll, rarely in the boll itself.

The bollworms are of two distinct kinds ; the pink bollworms, (*Gelechia gossypiella*, Saund.), a slender pinkish caterpillar ; the spotted bollworms (*Earias fabia* and *Earias insulana*), which are shorter, more thick-set, coloured in black, greenish-white and orange, with spine-like processes. Both behave alike so far as the cotton is concerned. One or other pest is found in cotton wherever it is examined in India, and generally both are found in the same field. The most careful investigation of the life-history and the habits has, as yet, not led to the finding of any simple method of checking them wholesale. For both there is one remedy, so simple as not to seem worth doing, so obvious that no one would think of it until every other remedy failed, and as effective probably as any remedy ever was, but a very laborious and tedious operation. If we consider the circumstances as a whole, we can follow the pest throughout its career, and hunt for the one vulnerable spot at which we can attack it. The eggs are very small, laid singly, not easy to find and impossible to collect or destroy in any effective way. The caterpillar is safely esconced in the boll, away from any insecticides we could bring to bear on it. The chrysalis is very small,

PLATE VIII.

SPOTTED BOLLWORM.



The spotted Bollworm.
Magnified four times.

Moth of spotted Bollworm. Magnified three times.

The spotted Bollworm.
Magnified four times.

Cocoon of spotted Bollworm.
Magnified three times.

Moth of spotted Bollworm.
Twice Magnified.

The Cotton Stem Weevil. Magnified.

Cotton Boll infested with Red Bugs. Natural Size.

The Cotton Stem Weevil. Magnified.

very like a dead cotton bud, and not to be captured or destroyed on a large scale. The moth lives but a short time, is very small and flies only in the dusk of the evening ; clearly one cannot easily catch it. If we turn to the history of the insect throughout the year, we get little help ; cotton is sown in June and comes into bearing, say, in November. In August we find the spotted bollworms eating the top shoots of the cotton, or feeding in the flower buds ; an energetic cultivator who understood his business would capture many such caterpillars by going over his cotton and cutting them out. This is the first brood in the cotton. The moths that come from these caterpillars lay eggs on the first bolls, and the attack begins. As the bolls develop, more moths hatch out, more come in from outside, and we find both bollworms plentiful in the cotton. This goes on till the cotton ripens, when probably the caterpillars hibernate. The spotted bollworms hide away in the ground, in waste lands or in any odd corner, and there become pupæ. The pink bollworms curl up in the seed of the cotton and make a cocoon there. The cotton is picked and sold, the seed ginned and kept till next year. In March or so of the following year, out comes the spotted bollworm moth, lays eggs on bhinda or some malvaceous plant, and goes on breeding ; very often it breeds in the old cotton plants still in the fields ; if this be not possible, it hides away until the rains or lays its eggs on the stalks of a suitable plant. The rains come again, and the pink bollworm moth comes out from its cocoon ; it has to live until the first bolls are ready for it and breeds in waste lands or jungle on wild plants ; possibly it lives till August as a moth. The spotted bollworm moths breed in bhinda, in garden hibiscus, in hollyhock and in other plants, and are ready for the cotton in August.

From this, we can select several points worth our attention. There is the pink bollworm hibernating in the seed ; this can be destroyed by care, by fumigation, by testing the seeds in water. The old cotton plants need not be left in the fields to afford food for the insect in March and April as is so often the case. Bhinda and similar plants are evidently dangerous and should not be grown in cotton areas. The first brood of bollworms in the cotton should be destroyed in August, by the simple expedient of pulling off the attacked shoots and burning them. These and other measures will help, but will not seriously affect the issue in the present state of things. There remains but one remedy, *to pull off and burn every boll of the first batch that is attacked ;* if we could induce the cultivator to go over his plant boll by boll, pull off all that have signs of bollworm and burn them, we could insure at least that there would be no multiplication of the insect in the cotton by the natural laws of increase. A boll eaten when young may fall off or goes on developing ; it is valueless, in any case, but if left on the

plant it develops and opens prematurely ; the plant gives as much of its vigour to forming the bad bolls as the good. Clearly there is no loss in pulling off these bolls; there would be much gain if the first batch of attacked bolls were removed, so as to kill the first brood and check the increase. For every boll removed when small, the plant will make another ; but it will not replace old worm-eaten bolls that ripen on the plant to worthless cotton and bad seeds.

The remedy is so simple that every Indian cultivator should make it a part of the practice of growing cotton just as sowing, weeding out, picking and the like are done. An insect pest is, after all, similar to a weed, and wants removing just as much. Had we in India the educated and enterprising farmer of the United States, we could say, as Professor Comstock did in 1879, " Hand-picking ; * we should be far from advising any planter to attempt to rid himself of the bollworm by collecting these from cotton by hand," and turn our attention to spraying or other artificial remedies.

The first necessity in India is for the cultivator to realise that his cotton is attacked : when the time comes for picking, there is nothing to show that the cotton has suffered from any bollworms ; there is nothing to connect the many bad bolls with the caterpillars that were in the fields a month earlier. Should the cultivator ever realise that bollworm injures his cotton, he will probably not be far from learning the connection between the bhinda he grows in his village in April, and the extra bad attack of bollworm he gets in September. Until he has realised what bollworm is and does, the remedies that would be suitable in the United States must give place to a simpler and more direct remedy for the cultivator in India.

We may turn back to our other remedies, some of which are within the reach of farm overseers. Everything that assists the bollworms out of the cotton season, adds to the chances of a bad attack of bollworms in the season. Cotton seed that is left for sowing should be treated with Carbon bisulphide before it is put away for the winter, to insure no pink bollworms hibernating there. The old cotton plants that will no longer yield, should be pulled out before March ; it is not uncommon to see many green cotton plants in March and April, with a plentiful brood of the spotted bollworms.

The cultivation of bhinda is a distinct help to the bollworms, especially when grown with irrigation in April and May. Whether we can use bhinda as a trap crop for the bollworms in cottons, remains to be seen. None of these are remedies for the pest ; they are precautions and preventives, and

* Report upon cotton insects, p. 312.

though they might do much in the hands of farmers, they are at present not practised by the cultivators.

It is impossible at present to estimate the loss of yield of cotton due to bollworms. Actual counts of many thousands of bolls have given from 10 to 75 per cent. of infested bolls at a picking. It is not uncommon to find that one-third of the ripe bolls have been attacked by bollworms and yield dirty lint of inferior quality. Ten per cent. was a low estimate of the total loss in the Surat District in 1903-1904, from actual counts in many fields. From 10 per cent. in a large area of cotton, we rise to any figure in cases where cotton is grown experimentally and only on a small scale. The loss that is normally spread over a large area is then concentrated in a small area. Where cotton is grown only experimentally, every possible precaution must be taken, and remedies that are impossible on a large scale become imperatively necessary ; spraying with lead arseniate becomes a necessity in such a case, as does the light-trap for the pink bollworm moth. These are discussed elsewhere and do not come within the scope of this article.

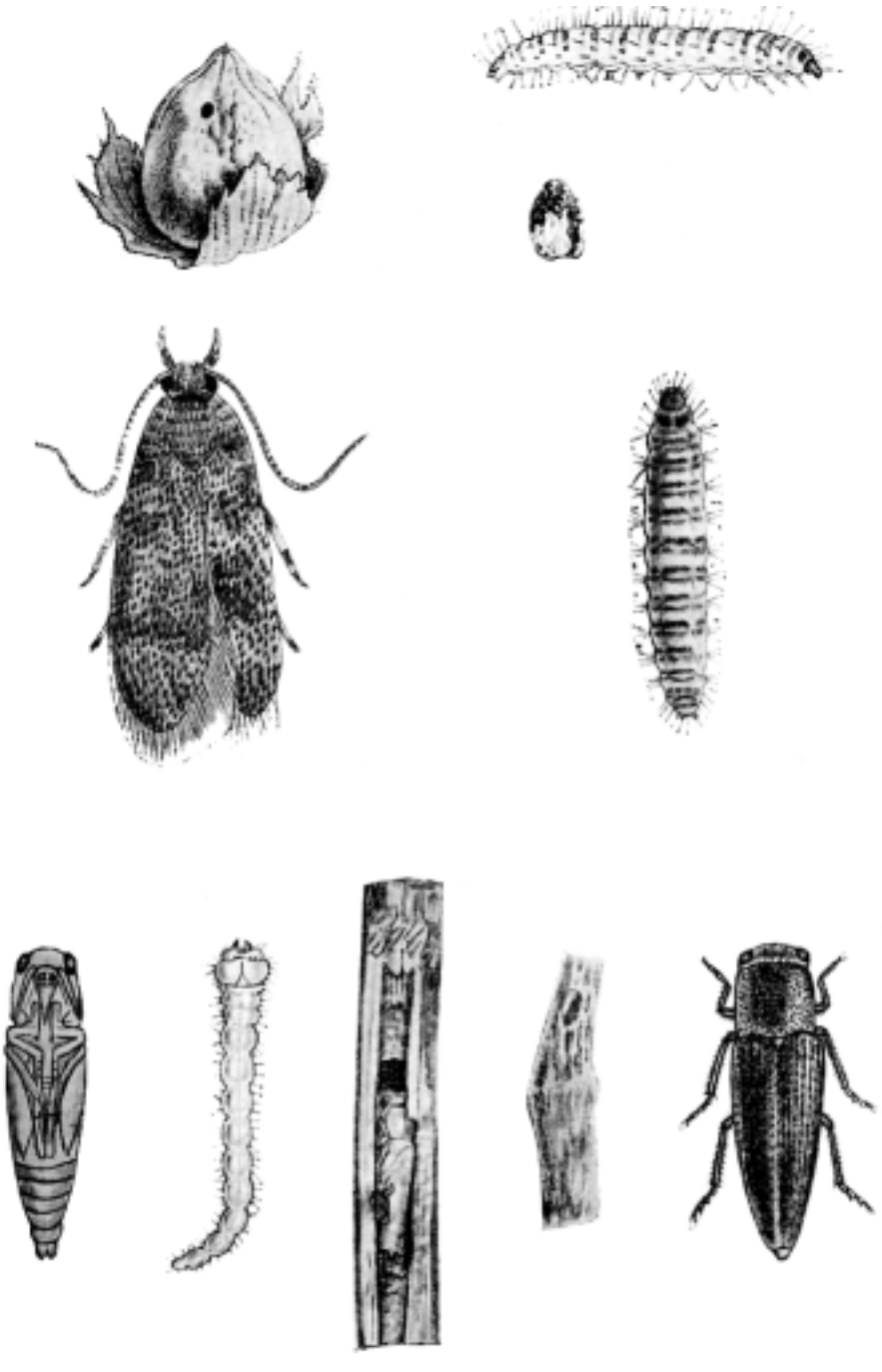
For the cultivator, there is urgent need of any measures calculated to bring home to him the nature of this pest and its work. No one can afford to neglect pests that make so direct an attack on the yield of the cotton, least of all the cultivator to whom a loss of 10 per cent. may mean his whole profit and living wage. The systematic plucking off of bolls sounds an impossible task ; it is not so hard as it sounds, and is well within the patience of the ryot if he can be convinced that it will pay.

If we turn from the cottons now grown by cultivators, to the American tree and other cottons under experimental trials, the question of varieties immune to bollworm naturally presents itself. There is at present a small amount of evidence for believing that certain indigenous tree cottons may be immune to bollworm, and it is quite possible that we may find exotic varieties similarly that are immune. Whether such varieties will remain so when cultivated on a large scale is another question ; it is at least desirable that the point should be borne in mind in estimating the comparative value of exotic and other cottons ; a cotton immune to bollworm starts on a better basis than a cotton such as Egyptian Metafifi,where the loss is very large.

This point is important in connection with tree cottons and all cottons in which the yielding period is spread over any length of time. The cottons of Gujarat, Khandeish and the Central Provinces would suffer far more were the yielding period longer ; a cotton that quickly produces its full crop of bolls is far more desirable than one that continues to yield slowly for months, or that bears more than once a year. It is imperative that the latter type of cotton should be immune to bollworm, or that it should be grown under such

PLATE IX.

PINK BOLLWORM.



circumstances that bollworm can be checked or is never introduced ; the latter is probably the least likely to be possible, and the cultivation of tree cottons or of any varieties that do not yield all at one period will be profitable only if an immune variety is discovered.

THE COTTON STEM BORER. (*Plate IX.*)

If we go into a cotton field in August or September, we may find a plant here and there yellow and withered. This is the work of *Sphenoptera gossypii*, a long white grub that is living in the stem of the plant, feeding on the wood. The grub lies inside, having made a neat round tunnel up and down the centre of the stem. It will stay there till it is full grown and then turn into the chrysalis, from which in course of time comes the beetle. Both grub and pupa are readily found by splitting up these withered plants ; the beetle after some days' rest in the stem, bores its way out, mates and lays a batch of eggs scattered over the field. The insect is a common one in most parts of India where the pests are known. In Bombay, Central Provinces, Cawnpore and parts of the Punjab it occurs plentifully. In Behar it has been found once, and does not yet seem to have become a pest of cotton. When the plant is young, the presence of this pest is not important ; the destruction, however, grows greater as the broods succeed each other, and the total loss of plants is a serious item late in the season.

The cultivator apparently knows of the work of the pest, if not of the insect. He pulls up these plants and leaves them in neat heaps about the fields. If he went one step further and burnt these plants, he would steadily check the pest and prevent its increase. Practically every plant that withers contains a grub or pupa. It may be many days after the plant withers before the beetle comes out ; if these plants were burnt, either when they withered or periodically every fortnight, practically every beetle would be killed before it was able to breed, and in the later stages of the cotton the pest would disappear altogether. The remedy is so simple and easy, that every cultivator should adopt it. It is true the destruction of the individual young plants does not in itself matter ; it matters only because the beetles become numerous in the second and third broods when the loss of every bearing plant means a loss of cotton. It should not be a difficult matter to explain this to the cultivator ; the whole affair is simple and straightforward, eminently suited to be an object-lesson to the agricultural classes where this pest is found.

THE COTTON STEM WEEVIL. (*Plate VIII.*)

We have lastly a pest of which little is known and concerning which we can now only sound a note of warning.

During the last few years, cotton has been experimentally grown in Behar ; many varieties have been tested and some have been found to be preyed on by a hitherto undescribed insect. The Egyptian, the Broach-Deshi and other Bombay cottons, and the Caravonica have been particularly attacked, some so seriously as to preclude the idea of growing them on small areas where this pest abounds. The grubs of the pest tunnel in the stems and branches, principally in the stem just above ground. The stem swells and forms a round lump in the case of the Broach-Deshi and other Bombay and the Egyptian cottons. The plant does not necessarily die, but it sooner or later breaks off at the crown and is liable to suffer heavily, if not very vigorous in growth.

The Caravonica cotton has died practically completely from the attack of this pest. The grub, the pupa and the beetle are found in the cotton plant, the beetle eating its way out of the stem and flying away. The beetle is figured (*vide* plate) ; it is very small, of a dark colour, with brown and white marks ; the lower surface is whitish, the legs brown, the whole body clothed in flat scales. It is active from April to November, hibernating as a grub inside the cotton plant during the cold weather. Its attack has been extraordinarily virulent upon the experimental cottons, and it is to be hoped it will not spread outside its present limits. Apparently it is an indigenous insect, feeding normally upon wild plants, but, finding cotton is a suitable food-plant, it has become abundant with abundant food.

No treatment at present known will protect cotton from its attacks, though it is hoped that further investigation may show how the pest can be attacked. It will be recognised with ease in the grub or pupa stage in the cotton plant, but cannot be readily identified from chance beetles caught in the fields.

CONCLUSION.

There are two main problems connected with cotton pests in India at the present time, which will be solved in distinct ways.

There is, first, the problem of checking the pests that lessen the yield of the staple cottons of India as grown by cultivators ; second, the question of how far these pests will hinder the introduction and dissemination of improved cottons, and the problem of checking pests in these cottons.

For the cultivator, the six pests discussed above are of prime importance. The minor pests which appear here and there do not affect the issue materially. It is sufficient now to deal with pests which take toll to the extent of one-tenth of the available cotton of all India. If this estimate is near the truth, the loss from these pests is in the neighbourhood of three crores of rupees ; it is of course a vague estimate, but as good as our data will give us.

How is this loss to be checked and this sum saved for the cultivator? The answer must be, by showing the cultivator the simple remedies, by teaching him something of his pests, so that he can act on his own initiative and understand how to save his crop. The crying need is for the cultivator to know that there are pests, that his cotton is not the normal amount or quality he should get, and that he can increase both quantity and quality if he will only do his best to check the pests.

The bollworm is not even known to him, as it works when the boll is green, and the ryot is not interested in green bolls. Nor does he know of the stem borer or the red bug, because they are not large, conspicuous insects that work openly. With all his inherited knowledge and instincts, the cultivator takes little heed of pests.

It is not a question of elaborate remedies or the introduction of insecticides, etc.; if we could be sure that he knew and understood, we could leave it to him to choose between adopting simple remedies and getting poor cotton. So long as the conditions remain as they are, science cannot help the ryot any further. This is the whole problem as it concerns the ryot, one that will be solved differently in different places and cannot be discussed here.

For the experiment farm, the matter is entirely different. We have a variety of plants, many exotic or unacclimatised to that locality, not yielding together and growing perhaps for long periods They are often tender plants, unable to resist pests, and not grown on a large enough scale to diffuse the pests over a large area. The result is a continual succession of pests, far more than on ordinary cultivation, acting unequally upon different plants and producing extremely curious results. If uniform results are to be obtained and if tender exotics are to be grown, pests must be checked by every device possible; the whole thing is artificial, the plant is growing under artificial circumstances, and we must adopt every means of checking the pests. The mere fact that we sow less than one acre of a particular variety means that pests are found in it to an extent that could never occur over a thousand acres, and when we consider also their entire lack of immunity to pests, we need not be surprised if cotton plants on experiment farms are ravaged by insects.

In these cases the spraying machine and the best insecticides must be at hand. Aphis can be checked with the sprayer without the smallest difficulty, and at a very small expenditure if taken in time. Lead arseniate sprayed on the plants as they form the first bolls does much to check bollworms; where pink bollworm is abundant, a lamp-trap is advisable. Bhinda should not be grown anywhere on or near the farm, nor should garden hibiscus, Deccan hemp, or any other malvaceous plants. Every individual red bug and stem borer should be rigidly destroyed; cotton, as picked, should be

fumigated ; the first plant seen to have stem weevil should be burnt, and, though no precautions can be taken against this pest, it may be possible to destroy a large proportion of the infested plants or prune off infested branches. Affected bolls and bored shoots should be burnt periodically, and no cotton plant should be allowed to grow for a day after it has yielded its seed and is finished with. These are the principal precautions, which should be familiar to every farm overseer who has charge of cotton. A good deal of trouble and attention is required, and some expenditure, far more than is within the reach of the cultivator; but if cotton is grown as an experimental plant, if new varieties are to be introduced, and hybrids obtained, the expenditure is a mere trifle compared to the other expenditure, and to the ultimate value involved.

EXPLANATION OF THE PLATES.

PLATE VI.—Winged and Wingless Cotton Aphis. Magnified.

PLATE VII.—Aphis enemies. Ladybird Beetle (*Chilomenes sexmaculata*). Syrphus Grub. (*Syrphus ægyptius*). Lace wing Egg, Grub and Fly. (*Chrysopa* Sp.) Magnified.

PLATE VIII.—Spotted Bollworm. (*Earias fabia*). Bollworm, Cocoon, Moth. Magnified.
Cotton Stem Weevil. Red Cotton Bug (*Dysdercus cingulatus*).

PLATE IX.—Pink Bollworm. (*Gelechia gossypiella*). Bollworm, Pupa Case, Infested Boll. Moth.
Stem Borer. (*Sphenoptera gossypii*). Grub, Pupa, Beetle.