1903.—No. 11.

DEPARTMENT OF THE INTERIOR.

BUREAU OF GOVERNMENT LABORATORIES.

BIOLOGICAL LABORATORY.

ENTOMOLOGICAL DIVISION.

BULLETIN No. 1.

PRELIMINARY BULLETIN ON INSECTS OF THE CACAO.

PREPARED ESPECIALLY FOR THE BENEFIT OF FARMERS.

By CHARLES S. BANKS,

Entomologist, Bureau Government Laboratories.

MANILA:

BUREAU OF PUBLIC PRINTING.

1904.

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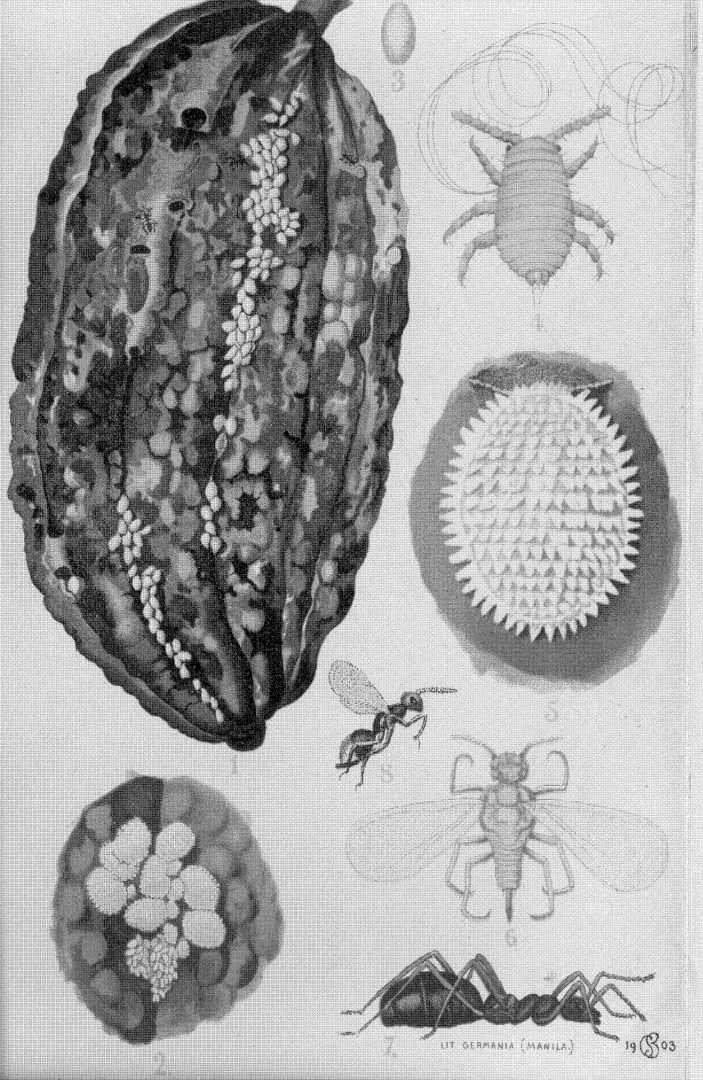

FRONTISPIECE.

[Drawn from nature, by Charles S. Banks, 1903.]

LEGEND.

FIG. 1. Cacao pod, showing mealy-bug, natural size, and the attendant ants and sheds built by the latter.
2. Female mealy-bug and young, enlarged four diameters.
3. Egg about to hatch, enlarged forty diameters.
4. Young insect just hatched, showing filamentous mouth-parts, enlarged one hundred diameters.
5. Female mealy-bug, enlarged nineteen diameters.
6. Male mealy-bug, adult, enlarged twenty-one diameters.
7. Ant, attendant to the mealy-bug, enlarged nineteen diameters.
8. Hymenopterous parasite of the mealy-bug, enlarged nineteen diameters.

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
BUREAU OF GOVERNMENT LABORATORIES,
OFFICE OF THE SUPERINTENDENT OF LABORATORIES,
Manila, P. I., September 14, 1903.

SIR: I have the honor to transmit herewith "A Preliminary Bulletin on Insects of the Cacao," by Mr. Charles S. Banks, Entomologist, Bureau of Government Laboratories.

I am, very respectfully,

PAUL C. FREER,
Superintendent Government Laboratories.

Hon. JAMES F. SMITH,
Acting Secretary of the Interior, Manila, P. I.

ILLUSTRATIONS.

A PRELIMINARY BULLETIN ON INSECTS OF THE CACAO, PREPARED ESPECIALLY FOR THE BENEFIT OF FARMERS.

By CHARLES S. BANKS,
Entomologist, Bureau of Government Laboratories.

This bulletin is prepared particularly with a view to its practical value to the farmers of the Philippines in the cultivation and protection of an industry which promises much in the future for these Islands.

As this bulletin is the result of only three months actual investigation of cacao insects, it does not in any way cover all the insects which are directly or indirectly associated with the growing of cacao.

Much has yet to be learned of the habits and life-histories of many of the insects treated herein, owing to the fact that the periods of their transformation extend over a year or more. The publication of the material at this time is in response to an urgent demand upon the part of growers for information that will help them in combating the more serious pests.

All the illustrations, where not otherwise credited, are from photographs made by myself or by the Government photographer under my direction, or are from original drawings made by myself or under my supervision by Juan de Guzman and José Garcia.

The frontispiece was drawn by me from nature, partly in the field and partly from material brought back from my trip.

I wish to acknowledge my personal thanks to Sr. Don Juan A. Araneta, of the hacienda "Louisiana," Maao, Occidental Negros, for the many ways in which he aided me in the work of investigation which I carried on upon his plantations.

C. S. B.

MANILA, P. I., *August 28, 1903.*

CACAO INSECTS.

Up to the present time, so far as search has revealed, very little has been published upon the subject of economic entomology in the Philippine Islands. In the several admirable works on the entomology of the Archipelago, we find not only that the economic side has been entirely neglected, but also that the same thing is true from the biological standpoint. The only attempts made in the past have been to determine the names of specimens, in most cases collected by one man and classified by others. For even the most common species of insects, few or no data are given regarding their habits, life-history, or relative abundance at certain periods of the year or in stated localities.

In preparing this brief preliminary bulletin on the insects of the cacao, I realize that I am but hinting at some of the more important pests which have been encountered during a comparatively short period of the year; so that all the conditions as they would occur consecutively during the course of twelve months, and undoubtedly changing slightly with each succeeding year, are not now noted, nor are all the subjects mentioned treated exhaustively, the object being at the present time only to set forth as clearly as possible some of the most common and more destructive insects, with practical suggestions for the prevention or treatment of their ravages. At the same time it is proposed to mention a few of those insects, which, because of their predatory habits in feeding upon the injurious forms, should be considered as beneficial to the farmer.

Perhaps one of the most valuable crops produced in the Philippine Islands in proportion to the quantity raised, is the cacao bean, the product of a tree of the family *Sterculiaceæ* and botanically known as *Theobroma cacao*. The tree averages from 4 to 12 meters in height, and, as grown in these Islands, usually assumes a somewhat oval form in its mode of branching, like the pear tree of the United States.

Like nearly all other plants, when brought into cultivation, it is subject to many diseases and the attacks of a large number of

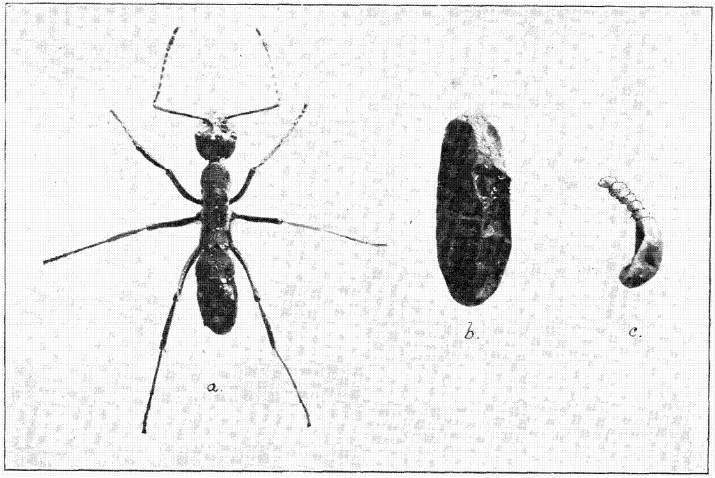


Fig. 1.

insects. This is more or less true in all parts of the world where it is grown, in Venezuela, Trinidad, Java, and particularly, it would seem, in the Philippines.

In this bulletin some of the injurious forms of insects will be mentioned, together with what has been learned of their life histories up to the present time. As it is very necessary to know the most susceptible stage of an insect's life in order to know what is the easiest remedy to apply to it, we can readily see the necessity for becoming familiar with its life-history. It is hoped that further observations will enable me to treat the subject more exhaustively at a future time.

In suggesting remedies, those are given which have been found most effectual for similar pests in the United States, but the effort has been made to so modify them as to make them fit local conditions.

For convenience, the subject has been divided according to the part of the plant attacked. Thus, beginning with the roots, we will in order discuss the insects of every part of the tree, giving their habits and mentioning the best means to be used against them.

INSECTS ATTACKING THE ROOTS.

BLACK ANTS.

The principal insects at present known to attack the roots are a species of large, ferocious ant, a species of *Cicada,* and the grub of a beetle belonging to the genus *Anomala,* but not yet identified.

The ants are black and are characterized by the ability to inflict a very severe sting. The abdomen is constricted between the first and second segments, the first segment having two backward-pointing spines on the upper part. The head, thorax, and first and second abdominal segments are beautifully corrugated. The legs and antennæ or feelers are very long. The light-brown cocoons, made of a silk paper, are usually very abundant in the nests, which are located at the base of the tree among the larger roots. Within these cocoons may be found the white grubs, which are shaped very much like a long-necked gourd, the head being at the smaller end. (See fig. 1 *c.*) The larvæ or grubs, before spinning their cocoon, and the eggs are simply deposited by the workers in any convenient part of the nest. The adults are the only injurious forms of these insects. They gnaw the bark from the large roots,

thus inviting decay, and making an opening for the entrance of the insidious white ant, another very serious enemy of the cacao, belonging to the genus *Termes*. The latter is called *anay* in Visayan and Tagalog, and is probably the most serious insect pest in the Philippines, destroying, as it does, nearly every conceivable class of material except articles made of metal. It has hitherto been supposed to attack only woods which had been previously cut, but in the work of investigation on cacao insects it has been conclusively proven that it also attacks the living tree, at least in the case of cacao. (See fig. 2.)

In the United States the members of the genus *Cicada* are restricted to not more than five species. In the Philippines there are several, some being large and black and others grey, while still another species is of a very light yellowish green. A singular thing about the individuals of the genus is that the males give forth a strident noise, produced by means of two drum-like organs on the lower side of the first segment of the abdomen. Unlike the members of this genus in America and Europe, which generally "sing" in the hottest days of summer, the individuals found in the Philippines almost invariably reserve their serenade till the falling of darkness, when their strident notes may be heard on every hand, especially near wooded lands.

All observations thus far made upon this interesting insect would lead me to infer that the habits and life history are the same in the Philippine Islands as in other parts of the world, particularly so in the case of the dog-day cicada in the United States.

Here the species may be found at all times, and the insects are so common as to be used as playthings by the native children, who capture them to make then sing. In Visayan they are called *"Ceriritan"* and in Tagalog *"Culiclic."*

The adult of the species which attacks the cacao tree measures 42 mm. to the tip of the wings, which project 13 mm. beyond the tip of the abdomen. The body is robust, somewhat conical, and is composed of a series of very regular segments, which may be more easily distinguished on the abdomen than on the thorax. (See fig. 3.) The insect has four very beautifully marked, transparent wings, the fore ones being much larger than the hind. The venation is shown in fig. 4. When at rest the insect's wings are laid over the abdomen, roof-like. The *Cicada* has a swift but erratic flight. This is due to the lack of coördination between the

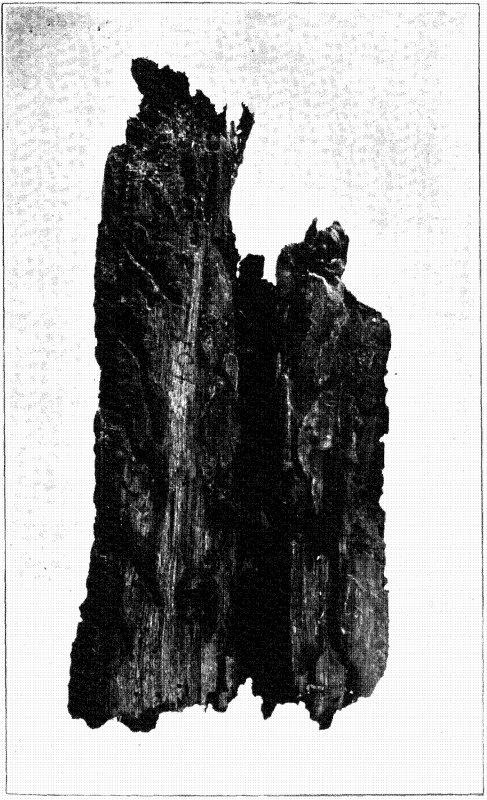


FIG. 2.

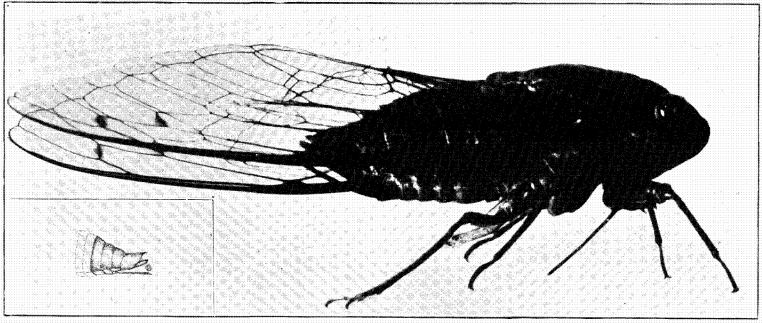


Fig. 5.

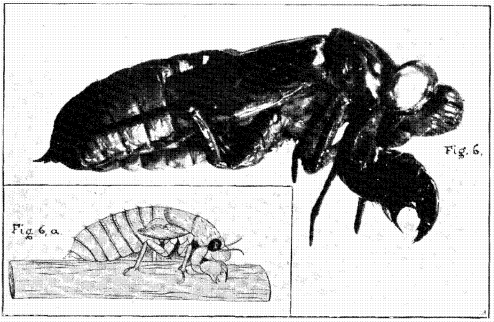


Fig. 6, Fig. 6 a.

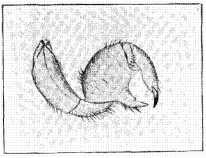


Fig. 7.

wing muscles of the opposite sides of the body. By holding the insect between the thumb and the forefinger, so that the wings are free to move, it will be seen that the opposite pairs move alternately.

The insects of this genus pass through a very remarkable series of changes from the egg to the adult stage. The total duration of the metamorphosis has not yet been determined, but it is safe to estimate that in this region the time occupied is not less than eighteen months. In America one species nearly related to this lives from thirteen to seventeen years in the ground before reaching maturity, while another completes its transformation in two years.

The female *Cicada* is provided with a very peculiar ovipositor or egg-laying apparatus (fig. 5), by means of which she slits the twigs of young branches of the cacao. Inasmuch as the wood of the cacao is comparatively soft, she finds no great difficulty in placing her eggs in branches which are larger than those ordinarily found with *Cicada* eggs in the United States. Within from four to six weeks from the time the eggs are laid, the young hatch. They are tiny white creatures which resemble very much the full-grown nymph, except in size. Their forefeet are adapted for digging in the ground, and they, dropping from the twigs, begin immediately to burrow down to the tender rootlets of the plant, where they settle and insert their beaks for sucking the juices of the roots. Fig. 6 shows the nearly full-grown nymph, and fig. 7 shows its forefoot. The larva or nymph forms a dirt cell around the spot where it decides to remain. This it does with its forefeet, using them as a mole would, and packing the earth at the rear and above it with its other legs. Thus is made a subterranean cavity where this little enemy of the roots of the cacao may live and feed.

The mouth of the insect is of the sucking class—that is, the various parts are modified to form a lancet for piercing the epidermis of the plant upon which it feeds, and a tube-like structure through which the sap is drawn up into the mouth cavity, whence it is conveyed to the stomach.

When very young, the larvæ may be found not more than 10 or 12 cm. below the surface of the ground, but as they grow larger they gradually work their way downward. In some cacao trees they have been found as deep as 80 cm. below the surface, clinging tenaciously to the roots by their beaks and their legs.

characteristic markings coming out upon its surface. Within an hour, seldom less, the insect begins to move its wings as if testing them, and now the slightest movement on the part of the observer will cause it to quickly take wing, giving a short clicking sound as it flies away. If the insect be a male, it at once makes its characteristic "creet," a noise familiar to all, as it starts to fly. If it be a female, it remains in silence. It is not definitely known how long a period elapses from the emergence of the insect from the ground, until it mates and begins the work of laying its eggs. Further observations will be necessary to determine this.

The principal injury to the cacao from these insects consists in the lacerating of the young wood by the females in placing their eggs, and in the damage done to the tender rootlets by the larvæ and pupæ. The former not only debilitates the tree from the mechanical injury, but also opens a path by which other injurious insects may enter the tree to do their damage. This is no inconsiderable feature of their harm, especially when they attack the larger twigs and stems, because it is more frequently upon the larger stems that *Scolytids, Cerambycids,* and other beetles do their work.

When fifty or more of the larvæ attack the young roots and rootlets, the principal food-getting organs of the tree, they not only use up the moisture which the roots have already taken up, but they likewise so mutilate and debilitate the latter as to impair the functions of moisture gathering. Of the several cacao trees which the writer dug up, none were more than 5 m. high and in no case did their roots extend more than 95 cm. below the ground surface, and as the pupæ of *Cicada* were found as low as 80 cm. it can be readily seen that they command practically the whole of the root area.

In the matter of combating these insects, several methods suggest themselves. As it is practically impossible in a large plantation to use preventive measures entirely, those means which also look to the extermination of the already established pests must be used.

The pupæ, when emerging from their ground retreats, are entirely helpless, and they, as well as the newly transformed adults, are easily captured upon the daily visits to all the trees by the watchers and workers in charge; in fact this could very easily be done by children, who seem particularly expert in capturing the in-

sects which they like to make "sing." Even the full-fledged adults of several days may be captured upon the trees at dusk, when the males begin their concerts and the females are close by to listen. During midday the insects may sometimes be caught upon the tree trunks, but are more wary and harder to take.

Certain species of birds are known to be enemies of the *Cicada,* at least in the Island of Negros. Repeatedly the writer, when in the cacao plantations, has heard the uneasy creet of the *Cicada,* and following with his eye the direction of the sound, has seen a bird carrying off the insect. The species could not be ascertained, but from its general size and form, it undoubtedly belonged to the Shrikes or *Laniidae.* This should lead the grower to carefully protect all birds which have the inclination to visit or live in the plantation of cacao, as being beneficial, not only in the destruction of the *Cicada,* but also in ridding the trees of other injurious insects like scale-insects, mealy-bugs, and caterpillars of various species.

If the insects are captured upon emerging they will have no opportunity to lay their eggs, but as this can not be done in all cases, a close daily survey of the trees at the time when the adults of *Cicada* are beginning to be numerous will reveal the work which they do on the twigs. The characteristic appearance of the twigs after eggs have been deposited in them is shown in fig. 8. It was claimed a number of years ago that the *Cicada* only deposits her eggs in dead twigs, but observation has since proven that this is not the case, she invariably choosing live wood for this purpose. The short time during which the eggs remain in the slit would not be sufficient for the growth to crush them, and moreover, the growth of a twig which has been lacerated by the ovipositor of the *Cicada* is away from the wound, causing the latter to gape within a year from its formation, as shown in fig. 9. If these twigs are carefully removed by means of a very sharp knife, and if they are afterwards destroyed by burning, while the eggs are yet unhatched, much can be done to lessen the number of *Cicada* attacking the trees.

If a twig, into which eggs have been newly laid, be examined by cutting it open longitudinally, the white eggs will be found arranged very regularly in the cavities which have been made to receive them. If the eggs have recently hatched, their transparent and shrivelled shells will be all that can be found. After a few days

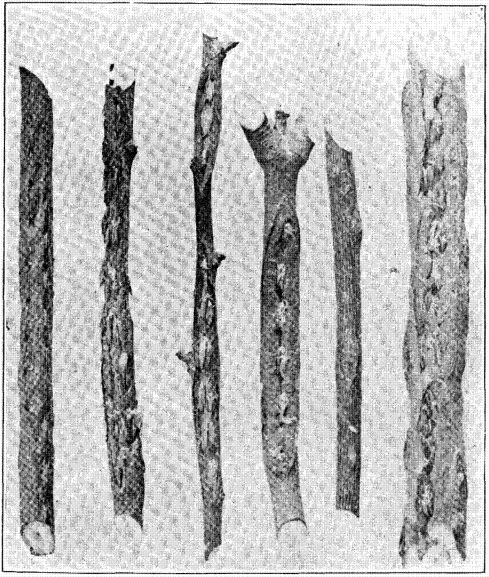


Fig. 8.—From Bul. 14, N. S., U. S. Dept. Agr., 1898.

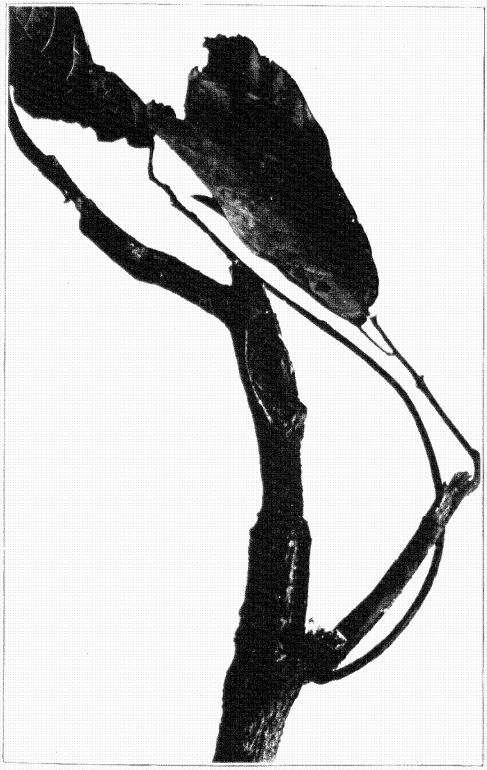


FIG. 14

these shells will have disappeared, being eaten by the numerous ants which constantly swarm on all parts of the tree. It may be that occasionally the eggs are found by the little red ants and eaten before they are hatched, but as the fibers of wood left by the boring of the female *Cicada* pretty effectually close the cavities, this is not probable.

During the months from January to April, 1903, all sizes of larvæ and the pupæ were found when cacao trees were dug out. During this same period the adults were fairly abundant, as were the cast skins of the pupæ on the trees. It is therefore probable that the period of greater abundance of the adults is during the latter part of the year, probably in October and November.

The question of the killing of larvæ after they have once entered the ground is a most difficult and serious one. There are few substances which have sufficient penetrating power to enter the soil and be effectual against the larvæ without endangering the young roots of the trees. Probably one of the most useful of these is carbon bisulphide, an extremely volatile transparent liquid resembling highly refined petroleum, but having, when not pure, an extremely disagreeable odor. It is highly inflammable and heavier than the air, and therefore sinks readily into holes or crevices in the ground. Its extreme inflammability renders great precaution necessary when handling it. It must not be kept in houses where lights are used, nor must it be left in large quantities in bright sunlight, and the vessel used to contain it must be capable of being sealed. The fumes of this chemical, while not actively poisonous when breathed by human beings in limited quantities, are extremely disagreeable and are productive of headache. If inhaled for a moderate length of time they cause suffocation. The substance should be handled only by those who are thoroughly acquainted beforehand with its properties, and then only by those who can be trusted to carry out instructions concerning its uses. It should be kept where it can not be reached by children, and should be labeled "Poison." Glass-stoppered bottles or tin cans having the best quality of cork stoppers are the best receptacles for carbon bisulphide.

It is possible that gasoline or naptha would in a measure serve the same purpose as carbon bisulphide, but no experiments have yet been made to verify this supposition. Either of the liquids would have the advantage of cheapness over carbon bisulphide.

At present the price of this chemical in the Philippines is such

that the general use of it as an insecticide is almost out of the question. In the United States, when bought in large quantities, it may be had for about 15 cents per pound. By the single pound it costs about 25 cents, gold. In the drug stores of Manila it may be bought at 75 cents, gold, per pound; or 55 cents, gold, in quantities of from 50 to 100 pounds. It is hoped that with this, as with other important insecticides, some plan may be devised to enable the farmer here to procure them at a lower cost.

The most effective method for the application of bisulphide to trees for the killing of insects attacking the roots, and the one which is least dangerous to the tree, is as follows: The trees may be treated successively by one or several men. An instrument should be used by which a hole 50 or 60 cm. deep and 2 cm. in diameter may be bored into the earth, about half a meter from the crown of the tree. There should be three of these holes equidistant around each tree, and into each should be poured not more than 25 c. c. of the carbon bisulphide. The hole, after introducing the liquid, should be immediately stopped up with wet earth or thick wet cloths, and left in this condition for several hours. The cloths can then be taken away, or the ground raked or leveled if earth only has been used. These measures can be tried at any time, but preferably just after a period when a large number of twigs of the trees have been found lacerated by the female *Cicadæ,* as in all probability the eggs will have been but recently hatched and the larvæ therefore but a short distance below the ground.

When *Anay* or ants are found working below the crown of the tree, similar measures for their extermination may be employed. A dampened canvas or other air-tight cloth may be placed around the base of the tree, in the form of a conical tent with a broad base. After earth has been packed around the base, a small quantity, from 15 to 20 c. c., of carbon bisulphide may be poured upon the ground within the tent and the whole thus left for half an hour. If rightly applied this remedy will kill all insects within the inclosed area without doing damage to the tree itself. The method here described applies only to trees which have attained their full growth, and just after the bearing season. With smaller ones a proportionately smaller amount of the bisulphide should be used.

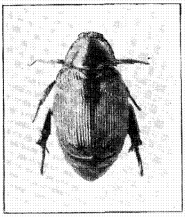


Fig. 10.

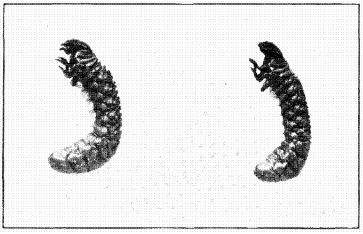


Fig. 11.

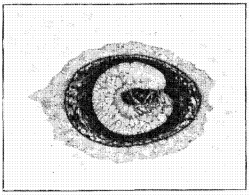


Fig. 12.

WHITE GRUBS.

Not only will the method described for the killing of the larvæ and pupæ of *Cicada* prove effectual for these insects, but it will also be equally so against the white grubs so commonly found among the roots of the cacao tree.

These white grubs are the larvæ of one of the *Lamellicorn* beetles and belong to the genus *Anomala,* the adults of which have been found in cacao plantations in some abundance. In general, the habits of all beetles of this genus are the same. The adult of a very common species is shown by fig. 10, and the larvæ of the form found in the cacao root by fig. 11. It is not known how or where the eggs are laid, but they are probably deposited in the débris which naturally collects around trees which are ill cared for. The larvæ, upon hatching, have but a very short distance to go, in the case of the cacao, before they find the young tender rootlets upon which they feed with avidity.

These larvæ can be very easily recognized. The form of the body is characteristic. When found they are invariably curled up, assuming this position as a means of defense. The full-grown larva measures 3 cm. in length and about 5 mm. in diameter. The long, rather slender, yellowish, hairy legs are bent forward at the first joint. In crawling the insect uses them very awkwardly. The head is ochre-yellow, shiny, and covered rather sparsely with stout bristle-like hairs. Examination with a strong hand-lens reveals the fact that there are no eyes, at least none externally. The dark-brown jaws or mandibles are well fitted, by their form and position, for cutting off bits of the roots upon which the animal feeds.

The body has a somewhat corrugated surface, and upon the back of each segment there is a transverse area covered with fine, brown, very short bristles, which aid the insect in burrowing into the ground. The rear four segments of the abdomen are somewhat broader than the others and are of a darker color, owing to the mass of excrement contained in the alimentary canal.

That these insects do much damage to cacao is evident from their abundance and the fact that they are related to species which are very injurious wherever found in other parts of the world. Living as they do for the greater part of their lives below the

surface of the ground, where cultivation of the plant will not disturb them, they form one of the hardest classes of insects to combat. The effects of their work are not apparent until the weak and dying condition of the tree, and its inability to bear fruit, tell the grower that it is being killed by some unseen insect enemy. The full-grown insect, a beetle, is shown in fig. 10. It measures from 9 to 12 mm. in length, is of a shiny greenish-brown color, and the wing-covers are very much rounded. Fine striations, running longitudinally upon the wing covers, heighten its sheen. The beetles are usually found upon the leaves or in crevices in the bark, where they appear to be always in hiding. These beetles are very peculiar in their habits, invariably simulating death when they are disturbed; they then drop to the ground, where they lie perfectly motionless among the rubbish around the tree until the disturbance has passed. If care be used, a very slight jarring of the tree will cause them to drop from it to the ground, where, if there be no débris, they may be seen and killed. A word of caution, however, should be given as to jarring the trees. Perhaps no tree cultivated is so susceptible to ill treatment as the cacao. The fruit, because it is so large and heavy, may be shaken off by even a strong breeze, and it is therefore evident that jarring, when the tree is in fruit, will prove most disastrous to it. Only such trees as are just out of fruit or in the blossom season should be treated in this manner, and the jarring should be done with the palm of the hand; a gentle blow being delivered, and only repeated two or three times for each tree. Anything more severe than this will result in disaster.

For killing the larvæ of the beetle above described the same methods as those employed for killing *Cicada* larvæ may be used.

When this insect is ready to change to the pupal stage it builds a cell, composed of compacted earth. This cell is somewhat larger than the larva, and, as the latter shrinks considerably just previous to the pupal stage, there is sufficient room for it to effect the final change to the adult, allowing for the proper expansion of the wings and wing-covers. While in this pupal cell the insect appears as in fig. 12.

While birds, particularly crows, feed most readily upon all forms of white grubs when they are exposed in fields by plowing, it is very doubtful if they perform any appreciable service in the destruction of the *Anomala* unless it be that they pick the insects from the trees when they have reached the adult stage. Therefore,

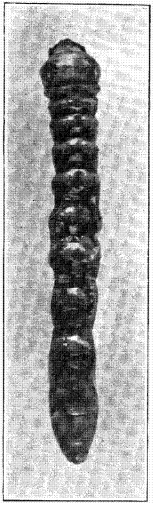


Fig. 14.

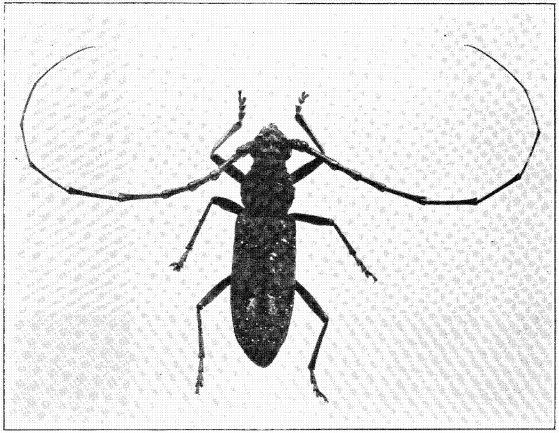


Fig. 13.

all efforts against these pests will consist of the destruction of the larvæ at the time of application of remedies for the *Cicada* and the jarring of the beetles from the trees as described above.

INSECTS ATTACKING THE TRUNK.

FLAT-HEADED BORER.

Of all the cultivated plants observed in the Philippine Islands, perhaps none has been found which suffers more from insect attacks on the trunk than does the cacao. The insect which is of first importance is the flat-headed borer of the cacao. It belongs to the family of long-horned borers, the *Cerambycidæ,* an adult of which is shown in fig. 13. The damage by this insect is much greater than that produced by any other insect attacking the cacao, inasmuch as it not only works for a long period unseen in the trunk, but finally effects the death of the tree, and the damage is hardly apparent to a casual observer until its work is completed.

Ninety per cent of all trees examined in the Island of Negros were found more or less completely damaged by this insect. The mode of attack and the results are so characteristic that when once described they will be noticed by the most careless observer, and will be always remembered as the work of this particular insect.

Going through a cacao plantation at certain periods in the year, especially in April and May, one will frequently notice at the bases or upon the trunks of the trees a kind of coarse fibrous sawdust. This may be of a light wood color, or of a very dark mahogany red if there has been a recent rain. One who is not acquainted with the facts might well suppose that this has been produced by the gnawing of some small animal like a rat, though upon closer examination it will be seen that the fibers are too regular to have been thus produced. If the bark be examined carefully one will soon find a small hole of irregular form, about 1 cm. in diameter, from which there appears to be exuding more sawdust, usually of a dark color and wet if recently pushed out of the burrow by the insect. If a hooked instrument or a knife be used to carefully remove the flakes of dead bark found around the hole, there will be found more of the same material underneath. If the search be continued, following the line of a now well marked burrow, the chances are that at its end, whether just below the bark in the sapwood or within a deeper burrow toward the heart of the tree will be found a large, yellowish grub with darker head and still darker

brown jaws. The body is larger toward the head and somewhat flattened, giving the insect the name flat-headed borer. The body segments are well defined, as shown in fig. 14. The darker color of the hinder part of the body is due to the fact that the digested wood becomes colored by the juices in the alimentary canal of the larva. It would be well to state here that the fibrous masses of wood found in connection with this insect have not been used as food, but were simply cut away in the process of making the pupal cell and in filling up its entrance, in order that the grub might not be disturbed in its transformations to the pupal and adult stages.

This larva may well be described as a footless grub; one which is perfectly helpless when removed from its burrow, for when once taken out it is not only at the mercy of predacious insects like ants, but is of itself so helpless that it would soon die from lack of moisture before it could reach a place of safety.

The full-grown larva measures 40 mm. in length and about 4 mm. in diameter at the middle of the body. Its powerful jaws or mandibles enable it to feed readily upon the hardest parts of the wood in which it lives, and specimens have been found which have excavated tunnels 50 cm. long, in addition to the irregular blotch-like cavities which are formed just beneath the bark at the beginning point of the attack.

The habits of this insect are very similar to those of related species in other countries, as the maple borer, *Plagionotus speciosus;* the sawyer, *Monohammus confusor;* the round-headed apple borer, *Saperda candida;* the oak pruner, *Elaphidion villosum.* The female lays her egg in a small puncture in the living bark of the tree, and as soon as the young grub hatches it begins its work of tunneling the bark, the tender growing wood, and eventually the harder portions of the tree. Were it true that a single borer did its work in the trunk, the damage, though considerable, would not be so serious a menace to the life of the tree. But when several borers appear simultaneously in different parts of the trunk they soon succeed in girdling it, after which the tree is sure to die. Figs. 15, 16, and 17 show several large-sized branches killed in this manner. The grubs having injured one side of the tree, the latter puts forth its strength in efforts to heal the wound, causing an abnormal growth to bulge over the bare space left by the insect attack. The wood and bark increase in thickness on the opposite side. Other grubs attack this part, which is particularly

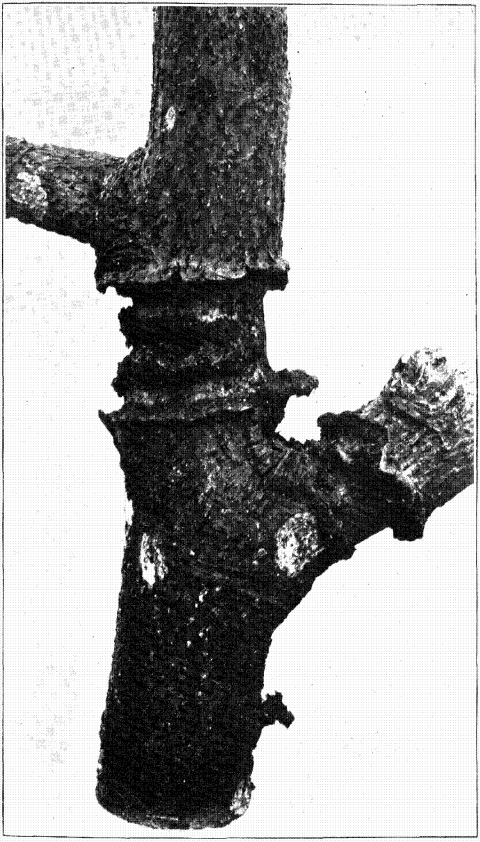


Fig. 15.

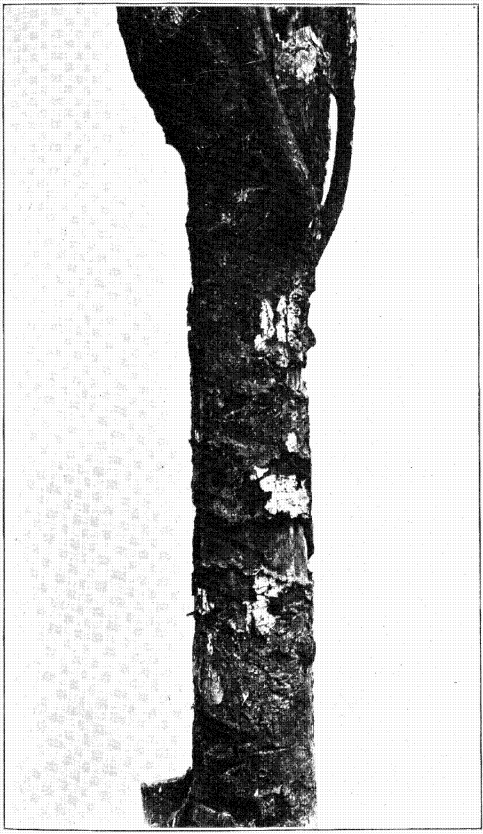


Fig. 16.

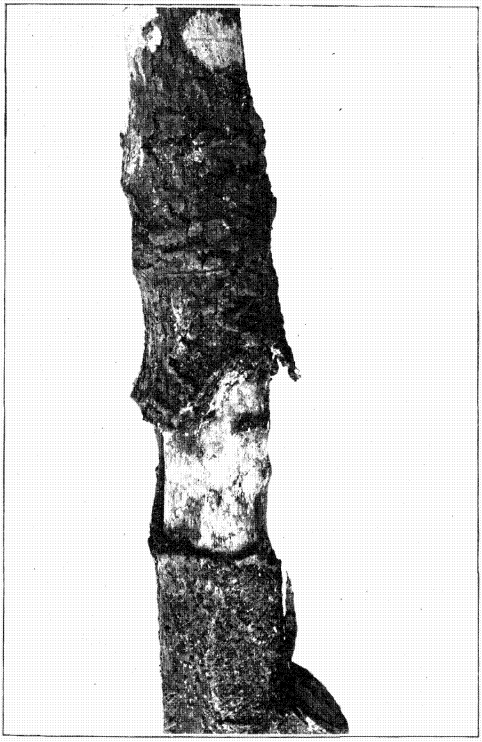


Fig. 17.

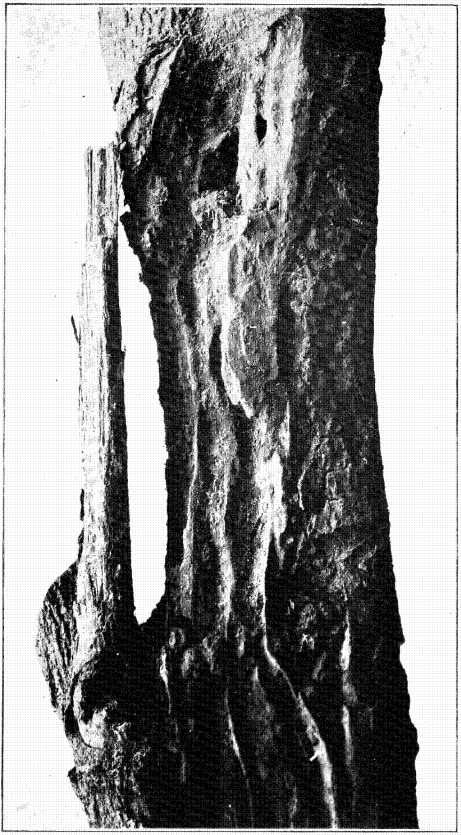


Fig. 18.

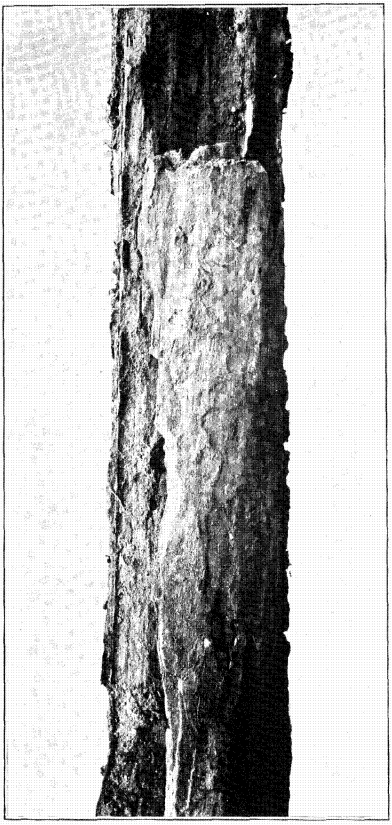


Fig. 18 a.

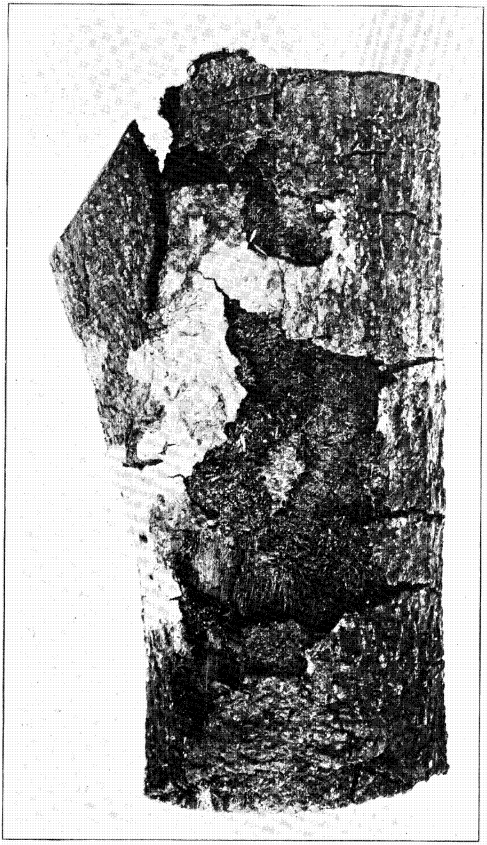


Fig. 18 b.

rich in food material, and thus by these successive attacks the living parts are all destroyed and the tree girdled.

Trees have been frequently observed in which, on a branch from 4 to 7 cm. diameter, there would be a strip of only 15 mm. of living wood, and yet this branch would be giving forth leaves above the wound. Of course the latter were small, being ill nourished, and no fruit could be expected upon such a branch. This illustrates the remarkable vitality of the cacao, and probably also explains its extreme susceptibility to injuries of any kind.

An interesting feature of the work of the flat-headed borers is the manner in which the excrement is packed behind it in the burrow, sometimes so solidly as to simulate the wood itself. It can, however, always be distinguished by its granular appearance instead of the fibrous structure of the wood. These filled burrows are frequently encountered in timber when it is sawed for building and other purposes. Wood having this appearance is called "wormy." Characteristic burrows of one of these larvæ are shown in figs. 18 and 18 *a*, and in fig. 18 *b* the frass as left behind.

When the grub is about to pupate it burrows toward the heart of the tree and upward, thus forming an oblique canal, which, when a short way in, is changed to a vertical direction and is thus parallel with the wood fiber. Into this burrow the insect retires and changes its position so that the head is toward the opening. Within a very short time after the larva has entered this retreat and has packed in the fibers to close up its doorway, it sheds its skin as a grub and assumes a form which, upon closer examination, shows that it possesses characteristics of a beetle. The legs, antennæ, wings, and wing-covers may all be readily distinguished if a careful examination be made. Unfortunately, there have not yet been sufficient observations upon this insect to enable me to state the length of time during which it remains in the larval and pupal stages. On March 11, 1903, a full-grown beetle was taken from a tree near one in which larval and pupal forms had been found at an earlier date of the same year. This would seem to indicate that the period for the pupa is from four to six weeks, possibly not so long.

The adult, after its outer covering has become thoroughly dry and hard, subsequent to its change from the pupa, begins the work of gnawing away the material which, as a larva, it had packed in the mouth of its burrow, and it comes forth a very beautiful creature, entirely unlike the uncomely grub which had been doing

Fig. 19.

Fig. 20.

prevent the entering of the adult for egg laying. This material is so cheap that it could be used constantly, even until the trees have attained a considerable size. The bags are made of a cylindrical form, open at both ends, and having a drawstring in one end. They may be slipped over small plants and the lower ends held close to the ground, either by embedding in earth or by the placing of stones upon the lower edge. In the case of larger trees, where it is impracticable to slip this bag over all the branches, it is well to simply use a straight piece of cloth, putting it around the tree and after doubling the edges together in the form of a hem, they may be either sewed with coarse stitches or pinned by means of sticks of bamboo made in the form of toothpicks. See fig. 19 for an illustration of a bag which was used for the protection of the upper part of the trunk in order that, during investigations, the adults which emerged from the tree might not escape. In fig. 20 are shown trees protected by these bags. Opened at the bottom and held close to the ground by stones or earth, they serve admirably for keeping off the beetles. Wire screening would serve equally as well were it not for the fact that the extreme dampness would cause it to rust and thus quickly become useless. In the United States a heavy grade of tarred or roofing paper serves the same purpose, but its cost would be against its general use in the Philippines.

Where it is not practicable to use the method described above, some repellant to the insects, should be applied to those parts of the trunk which are most likely to be affected. Inasmuch as these repellants are simply supposed to keep the adult insect from laying her eggs, it is very obvious that they should be applied before any insect has had a chance to deposit its eggs in the tree trunk. If the grub has once entered the bark, no application of remedies externally will have the least effect upon it and other means must be taken. These will be spoken of later. Any strong-smelling substance, such as fish oil, tar, or pitch, which will adhere to the tree, or pure crude petroleum, would prove effectual, but perhaps the best and most easily applied material for warding off the attacks of this borer is what is known as the soap and carbolic-acid wash. This is prepared by dissolving four liters of soft soap in four liters of hot water and adding one-half liter of crude carbolic acid. This mixture should stand for at least twenty-four hours, or until it has become perfectly dissolved. Into this should

be poured from 32 to 40 liters of rainwater and the whole carefully stirred until thoroughly uniform. It may then be used with a broad paint brush or swab on the end of a stick, covering all the parts of the trunk and branches which might be supposed to offer a place for the borer to lay its eggs. No fear need be had that this mixture will injure the trees if properly prepared in the proportions given. The period from the first of April to the first of June would be the best in which to apply this preventive, as it is during this time that the beetles come forth and are ready to lay their eggs.

An excellent preventive which has been used most successfully against the peach borer in the United States and which would probably prove of value equal to that of the carbolic wash, is a preparation composed of lime, coal tar, and whale-oil soap. This mixture may be put on in a comparatively thin coating, as ordinary rains do not easily wash it from the trees. It must be thoroughly applied to all parts of the tree likely to be attacked by the borers.

Tobacco dust has been advocated by some fruit growers in America as a preventive of the borers. The author leaves this matter until more thorough experimentation in the Philippines shall determine the advisability of recommending it for general use. If it be found an effectual remedy, there would be a decided advantage in employing it in lieu of insecticides which would have to be brought from abroad.

An effective measure to be used against the grubs which have already entered the tree is to carefully search for evidence of their existence beneath the bark, and when they are located to thrust in a stout piece of bent wire, which which they can be crushed. It is not necessary to extract the crushed insect, as when so injured it can not transform further and there will be no danger of its coming forth as a beetle.

The fact must be constantly borne in mind by those who would grow cacao successfully in these Islands that vigilance, not only over those charged with the work of caring for the trees, but also personal inspection of the orchards themselves by the owners, will be necessary to detect not only the presence of these insects, but also a large number of other forms whose insidious working in places in which it is not easy to get at them, renders them all the more pernicious. As in a clean house or in a clean city, diseases are less liable to enter and play havoc, so, in a clean cacao orchard, insects

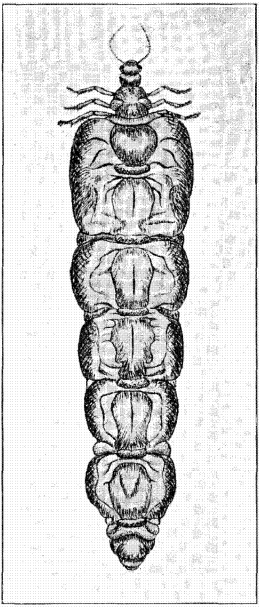


Fig. 21.

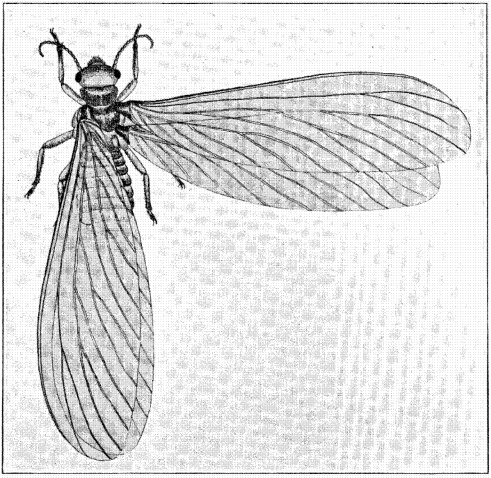


Fig. 22.

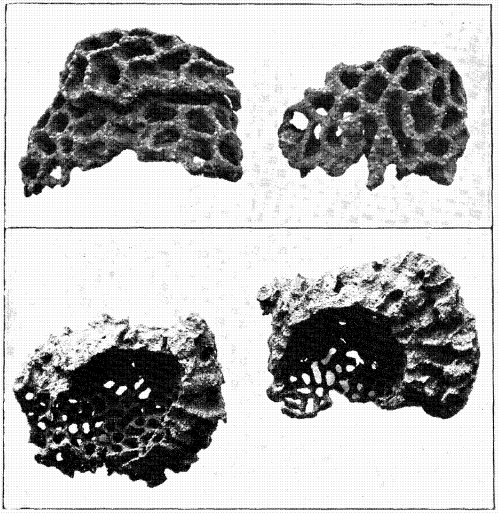


Fig. 23.

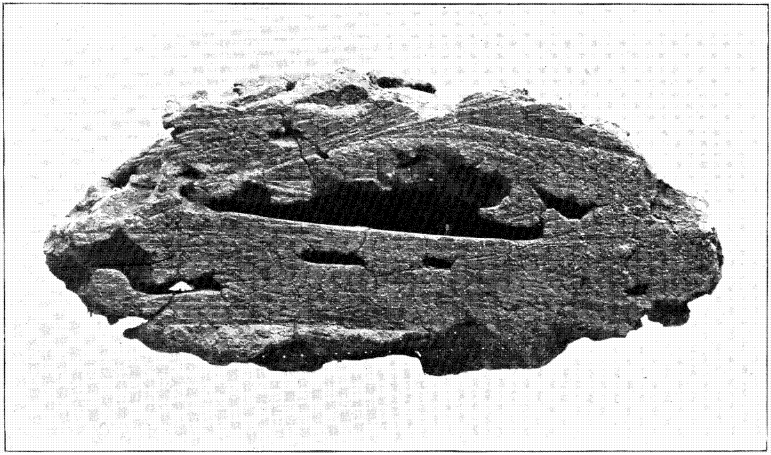


Fig. 24.

find less favorable fields for their ravages. This means that thorough and scientific pruning, careful cultivation as set forth in Lyon's Bulletin on Cacao Culture,[1] and a constant care must be taken against insect and other pests. Clean ground around the cacao trees proves less inviting to all kinds of insects which would be liable to lurk in the rubbish and dead leaves which often litter the plantations so far observed.

WHITE ANT OR TERMITE.

Another insect which has proven seriously destructive to the trunks of cacao trees is the "white ant" or termite. This insect, described as being destructive to the roots, does not by any means confine itself to these parts of the tree. Fig. 2 shows the work done in the living trunk of a cacao which had first been seriously injured by the borer. When once the white ant becomes abundant in a tree, the life of the tree is practically doomed, unless the measures suggested on page 16 be followed before the insects have extended high into the tree. These termites have an underground cell in which the queen-mother of the colony is confined; owing to her great size she can not leave this cell, and performs no other function save the laying of eggs, with which her enormous body is distended. Fig. 21 shows a female, natural size, of a species closely related to the one which damages cacao trees. Fig. 22 shows the same kind of insect before her body has become distended with eggs. Unless this queen-mother be destroyed in some way the colony will go on multiplying indefinitely, it matters not how many of the ants found in the tree be killed. There are always thousands of workers in the ground chambers of the nest to attend to the rearing of the enormous brood. Fig. 23 shows the cells in which the young are reared.

In order to find out approximately the number of eggs laid by a female, a complete queen cell in which the queen-mother was confined, was dug out. Fig. 24 shows the appearance of a cross section of this cell. The female was carefully watched for several hours and was seen to be continuously laying eggs. These eggs were carried away in tiny adherent masses by the workers. A watch was made for one minute, and instead of allowing the workers to remove the eggs during this period, the mass was carefully picked up with a fine forceps as fast as it had assumed the size of those

[1] See Bul. 2, Philippine Bureau of Agriculture, 1902.

previously carried away by the workers. A count revealed the fact that during one minute 165 eggs had been laid by the queen-mother. No exact estimate of the weight of this mass was made, but it is safe to say that it represented not more than 1-1000 of that of the female when fully distended. Some idea can be gained from this of the wonderfully prolific character of the termite, and the futility of attempting to destroy a colony without first killing the queen-mother.

The same species of large black ants, which were mentioned as attacking the tree below the crown and among the roots, will likewise be found in the trunk, especially after the attacks of the borer and the termite or *anay*. They do not attack the trunk very high up, seeming to prefer living half beneath the ground. The same treatment recommended for this insect when found among the roots will apply to it when found in the trunk of the tree.

PSOCIDÆ.

A little insect which is often rather abundant upon the trunks of cacao trees is a species of *Psocidæ*. This little fellow is perfectly harmless, feeding only upon the lichen growths which are to be met with. It should not be confused with the winged forms of plant lice which are very injurious. This species of *Psocus* is red and black; the body being red and the wings mottled and of a smoky color. They are often found bunched together in considerable numbers on the lower trunk near the ground, and when disturbed scurry to one side like a flock of sheep, leaving a bare spot where the disturbing influence touched them. Among these aggregations the larvæ, which are wingless, the pupæ, which have tiny wingpads, and the adults, which have fully developed wings, may be found. Fig. 25 shows a portion of a cacao tree trunk covered with these insects. As they feed upon substances entirely foreign to the life of the tree and simply use the latter as a place of abode, they may be classified as not being harmful.

Very frequently caterpillars will be found resting upon the trunks of cacao trees during the day, while at night they will be found feeding upon the leaves. These are often so nearly of the same color as the bark that they escape all except an eye trained to look for such things. On particular species of caterpillar belonging to the family *Lymantriidæ* is so nearly like the caterpillar of *Porthetria* (*Ocneria*) *dispar*, the Gypsy Moth, as to indicate a very

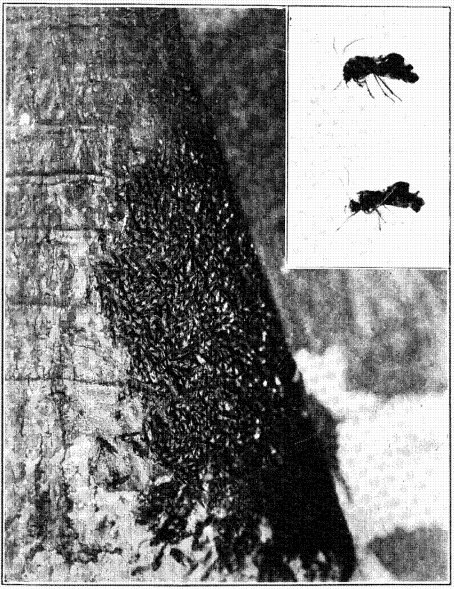


Fig. 25.

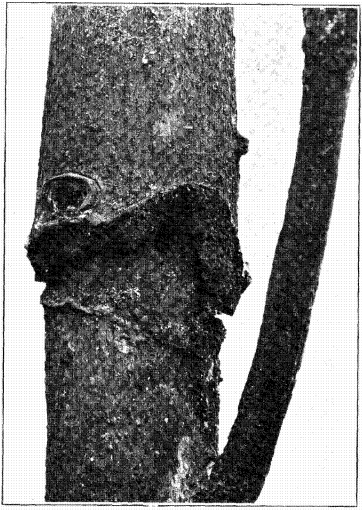


Fig. 26.

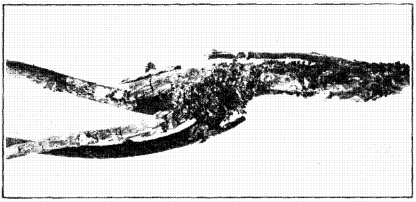


Fig. 26A.

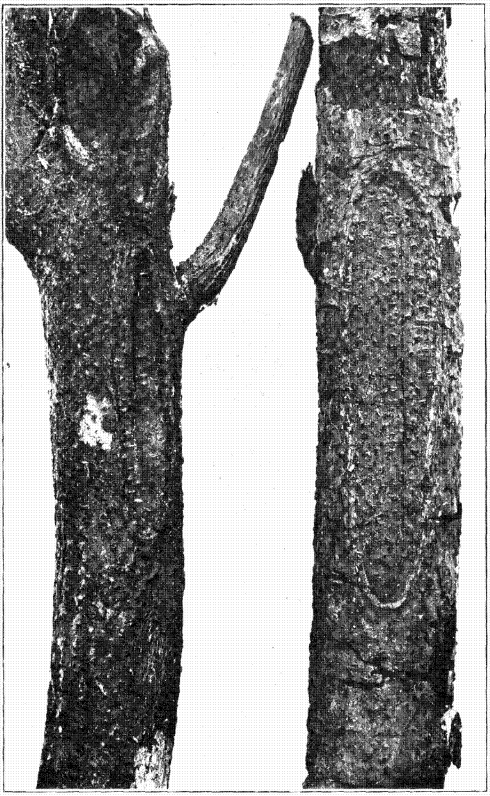


Fig. 27.

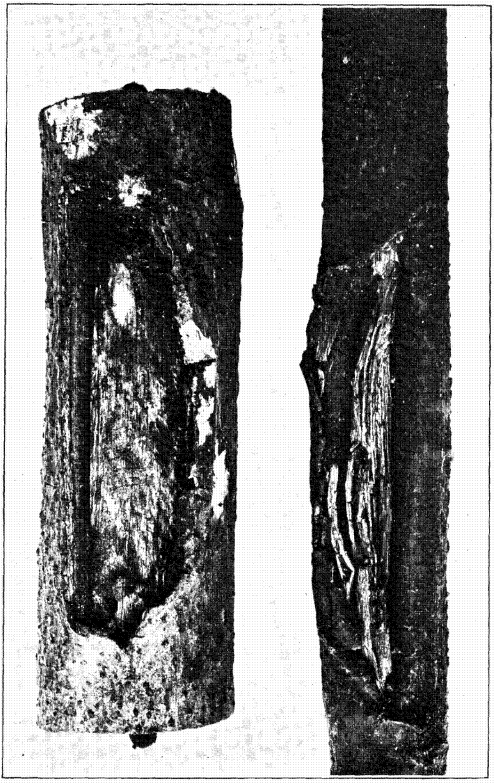


Fig. 28.

close relationship between the two, but as I have not yet succeeded in rearing the adult, the insect has not been determined. The habit of placing the cocoon or nearly naked brown chrysalis in forks of the twigs and in holes in the bark is almost identical with that of *Porthetria.*

The caterpillar will be described when the insects which injure the leaves are discussed.

INSECTS ATTACKING BRANCHES AND TWIGS.

Three very serious insect pests which attack the small branches and twigs, girdling the bark of the latter at its junction with the stem, have been found in the larval stage, but all attempts at rearing or finding the adults have so far proven failures. (Fig. 26 will show how thoroughly the larva of one has done its work of girdling a twig which was 26 mm. in diameter. Fig 26 *a* shows a twig 13 mm. thick which is also completely girdled by the insect.)

A peculiar and interesting habit of the larva, which first attacks the twigs to girdle them, is that of using its excrement, together with silk, for covering up the burrow or retreat in which it lives. This is very neatly done by fastening the particles together with a kind of silk and these pellets or particles of frass are so nearly the color of the bark from which the animal has obtained its food that the difference between this and the sound bark is often not noticed except upon closest observation. This larva is of a dull greyish color with a brownish head. Its body is sparsely covered with stiff bristles and its general habits are similar to those of the *Tortricidæ.*

The second larva is undoubtedly a *Cerambycid,* but as has been said it has only been found in this stage and can therefore not be identified at present.

The destructive work of *Cicada* has already been mentioned in reference to insects which affect the roots of the cacao and its habits of laying its eggs in the twigs make it likewise one of the insects injurious to the twigs and branches. The mode of treating twigs thus affected would be to cut off and burn all twigs in which the *Cicada* eggs have been laid. One will frequently come upon a twig or even a good-sized branch which bears a peculiar scar like those shown in fig. 27. If a careful examination be made this will be seen to contain shrivelled egg shells about 4 mm. in length. Twigs will be found like that represented in fig. 28, in which the

eggs show very plainly. The adult which lays these eggs has not yet been found, but from the general appearance of them it is very likely that the insect is an *Orthopteron*; that is, belonging to the order of grasshoppers, crickets, etc., and may be one of the katydids, some very large species of which have already been taken in cacao groves.

Microcentrum retinervis, the angular-winged katydid of the Southern United States, lays its eggs, which are of about the same size as those shown in fig. 29, upon the edges of leaves and upon the stems of the trees which it inhabits, and therefore it may reasonably be supposed that the destructive insect in the case of cacao is a related species.

With many insects of this and other species affecting the cacao, long periods of observation and the collection of more material will be necessary in order to become thoroughly acquainted with their entire life history. In many instances thus far only one stage, or the work alone, of the insect doing the damage, has been obtained.

INSECTS AFFECTING THE LEAVES, ETC.

PLANT LICE.

One of the most serious pests of the leaves, tender buds, and flowers is a species of black plant louse. This insect attacks the young buds even before the leaves or the flowers have opened. The tiny eggs are laid in the folds of the buds and the bud scales, beneath the stipules of the leaves, and in the crevices of the unopened sepals of the flowers. They are so minute that they can only be seen with the aid of a magnifying glass. As soon as the young hatch, they pierce the skin of the twig upon which they rest and begin sucking the plant juices. Some broods of plant lice give birth to living young which in turn lay eggs. This question of the alteration of the mode of reproduction is very interesting to the student of biology, but has little value economically, at least in this latitude. The young plant lice resemble the adults in form. They are of course much smaller and have no wings, but as certain forms of the adults are also wingless, this feature alone will not aid in distinguishing the stages.

Plant lice are provided with a pair of spine-like projections which are little tubes on the back of the abdomen and which secrete a waxy substance which is much sought by ants. This

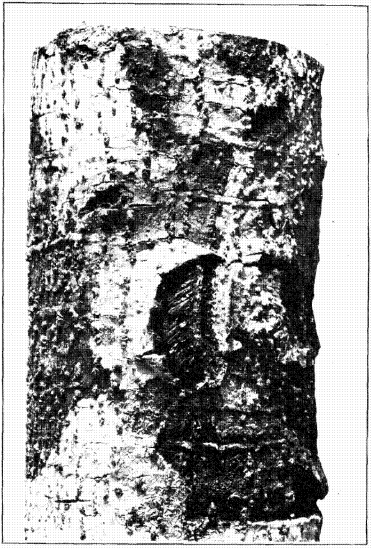
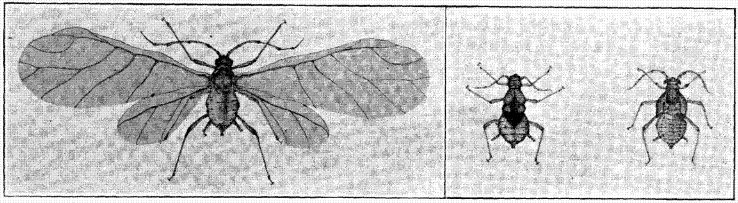


Fig. 29.



C Fig. 30. A B

substance is commonly known as "honey dew." Its nature is not clearly known. Generally, in examining a colony of plant lice the surface upon which they rest will be found to be sticky and glistening, as though covered with sirup. This is the "honey dew" secreted by the plant lice. It is for the purpose of collecting this that ants invariably attend a colony of the former, caring for them assiduously in return for the "honey" which they secure. They frequently carry the plant lice from place to place when the leaves or twigs, upon which the latter have been feeding, become dry and hard.

Even though only a single plant louse be found upon a leaf or flower, it is almost invariably attended by an ant and sometimes by two or more. Thus cared for, it is little wonder that the plant lice multiply and flourish to a remarkable extent. Fig. 30 represents the different stages of the plant louse. It will be noticed that at *b* the pupa is distinguished by the tiny wing pads which contain the wings. These insects feed in all stages, from the larva to the adult, and therefore their damage is considerably greater in proportion than that done by insects which feed only in the larval stages, like *Lepidoptera, Diptera,* and *Coleoptera.* Their small size appears to be fully compensated for by their numbers, and so the cacao grower has to be ever vigilant in order that he may successfully combat them.

The immediate effect of the attacks of the plant lice is to cause a drooping or wilting of the leaves, flowers, or flower stems which they attack. This is followed by a distortion of the part, the leaves curling toward the under side, where the plant lice are usually found. This shrivelling is very marked upon some trees, and when the leaves have attained their full growth they will be found to be undersized and broken because of their efforts to outgrow the attack. Flowers, when attacked by the plant lice, shrivel and die without producing fruit. Occasionally the plant lice are found upon the very young fruits, the skin of which is almost as tender as the young leaves. Invariably fruits thus attacked either die from exhaustion, or if they survive are very much distorted, presenting, instead of the regular, even-lobed appearance of the perfect pod, a scarred smooth side which has no semblance of the characteristic ridges. In this way the pods are formed in which the tip, instead of being straight, is twisted by arrested growth on one side and by the normal development on the other.

Fig. 31 shows a fruit thus distorted, and a perfect fruit is shown in the frontispiece.

When the fruit pods have attained the size of a hen's egg they are not subject to the attacks of the plant lice and thus it will be evident that any remedy should be applied before this period.

As a means of treating plant lice upon the flowers and leaves of cacao, there is no better material than kerosene emulsion. There are several ways of making and applying kerosene emulsion, but the best preparation for this purpose will be found to be the kerosene and soap emulsion. This, if properly prepared and applied according to directions, will be found to be harmless to the most delicate parts of the plant. For its preparation see the chapter on Insecticides.

In applying the kerosene emulsion some kind of spray pump should be used to facilitate the uniform distribution of the liquid and to enable the sprayer to reach the higher branches of the tree with the emulsion. In another chapter brief descriptions will be given of some of the essentials of standard spraying machines which have been used successfully in the United States in combating insects similar to those found on the cacao.

BLACK THRIPS.

Another enemy of the young cacoa leaves which is likely to prove of considerable importance is the black thrips. This minute insect may escape even a close observer if he does not know the signs which indicate its presence. As in the case of the plant lice, the injury caused by the thrips makes the leaves curl up, as shown in fig. 32, but not as markedly as with the former. If we carefully examine a few leaves which show evidence of curlings, we will find upon the under side a number of very slender black and red objects moving very slowly from place to place. The black ones are the adults, the red ones the young thrips. The rear part of the abdomen is decidedly pointed, and the thorax bears a spine on each side. These insects are provided with sucking mouth-parts and cause an injury to the leaf similar to that caused by the plant lice. They may be combated by the same means employed to destroy the latter, and large numbers of them will be killed when the trees are sprayed for the *Aphids*. Two adult thrips are represented much enlarged at fig. 33.

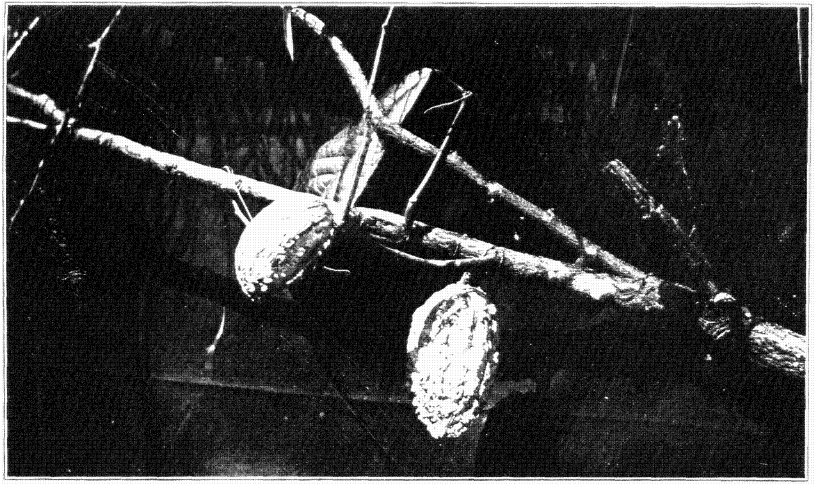


Fig. 31

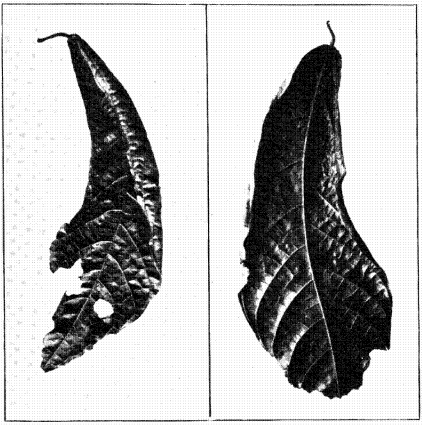


Fig. 32.

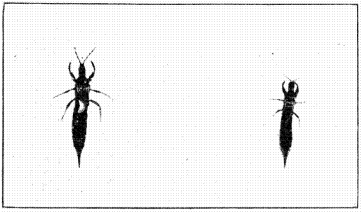


Fig. 33.

Fig. 34.

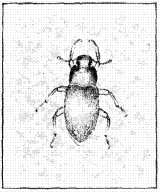


Fig. 35.

YELLOW SCALE.

Another insect which, while not occurring in great abundance at the time when observations were made, is likely to prove a pest to the cacao, is the large yellow scale represented magnified in fig. 34. Its eggs are shown at A. The adult female measures 17.5 mm. long, 13 mm. wide, and 9 mm. high. It is of a light salmon-yellow color and is covered with a fine powdery substance. Beneath, the scale secretes a white material which is fibrous in structure. The upper surface is corrugated; the hinder part of the body is much higher than the fore part, and when at rest upon the twig or leaf the black legs and antennæ are completely hidden by the shell-shaped body. The forward part of the body is slightly notched. When the animal is disturbed and moves from place to place, the tiny black antennæ and tips of the black feet may be seen protruding from beneath the shield-like body. In February and early March these insects will always be found with the space beneath the dome of the body completely filled with tiny orange-yellow eggs which are 1 mm. long and 0.6 mm. wide. It is not yet known when the young hatch, nor has anything definite been ascertained concerning the full life history of this insect. Further studies will elucidate points concerning this and other scale-like insects of the cacao.

The same method employed in ridding the trees of the *Aphids* will apply to the combating of the large yellow scale. Its soft body will make it peculiarly susceptible to the effects of kerosene emulsion.

Very frequently there will be met in the cracks and crevices under the dead bark and in holes where limbs have been broken off from the cacao a beautiful, irridescent, blackish green or blackish purple beetle with very convex wing covers and antennæ which have the appearance of a string of beads. This beetle belongs to the family *Sphindidæ*, a class of beetles whose larvæ feed upon dry fungi and decaying vegetable matter and which are not injurious to the tree. When disturbed these beetles readily simulate death and will drop to the ground until the disturbance has passed. They have been found in fair abundance in all cacao plantations.

The beetle measures 14 mm. in length and 5.5 mm. in width, the wing covers being 9 mm. long. The wing covers are marked

by a series of 9 longitudinal lines which are punctuated by fine dots. The under surface of the body is of the same color as the upper surface. See fig. 35.

Occasionally there may be found upon the under surface of the beetle, tiny light-brown, roundish mites which are parasites. This is a thing which is very common to many *Coleoptera,* especially those living in dark or obscure places.

Associated with the beetle may be found several species of cockroaches, some of a very pale yellow and about 15 mm. long, others mottled buff color, 20 to 25 mm. long, and still others which are about 35 mm. long and of a reddish-brown color. None of these do damage to the trees, as they live upon the decaying matter found in the crevices and wounds.

Other harmless forms pertaining to *Thysanura, Coleoptera, Corrodentia,* and *Orthoptera* have been met with upon the trees, but a description of these minor insects and of their life histories and habits will be left for a later bulletin. In any attempt at treating the trees for injurious insects many of these will inevitably be killed.

CATERPILLARS.

The two principal destructive insects found upon the leaves are a species of caterpillar of the family *Lymantriidæ* and others of the family *Eucleidæ.* The caterpillar of the former, mentioned on page 27 can be easily recognized by its size and its hairy appearance. When full-grown and ready to transform it measures 33 mm. in length and 10 mm. wide, without the hairs, which add 12 mm. to these dimensions all around, making the entire caterpillar occupy a space of 53 mm. by 30 mm. on the surface of the leaf. The adult and the egg-laying habits of this insect are not known, but it is probable that the female lays her eggs in patches upon the twigs, covering them with soft down from the outside of her own body, like a closely related spcies found upon the ylang-ylang and the *talisay* trees. These caterpillars, as has been stated, have the habit of feeding at night and resting upon the branches and the trunk of the tree during the day. When disturbed, they raise the head and twitch the fore part of the body from side to side. If the disturbance be continued, they drop either to the ground or to a lower limb. The color is a dull gray with a few reddish markings. The head is very large, grayish, and marked by darker

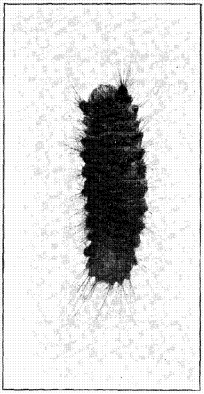


Fig. 36.

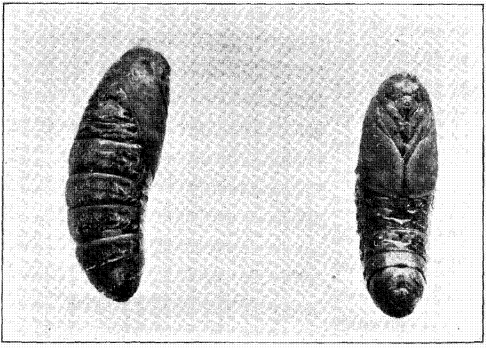


Fig. 37.

patches of small dots. The hairs which project forward from the neck give the insect the appearance of wearing a ruff. When at rest upon the bark, the false legs of the abdomen, ten in number, are spread out beyond the sides of the body, firmly grasping the surface upon which the insect is resting. When the caterpillar is about to change its skin or moult, a process which it performs five times before changing to the chrysalis, the six true feet are drawn up together, the head is drawn down toward the legs and the fore end of the body is elevated. This insect, before pupating, finds a convenient place at the fork of a small twig or in a crevice in the bark, and there it spins a very poor apology for a cocoon. The cocoon looks more like a wide-meshed basket than a true cocoon and doubtless serves simply to keep the large brown chrysalis from falling to the ground. Unfortunately, several of these chrysalids which were put into a box for rearing, transformed to the adult stage in transit to Manila from the place of capture and were so disfigured as to be unrecognizable when the box was opened.

In addition to the long hairs which cover its body, this caterpillar is provided with short, stout bristles 3 mm. long. They grow from tubercles on the upper parts of the abdominal or thoracic segments, and are spread out in tuft form. These bristles are very sharp and when the observer is pricked by them the sensation is a very painful one. It is claimed by Filipinos that these animals are very poisonous and undoubtedly this belief comes from painful experiences with their poisonous spines. On many people the prick of these spines causes great swelling aud inflammation, which may continue for some days. This is due to the fact that the spines work their way through the epidermis into the lower skin and there remain for some time. If one handles these insects by mistake, the best way is to carefully pick out all the spines with a pair of pincers, using a magnifying glass if necessary to aid in the work.

The pupa is likewise covered upon certain areas with very minute spines not more than 1 mm. in length, which have the same properties as those upon the caterpillar.

The pupa of this insect is much shorter and stouter than the larva, measuring only 23 mm. in length. Fig. 36 shows the full-grown larva and fig. 37 the pupa.

SLUG CATERPILLARS.

The other caterpillar which is nearly as severe in its attacks as the hairy form is what is commonly termed a slug caterpillar. The slug caterpillar is so called from the fact that instead of possessing well-developed legs and prolegs (false abdominal legs) it has the under side of the body so modified that for its entire length it is closely applied to the surface upon which the insect crawls. The form of the caterpillar is most striking, and once recognized, these larvæ can not be mistaken for any other. The body, which in the full-grown larva measures 9 mm. long, is shaped much like a slug or snail, except that it is perfectly square across the back, the sides being also perpendicular to the back. The very pronounced margin which separates the side from the back is armed with a series of erect spines of a mottled brown color with black tips. There is also a row of these spines on each side near the ventral or lower surface of the caterpillar's body. A peculiar little tubercle armed with two of these spines projects from the rear of the body and slightly upward. When feeding, the caterpillar protrudes its head from beneath its spiny armor and when disturbed it can immediately withdraw it, pulling the fore part of the body down over it for protection. When touched upon one side the insect immediately doubles over toward that side, just as a person would do if tickled. If touched upon the opposite side, it performs a similar movement in that direction. The general color of the insect is dull brown, but the under surface is pale, almost white, and very smooth. The caterpillar secretes a kind of a slime which is evidently useful to it in its movements upon the leaf, serving in place of legs to hold it. When it is about to transform to the pupa, it spins a very tough, thick cocoon which is nearly spherical in form and is attached to the leaf or the twig. This little cocoon is brown and very smooth and glossy. It bears no resemblance to anything pertaining to an insect except to the tiny galls formed by certain hymenopterous insects upon trees like the oak, etc. It looks more like a little, dry, brown fruit of some kind.

The damage the caterpillar does to the leaves is shown by fig. 38. As the eggs are always laid upon the under side of the leaf, the insect begins by eating off the lower skin or epidermis, leaving only the veins which give the peculiar skeletonized effect shown in the figure. The insect enlarged is shown by fig. 39, while the cocoon

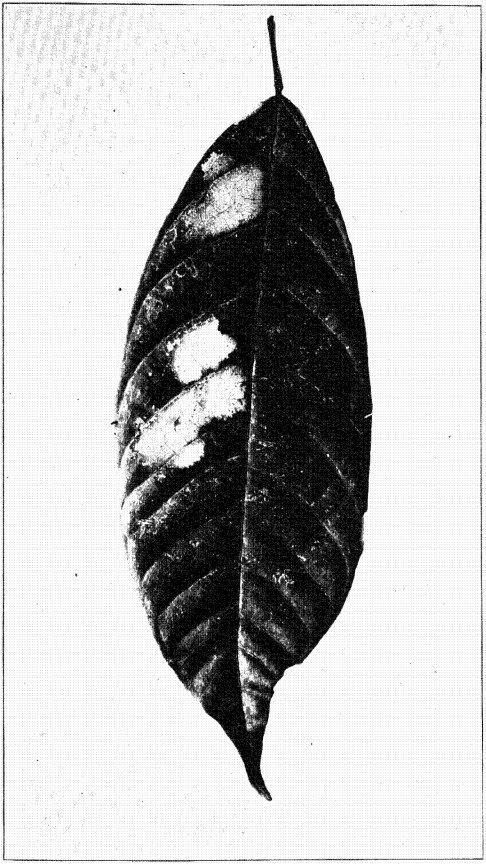


Fig. 28.

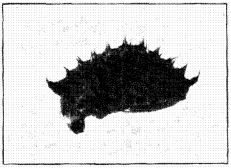


Fig. 39.

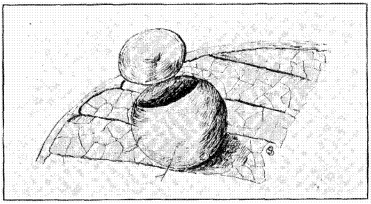


Fig. 40.

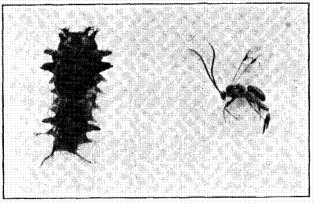


Fig. 41.

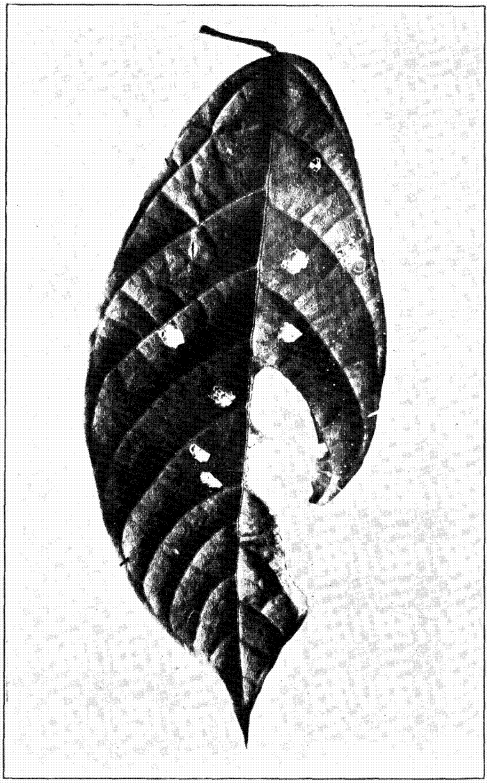


Fig. 42.

Fig. 42.

from which the adult moth has escaped is shown by fig. 40. In escaping, the moth pushes off a little round lid in the cocoon.

There is another member of the same family which, when full grown, is somewhat larger, of a bright yellowish green with a peculiar brown mark upon the back and having a double row of tubercles on either side from which grow tufts of bristles or spines very much like those described on the hairy caterpillar of the family *Lymantriidæ*. This caterpillar, shown enlarged by fig. 41, has habits similar to those of the other species of *Eucleidæ*, except that it eats holes in the leaf as shown by fig. 42.

This insect in the larval stage is attacked by a little hymenopterous parasite which lives within the body, devouring the fat and finally the internal organs of the caterpillar. When this parasite has reached the stage for transformation to the pupa, it spins its white silken cocoon within the caterpillar's body, and the latter may often be found dead upon the leaf, looking as though it were still alive but motionless.

Inasmuch as these three insects, like all caterpillars, obtain their food by biting, they will be susceptible to any poison which may be placed upon the leaf and which they can take into the mouth. Among the many insecticides prepared for this class of insects, those which are among the best are arsenate of lead, Paris green, and hellebore, the first named being probably the cheapest and most effective. When once the solution of arsenate of lead is dried upon the leaves it will withstand rain for some time before it is finally washed off, and it is doubtful if it would be all removed before the insects would have secured a sufficient quantity to kill them. As obtainable in the United States the arsenate of lead is a commercial compound, but it can be made in the quantity necessary by following the directions for its preparation in the chapter on insecticides. The preparation and use of Paris green, with other useful insecticides, will be treated in the same chapter.

Of the family *Chrysomelidæ*, there has been found at least one species which does damage to the leaves of the cacao. As this beetle is very small and of an obscure color it might be readily overlooked when searching for insects upon the plant. The female is about 4.5 mm. in length, is of an oval form and very much rounded upon the back. The male is smaller, being 3.5 mm. long. These insects vary from light to dark brown, the majority being a very dark brown. The wing covers are very glossy and are marked

by longitudinal dotted lines extending from the base to the tip. The adults are quick in their movements, both when walking and flying, taking readily to wing when disturbed or dropping quickly to the ground. They are very difficult to catch unless a bag is held beneath the leaf upon which they are resting and the latter be shaken. Even then, upon alighting in the bag they will almost immediately fly away unless promptly killed. The eggs of these insects have not been found, but as with most beetles pertaining to this family, they are probably laid upon the lower sides of the leaves in patches in which the single eggs stand on end. The young grubs are very peculiar in form, being shaped like the larvæ of ladybirds, *Coccinelidæ,* except that their abdomens are thicker at the rear. They move very slowly, and when disturbed cling to the surface rather than drop to the ground. Their bodies are covered with short black spines as a means of protection.

When young, these insects feed only upon the lower epidermis of the leaf, but as they grow larger they eat away both upper and lower skin, leaving a few of the larger veins which are too tough to be eaten. The adults as well as the larvæ are leaf feeders, eating through the entire substance of the leaf.

As many as twenty of these beetles are sometimes found upon the same leaf, and as each consumes an area equal to about ten times that occupied by its body, it can be readily seen that the damage done by the cacao leaf-beetle is considerable. For the combating of these insects a spray of arsenate of lead is recommended as fatal to both larvæ and adults.

Further observations are necessary in order to determine where these insects pupate. Most of the leaf-eaters pupate in the crevices of the bark and in dried leaves and other secluded places, such as wounds in the trees and rubbish which accumulates around the neglected ones, and doubtless those of cacao have the same habits. Fig. 43 represents the full-grown beetle, *a* being the male and *b* the female, both much enlarged. Fig. 44 shows the larva of a related species.

SCALE INSECTS.

Cacao leaves are affected by at least two species of scale insect. This is an insect which, in the larval stage, exudes a waxy secretion which forms a shell or scale which soon completely covers the individual so that none of its body is visible. This is of peculiar

B

A

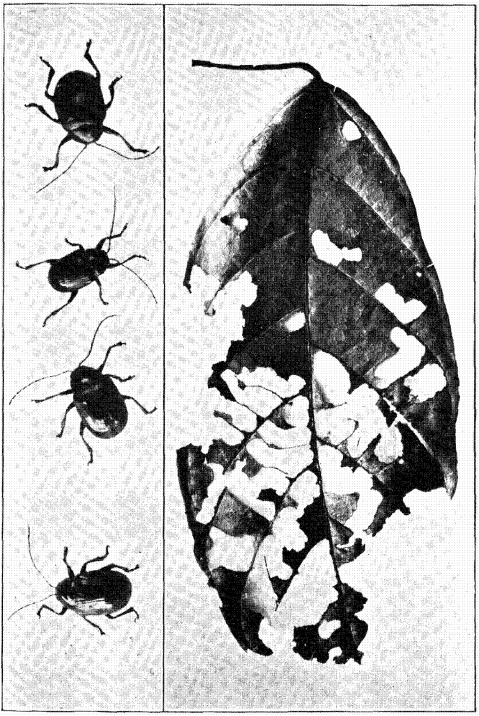


Fig. 43.

form, according to the species. Some species are long and narrow, others are elliptical, oval, or circular, others oblong. Usually there is a prominence near the center called the nipple of the scale. The scale of the adult contains the successive exuviæ which have been shed by the young in its transformations. Only the adult females are found beneath the scale. They are legless, wingless, rounded masses with no eyes. Their mouth-parts consist of a very fine filament composed of three parts. This is inserted into the substance of the leaf or through the bark, and by this means the insect obtains her nourishment. Once fixed in a certain spot upon the food plant, she never moves and probably never removes her proboscis from the place where it is first inserted. She lays her eggs under the scale and the young come forth from beneath it to begin their own independent existence. The hinder end of the female's body is composed of a series of what are called anal plates. These are portions of chitine, the hard material found in the walls of all insects' bodies. They are lobed, and between the lobes are arranged series of bristles or spines. The form, number, and position of these plates are characters upon which are based the classification of these microscopic insects. Very frequently the food plant of the scale is used as an aid in its determination, but this is variable, as there are certain scales like the San José scale, *Aspidiotus perniciosus* Comst. and the oyster shell-back louse, *Mytilaspis pomorum* Bouché, which have a variety of food plants. The male larva of the insect forms a scale as does the female, but when it reaches the adult stage it comes forth a winged insect similar in appearance to the one shown by fig. 6 of the frontispiece. A young scale insect with its legs and other parts of the body complete is shown by fig. 4 of the frontispiece. At certain seasons these minute insects may be seen crawling around upon the infested leaves or twigs, but they soon settle, usually within a few days.

It is impossible to observe or attempt to study this class of insects without the aid of a fairly good hand magnifying glass. They are so small and have so little of the appearance of insects as we usually know them, that they would scarcely be taken for such by persons not familiar with the subject. For this reason they are enabled to gain a good foothold and to multiply to very great numbers unless checked by some natural enemy. In connection with the question of their multiplication it may be said that these insects, like *Aphids,* multiply with very great rapidity and

in numbers which are simply astonishing to those not familiar with their habits and life history. It is claimed that a single pair of the San José scale will in the course of a summer in the United States become the progenitors of more than three billion offspring.[1] Thus the cacao which might be slightly infested with scale at one time might very shortly thereafter be completely covered.

The first of the scale insects found upon the cacao, the *sisí* scale, so named from its resemblance to a Filipino oyster so called in Visayan, is black, shiny, and has the shape shown in fig. 45. It has thus far been found only upon the upper side of the leaf near the midrib. It is very slightly convex. Upon reversing the leaf a yellowish spot can be seen beneath the spot where the scale is lying. This is caused by injury to the leaf tissue, a result of the insertion of the insect's proboscis.

The combating of scale insects has presented one of the most serious problems which has confronted not only the grower of fruit and other trees, but also the economic entomologist, during the past few years. All kinds of remedies have been tried, such as kerosene, crude petroleum, whale-oil soap, hydrocyanic acid gas, lime, sulphur and salt wash, as well as patent articles, all of which contain some one or more of the above ingredients. Even now it is extremely difficult to say with any certainty which of these remedies, or whether any of them, will prove best adapted to the needs of the cacao grower who finds his trees threatened by this evil. No experiments have thus far been made anywhere in the Philippines with this class of insecticides with reference to the treatment of the scale insect, owing not only to the lack of the proper materials and also to lack of the machinery for their application, but also, thus far, to lack of opportunity to devote to this very interesting and important subject.

INSECTS ATTACKING THE FRUIT.

CACAO MEALY BUG.

Many plants in the Philippines, as elsewhere, are attacked upon their leaves, branches, and fruit, by several species of insects known as mealy bugs. These insects belong to the same family as the scale insects, the *Coccidæ,* and their effects upon the cacao are only second in importance to the work of the cacao borers.

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[1]Bul. 3, n. s., p. 44, U. S. Dept. Agr., Div. Ent.

Going through a cacao grove at the time when the trees are in fruit one notices many pods which seem to bear a whitish fungus-like material. Upon closer examination the fungus-like growth will be seen to consist of large masses of whitish insects. These insects are 3 mm. long and 2.35 mm. broad and the bodies, which are pinkish yellow, are covered with a fine powder-like substance. If examined with a magnifying glass it will be seen that this powder extends only to the sutures or joints of the segments and that the latter may be readily counted even in those individuals which have much of the powder. These bugs attack the fruit just after it has set, and multiplying thereon with great rapidity, often cover it entirely by the time it is ripe. They first begin in the depressions or grooves and gradually spread upward upon the lobes of the pod. They crowd together in large numbers and are invariably attended by swarms of ants, whose purpose is to secure the honey-dew voided by them. One of the most interesting examples of the interdependence of insects is shown in the relation of the ants to these plant lice. Upon certain pods it is a not uncommon sight to see the valleys between the lobes of the pods completely roofed over by a gray material, which upon examination proves to be a kind of crude paper, formed from particles of the decayed wood of the cacao tree. Small black ants will be seen running in and out through the openings in these sheds, and curiosity upon the part of the observer leads him to break away a portion of this material in order to find out what, if anything, is beneath it. He is rewarded by finding in the grooves thus protected, large numbers of the white mealy bugs, with their young and with willing servants, the black ants, attending and caring for them. The ants will be seen taking individual mealy bugs in their jaws and carrying them from place to place, and especially is this true of those which are exposed to view by the destruction of their roofs. The bugs submit to this with no sign of displeasure. If the observer watch long enough, he will see the ants building the roof or repairing the parts which have been broken away. They manifest great uneasiness when disturbed and all those individuals which are under the roof at the moment, come forth and assume an aggressive attitude, sitting up on four of their legs with the front ones in the air and the abdomen doubled under as if about to sting. They, however, possess no sting and only assume this attitude in instinctive imitation of those forms which do possess one. The author has found

cacao pods upon which all of the ten grooves were completely filled with the mealy bugs and roofed over by the ants. A unique feature of the fruit thus attacked was that one of the tunnels extended to the fruit stem and along the limb to the tree and then down the trunk to a spot where the ants entered a part of the tree which was decayed. Upon opening this decayed wood the true nest of the ants, with their young in all stages, was found. This would seem to indicate that the tunnels or roofs are not built solely for the benefit of the mealy bugs, but also as a protection for the ants in going back and forth from their nests to the pods where their "cows," as they are sometimes called, live. This double and somewhat intricate system shows, in a way, the wonderful provision of Nature whereby, through their inter-relationship, certain species of insects are propagated and perpetuated. It is undoubtedly true that without this provision either one or the other of the species would soon be exterminated. In as far as these animals are related to man and to his economy they must both be considered enemies, the mealy bug as being directly injurious to the product of the cacao, and the ant indirectly, as protecting and caring for the mealy bug in order to secure the product of its attack upon the tree. The latter must, therefore, share with the former in any treatment looking to its extermination.

Little is so far known of the life history of this cacao mealy bug. Its eggs have been discovered; the young have been found in great abundance in the deeper grooves of the cacao pod. In the frontispiece is shown a ripe cacao pod upon which the adult and young mealy bugs with the adult male and female, the ants which attend them, an insect parasite, and tunnels or sheds built by the ants are represented. The openings of these sheds are regularly constructed so that the ants can go in and out at certain places without disturbing the bugs. By whatever method these insects are treated, the sheds would offer but little if any hindrance to the effects of the insecticide, inasmuch as they are built of an extremely porous material through which kerosene, crude petroleum, or other similar material would soak very readily. Probably the very best solution to apply to these insects would be the kerosene emulsion recommended for plant lice on page 30. The bodies are fully as tender and delicate as those of the plant lice and therefore the same proportions of ingredients could be used. The sheds where they

are present would hold the insecticide longer in contact with the insects' bodies and would thus be a help in the extermination of the mealy bugs. Naturally the best time to spray the trees for these insects is just after the fruit has attained the size of a small hen's egg. If successfully subdued at this time the chances are that they will not reappear.

The amount of injury that these insects inflict is shown in the smaller size of the pods attacked by them, the scars which extend down into the fiber of the pods and the general inferiority in size and quality of the beans or kernels themselves. Pods infested by these bugs are not only inferior in quality to those not infested, but they are also very unsightly to those who have to handle and open them. I am thoroughly convinced that with sufficient care and the judicious use of the spray pump and the kerosene emulsion of a proper strength these minute pests may be entirely eradicated from the cacao grove, and clean, healthy, well-filled pods will be produced where now inferior ones exist.

There is another species very similar to the mealy bug, which has been found upon the cacao in a few instances. It is also quite prevalent upon the nangka, *Artocarpus integrifolia* Linn., being situated on the fruit stem and often on the small twigs. It is covered with a thin, white or yellowish-white incrustation which breaks very readily upon being touched, however lightly. As this insect has been found only in a few instances and on trees which were in close proximity to nangka, it is probable that it will not naturally attack the cacao. However, it would be well to be on the lookout for it. Further observation will reveal the facts with regard to its preference for cacao and its life history and habits may then be discussed at greater length.

BENEFICIAL INSECTS.

There are few trees which have a host of enemies without at least a proportionate number of friends in the insect world, and the cacao is no exception to this rule. In many cases the insects which in some way or another prove beneficial to the cacao are not found solely upon this tree. This does not have reference to the parasites of the insects which affect the cacao, but includes such insects as wasps, aphis-lions, ant-lions, and spiders, the latter not being insects in the technical sense.

WASPS.

Among wasps which are found upon the cacao and which are known to feed upon larvæ and adults of noxious insects may be mentioned the *aliñgayo* and the *amomó-ong,* called here by their Visayan names. The former belongs to the true wasp family, the *Vespidæ,* and the latter more strictly to the hornets. The *aliñgayo,* which is familiar to all who live in the Visayas, because of its very sharp and severe sting and the fact that it often builds its nest in houses, is not more than 13 mm. in length. It is of a light brown color with transverse bands of yellow upon the abdomen and diagonal ones upon the thorax. The second segment of the abdomen is as long as all the other segments together and when at rest the insect retracts the hinder segments within this long one, giving it a very short, stubby appearance; but when angered and about to sting it can increase the length of the abdomen more than twice the normal size. A broad band of yellow borders the hinder edges of the second abdominal segment, which is of a deeper brown than the rest of the body. The stinging instrument is very sharp and about 2 mm. long, curving slightly downward. The eyes are slightly yellowish, the antennæ are broken or jointed at a distance from the head of about one-third of the entire length, and they droop forward in front of the eyes. When at rest, this insect folds its two pairs of wings down between the thorax and abdomen and thus they lie for a part of their length below the abdomen as shown in fig. 46 *d*. The general appearance of this insect is given in the same figure at *b*. This insect builds a nest like the one shown by fig. 47. It is often as large as a man's two hands and every cell contains a grub or a pupa. The larvæ are fat, white grubs with no sign of legs, eyes, or other appendages, and they feed upon the masticated and partly digested insects which the adult brings to them. Fig. 46 *a* shows the full-grown grub and fig. 46 *c* the pupa, which has been removed from its cell and from the delicate silken cocoon which was spun before its transformation. Soon after changing to the pupal form, the insect is a creamy white, but as the process of development goes on it assumes a darker color, beginning at the eyes, which are the first to show evidence of the true color of the perfect individual.

These insects have been seen to capture small caterpillars and

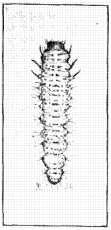


Fig. 44.

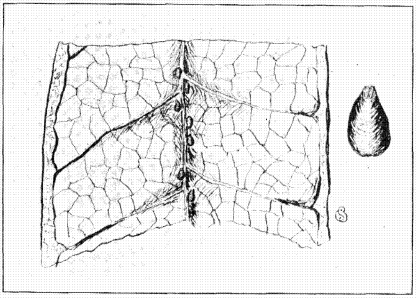
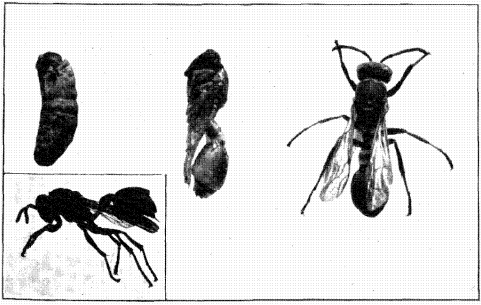


Fig. 45.

A C B



D

Fig. 46.

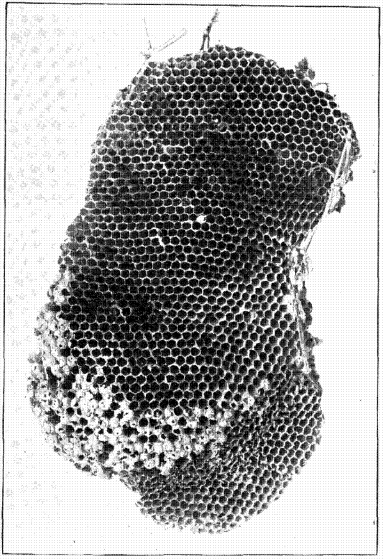


Fig. 47.

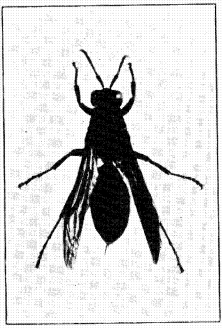


Fig. 48.

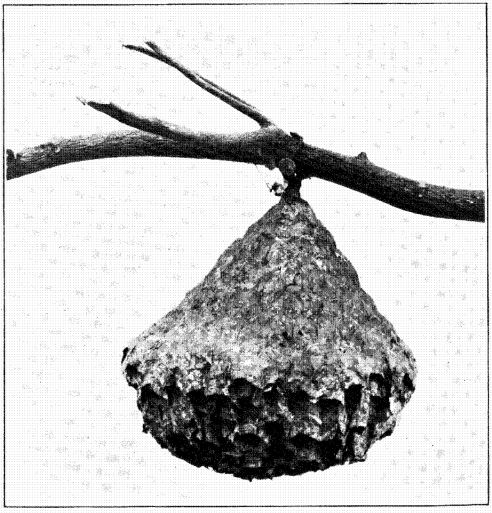


Fig. 49.

to gradually chew them into a soft mass which they carry in their jaws to their nests. They feed upon other insects and do not disdain flies. It is estimated that a colony of 100 adults will destroy in a month more than 3,000 caterpillars and other insects. Fig. 46 shows the larva, pupa, and adult of this interesting and useful little wasp.

The *amomó-ong* is very much larger than the *aliñgayo* and is one of the most beautiful wasps which I have ever seen. It is 30 mm. long and 7 mm. wide, of a jet black with three transverse bands of orange red, one on the upper part of each of the first three abdominal segments, the second being about thrice the width of the first and third. The head and thorax are of a dull velvety black. The compound eyes are black and glossy and in the top of the head are three little black glistening ocelli, or simple eyes, forming a triangle. The wings of this beautiful insect are of a reddish brown, the fore wings measuring 23 mm. in length. They are somewhat smoky. They extend beyond the tip of the abdomen. The antennæ are elbowed, as with the *aliñgayo,* and droop over the eyes. The legs and feet are of a color uniform with the body and are provided with claws for grasping the surface upon which the insect rests and for obtaining its prey. These insects have the same habits as the *aliñgayo,* but instead of building a flat nest with all the cells in the same plane, their nest has the appearance shown in fig. 49. Fig. 48 shows the adult. With this nest were captured some eight adults, about half those present, the rest escaping in my attempt to get them. These insects are valiant protectors of their homes and their young. They will remain in the nest even when struck at with poles, one or two of them darting at the intruder. When the nest has been torn away they will even come back to the same spot and attempt to build another in its place. This is contrary to the usual habit among insects, of giving up a place when once their nest is damaged or destroyed. That these insects render a valuable service in the destruction of larvæ of injurious species is beyond question of doubt. They have been repeatedly caught when returning to their nests with full grown larvæ in their claws. They carry their prey in their claws rather than in their jaws, as is the case with the *aliñgayo,* and they do not masticate it until they reach their nests.

Among the species of caterpillars which have been taken away

from these wasps are those of *Geometridæ, Lymantriidæ, Cetonia,* and *Tortricidæ* in large numbers. In all cases where they are not so numerous as to prove annoying by stinging unsuspecting workers among the trees, they should be left alone in their nests.

RED CORSAIR.

Another insect which is frequently met with upon the cacao tree and which might be mistaken for its enemy is one of the true bugs, a Reduviid which I propose to call the *"red corsair."* This *Hemipteron* belongs to a class of insects which are very properly called assassin-bugs, because their instinct is directed to the killing of other insects. The *red corsair,* a picture of which is shown by fig. 50, is a very showy insect, having a black underbody with red thorax and red wings. The head and feet are black, as are the antennæ. The insect measures 17 mm. long and 5 mm. wide. The head, which is very long and narrow, has a peculiar beak which curves under toward the thorax. This beak is very sharp and is used for sucking the blood of insects which the *red corsair* captures. At *a* is shown a dorsal view of the insect, while at *b* it is shown enlarged twice with the beak visible. The nature of the beak can be readily seen from the drawing.

This insect moves very stealthily about upon the surface of the leaf and pounces upon whatever insect it may find. It has been observed most frequently feeding upon geometrid caterpillars which it holds between its fore-feet while sucking their blood. When not seeking its prey, it rests quietly with its legs spread far apart and the body suspended above the surface upon which it is standing.

If caught in the fingers this insect is liable to inflict a sting with its beak which, while not poisonous, is very painful to say the least, and with some persons the result may be a disagreeably sore swelling. They do not, however, need to be handled and the good they do on the trees in the matter of destroying noxious insects is of incalculable value when compared with the occasional bites they may inflict on those who carelessly manipulate them. Their eggs are laid in crevices of the bark and when the young come forth they look very much like the adults, save that they have no wings. The young also feed upon small larvæ and other insects. Stål in his "*Hemiptera Insularum Philippinarum,*" calls this insect *Sphodronyttus erythropterus* Burm., var. *convivus* Stål.

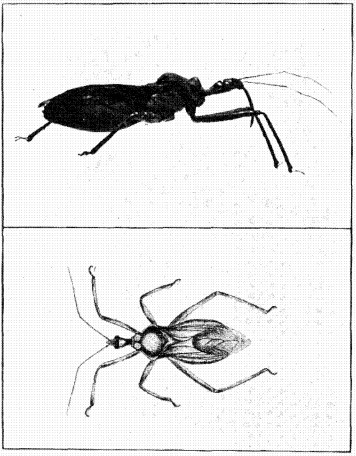


Fig. 50, a and b.

ANT-LION.

In a cacao plantation in which the top soil is sandy and in which there has been no rain for some time, one will very frequently see around the bases of the trees a number of cone shaped pits with the sides, which are composed of loose sand thrown at an angle of about 45° to the surface of the ground, coming to a point below. If an ant or a fly be tied to a string and let down into the bottom of this pit it will be at once seized by a pair of jaws which is lying concealed in the sand. If the observer be quick enough he may succeed in jerking out a peculiar-looking grey insect resembling a large-sized louse, and in fact so called by the Visayans, who name it *cotú-cotú,* meaning a big louse. This animal which measures, when fully grown, 12 mm. long and 5 mm. wide, is the larva of a very delicate and beautiful insect of the family *Myrmeleonidæ* of the order *Neuroptera.* The adult measures about 29 mm. in length and has an expanse of wings of about 60 mm. The wings are iridescent and the general color of the insect's body is a smoky grey. The eyes are rather large and spherical, being prominently set, like those of the damsel flies, relatives of the dragon flies; or, as they are called in Visayan, *tumbuc-tumbuc.* One would never associate this delicate insect with the voracious *cotú-cotú.*

The larva has habits which are as strange and incongruous as its appearance. Its two forcep-like jaws are well adapted to sucking the blood of unfortunate insects which drop into the pit which it has dug for them. It invariably moves backward instead of forward. If dropped upon a sandy spot it almost instantly disappears. It uses its tail as a sort of shovel to dig its way into the ground.

Its method of constructing its pit is interesting in the extreme. After working its way below the surface it begins to move around in a circle, the diameter of which is in proportion to the size of the insect and consequently in proportion to the hole which it will finally have excavated. When it has completed its circle, it begins throwing out the sand with its head, which serves as a shovel. As the sand is thrown out the larva gradually moves toward the center of the pit which, from the force of the caving sand on the sides, begins to assume a conical shape. When the ant-lion, for such it is called in English, encounters a pebble or small stone it immediately lifts it upon its opened jaws and attempts to throw it out. It can throw out a stone which weighs much more than its body.

When the pit is completed the ant-lion goes into the sand at the apex of the cone-shaped hole, and with only its jaws and its eyes protruding, awaits the coming of some unwary insect. It usually has not long to wait, for as a rule ants and such crawlers are very curious when they come to a hole. They invariably like to investigate, and peering over the edge of this pit they lose their balance and begin to slide down just as a boy would if playing at the top of a sandhill. Their downward motion is very much accelerated by the ant-lion, which immediately begins to throw sand up over them. This takes the sand away from under their feet, and in a shower of the material they are gradually forced down into the pit. Finally, reaching the bottom completely exhausted, they are seized upon by the skillful foe, dragged under the sand, and their blood is sucked out. Afterwards their dried skins are flung out of the pit by the ant-lion.

Fig. 51 shows two views of the ant-lion's nest, one being sectional, with the insect seen at the bottom. Fig. 51 *a* shows the larva.

The ant-lion will not attack large insects such as beetles or big spiders which occasionally fall into its pit, but remains quiet until the intruder can get out. It will attack the termite, any kind of ant, small flies and bugs which fall in, and it has been seen to drag small moths under the sand. When ready to pupate, the ant-lion spins a spherical cocoon of grains of sand fastened together by a beautiful, pearly white silk, and lined with this material.

This insect can certainly be called a decidedly beneficial one, for of all the insects which it has ever been seen to capture not a single one was other than noxious, and the number of ants and *anay* which it catches and kills in course of its somewhat lengthy larval stage must be great indeed.

PRAYING MANTIS.

To the *orthopterous* family *Mantidæ* belong several very peculiar-looking animals which from time immemorial have received the attention of even the most careless observers. They are called mantis, devil's riding-horse, camel-horse, mule killer, etc., in English, and *tagâ-tagâ* in Visayan. In Tagalog they are known as *sa-sambá.* Unlike most *Orthoptera,* they are carnivorous, living upon other insects, and are therefore to be classed as beneficial.

They lay their eggs upon the twigs of the cacao and other plants,

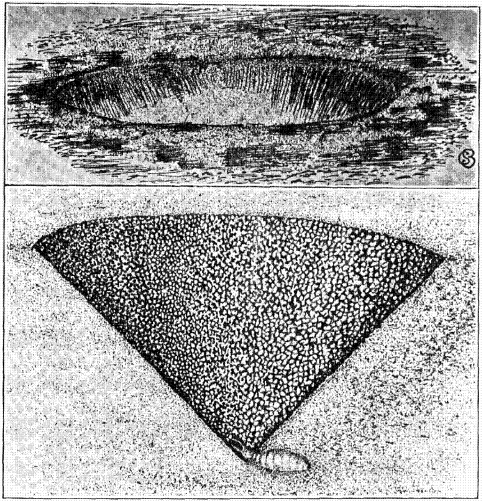


Fig. 51.

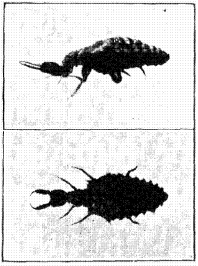


Fig. 51 a.

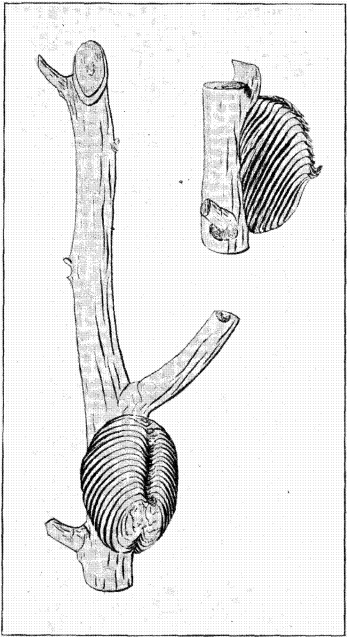


Fig. 52.

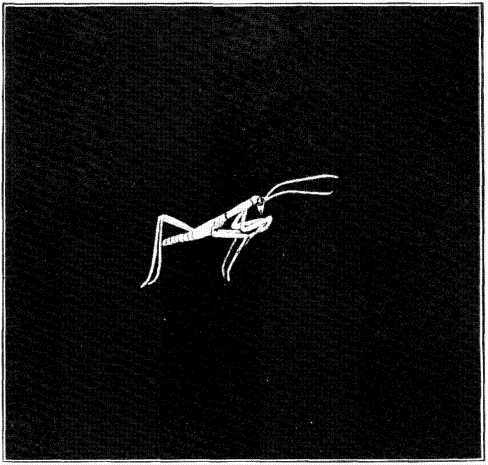


Fig. 53.

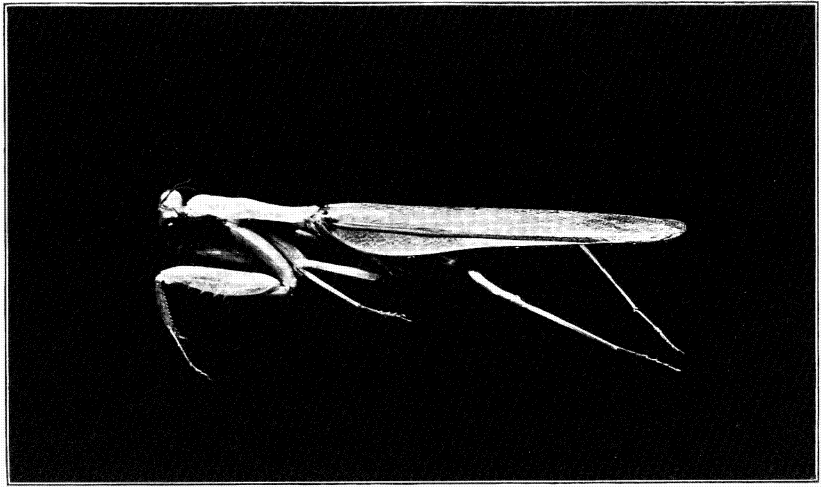


FIG. 54

and as many as 200 of the young hatch from an egg mass such as shown by fig. 52. The young are very much like the adults in appearance. Fig. 53 shows a young mantis and fig. 54 an adult. The forelegs are fitted for grasping the prey. These insects often remain motionless upon a twig for several hours, but if an insect comes within reach, they immediately, with great rapidity, grasp it in their forefeet and proceed to eat it, only rejecting the harder parts and the wings. After feeding they very neatly clean their faces, antennæ, and front feet and again begin their watch. They run readily and are also good fliers. They rest entirely upon the two hinder pairs of feet. They have the habit of sitting up and watching the observer, who in turn becomes the observed. The large eyes and peculiarly shaped head, together with the large body, make them objects of very grotesque appearance.

SPIDERS.

The many kinds of spiders which live upon the cacao and which undoubtedly do it a service by the number of insects which they capture and devour, should be the subject of special attention, although they do not come under the technical classification of insects.

Among those which have been found most abundant are the orb weavers, the jumpers, one species of tarantula, and many species of the crab spider, or *Thomisidae*. Perhaps the most peculiar and one of the most beautiful of the orb weavers is the crescent spider, which is illustrated by fig. 55. It has its abdomen shaped in the form of a perfect crescent, is of a beautiful jet black and yellow, and the horns at the sides of the abdomen are pubescent at their tips. This spider builds a true orb web and catches many insects, the most of which are harmful to the plant. Among these have been noted plant lice, moths, plant bugs, and small *Coleoptera*, like *Scolytidæ*, *Chrysomelidæ*, and *Scarabaeidæ*, all harmful species.

The crab-spiders are so called because of their resemblance to crabs in form and arrangement of the legs. They are of a light color, usually like that of the flowers which they inhabit, and they lie concealed in the clusters. They seize plant lice and other small insects as they come to the flowers. Undoubtedly they occasionally capture beneficial insects like hymenopterous parasites.

The majority of spiders found upon the cacao belong to the

jumpers or *Attidæ*. These spiders are sure to attract the attention of the observer because of their peculiarly beautiful and varied colorings and their activity. They are light green, golden yellow, brown and red, black, grey, and of many other and striking colors. They are extremely active, jumping forward, or backward, or sidewise with equal celerity, and they invariably capture their prey by pouncing upon it. Their eyes glow with what appears to be an internal fire, and the position on the head and the form suggest in a most remarkable way the headlights on an automobile.

A most peculiar and common form of the *Attidæ* is the ant-like jumper. These insects vary in length from 3 to 10 mm., according to the species, and their resemblance to black ants is so very great, not only in their form but in their movements, that they often deceive the close observer. They run upon only six legs, carrying the two fore legs high in the air and moving them with the same uncertain motions that ants have when using their antennæ. They will run a short way, then stop and wave their front feet, then start off sidewise, then back, and before one knows what they will do next, have pounced upon some unsuspecting fly or bug. In form and movements they really represent one of the most striking cases of mimicry. Fig. 56 shows an example of the ordinary jumping spider and the ank-like form.

At the base of the cacao one frequently sees a hole 15-20 mm. in diameter, carefully and neatly lined with snowy white silk which sometimes extends out upon the ground for some little distance. If one will dig out this hole, following its twists and turns, at the inner end, which is usually 40 or 50 cm. in the ground and parallel with the surface, if the ground be level, or horizontal if the hole be in the side of a hill or a mound around the tree, he will be almost sure to find a most beautiful dark brown hairy spider of the tarantula family, *Theraphosidæ*. This spider measures when extended, including legs, 85 mm. in length and 65 mm. in breadth. Its brown velvetry coat appears almost black when it is seen curled up against the white background of its silken cell. If one of these spiders be examined when dead, it will be seen to have two very strong, curved, brown forcep-like mandibles which, instead of approximating point to point as in most spiders, are bent forward and downward so that the tarantula can not really grasp its prey with its jaws. It is, however, provided with two foot-like palpi, which serve to hold its food while it is eating. These palpi give the

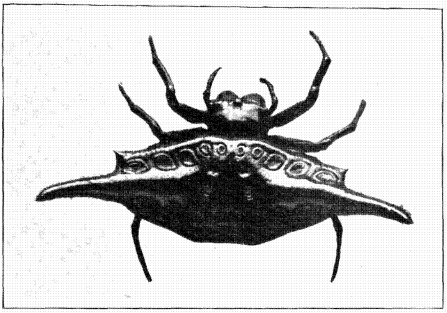


Fig. 55.

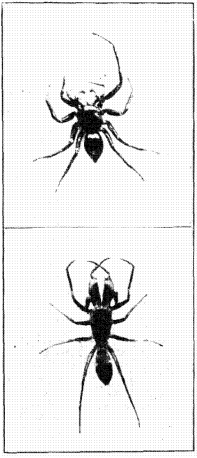


Fig. 56.

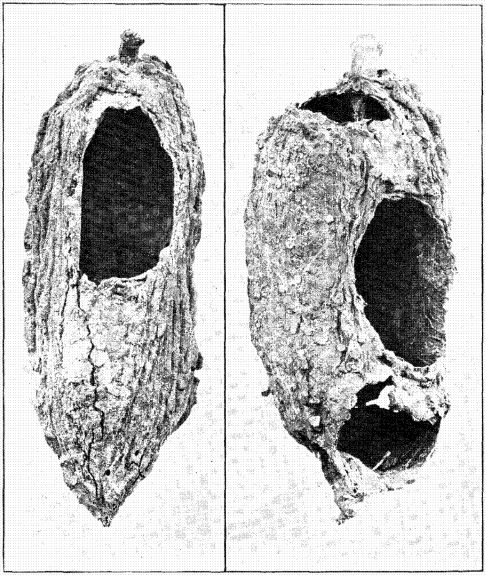


Fig. 57.

tarantula the appearance of having 10 legs instead of the true the number, which all spiders have, namely, eight.

The area around the mouth is covered with golden reddish hairs. This characteristic seems to be common to members of the tarantula family. The spider feeds upon most kinds of insects; the exuviae of various larvæ and pupæ being found in some of the nests opened. It seems to show a great preference for cockroaches, skeletons of several kinds having been found in its abode.

PESTS OTHER THAN INSECTS.

A word should be said before concluding this paper regarding some other animal pests of the cacao. In all parts of the world great trouble has always been experienced in cacao growing because of the ravages of rats and mice. These rodents, working at night when vigilance is relaxed, often do an incalculable damage to the fruits, destroying many pounds of the nuts in a season. Fig. 57 shows two cacao pods, each with a hole in the side just large enough for the small rodent to enter. The intruder very skillfully removes all the kernels from a pod and leaves it hanging on the tree, where it dries, if not removed by the grower.

No effective remedy has been devised for this pest, but the writer would suggest that an excellent one can be found in the discarded pods after the ripe nuts have been removed. The pulp on the inner side of the pod being scraped out and mixed with some kind of effective poison like arsenic or paris green, is replaced in small quantities in each pod. The pods are then to be fastened together with two bamboo toothpicks and the decoys placed beneath the trees, two or three under each one. It is more than likely that the rats, finding these upon the ground, will attack them first, and, gnawing into them, will eat the sweet pulp within. The results will then remain to be seen, but certainly the chances of success are very much in favor of the growers. All hogs and other domestic animals should be excluded from plantations in which these experiments are being tried and the refuse should be collected as soon as it is seen that the pods have been gnawed into by the rats, and it should be buried at a sufficient depth to insure its not being dug up by hogs, etc. As the pods are liable to shrivel and open during dry weather, they should be renewed from time to time as occasion will require.

INSECTS ATTACKING DRIED CACAO.

Very little can be said at present concerning insects attacking the dried product of the cacao, namely, the beans and husks. In visiting various wholesale establishments for the handling of cacao in Manila, beans have been found giving evidence of the work of some form of the common dried-fruit moths, but thus far neither the larvæ nor the adults have been discovered.

Chittenden, in his bulletin on "Some little-known insects affecting stored vegetable products,"[1] says the following in connection with a moth which he calls the "chocolate" moth. I would, however, suggest that instead of being called the "chocolate" moth it be called the cacao-bean moth, as it is more frequently found in the bean than in the manufactured chocolate:

> The habits of our flour and meal feeding phycitids, *Ephestia kuehniella* and *Plodia interpunctella*, are so well known as to necessitate no further comment here, but there is still a fourth moth which, although represented in our faunal lists, seems never to have received mention as an injurious species in this country. I refer to *Ephestia elutella* Hbn. Its habits have been known in Europe since early in the last century, yet so far as I know at present, American records show nothing positive regarding injuries.
>
> Réaumer's account of the moth that injures chocolate, published in 1737, is generally conceded to refer to the present species, and as it is this species that is most often associated with the chocolate nut of commerce it may be called the chocolate moth. Recent study of bred material shows this to be the moth mentioned in Insect Life (Vol. IV, p. 332) as having been received at this office from Mr. H. F. Wickham, who found it injurious to cayenne pepper in one of the drug houses at Iowa City, Iowa. We have also specimens bred from dried apples obtained from a New York City dealer and submitted to this office by the Division of Chemistry, and others from cacao beans received from Mr. C. A. Barber, who obtained them from Montserrat, West Indies. According to various European authorities, this species also attacks manufactured chocolate, coffee and various dried fruits, and even does considerable damage to ship biscuit, which it injures after the manner of *E. kuehniella*.

It may prove that the above-mentioned species is the one which has been found in the cacao in Manila, and the possibility is more strongly emphasized by the fact that the condition of the beans, the class of holes made, and the frass contained within the beans all point to the work of a phycitid.

Certain beetles of the families *Tenebrionidæ*, cadelles, or dark-

[1] Bul. No. 8, n. s., p. 9, U. S. Dept. Agr., Div. Ent.

ling beetles, and the *Nitidulidæ* or sap beetles, are also found in stored cacao products as well as in decaying or over-ripe fruits and on wounds in trees, the sap of which they suck.

For these insects, as for all insects which are found in stored products, it is difficult to suggest an effective preventive, inasmuch as they find such ready means of entrance through the meshes of the sacks. Even where the adult insects can not themselves get into the bags and sacks, instinct seems to lead them to lay their eggs upon the outside, and the tiny larva, upon hatching, find easy ingress. Once inside, the insect passes through its transformations, but upon becoming adult it can not escape and continues to multiply.

Frequent handling of the contained cacao and a careful shaking of the bags, afterwards placing them in bright sunshine, renders the cacao less liable to be attacked by any form of insect which would eat the dried nut.

Where prevention has failed, or where infested cacao is received by the dealer, the best plan is to submit the full sacks, or better, if possible, the exposed contents, to the fumes of carbon bisulphide in a closed bin or other absolutely tight receptacle. If an air-tight room can be had, the sacks may be left in it for two or three days or even longer without any harm being done to the beans, and with the perfect assurance that all insects contained therein will be destroyed at the end of that time. The bin or room should then be opened and thoroughly aired and the cacao spread out in a draught or in the sunlight.

Under no conditions should a lamp or other light be permitted in a room where the carbon bisulphide is being used, nor should persons remain in the room. If a bin be used, the bisulphide may be put on top of the cacao in a small dish, allowing 30-40 grams for every cubic meter of space. As the bisulphide is heavier than the air and very volatile, it will evaporate quickly and settle downward in the bin, suffocating all insects therein. If a room be used the vessel may be put upon a high shelf or upon some object so that it will be as near the ceiling as possible. In this way the entire room will be fumigated.

DISEASES AFFECTING CACAO.

Although the question of plant diseases such as fungi, rust spots, mould, and rot do not belong in the province of entomological

investigation, the fact that these diseases were given some attention by me during my study of cacao insects will warrant my saying a few words about them and suggesting means for their prevention upon the leaves and fruit of this valuable plant.

There are four types of fungus attack which have been most frequently met with, namely, cacao leaf-spot, cacao leaf-blight, cacao pod-spot, and pod scab. The first of these diseases attacks the leaf in spots as suggested by the name. (See fig. 58.) These spots are irregular in shape and in an advanced stage are a dull whitish grey as though the leaf had been scorched to an ash at the point, which dries and breaks off. The two types of fungus disease which attack the pod are very characteristic and will be recognized by the growers at once, as those represented in fig. 59 and fig. 60. Both of these attack the fruit in all stages of its growth. The pod spot occurs in spots similar to that which attacks bean pods in the United States. The spots soon completely cover the affected pod and not only cause a very unsightly growth, but also materially affect the development of the fruit. Fruits which are thus affected are smaller and the beans are found to be misshapen and in some cases not developed. The history of this disease, its causes, and morphology are yet to be investigated.

The pod scab is undoubtedly the worst form of disease which attacks the cacao. It is recognized in its advanced stages by the fact that the pod becomes dry either upon one side or over its whole surface. It then cracks open in unsightly gashes as though hacked with a knife. Of course the contained beans in such pods are worthless. This is another disease of which the causes are not clearly known.

Although diversified in their modes of attack, it is undoubtedly true that the same means of prevention will apply to them all since they are fungoid or bacteriological in character. Many thorough tests covering a period of several years have demonstrated the efficiency of a mixture of copper sulphate (blue vitriol) and quicklime, commonly called Bordeaux mixture, for nearly all kinds of fungus diseases affecting plants. The blue vitriol is the fungicide or destroyer of the fungus spores, and the lime is added to keep the vitriol from burning or scorching the leaves or fruit. This solution, a formula for which will be given under "Insecticides and fungicides," will of course have to be applied to the trees by means of spray pumps and a very fine spraying nozzle.

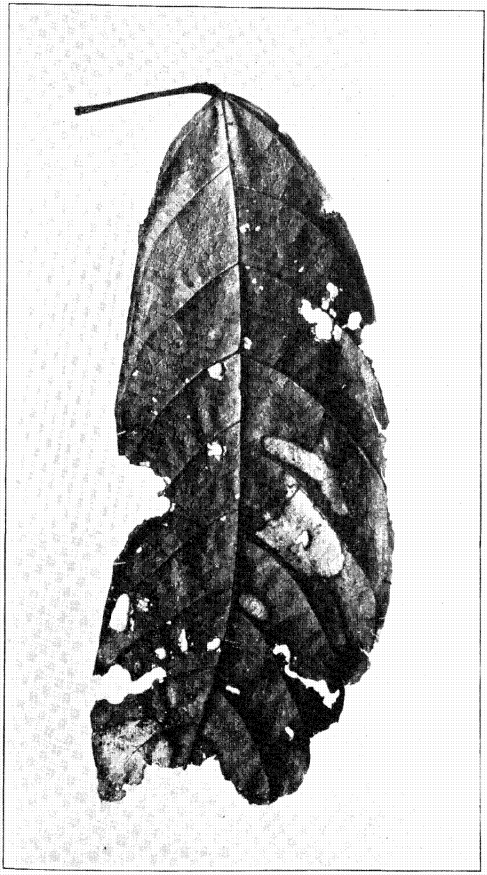


Fig. 58.

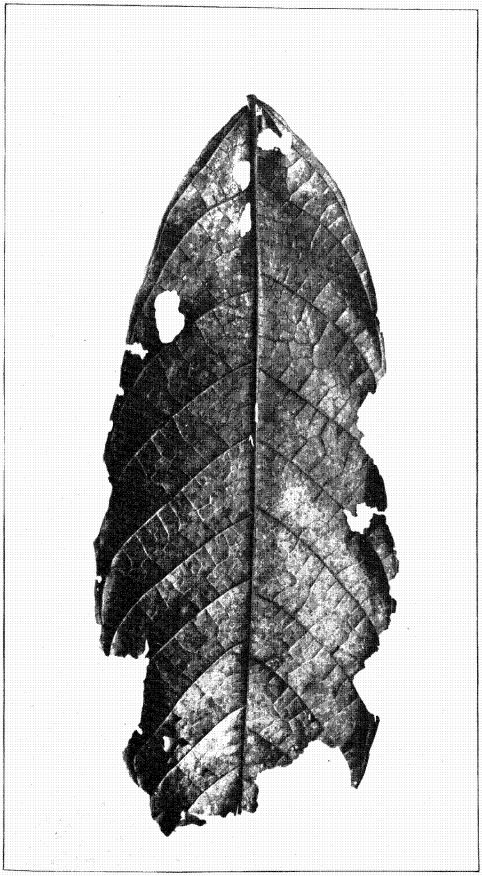


Fig. 58.

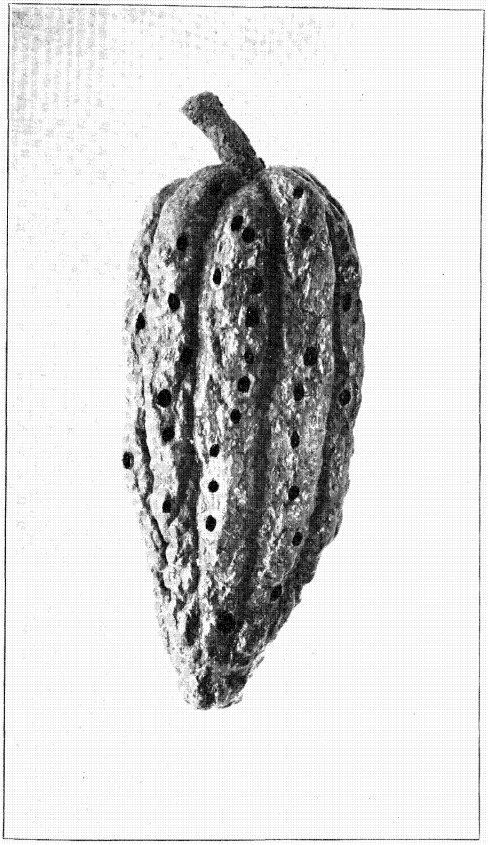


Fig. 59.

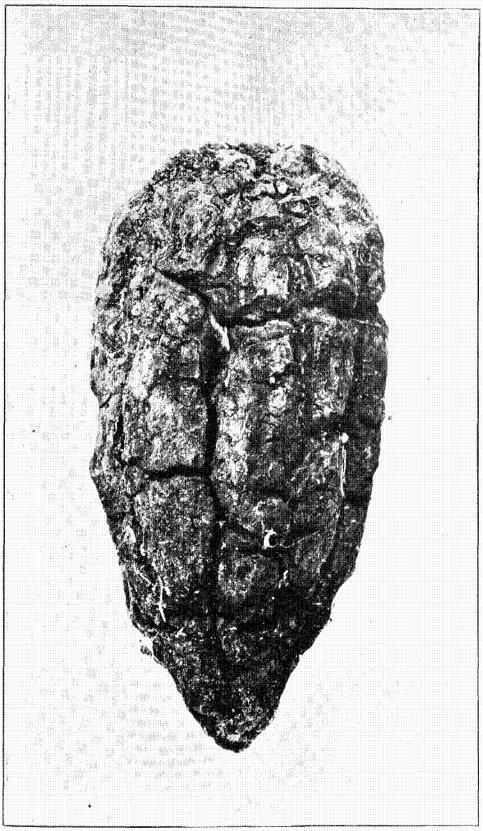


Fig. 60.

The writer is well aware of the fact that in the limited time during which he has studied the questions of insects and diseases of the cacao, many forms and conditions have escaped his notice, but as this is only a preliminary bulletin and issued so that the grower may have something at hand to guide him in the recognition of and dealing with the most important pests, the fact that all pests are not treated will not detract from its usefulness. He would be under great obligations to all growers of cacao to whom this bulletin shall come if they will send him suggestions of methods which they have tried with success.

There is a disease called "die-back" mentioned by Lyon in his bulletin on cacao, which I have not found in the Philippines, and I would be grateful for specimens showing this disease.

The production of cacao has such a favorable future in these Islands that any measures which will tend to a better degree of cultivation and a more thorough protection of trees from unnecessary ravages should be welcomed by growers and prospective growers throughout the Archipelago.

SOME INSECTICIDES AND FUNGICIDES.

THEIR USE AND PREPARATION.

Insecticides and fungicides have for their object the prevention of the attacks of insects or fungus diseases or the killing of forms already present, either upon the plant or other substance affected by the insect or the disease.

With reference to insects there are two kinds of insecticides, the internal and the contact. Of the latter there are the corrosive poisons, which destroy the substance with which they come in contact, and the suffocating poisons, which act upon the breathing apparatus, producing suffocation.

Internal poisons are those which are intended for the insects which eat the substance of the leaf or other part of the plant. Applied to the surface of the leaf either as a powder or as a solution they are taken by the insect along with its food, and, acting upon the alimentary canal and other internal organs, accomplish their work.

Contact insecticides are those which, coming in contact with the body of the insect, produce a condition, usually like that caused by a corrosive, which results in death. To this class belong ashes, lime, kerosene, carbolic acid, crude petroleum, pyrethrum, and smoke.

Suffocating poisons are those which, entering the tracheæ, either

clog them up or paralyze the muscles of respiration, thus killing the insect. To this class belong carbon bisulphide, napthaline, bezine, petroleum, kerosene, whale-oil soap, and the fumes of hydrocyanic acid gas.

Among the most important of the internal poisons are those which have as a basis some form of arsenic. This substance in any form is deadly to all animal life. As there are many forms of arsenical insecticides, only those which are considered as of value in connection with the combating of cacao insects will be mentioned.

Arsenate of lead.—This insoluble chemical compound is prepared as follows:

	Grams.
Lead acetate	200
Sodium arsenate	50

Dissolve each ingredient in 16 liters of water separately in wooden or stone vessels. Then pour these at the same time into a barrel or tank containing 450 liters of water. The mixture should be stirred constantly and rapidly while making. Inasmuch as the compound which is formed (arsenate of lead) is insoluble it is precipitated as a white powder and must be kept in suspension. In order to make this mixture stick well on the foliage to which it is applied about two and one-half liters of glucose or grape sugar should be added to it before spraying.

A commercial compound of arsenate of lead mixed with glucose, in the form of a thick white paste, is sold in kegs in the United States, one form bearing the trade name, "disparene." This insecticide possesses all the good properties of that made at home by the grower, with the advantage that it is mixed and ready for use upon the addition of water in proper quantities. This has proven one of the most effectual and therefore most economical of insecticides against insects preying upon the foliage of fruit, shade, and ornamental plants.

Paris green.—This is a copper arsenite-acetate and contains from 55 to 60 per cent of arsenious acid. It is a bright green powder, very heavy, and hence does not stay suspended in the water of a spray pump unless continually agitated. As it does not dissolve in water it is not liable to "burn" the foliage. If, however, twice the amount of freshly slacked lime be added to a given quantity of paris green, one can be sure that all danger from free arsenious oxide will be averted and there will be no "burning" of the foliage of the most delicate plant.

Paris green would undoubtedly prove an excellent poison for mice if applied, mixed with meal or bran, and the pulp of the cacao in the manner mentioned on page 49. The proportion should be one part of the paris green to fifty parts of meal or bran.

In using paris green as a liquid insecticide it is applied as follows:

Paris green	grams	450
Lime (fresh slacked)	do	900
Water	liters	1,500

This is a cheap insecticide, is in universal use, and if care is used to keep it in suspension in the water while spraying, it will give as good results as any insecticide of its class.

Numerous other arsenates are sold under the following names, and others: White arsenate, pink arsenate, white arsenoid, parine green, laurel green, London purple, paragrene, and green arsenoid.

Kerosene.—This is a refined product of petroleum which is so well known as to render a description of it unnecessary. Applied pure, to any kind of insect, it immediately destroys life. It is likewise fatal to plant life if undiluted. Used in a mechanical mixture with water, it is a remedy against scale insects and plant lice. A safer and much more effective preparation is the kerosene-soap emulsion, which is prepared as follows:

	Per cent.
Kerosene (9 liters)	67
Water (4.5 liters) Common or whale-oil soap (225 grams)	33

Heat the solution of soap and water and add it boiling hot to the kerosene. Churn the mixture by means of a force pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream, which thickens on cooling and should adhere without oiliness to the surface of glass. The above formula gives 13.50 liters and makes when diluted 120 liters of wash. (Report of the entomologist: In Report of the Commissioner of Agriculture [U. S.] for 1883, p. 152.) Another formula which may be of interest is the following, taken from Dr. J. A. Lintner's Second New York Report on Injurious Insects, 1885, page 38:

"*Eight parts of water and one part of soft soap thoroughly amalgamated* forms the lye which *takes* mineral oil and thoroughly mixes with whatever proportions of the oil be added. As heat aids much in quickly producing thorough amalgamation of the

ingredients, boil the soap and water together, and when ready, turn into ordinary wine bottles (costing little or nothing, especially in the Philippines) which have been placed in boiling water. About half fill the bottles, turning 125 c. c. of the oil into each bottle, then fill up with the boiling lye, cork at once and store away for use.

"When required for use a bottle of the mixture is poured into an 18-liter watering pot which is filled up with soft water, and is ready for use, at a strength of 70 c. c. to 4.5 liters of water (1 part oil to 64 parts water is about $1\frac{2}{3}$ per cent). Seventy c. c. of oil to 4.5 liters of water is strong enough to kill *aphides* (the plant lice in question) and such soft-bodied insects.

"By bottling the mixture as above, no mistake need be made in using it of proper strength."

Whale-oil soap.—A preparation made of fish oil with lye. Effectual against scale insects and plant lice, and when mixed with carbolic acid makes an excellent deterrent for borers. When used as a spray for plant lice the proportions should be:

Whale-oil soap	grams	450
Water	liters	45–90

This should be thoroughly dissolved before using, and the weaker solution is advised for trees when in young leaf. Even 450 grams to 125 liters of water is not too weak. If ordinary soft soap or turpentine soap be used the following are the proportions:

Common soap	grams	450
Water	liters	18–36

Another excellent preventive which has been used most successfully against the peach borer in the United States and which would probably prove of equal value to that of the carbolic wash is what is known as the "Lime, coaltar, and whale-oil soap wash." It is prepared according to the following formula:

Unslaked lime	kilos	25
Coal tar	liters	6
Whale-oil soap	kilos	6

The lime and tar should be slaked together with water sufficient to make the whole of the consistency of paint. The whale-oil soap is dissolved in hot water and added to the lime and tar solution. When water is added sufficient to make the whole mass as thick as ordinary paint, it may be applied to the trees.

Tobacco wash.—This very effectual remedy against plant lice has certainly the advantage of cheapness in a country where tobacco is abundant. It is applied as a spray after being prepared as follows:

Dry stems or tobacco leaf	grams	225
Water	liters	4.5

Steep over a slow fire for some hours, then when ready to use it, dilute the quantity with 200 to 400 liters of water.

Carbon bisulphide.—This is a colorless liquid resembling refined kerosene in appearance. It is of a very disagreeable odor and extremely volatile. It can not be handled around fires, and even smoking while using it is dangerous. It is explosive and also takes fire very readily. Its vapor is heavier than the air, hence it should be placed above whatever it is desired to fumigate. In closed bins or in rooms the proportions to be used are: 450 grams for every 27 cubic meters, or 17 grams for every cubic meter. Whatever it is placed into should be perfectly tight in order that the fumes may not escape.

Bordeaux mixture.—This valuable fungicide has as its essential ingredient the sulphate of copper, commonly called blue vitriol, or blue stone. It is prepared as follows:

Copper sulphate or blue vitriol	kilos	1.80
Quicklime (unslacked)	kilos	2.25
Water	liters	225

The copper sulphate should be dissolved in half the amount of water or 100 liters in a wooden vessel such as a half barrel. The lime should be slacked in the remainder of the water, and when ready for usé the two solutions should be poured together into the spray-pump, barrel, or tank. In order to save time a stock solution of each substance should be made and kept on hand.

First slack in a wooden vessel 22.7 kilos of lime. This should be immediately strained into a barrel holding 225 liters and the barrel filled with water. Cover the barrel to prevent foreign matter from getting into it.

The copper sulphate stock solution should be prepared by dissolving 18.1 kilos of the crystal in 225 liters of water and putting it into a barrel, covering the same.

When it is desired to use Bordeaux, take 22.5 liters of each solution and add enough water to make 225 liters of the Bordeaux mixture.

SPRAYING APPARATUS.

At the present time the question of spraying in the Philippines is a very serious one, owing to the fact that none of the goods of large and reliable firms of spray-pump manufacturers are represented in the Philippine market. For several years past the United States Government has carried on experiments for ascertaining the best apparatus for combating insects on a large scale, and as a result of its work and the experimentation of individuals, there are now upon the American market several very excellent spray-pumps which, considering the ease of manipulation and the fact that they will last for several years if given proper care, are very reasonable in price.

The principal essentials of a good spraying apparatus are: That it deliver a fine spray, that it keep the mixture to be sprayed in constant agitation in order that the ingredients may be kept in uniform suspension, and that it have sufficient capacity so that a reasonable amount of the insecticide may be made and used at one time.

The two types of spraying apparatus which would give the best results in cacao plantations are the barrel pump, and the small power spray pump. The former would be useful in small plantations of not more than two or three hectares, and the latter for large plantations. With a barrel pump and two nozzles, and three men to operate it in the orchard, from 50 to 75 cacao trees could be sprayed in a day. With the power spray pump a proportionately larger number of trees can be sprayed. The best nozzle is one which will break the liquid up into the finest particles possible and at the same time is not liable to clog, or, if clogged, may be easily cleaned.

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