*Insect Pests of Coffea arabica in the New Guinea Highlands.**

J. H. BARRETT.†

ABSTRACT.

Distribution, life history and biology, nature of damage, and natural, cultural and chemical controls are discussed for the more important insects. Climate and flora are briefly described. In the conclusion attention is drawn to the general problem, and a possible future problem is highlighted.

INTRODUCTION.

SMALL areas of coffee were planted at Kainantu and Korn Farm (Mount Hagen) as early as 1935. Little more was planted before 1939, except at Wau. Establishment of plantations was begun in 1949. Native planting began in 1952 in the Asaro Valley and there was rapid expansion in all areas in the following ten years. The early history of the area is summarized by Brass (1964).

Tentative controls for coffee pests were published in a paper by Barry (1956) and a comprehensive list of insects is dealt with in a paper by Szent-Ivany (1958). The present author was stationed at the Highlands Agricultural Research Station from 1957 to 1964.

Field trials and observations, in parallel with laboratory work, have provided a fund of data which has been drawn on to bring published information up to date, and at the same time to attempt to provide a balanced discussion of the insect problems.

Some species will be dealt with in greater detail in later papers. Specific identifications of a number of pests and most of the parasites have been omitted.

COFFEE IN RELATION TO THE NATURAL FLORA.

Since native insects are involved, a description of the location of plantations in relation to natural vegetation is relevant. Coffee is grown mainly within elevations of 5,000 and 6,000 ft. in the Eastern and Western Highlands, and down to 3,000 ft. in the Southern and the Morobe Highlands. The planted areas are on ridges and alluvial terraces low in the valleys, and on the valley floors. The ranges, reaching to over 10,000 ft. in many parts, are covered with a monsoon (montane) forest which extends down, in some localities, to the vicinity of the higher coffee plantings.

Blocks of coffee are bordered by 'kunai', 'pit-pit' swamp, village 'gardens', or areas of 'regrowth' vegetation.

KUNAI consists of Blady grass *Imperata cylindrica,* or Kangaroo grass *Themeda* spp. which usually dominate a mixture of other species.

PIT-PIT develops on the more swampy areas. The two common species are of the genera *Saccharum* and *Phragmites,* and each may occur in pure stands.

VILLAGE GARDENS are devoted mainly to the Sweet Potato *Ipomoea batatas,* but Sugarcane *Saccharum* sp., is also of major importance. A wide range of other crops is grown as scattered individual plants or as small plots within these areas.

REGROWTH vegetation develops in abandoned gardens or clearings, following on from grass and weeds. Common genera present are *Alphitonia, Dodonaea, Ficus, Trema, Pipturus* and *Homolanthus.* Brass (1964) discusses the ecological classification of the flora and gives references.

Of some 9,000 acres of coffee at least one half is planted in small blocks in, or adjacent to, old village gardens. The remainder, mostly

* Based on a paper presented at the Pacific Science Congress of the Pacific Science Association, August-September, 1961, in Hawaii.

† Formerly Entomologist, Department of Agriculture, Stock and Fisheries, Aiyura, Eastern Highlands, Territory of New Guinea, and now Research Entomologist, Department of Primary Industries, Brisbane, Queensland, Australia.

in areas of 40 to 80 acres, is of necessity less associated with such areas and, in some cases, is isolated in ' pit-pit ' or ' kunai ' country.

Rainfall, ranging from 60 to 100 in. per year, is seasonal to at least some degree, June to August being the driest period. Hours of sunlight per day (average five hours approximately) are relatively low in most areas.

Permanent leguminous shade trees are in general use, the main effects—reduction of maximum day temperatures and the increase of minimum relative humidity—being more marked in drier parts of the region.

I.—BORERS.

A weevil in this group has been the only very serious pest of coffee. Larvae of a moth are found occasionally. Damage by Longicorn beetles is unknown. The notorious White Coffee Borer Beetle *Anthores leuconotus* Pasc. of Tanganyika and Kenya belongs to this latter group.

(i) *Coffee Ring Borer* Meroleptus cinctor Mshl.

Distribution.—This insect is common in the coffee plantings of the Eastern Highlands, and occasional damage has been noted in the Monono area of the Chimbu. Reports of light infestations in the upper Watut Valley and on the hills behind Finschhafen (Morobe District) are unconfirmed. Specimens have been collected at Hollandia, West New Guinea. Publications from Java dated before 1900, describe and illustrate a weevil which appears very similar to this species. The type of damage described was identical with that found in Highland coffee, but apparently the species was never described.

History.—First reports of damage were from Aiyura, as early as 1949. Trunks of bushes in the Extension Block at North Goroka, in about 1952, were found on splitting to contain old scars indicative of attack when the trees were small. The highest incidence appeared in the Asaro Valley below Goroka and in the Dunantina and Kompere Valleys, in the late 1950's.

Hosts.—The common host is the Sweet Potato. Breeding on this plant is much more successful than on coffee and the bulk of infestations has resulted from nurseries or field plantings on, or adjacent to, garden land. Native hosts are not known.

Damage-description.—The larva feeds in the inner bark and the outer layer of wood forming a tunnel, usually horizontally, around the trunk. On trees up to two years old the ring may be completed quickly. In larger trees the damage heals progressively and the larva continues to feed on the scar tissue on its second traverse round the stem. Radial holes are occasionally found joining an old grown-over ring and a new outer ring.

Damage-effect.—Severity depends on the size of the tree and also on the number of rings. If the trunk is less than about three-quarters of an inch in diameter the ring may be completed, the bush wilting above the ring. Usually the trunk thickens above the site of attack and new shoots develop from below. The tree will break off easily at this point. If the trunk is of an inch or more in diameter the damage is repaired progressively and the wilting is less severe (*Plates* II and III).

Plate II.—Trunk of coffee bush showing scar from one year old Ring Borer attack. (x0.5)

Plate III.—As *Plate* II, with dry bark rubbed off.

Following wilting there is a general yellowing and a hastened fall of leaves. The bush shows symptoms typical of 'die-back' or 'overbearing'. Splitting of an old damaged trunk will reveal a flaw in the wood. There is little doubt that this weakens the tree to some degree, reducing its ability to withstand dry conditions or the extra strain of a heavy crop. In general the effect of attack on a young tree, provided it is not repeated, is to delay cropping or an increase in yield by one year.

Areas have been examined in which there was an average of four rings per tree, 80 per cent. of all trees being attacked. Up to fourteen rings have been observed on one tree. Levels of attack of up to 30 per cent. are more usual. A careful survey in 1960 indicated that the loss since planting in all coffee in the Asaro Valley was of the order of 200 tons of dried beans. Annual losses were then decreasing rapidly as a result of the general use of control measures.

Life History.—The adult (*Plate* I) was described and named by Marshall (1959), drawings being included. The weevil is about 0.15 in. in length and brown to black in colour depending on age. On being disturbed it folds its legs and falls to the ground. Adults have been kept alive in the laboratory for periods of up to four months, being fed on cut sugar-cane stalks. There was no evidence of egg-laying when caged on Sweet Potato.

The larva is relatively short and fat and whitish with a dark head. It adopts a partially curled position when resting. The larval stage may take one or possibly two years. This is suggested by the prolonged damage observed on dissection of attacked coffee stems, and from limited rearing of larvae. In the Sweet Potato the larva is a borer in the vine. With few exceptions attack develops in the original planted portion of the runner and it is probable that the life history is only completed in runners infested prior to planting. Populations of up to 500 per acre have been observed at Aiyura.

The pupa is off-white in colour, turning brown prior to the emergence of the adult. It is to be found in an enlarged portion of the gallery.

The pupal period is about three weeks. When ready to move about the new adult chews a neat hole through the thin covering layer of bark and escapes from the pupal chamber.

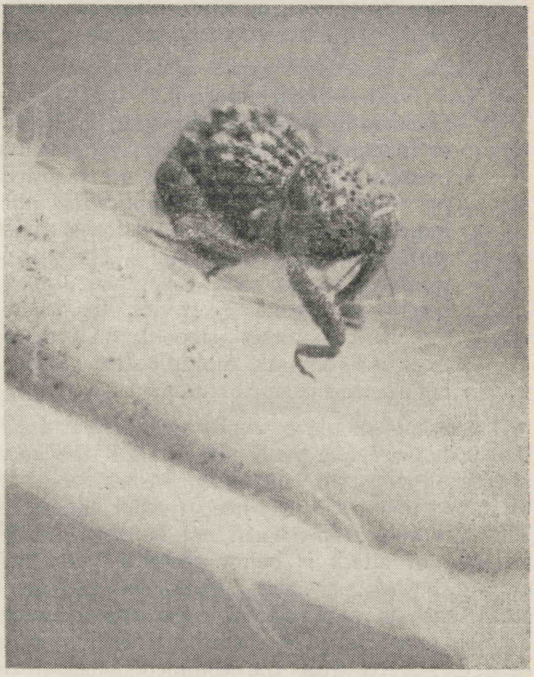

Plate I.—Adult Coffee Ring Borer *Meroleptus cinctor* Mshl. on Sweet Potato vine. (x5)

Natural Control.—In 1958, a parasitic wasp was bred from small larvae in coffee at Goroka. Large larvae often die in the gallery in coffee, the percentage of rings eventually showing emergence holes being low (less than 1 per cent.). This may be due partly to coffee being unsuitable as a host plant.

Cultural and Chemical Control.—Sweet Potatoes should be eradicated from prospective planting areas and/or other crops planted for at least six months before the planting out of coffee. As far as possible Sweet Potatoes should not be grown adjacent to coffee in districts where Coffee Ring Borer is known to occur. Alternatively, Sweet Potato planting material dipped in 0.1 per cent. Dieldrin in water might be satisfactory.

On the basis of results from field trials a chemical treatment of coffee bushes is recommended and is as follows :—

(*a*) *Seed bed.*—Spray with 0.1 per cent. Dieldrin in water at about six-monthly intervals from when the plants are 10 to 12 in. high until field planting ; the last spray being a pre-planting-out treatment. In most instances only two sprays will be possible ; and

(*b*) *Field.*—Brush on 0.2 per cent. Dieldrin in water once per year, in March or in April as the plantation programme permits. Six to ten gallons are required per acre. To facilitate application, the loose bark may be rubbed off the trunk with pieces of 'sacking.' The main trunk or trunks should be treated to a height of about 3 ft. or to where the bark becomes smooth on young trees. Forks in 'multiple-stem' coffee require particular attention.

Treatments should be repeated each year until the bushes are five years old or until the area is free of rings for one year. Bushes cut back to start a new cycle may need further attention. The cost of treatment will not be recouped if the rate of attack is below about 1 per cent. of the bushes per year. Areas of increased attack, such as rows adjacent to gardens or Sweet Potatoes, may be given special attention if it is desired not to treat the complete block. A treated buffer strip of seven to ten rows on the margin will be satisfactory.

The dye *Methylene Blue* has proved satisfactory as a marker to enable checking of the efficiency of application ; a concentration of 4 to 8 oz. per 40 gal. being used.

Before the effect of Dieldrin was determined it was regular practice to cut out the rings to remove the larvae. This tended to complete the ring-barking and so intensify the damage initiated by the insect.

(ii) *Coffee Centre Borer* Zeuzera *sp.*

Distribution.—This insect attacks coffee in all areas of the Highlands. It is also generally distributed in the coastal areas of the Territory.

Host plants.—Beside coffee attack has been noted on citrus, roses, and also on cacao The normal hosts are native trees and the moth commonly comes to collecting lights on the bush margin.

Damage.—The larva excavates a number of tunnels, in laterals and in the main trunk of the bush. The first is within two or three internodes of the tip of the main growing point or of a lateral (*Plate* VI). The second is a little lower down the stem and also a little larger in diameter. A third and fourth follow. The last gallery is about a quarter of an inch in diameter and usually traverses the main trunk for a distance

Plate VI.—The leader of a coffee bush with the top six laterals wilting as a result of a borer hole at the position indicated. This is the second gallery produced by this larva (*Zeuzera*).

of 8 to 12 in. There are usually associated cross galleries and the stem may be partially ringed just inside the bark. Each separate gallery or tunnel has an entrance hole through which faecal pellets are passed, the orifice being protected by two flaps of webbing.

Attack may be detected by the presence of a heap of the whitish faecal pellets on the ground (*Plate* VII). If this is not noted then the tree is seen to wilt above the site of attack, or in the case of a final gallery, the trunk may break off. Incidence is usually of the order of one bush per acre per year on plantations in the Wahgi Valley, and less in other areas.

Life History.—The moth (*Plate* IV) is light grey or white with many small black dots or marks on the wings and body (Leopard Moth). It is $1\frac{1}{2}$ to 2 in. long and settles with the wings folded.

Plate VII.—Coffee trunk with final gallery and entrance hole of larva of *Zeuzera* (indicated), and white faecal pellets on the ground. This tree was subsequently stumped back to a height of 1 ft.

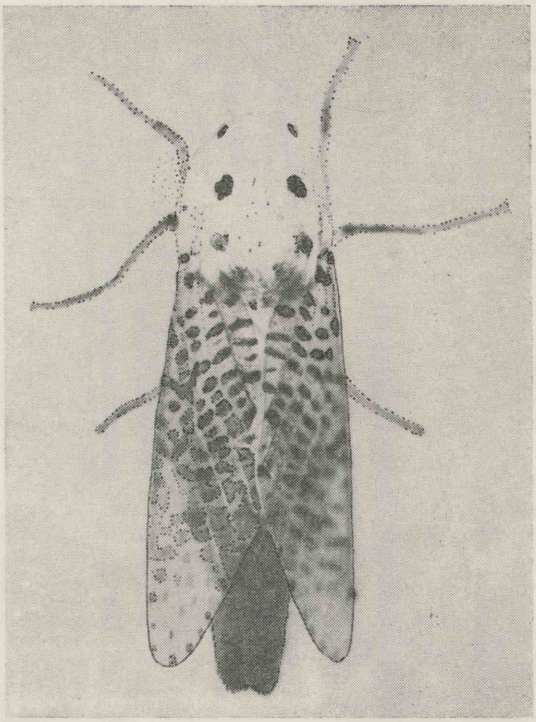

Plate IV.—Coffee Centre Borer moth. *Zeuzera* sp. (x2.3 approx.)

It is presumed that the eggs are laid on the bush although some members of this group scatter them indiscriminately while in flight above vegetation. The larva grows to 2 in. in length. The head and the shield behind the head are dark brown, the body colour varying from orange-red to yellow. A few hairs are present on the body, which is cylindrical and slightly tapered towards the hind end. The segments are not well divided off, in contrast to the larvae of the Longicorn beetles. These, commonly seen in rotting logs, are well segmented, creamy in colour, and usually have a broad 'head end'.

The larva excavates a gallery, moults and then moves outside the plant before starting the next gallery. The fully fed larva makes a hole close to the outside, leaving a very fine layer of bark (*Plate* VIII, *ii*) intact over this future exit hole. It then retires upwards to a prepared part of

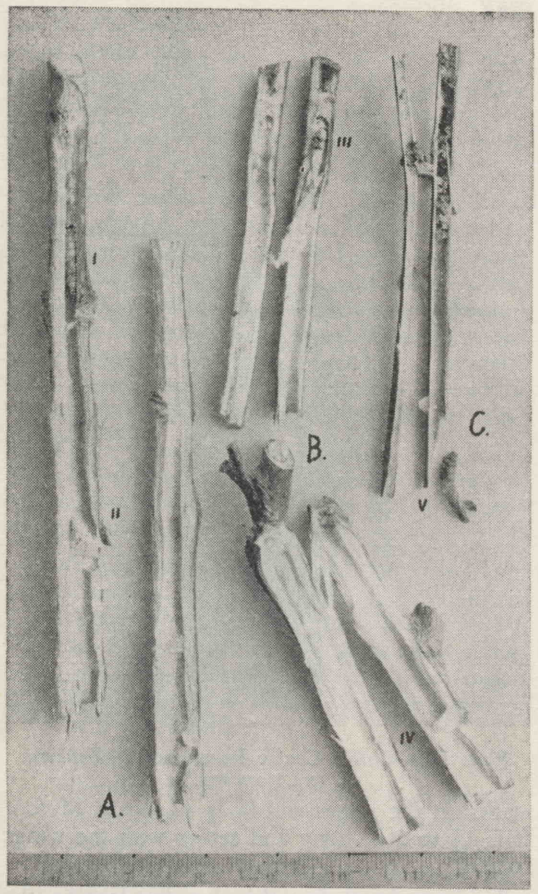

Plate VIII.—Damage by *Zeuzera* on Coffee (A), Citrus (B), and Rose (C). A pupa (i) is present in the gallery, with a web partition immediately below it, and a plug in the gallery above the entrance hole. The bark flap over the exit hole has been lifted (ii). The remains of the larva (iii) are present along with a mass of parasite cocoons which extends down almost to (iv). Pupal case (v). (Scale in inches)

the gallery, webs off the end, and pupates (*Plate* VIII, *i*). When the moth is fully formed it works its way partially out of the hole before finally emerging from the pupal case, the empty case being left in the exit (*Plate* V). The life cycle extends over about one year.

Natural Control.—Wasp parasites were bred from a larva on one occasion, an extensive mass of white cocoons being present in the gallery (*Plate* VIII B).

Cultural Control.—Bushes should be cut off to remove the gallery and the larva destroyed. Remaining laterals may be shortened.

(iii) *Shot-hole Borer* (Fam. *Scolytidae*).

Distribution.—*Crotalaria anagyroides* is commonly attacked by a 'shot-hole' borer in all areas of the Highlands. On one occasion a small area of coffee was attacked by a similar beetle on a plantation in the Upper Asaro Valley.

Hosts.—Probably common in unthrifty or damaged 'regrowth' species.

Damage.—A hole about 0.05 in. in diameter is bored in the trunk, at right angles to the bark surface. Galleries may run up or down for an inch or so from the end of the entry gallery.

On Crotalaria a similar gallery is excavated and the eggs, larvae, pupae and adults may be found in the vertical galleries. It is the habit of this group of beetles to feed on fungus growing from the walls of the galleries or on especially

Plate V.—Pupal case of *Zeuzera* sp. remaining in exit hole in coffee trunk after the emergence of the moth.

prepared beds of wood chips and faeces. The spores of the fungus are carried in on the body of the beetle when the first gallery is formed, and these germinate to produce a fungal growth.

Damage is rare on coffee, indicating that the beetle will attack only under special conditions. These are induced by very poor drainage.

Control.—Drainage should be maintained in all areas irrespective of borer attack. Insecticides are not necessary to control 'shot-hole' borer in coffee.

(iv) *Coffee Berry Borer* Stephanoderes hampei *Ferr.*

Distribution.—This beetle, related to the 'shot-hole' borer, is present in most coffee producing countries but is most important at low elevations. It is present in New Caledonia (Dumbleton 1954), and was collected at Wosi (Manokwari) in West New Guinea in May, 1960 (Simon Thomas 1962).

Damage.—The bean is destroyed.

Life History.—Eggs are laid in large green berries. The larva feeds in the bean and pupates, the adult emerging at a stage when the cherry is over-ripe.

Control.—The technique of stripping the bushes of all green berries for one season has been followed. Endrin sprays have also been used.

In areas of coffee at higher elevations in the Territory control could be achieved by such measures as :—

(*a*) Frequent and thorough picking ;

(*b*) Removal and destruction of all black cherries and 'buni' (dried cherries) ;

(*c*) Treatment of 'floaters' to destroy the insect ;

(*d*) Collection and treatment of old and refuse berries and bean which tends to accumulate on floors and ground in the factory or drying areas. Regular collec-

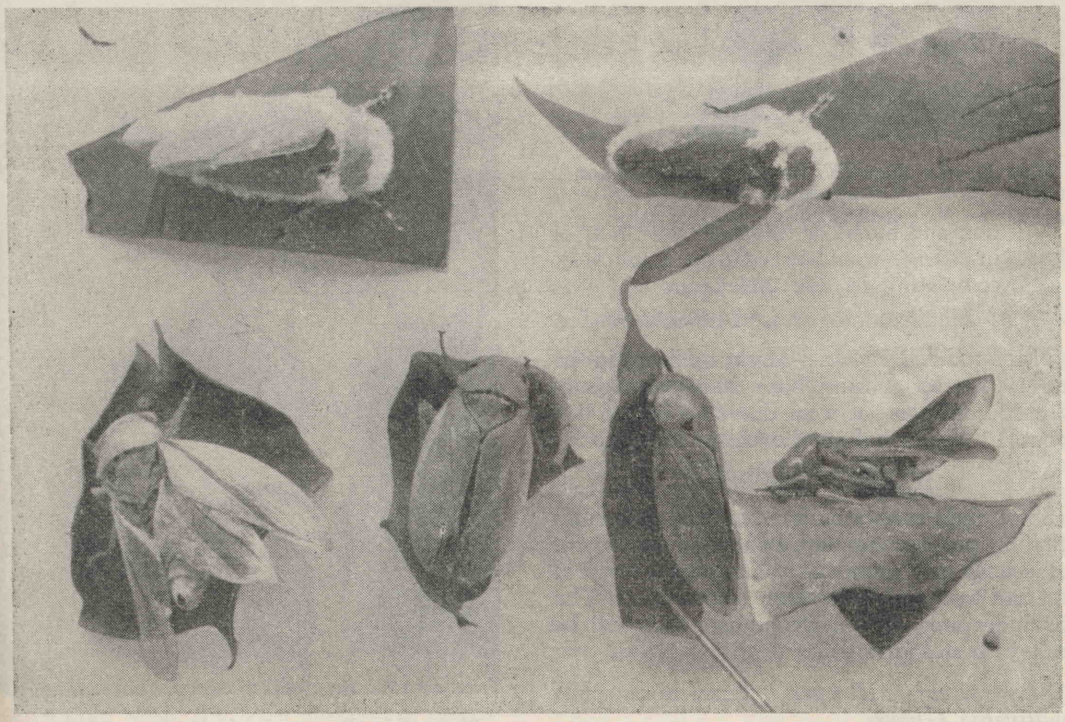

Plate IX.—Brown Leaf Hopper *Batrachomorphus szentivanyi* Ghauri dead from entomogenous fungus attack. The insects are held on to the leaf by the fungus. The two upper specimens have developed a mass of mycelium while held in damp conditions. (x2.5)

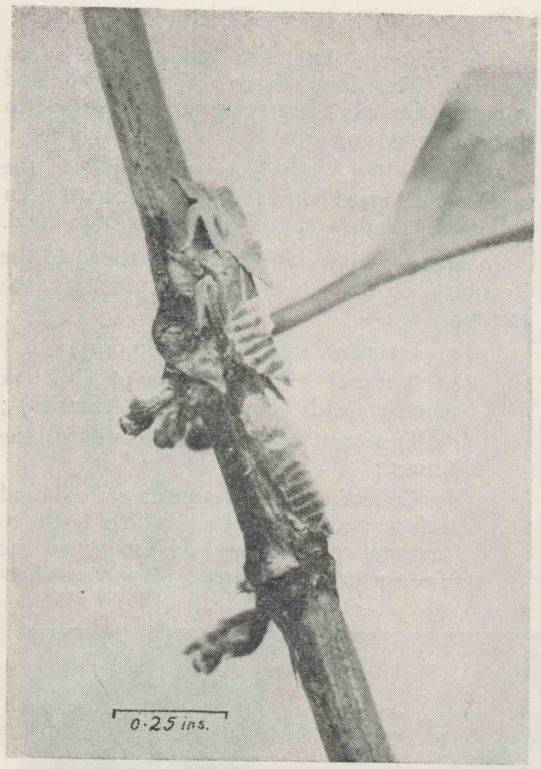

Plate X.—As *Plate* IX, fungal development on nymphs.

tion and burial or treatment with heat or insecticide would prevent the insect from completing its life cycle ; and

(*e*) Elimination of areas of untended coffee.

NOTE : *Hail Damage.*—Marks on beans in the late 1962 crop at Minj bore some resemblance to beetle damage but were due to a fall of hail about 12 weeks before the cherry ripened.

II. LEAF HOPPERS.

Some eight species of leaf hoppers, of various families, are common inhabitants of coffee but are usually not numerous. One has become a pest and a second is common in one area. The remainder are not considered here and will be dealt with at a later date.

Brown Leaf Hopper **Batrachomorphus szentivanyi *Ghauri.***

Distribution.—This is present at Aiyura and on plantations close to Kainantu. *B. blotei* Ghauri is present on coffee in the Wau area, and another species has been reported from West New Guinea.

History.—Collections of this species (*Plate* IX), only recently described, were made on coffee in the Kuminakera block at Aiyura about 12 years ago. It later spread to other blocks on the station, and was found in 1958 on three plantations to the north of Kainantu.

Hosts.—The natural host at Aiyura is a native species of *Ficus* which is common on stream margins, road sides, and other regrowth areas.

Life History.—Eggs are inserted in the internodes of young shoots (*Plate* XII). The nymphs which hatch from these are blackish but later stages are green (*Plate* XI). The adult female is brown, and the male varies from dark

Plate XI.—Brown Leaf Hopper adults and nymphs. Heavy 'Sooty mould' has developed on one leaf (upper left). This population bred up in the laboratory. (x0.75 approx.)

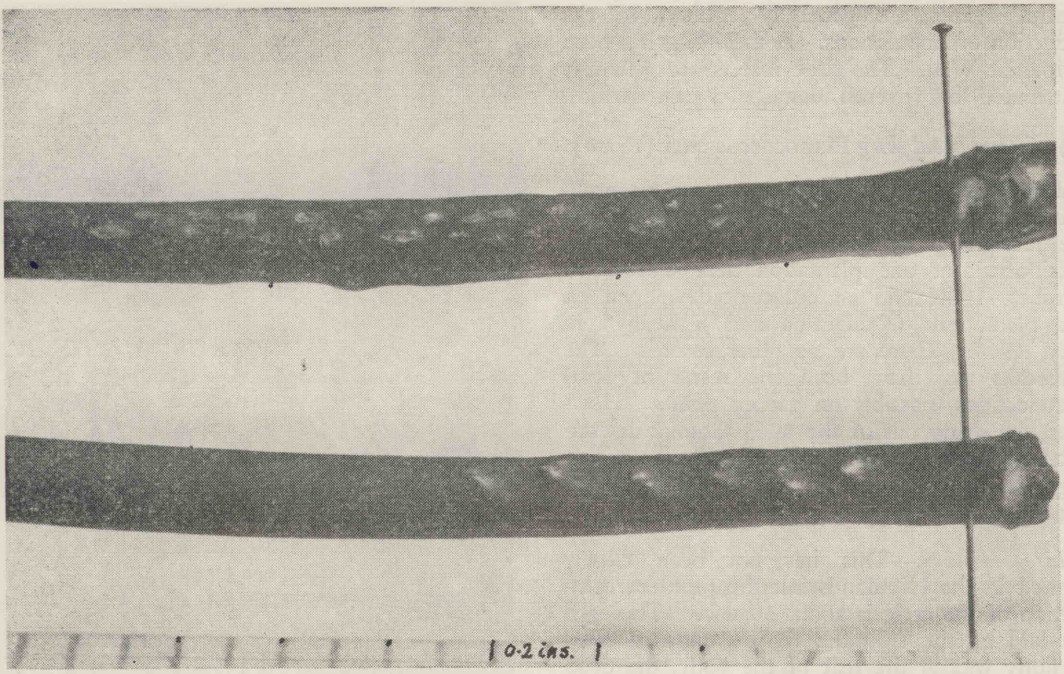

Plate XII.—Brown Leaf Hopper egg-laying sites on soft internodes of coffee lateral. The eggs in the lower piece are fresh. The upper piece shows three round holes from which egg parasites have emerged (indicated by dots).

bluish colour to dark green. Populations are usually in 'single phase' form, the bulk of the population being nymphs then adults, followed by a lull before the new generation of eggs hatches. The life history takes about four months.

Damage.—Large number of eggs may be laid in internodes, resulting in reduced growth and warping of the wood. Some yellowing and leaf fall may be associated with feeding. The most notable feature of plants carrying heavy populations is the presence of 'sooty mould,' a fungal growth which develops on leaf surfaces covered with sugars excreted by the insects. There is a general lack of severe symptoms.

Natural Controls.—Eggs are attacked by a wasp parasite (*Plate* XII), up to 50 per cent. parasitism being normal. Nymphs are attacked by a Dryinid wasp, the larva developing externally on the nymph. Adults are killed by an entomogenous fungus which is often prevalent when populations are high (*Plate* IX). Predators include various bugs which kill both nymphs and adults, sucking the body fluids (*Plate* XXII).

Chemical Control.—A number of materials have been used and of these Diazinon as a 0.1 per cent. spray in water is the most effective.

Should very heavy populations develop on extensive areas in a coffee block a control spray may be advisable. Such a population would average two insects per lateral, with up to twenty on some laterals (taking five terminal internodes only). One application, at a time when the poplation consists of equal numbers of nymphs and adults, will give a completely adequate control. Some nymphs will hatch after an early treatment, and more eggs will be laid before a late treatment. Natural agents will give sufficient control on most occasions.

III. MEALYBUGS AND SCALE INSECTS.

This group consists of sedentary sap feeders. Their rate of reproduction is high but rarely do they become a persistent problem. Natural

control agents are generally efficient in the reduction of populations. A mealybug has been serious at Wau. The scale insects are generally distributed but overall damage is not serious.

(i) *Citrus Mealybug* Planococcus citri (*Risso*).

Distribution.—This insect was a serious problem at Wau in the years following 1956. In the Eastern Highlands it was collected on passionfruit at one plantation near Goroka in October, 1960, and an outbreak developed on two plantations (Dunantina and J. Leahy) in May, 1963. There are no other records. The outbreaks may have been the result of local introductions, possibly on garden plants. However, the dying out of the 1963 Goroka infestations, without general spread to all plantations, suggests that the insect is present on the native flora.

Life History.—This has not been closely studied in the Highlands but the time for completion of the cycle is about 30 days. The eggs are laid by the fully-fed female under a mass of fluffy wax at the rear of the body, the dead female drying out and remaining attached to the egg mass. The eggs produce 'crawlers' which move to the softer parts of the plant to feed. These develop and shed their skin to produce the next stage or instar. This is repeated a number of times until the final adult is produced. The adult is similar to the earlier instars except in size and in its ability to produce eggs.

Hosts.—A wide range is recorded including coffee, *Leucaena leucocephala, Crotalaria anagyroides*, and passionfruit.

Damage.—The sucking of sap by masses of these insects debilitates the tree. Leaves turn yellow and fall, and fruits fail to ripen. Fruit may also be covered with plant debris as a result of the construction of 'houses' over the colonies by ants.

Natural Control.—Lady-birds (*Plates* XIII and XIV) are the main agents. At Wau the introduction of the beetle *Cryptolaemus affinis* (Crotch) from the Lae area resulted in the eventual cessation of the outbreak. A similar lady-bird was effective in the Eastern Highlands, its presence being natural.

***Plate* XIII.—Scale insects on *Crotalaria* (left). Pupal cases and adult of a scale-eating ladybird on scale infested stick (right). (x1.7)**

Chemical Control.—A spray of white oil at a concentration of one part in 40 parts of water, repeated within 21 days, gives a fairly effective control. Spraying must be thorough.

In persistent outbreaks the use of 0.1 per cent. Dieldrin in water on the trunks of bushes and soil will reduce ant populations. The Dieldrin should not be used as a general spray because of its severe effects on natural enemies of mealybug, scale, and other insects.

(ii) *Pulvinaria* (*Green*) *Scale* Pulvinaria psidii *Mask.*

Distribution.—This insect is common on native plants and coffee in all districts.

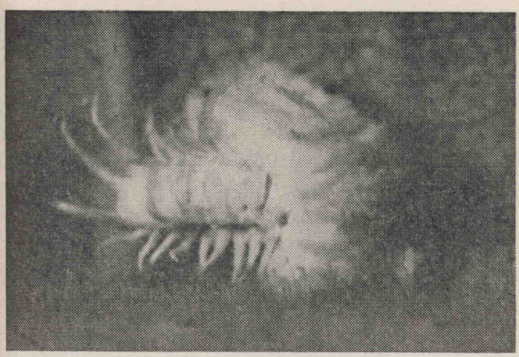

Plate XIV.—Larva of a ladybird (left) feeding in an egg mass of a scale insect. (ex *Ficus*) (x7 approx.)

Life History.—Similar to that of the mealybug.

This scale is flat, elongate-oval in outline, and pale green in colour. Large numbers of small scale are common on leaves but the later stages usually move to the softwood of laterals and leaders, the adult returning to the leaf to produce the egg mass.

Hosts.—Common on a number of native plants, particularly *Ficus* spp.

Damage.—General debilitation of the plant and the development of 'sooty mould'. Populations are rarely high enough to cause damage and such infestations have not been observed on more than a few trees in any one block. Development is more common in areas of young coffee.

Natural Control.—Parasitic wasps are effective and lady-birds assist to some degree. Populations build up in the dry season but are usually decimated by the fungus *Cephalosporium lecanii* Zimm. soon after the weather becomes wet.

Chemical Control.—White oil, as for mealybug.

(iii) ***Hemispherical Brown Scale*** **Saissetia coffeae (Walk.).**

This scale is similar in distribution, hosts and life history to Pulvinaria scale. Points of difference are considered below.

The adult scale is shaped and coloured as the common name implies. The young scales are less elongate than Pulvinaria scale and are not so flat. The body of the young scale is pale or tinged bluish-grey, and creased above.

The adults settle on leaves, branches and also within fruit clusters, to produce eggs. Eggs remain under the scale cover and 'crawlers' leave this protection to settle and feed.

Controls are similar to those of Pulvinaria scale although fungal attack is probably less frequent.

General Note.—The development of scale populations on young coffee is usual. The use of white oil can be helpful in reducing populations but the best control is the development of a natural parasite fauna in the area. This may be assisted by the introduction of infected branches, for example prunings, from older coffee areas, but may not be practical due to the low populations of scale on older coffee. A few scattered heaps of prunings could be placed close to isolated blocks and preferably under some shade. Parasites would breed out and disperse through the area over a period of two to three weeks.

Attention to the nutrition of the young bushes is probably the most useful approach to this problem.

IV. APHIDS.

Black Citrus Aphid **Toxoptera aurantii *B.d.F.***

Distribution.—Small colonies of this species are to be seen on a few bushes on most coffee plantations.

Life History.—Infestations are spread by the winged females. They settle on shoots and produce small live young which remain in colonies and suck sap. When fully grown they may be wingless and produce further live young. More alate (winged) forms are also produced.

A colony is typically a mass of black, wingless insects of varying sizes, along with a few winged individuals, on one or two internodes and leaves at the tip of a lateral.

Hosts.—Other hosts have not been recorded in the Highlands. The aphid common to citrus is the larger *Toxoptera citricidus* (Kirkaldy).

Damage.—Minor damage may occur on growing points.

Natural Control.—Lady-birds and Hover-fly larvae.

Chemical Control.—White oil if necessary, as for scale insects.

V. LEAF EATING INSECTS.

Weevils, grasshoppers and the larvae of various moths commonly cause minor damage to coffee. Under special circumstances the effects may be serious.

(i) *Shot-hole Weevils* Oribius *spp.*

Distribution.—Two species, *O. destructor* Mshl. and *O. inimicus* Mshl., are the most common insects seen in the Highlands. The former is present in the Asaro Valley, south to Okapa, east to the Komere-Barola divide, and has also been present in the Kainantu township since about 1958. *O. inimicus* is common in the Chimbu-Wahgi Valley, the Jimi and Baiyer Valleys, the Wabag-Wapenamanda area, and Mendi and Erave in the Southern Highlands. In the vicinity of Daulo Pass the populations of these two species are mixed.

Two other smaller species are also present in the Bena area and parts of the Asaro Valley, and others have been collected in the Wahgi Valley.

History.—*Oribius* is well known in native gardens. As early as 1951 it was a problem on passionfruit at Korn Farm (Mount Hagen).

Hosts.—The host range is very wide. One of the preferred food plants is the 'Tanket' (*Cordyline* sp.) but the introduced passionfruit is also favoured. Attack on coffee is very common but mostly on young bushes in small blocks where weed growth has not been controlled.

Life History.—The cycle probably takes one year. Soft newly-emerged adults are most common in September and October. The larvae are found in the soil and feed on plant roots. In plantations weeds are the main source of food.

Damage.—Leaves are chewed producing the characteristic small rounded or irregular holes. When attack is severe up to half the leaf area may be removed.

Natural Control.—Attack by a pathogenic fungus was noted on one species on coffee in the Mount Hagen township area.

Cultural and Chemical Control.—Distribution of damage on plantations clearly indicates that clean weeding, both within the block and on the headlands, is most important. Mulching or shading to eliminate weeds has a similar effect in reducing the breeding of the insects. If heavy populations of adults are present, damage to the coffee may be increased temporarily by removing food weeds. However, maintenance of weed control through the dry season will reduce the survival of larvae to adults in the following season.

In certain circumstances it may be wise to reduce populations by the use of a 0.2 per cent. DDT spray. This should not be allowed to become routine as build-up of scale insects is inevitable. Hand-picking may be resorted to, the insects being picked into a tin containing water with a thin layer of kerosene on the surface.

(ii) *Horned Weevil* Apirocalus cornutus *Pasc.*

Distribution.—This is one of five species in the genus and is found at elevations up to around 5,000 ft. In the Highlands it is restricted to the Ramu headwaters—Kainantu and Arona area—and the Arau area.

Life History.—Similar to *Oribius.*

Hosts.—Coffee, Sweet Potato, *Crotalaria anagyroides* and various garden and native plants.

Damage.—Mainly leaf chewing but attack on growing points and soft shoots is common on coffee.

Control.—As for *Oribius,* although chemical control is less effective against this species.

(iii) Aulacophrys fascialis *Mshl.*

This weevil is very similar to the *Oribius* spp. but is slightly larger, darker in colour and is characterized by a distinct white area on the side of the abdomen.

Distribution.—It is found in the area south-east of Kainantu as far as Arona and Arau.

Hosts.—Tea, coffee and native flora.

Damage.—Similar to *Oribius.*

Control.—Similar to *Oribius* but usually not necessary.

(iv) *Coffee Leaf Roller* Homona coffearia *Nietn.*

Distribution.—This moth is distributed throughout the coffee growing areas.

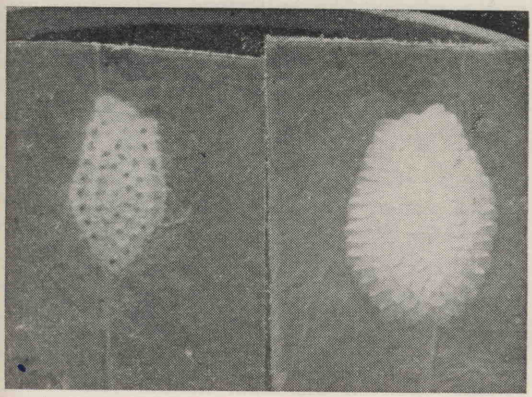

Plate XV.—Egg masses of Coffee Leaf Roller (*Homona* spp.) on leaf surface. The mass on the left contains larvae ready to hatch. (x3.5)

The eggs are laid on the leaves in scale-like masses of 20 to 40 (*Plate* XV). They hatch in about ten days to produce larvae which wander in search of soft leaf tissues. The survivors are mainly those which find the growing tip and enter between pairs of juvenile leaves which have not completely separated one from the other. As the larvae grow they are able to feed on older leaves, usually where two are touching and easily webbed together, and final stage larvae are able to web together the margins of mature leaves.

The larva grows to about three-quarters of an inch in length. The body is dull green to bluish green in colour and clothed with scattered, fine hairs. The head and the upper part of the segment behind the head are hard and dark in colour. It is very active and can wriggle forwards or backwards when disturbed, the direction depending upon which part is irritated.

The pupa is to be found in a webbed leaf. The larval period lasts four to five weeks and the moth emerges from the pupa after a further two weeks.

The female moth is pale brown in colour, with relatively broad wings. The male has darker brown markings and has also a distinctive upturned margin on the inner part of the forward edge of the fore-wing.

Hosts.—Host species are numerous and, apart from coffee, attack may be noted on *Crotalaria,* Dahlia, *Dodonaea* Wild Hops, *Grevillea robusta* Silky Oak, and also on *Albizzia stipulata.*

Damage.—Defoliation of bushes to a varying degree. In a single case of severe attack, loss of leaf approached 80 per cent.

Natural Control.—Normally only a small proportion of young larvae survive. Large larvae are attacked by a small parasitic wasp. More commonly pupae are killed by a larger wasp (Chalcid). Parasitism may reach 60 per cent. or more under natural conditions.

Chemical Control.—A trial on a plantation at Goroka clearly indicated that a low concentration of DDT (0.05 per cent. in water), as a spray, would give adequate control. Dieldrin at 0.1 per cent. was ineffective.

Control measures are rarely necessary. In the single case where severe damage was apparent (a 30-acre block) the area had been treated at about three-monthly intervals with Dieldrin for about one year to control Ring Borer. Scattered damage with up to 10 per cent. leaf loss on some bushes may be regarded as normal and control treatments should not be applied. Occasionally on young coffee a single DDT spray may be beneficial.

(v) *Homona* (?) sp.

A second species of leaf roller is less common. The larva of this is darker in colour, with two dark areas behind the head, and pale markings on the following three segments. The adult is a mottled-grey moth. This species is common

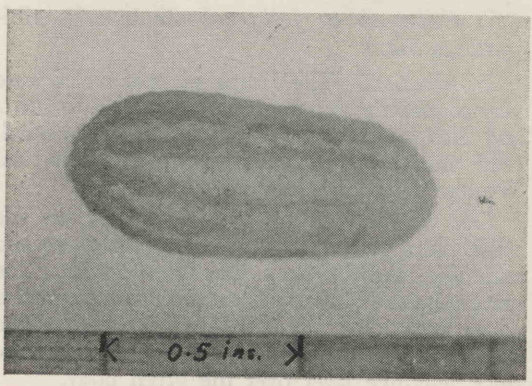

Plate XVI.—'Jelly-grub' type larva of the cup-moth *Chalcocelis* sp.

Plate XVII.—A lateral of coffee showing leaf chewing from cupmoth larvae *Chalcocelis* sp., and cocoons of same attached to leaves.

on roses and citrus, and a few larvae are usually found on coffee along with the more common leaf roller.

(vi) *Cupmoth or Jellygrub* Chalcocelis albiguttatus *Sm.*

Distribution.—The larvae of this moth were very common at Aiyura in the years 1958 to 1961, and also appeared at Wau during this period. Odd individuals have been collected in the Western Highlands.

Life History.—Eggs are laid singly on the under-sides of leaves. These are pale green and scale-like, and are very difficult to detect. The mature larva (*Plate* XVI) is about three-quarters of an inch long and about half as wide. The colour is a translucent bluish green from the thick jelly-like layer over the green body.

The cocoon (*Plate* XVII) is usually attached to a leaf. It is light grey in colour, very smooth and parchment-like in texture, and almost perfectly egg shaped. The moth emerges by lifting off a neat round cap from the unattached end, the pupal skin being left protruding from the cocoon. The life history takes about three months to complete.

Hosts.—Coffee, occasionally tea. The only known native host is Wild Hops, *Dodonaea viscosa.*

Damage.—Leaves are chewed on the underside by young larvae. Larger larvae eat out large irregular sections of leaf.

Natural Controls.—In the early stages of the Aiyura outbreak the main natural control was exercised by an entomogenous fungus (*Plate* XVIII) and by a second disease, possibly a virus (*Plate* XIX). Larvae were infected and decomposed and pupae failed to hatch. In breeding cultures in the laboratory up to 100 per cent. loss was usual and in the field up to 50 per cent. of larvae were observed as sick in some populations.

Predatory bugs (*Amyotea* sp. and *Platynopus* sp.) attack the larvae (*Plates* XX-XXII).

Later in the outbreak at Aiyura (1962) a parasitic wasp was bred from dead larvae collected in the field. This wasp is about half-an-inch long and brightly coloured in black, red

Plate XVIII.—Larva of *Chalcocelis* attacked by an entomogenous fungus. The whole larva is covered with a tufted layer of mycelium on which has formed a 'crust' of spore producing organs. These organs explode, ejecting the spores. The spores show here as a halo on the glass around the larva (spores scraped on lower right). (x2)

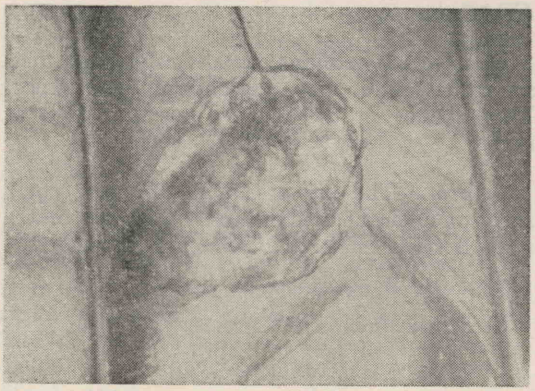

Plate XIX.—Larva of *Chalcocelis* dead from a virus (?) infection. The body became watery and then collapsed. (x2)

and white. Larvae became scarce following the arrival of this insect and are now rare.

Chemical Control.—Both DDT and Diazinon sprays were very effective at a 0.1 per cent. concentration in water.

(vii) *Stinging Cupmoth.*

This, a second species of the group, was common at Dunantina and at one plantation (Riley) in the Asaro in 1962. The larva is brightly coloured, roughly rectangular in form, and near both ends of the body has processes bearing clusters of spines. The spines can cause severe pain and a skin rash if they brush against soft skin. This larva causes some discomfort to pickers.

(viii) *Other Lepidopterous Larvae.*

Larvae of some dozen other moths may be found eating coffee leaves. Populations are usually low and control unnecessary. A *Tiracola* sp., similar to the cocoa grub which has produced armyworm-type plagues at Popondetta, is general throughout the Highlands and is well parasitized.

A brown looper-type larva of a light-grey moth is also generally distributed.

Cutworm-type moths commonly breed on weeds in blocks of young coffee where shade has not yet developed. Weeding results in starvation of the grub population and in such circumstances the young coffee bushes may be attacked. Regular weeding, particularly in the wet season, will prevent the development of heavy populations of the larvae.

(ix) *Long Horned Grasshopper* Phaneroptera brevis *Serv.*

Distribution.—General in the Highlands.

Life History.—The eggs are laid in a mass on the main stem of the bush and are then covered with bark fragments, producing a dome-shaped structure about half-an-inch across. The nymphs are greenish in colour and develop to the green, winged adult. Both the feelers and the hind legs are long and slender, this being fairly typical of this insect group.

Hosts.—Coffee, weeds and probably grasses.

Damage.—Chewing of young leaves.

Control.—Not usually necessary. A 0.1 per cent. DDT spray (in water) should be very effective.

VI. OTHER INSECTS.

(i) *Leaf Miner* Agromyza (?) *sp.*

This small fly, very similar to the Bean Fly is generally distributed. The larva produces a narrow, wandering, pale or silvery band on the leaf and the small, brown pupa is usually found at the end of this mine. This insect is well parasitized.

(ii) *Springtail* Salina *sp.*

Heavy populations are commonly present on coffee. The older leaves may be covered on the under-surface with the cast-off skins. No damage has been definitely attributed to this insect although Shaw (1967) describes lesions of unkown origin on coffee leaves.

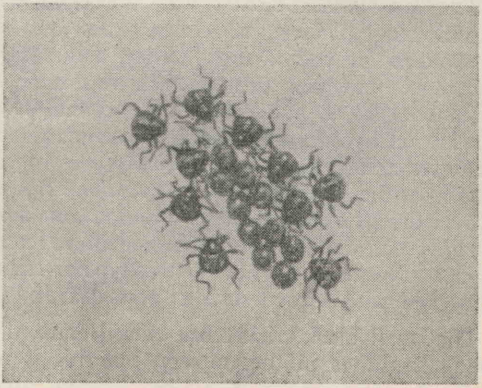

Plate XX.—Eggs and newly emerged nymphs of *Platynopus* sp., a predatory bug of cupmoth larvae, leaf hoppers, etc. (x3 approx.)

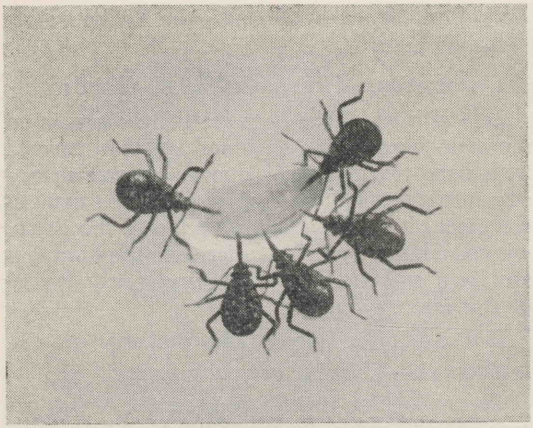

Plate XXI.—Nymphs of *Platynopus* sp. feeding on a larva of cupmoth in the laboratory. (Under-side view ; x2 approx.)

The insect is small, elongate and active. The colour is a very pale grey.

(iii) *Psocids.*

These insects are fairly common on the under-side of leaves in some blocks of coffee. They build a small flat ' tent ' of webbing and shelter under it. They may be fungus or debris feeders.

VII. NURSERY AND ROOT PESTS.

(i) *Crickets.*

LARGE BLACK CRICKET, *Brachytrypes achatinus* Sauss.

SMALL BLACK CRICKET, *Acheta commoda* Walk.

The large black cricket was associated with partial ring barking of coffee trees on two plantations in the Wahgi Valley about eight years ago. Irregular areas of bark were removed within 2 in. above and below ground level. The cricket lives in a hole about three-quarters of an inch across and 2 to 3 ft. deep in the ground at the base of coffee or *Crotalaria* bushes. At Aiyura the holes were common on drain margins but damage was not evident in coffee blocks. Normally the hole of this type of cricket is stocked with a food such as grass leaves.

The small black cricket has caused damage to young seedlings in the nursery, but this is not common.

Control.—Soil sprays of 0.2 per cent. DDT or Dieldrin may be used.

(ii) *Cutworms.*

Damage to seedlings, usually when less than six inches high, may result from these grubs. They shelter in the soil by day and feed at night.

Control.—The use of DDT (0.2 per cent.) spray or Dieldrin in the nursery (0.1 per cent.) spray is fairly effective in reducing damage.

(iii) *False Wireworms.*

Gonocephalum biroi Kasz.

Pseudolyprops serrimargo Geb.

Pseudolyprops szentivanyi Kasz.

Distribution.—One or other of these beetles is present throughout the Highland areas. The species are similar.

Habits.—The adult is a beetle a little less than half-an-inch long, long-oval in outline, with a curved upper surface and fine longitudinal ridges on the wing cases. They may be found on open ground but tend to congregate under mulch and dead plant material lying close to the soil. The beetle is usually dirty, assuming the colour of the soil.

The larvae are light yellowish brown in colour, very smooth, shiny and hard. The body is up to one inch long and round. They are root or humus feeders and are found in the soil.

Plate XXII.—*Platynopus* sp. bugs feeding on the larva of the cupmoth *Chalcocelis.* (x1.2)

Damage.—Root damage in nurseries has been reported. In view of their general distribution and absence of damage they cannot be regarded as pests of any consequence.

VIII. OTHER PESTS.

(i) *Rats.*

On two plantations along the Asaro River these animals have been responsible for harvesting ripe or over-ripe cherries. The cherries are taken from the tree, the pulp removed, and the clean 'parchment' left in a neat heap near the base of the tree. Similar damage was present on the borders of Danal Plantation (Minj) in March, 1960.

Another type of damage was reported from the Yonggamugl area of the Chimbu by R. N. Amos in early 1962. Partially ripe as well as ripe cherries were damaged, many remaining on the tree. Uneaten cherries were present on the ground as well as skins and clean beans. Damage was general in the area and severe in some blocks.

An odd report has been received of branch chewing but this type of damage is virtually unknown in New Guinea.

Control.—The rat holes are usually in long grass or undergrowth along border fences or in steep banks. The areas should be cleared to allow predators clear access to the animals. Burrows may be dug out.

(ii) *Birds.*

Chlamydera lauterbachi Reich.

This Bower-bird will construct its 'H' shaped bower in coffee blocks. Two have been examined in the Aiyura area. Green coffee berries, along with water-worn stones and a large bluish-green bush fruit, are used to decorate the floor of the bower.

CONCLUSION.

Arabica coffee growers in the Territory are in an unusually fortunate position with regard to insect pest problems. Perusal of the spray schedules necessary to control coffee pests in East Africa should thoroughly convince any grower that this is the case. In the coffee growing areas of the New Guinea Highlands there are ample insect species able to feed on coffee and to pose very serious and costly problems in control should the situation be mishandled. Other factors could also influence the maintenance of the present policy of absolute minimum use of chemical insecticides.

It is general experience that insect problems are more marked in young coffee and decrease with the age of the area. Pest species noted in the Eastern Highlands before the bushes were five years old are now causing anxiety in newly planted areas in the Western Highlands. It is perhaps timely to point out that attention to the nutrition and general welfare of the bushes will probably return a greater final dividend than attempts to control transitory pests.

In the past it has been possible to concentrate on understanding the biology of insects found to attack coffee. The other task has been to convince growers that the use of insecticides can be very dangerous in that new insect problems may be created by their general use.

The first outbreak of coffee rust in the Territory has been successfully combatted (at the date of writing). However, it could return. The problem to be faced is that the schedule of fungicide treatment required for this or other diseases will affect the ecological balance of at

Plate XXIII.—An insect larva attacked by the Green Mascardine Fungus *Metarrhizium anisopliae* Metsch. The body is almost completely covered with spores, and sticky masses of spores are also present on the leaf. (*Helicoverpa* [*Heliothis*] larva ; x2.2)

least some of the insects. This will result from the removal of insect pathogens, (e.g., *Plate* XXIII), mainly the fungi, which markedly assist in the control of these insects. Research to determine these effects is the most pressing need in coffee entomology at present. From the wide range of new fungicides available it should then be possible to select those which have minimum side effects on insect populations.

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[Plates by Author]