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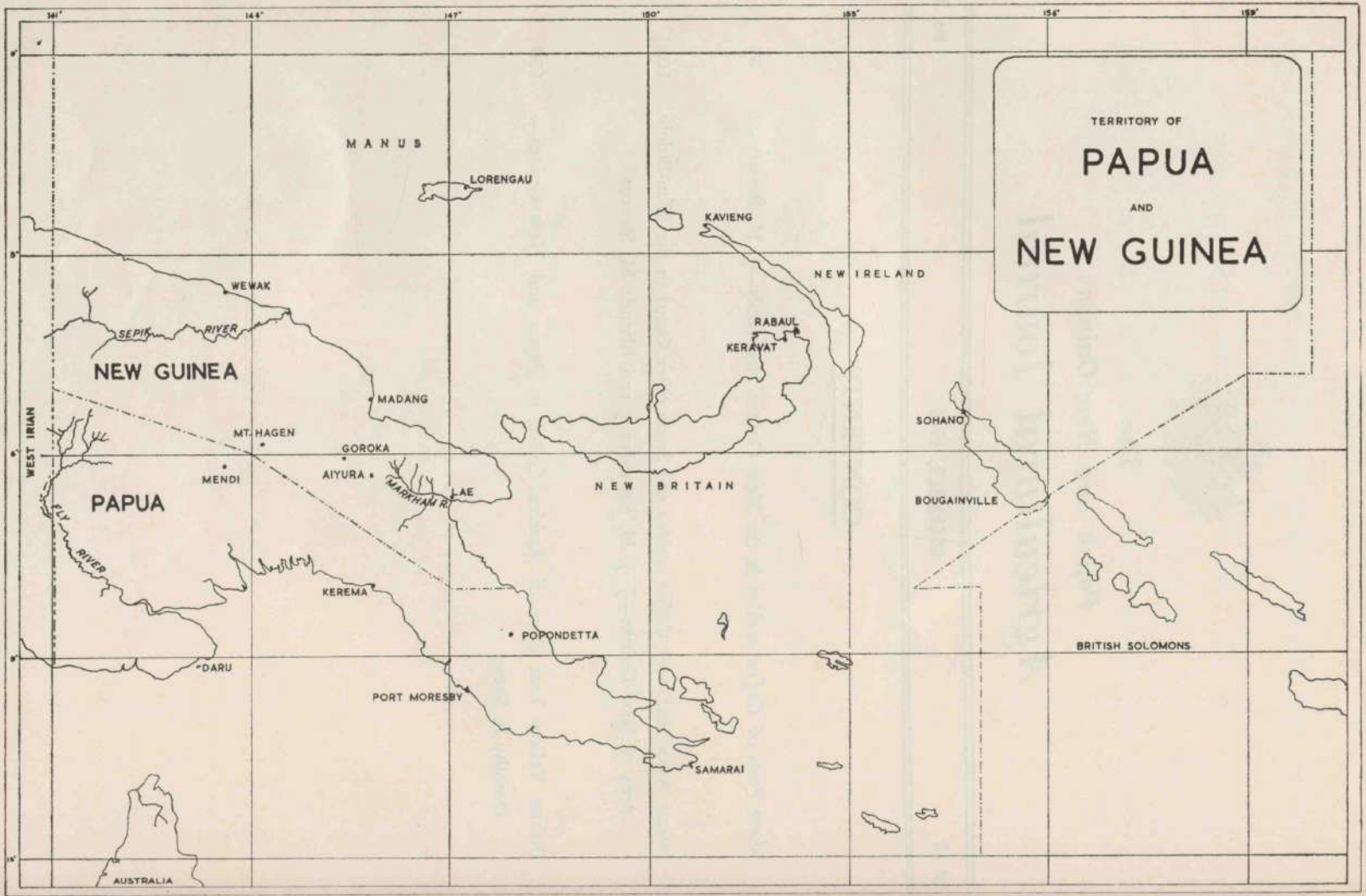
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*Insect Pests of Coffea arabica in the New Guinea Highlands.**

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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.

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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.

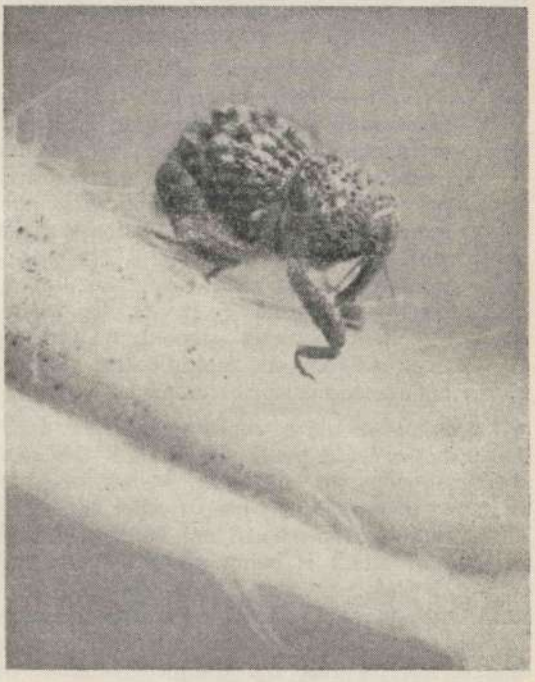

Plate I.—Adult Coffee Ring Borer *Meroleptus cinctor* Mshl. on Sweet Potato vine. (x5)

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 1½ 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.

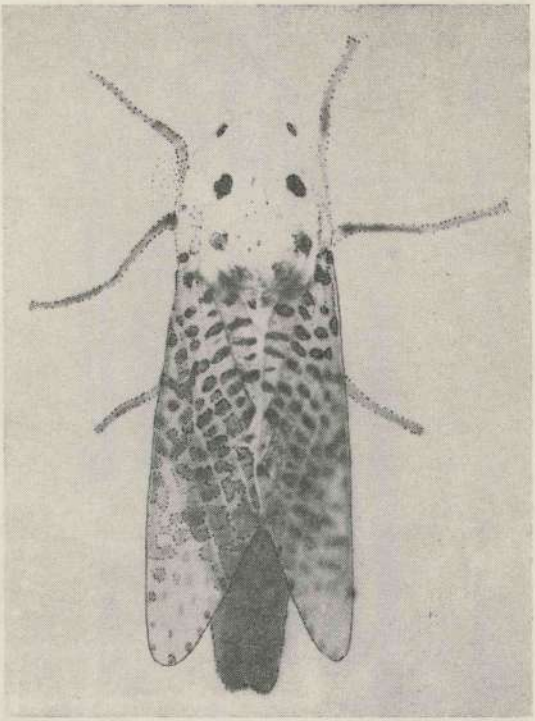

Plate IV.—Coffee Centre Borer moth. *Zeuzera* sp. (x2.3 approx.)

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

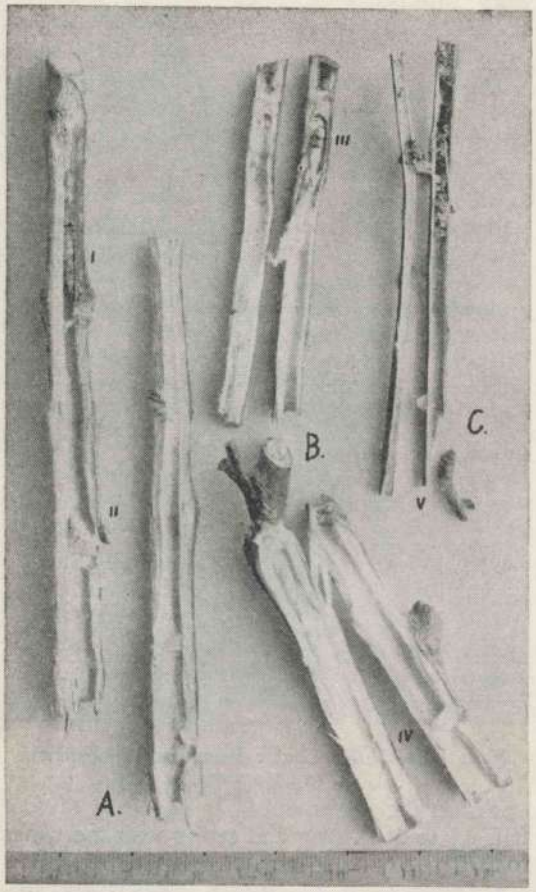

Plate VIII.—Damage by *Zeuzera* on Coffee (A), Citrus (B), and Rose (C). A pupa (i) is present in the gallery, with a web partition immediately below it, and a plug in the gallery above the entrance hole. The bark flap over the exit hole has been lifted (ii). The remains of the larva (iii) are present 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-

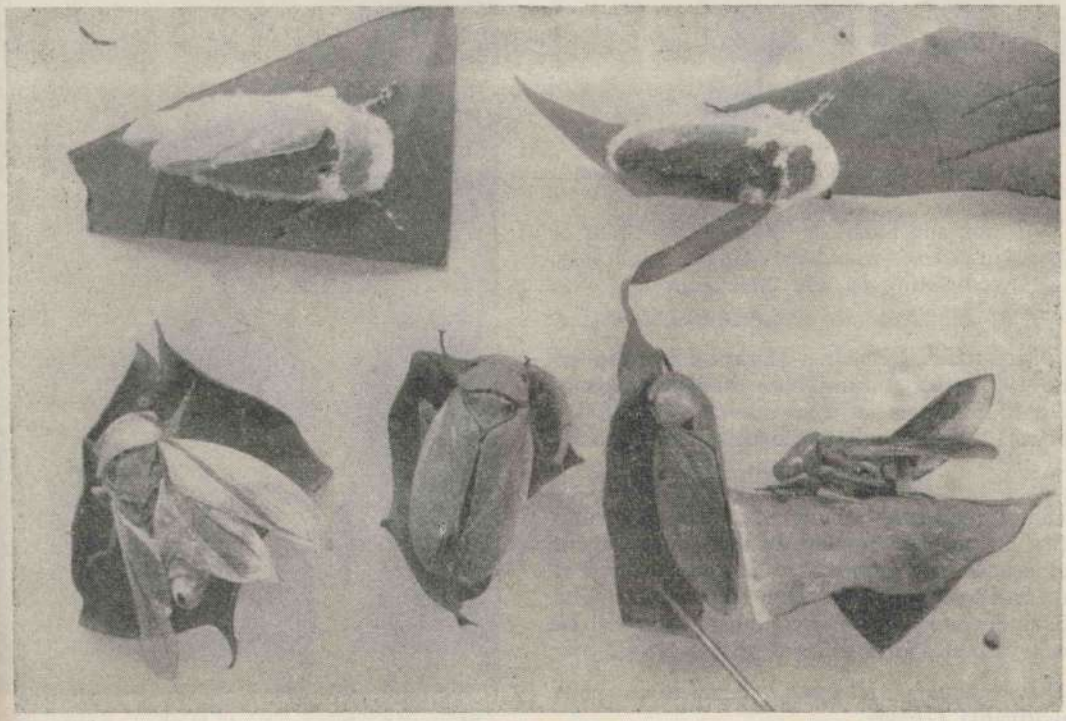

Plate IX.—Brown Leaf Hopper *Batrachomorphus szentivanyi* Ghauri dead from entomogenous fungus attack. The insects are held on to the leaf by the fungus. The two upper specimens have developed a mass of mycelium while held in damp conditions. (x2.5)

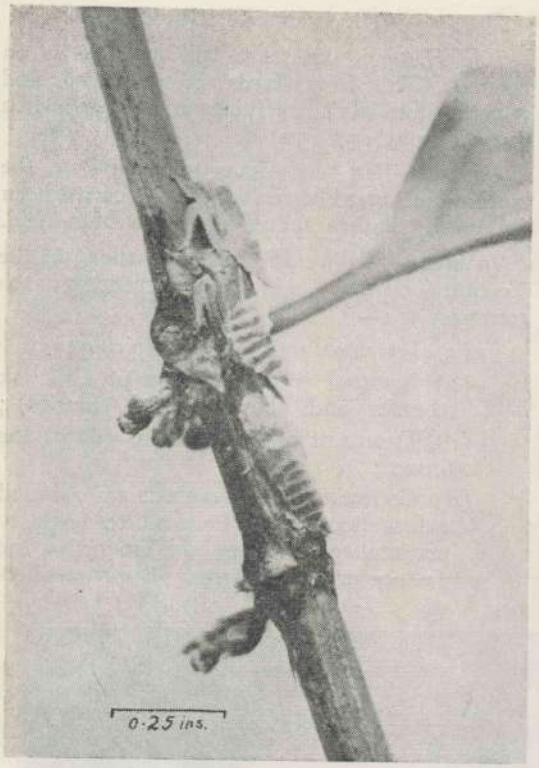

Plate X.—As *Plate* IX, fungal development on nymphs.

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.)

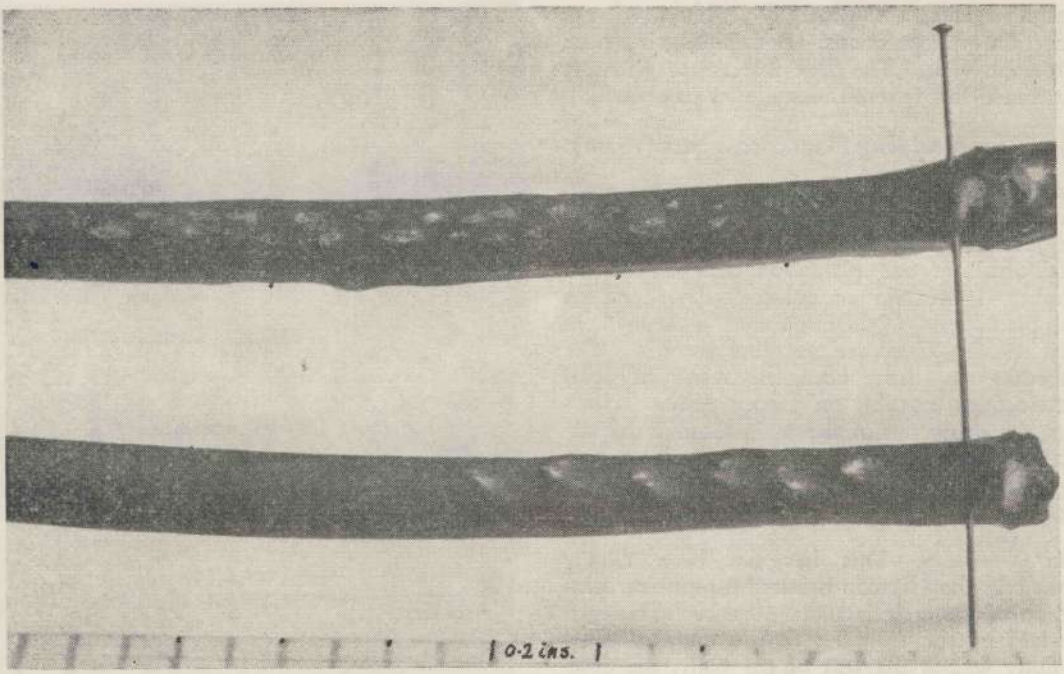

Plate XII.—Brown Leaf Hopper egg-laying sites on soft internodes of coffee lateral. The eggs in the lower piece are fresh. The upper piece shows three round holes from which egg parasites have emerged (indicated by dots).

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.

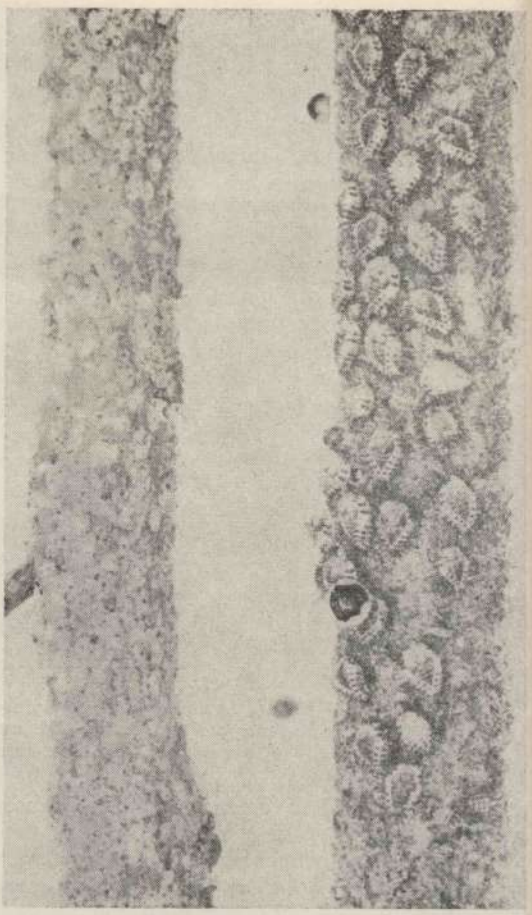

***Plate* XIII.—Scale insects on *Crotalaria* (left). Pupal cases and adult of a scale-eating ladybird on scale infested stick (right). (x1.7)**

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.

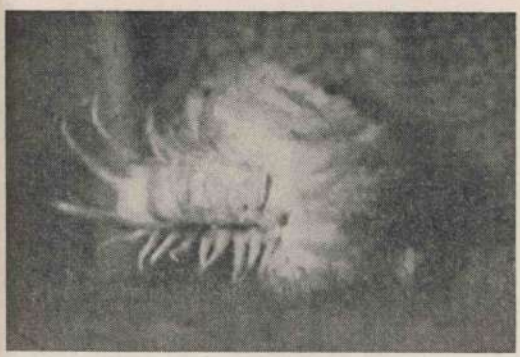

Plate XIV.—Larva of a ladybird (left) feeding in an egg mass of a scale insect. (ex *Ficus*) (x7 approx.)

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.

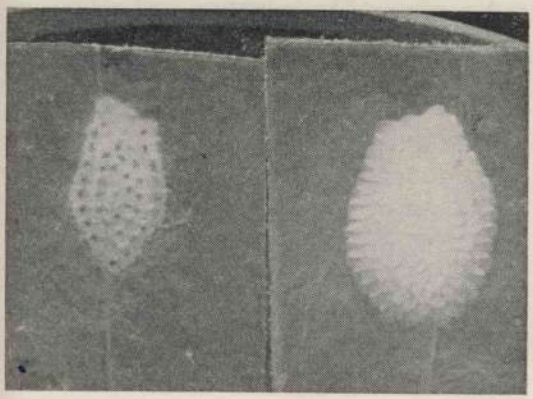

Plate XV.—Egg masses of Coffee Leaf Roller (*Homona* spp.) on leaf surface. The mass on the left contains larvae ready to hatch. (x3.5)

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

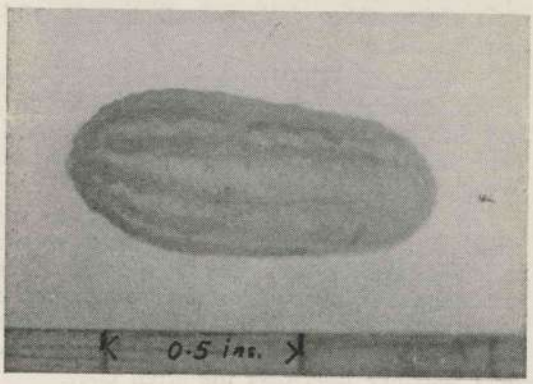

Plate XVI.—' Jelly-grub ' type larva of the cup-moth *Chalcocelis* sp.

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

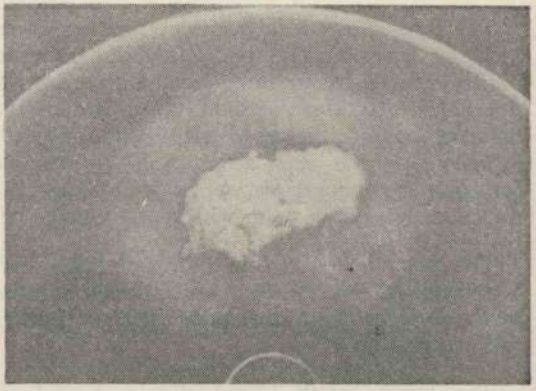

Plate XVIII.—Larva of *Chalcocelis* attacked by an entomogenous fungus. The whole larva is covered with a tufted layer of mycelium on which has formed a 'crust' of spore producing organs. These organs explode, ejecting the spores. The spores show here as a halo on the glass around the larva (spores scraped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

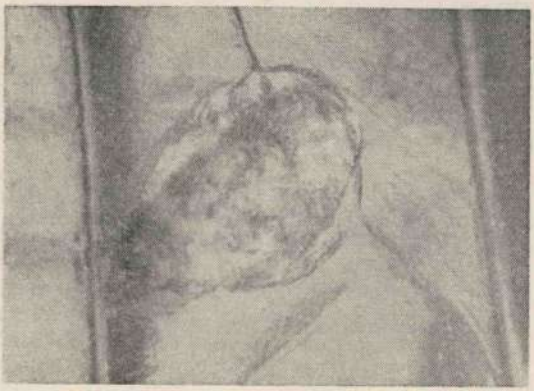

Plate XIX.—Larva of *Chalcocelis* dead from a virus (?) infection. The body became watery and then collapsed. (x2)

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.

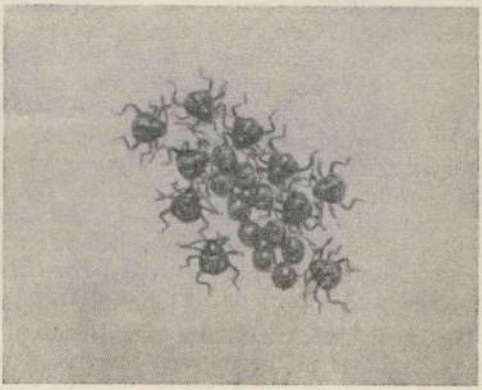

Plate XX.—Eggs and newly emerged nymphs of *Platynopus* sp., a predatory bug of cupmoth larvae, leaf hoppers, etc. (x3 approx.)

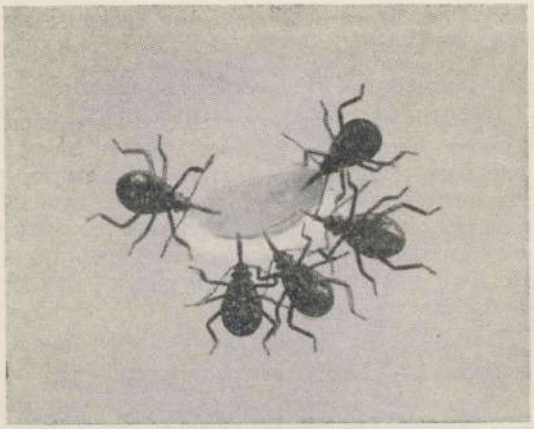

Plate XXI.—Nymphs of *Platynopus* sp. feeding on a larva of cupmoth in the laboratory. (Under-side view ; x2 approx.)

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

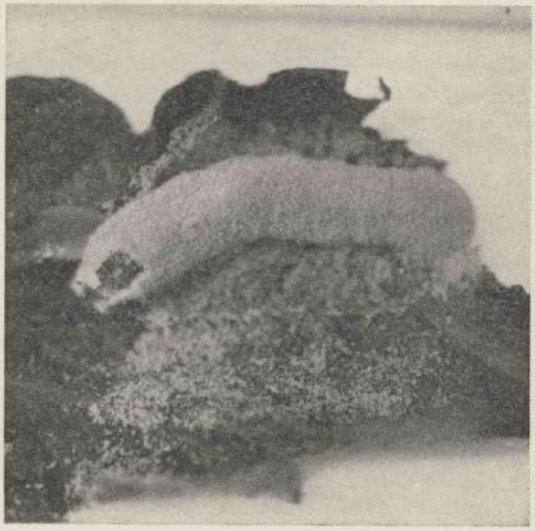

Plate XXIII.—An insect larva attacked by the Green Mascardine Fungus *Metarrhizium anisopliae* Metsch. The body is almost completely covered with spores, and sticky masses of spores are also present on the leaf. (*Helicoverpa* [*Heliothis*] larva ; x2.2)

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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ACKNOWLEDGEMENT.

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[Plates by Author]

Insects Associated with Coffea arabica *and Some Other Crops in the Wau-Bulolo Area of New Guinea.*

J. J. H. Szent-Ivany * and Rhonda M. Stevens.†

ABSTRACT.

In this paper all agricultural and forest pests found in the Wau-Bulolo area are listed in most cases with exact locality and chronological data. Many data represent new economic records or new distribution records. Reference is made to records mentioned in previous publications. Ninety-six phytophagous insects are listed and six predacious and parasitic insects. Certain ant species, which were found as nursing ants of scale insects and mealybugs, are mentioned in the chapter on Coccidae.

INTRODUCTION.

THE Senior Author visited the Wau-Bulolo area on many occasions between 1954 and 1966, studying agricultural and forest pests and conducting general insect collecting. An extensive coffee insect survey was carried out by the Senior Author in the Wau Valley in July-August, 1963, and another one by the Junior Author in February, 1966.

The insect Orders are listed in phylogenetical order (Imms, 1957), the families within the Orders, the genera within the families and the species within genera in alphabetical order. Abbreviations of the names of collectors which occur more often in this paper are—F. = A. Fischle ; K.= B. J. Kebby ; St.= R. M. Stevens ; Sz. = J. J. H. Szent-Ivany.

COLLEMBOLA.

Entomobryidae.

Salina sp.—This species was collected in large numbers in some plantations of the Wau Valley in July-August, 1963, on the leaves of *Coffea arabica* (Coll. Sz. and K.), however, it does not seem to cause such a degree of leaf shedding as was observed in the case of *Salina celebensis* Schaff on cacao and *Salina indica* on *Coffea canephora* in the Lowlands. Only minor damage is caused by leaf-etching.

ORTHOPTERA.

Acridiidae.

Valanga sp.—Agricultural Extension Station, Wau, IV.1965 on *Piper nigrum* (Coll. Sz.). Garden near Agricultural Extension Station, Wau, VII.1963, on *Brassica chinensis*, *B. oleracea* and *Hibiscus manihot* (Coll. Sz.).

Tettigoniidae.

Phaneroptera brevis Serv.—Rapagah Coffee Estate, Wau Valley, VII.1963, on the foliage of *Coffea arabica* (Coll. Sz.). Garden near Agricultural Extension Station, Wau, VII.1963, on *Brassica chinensis*, *Brassica oleracea* and *Hibiscus manihot*. New Guinea Goldfield Farm, Wau Valley, VII.1963, on *Coffea arabica* (Coll. Sz. and K.).

ISOPTERA.

Calotermitidae.

Neotermes sp.—Upper Crooked Road, Bulolo, 2,000 ft., 20.V.1963. In living *Terminalia catappa* (Coll. L. Clifford).

Rhinotermitidae.

Coptotermes elisae (Desneux).—Found many times in hoop-pine (*Araucaria cunninghamii*) of which it is a major pest in the Bulolo area (Ardley, Clifford and Gay, 1965).

HEMIPTERA.

Aleyrodidae.

Neomaskellia bergii (Sign) Wau, 3.VII. 1963.—In garden on the leaves of *Saccharum officinarum* (Coll. Sz. and K.).

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Aphididae.

Rhopalosiphum maidis (Fitch.).—Agricultural Extension Station, Wau, VII.1963, on *Zea mais* (Coll. Sz.).

Toxoptera aurantii (B. de Fons.).—Agricultural Extension Station, Wau, 3.VII.1963, on leaf of *Coffea arabica* (Coll. Sz. and K.). Riverside Estate, Wau Valley, 18.IV.1965, only a few leaves affected on a *Coffea arabica* bush (Coll. Sz.).

Toxoptera citricidus (Kirk.).—Kaisenik Village Plantation, Wau Valley, approximate altitude 3,200 ft., 19.IV.1965. On *Citrus* leaves (Coll. Sz.).

Cicadellidae.

Batrachomorphus blotei Ghauri.—This insect together with *Batrachomorphus szentivanyi* of the Central Highlands was recently described by Dr. M. S. K. Ghauri (1964). During the Senior Author's coffee insect survey this species was found in medium to dense populations in various plantations in the Wau Valley (Coll. Sz. and K.). However, it appeared to cause similar damage to that of the related *B. szentivanyi* at Aiyura (Barrett 1966) in only one plantation. In an area of this plantation about a dozen young coffee bushes showed set-back in growth, distortion of the growing point, tip-wilt of laterals, and drooping and wilting of the foliage. An unidentified disease (probably fungal), seems to control this and various other leaf-hopper pests in the Wau Valley. In the plantation where some of the trees were severely damaged, the Senior Author found 65 dead specimens of *Batrachomorphus blotei* on and around the growing point and the upper laterals of a coffee bush. These showed the symptoms of a fungus infection. On some bushes 80 to 90 per cent. of the leaf-hopper population was dead. This species was also collected on *Coffea arabica* at Nondugl, Western Highlands District of New Guinea (approximately 5,500 ft.), on the 18.X.1954 (Coll. Sz.) and on *Piper nigrum* at the Agricultural Extension Station, Wau, on the 18.IV.1965 (Coll. Sz.).

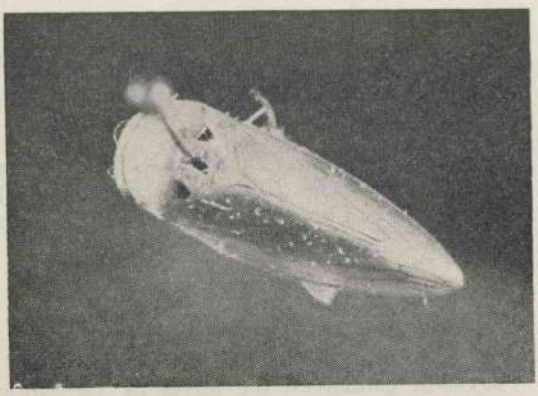

***Plate* I.—*Batrachomorphus blotei* Ghauri.**

Tartessus sp.—New Guinea Goldfield Coffee Block, 3,400 ft., 26.VII.1963. In low population density on *Coffea arabica* bushes (Coll. Sz.). Agricultural Extension Station, Wau, 15.II.1966, on *Coffea arabica* (Coll. F. and St.).

Coccidae.

Aonidiella citrina (Coq).—Wau, 16.II.1958, on fruit of *Citrus aurantiaca* (Coll. Sz.) (Szent-Ivany, 1956 (1959)).

Aspidiotus destructor Sign.—Wau, town area VIII.1959, on fronds of *Cocos nucifera* (Coll. Sz.) (Szent-Ivany and Catley, 1960).

Ceroplastes destructor Newst.—This waxy scale occurs in low population density in various plantations of the Wau Valley on *Coffea arabica*; it is usually found in pockets (Coll. Sz. and K., July-August, 1963, Coll. F. and St., February, 1966). Riverside Estate, Wau Valley, 21.IV. 1965 (Coll. Sz.). The damage to the foliage and twigs in Wau Valley coffee plantations is insignificant. The only place where almost every coffee bush was affected by this coccid, was in a small *Coffea arabica* block, planted along the road, near Sunshine Plantation in the Snake River Valley (20.IV.1965; Coll. Sz.). Other hostplants of *Ceroplastes destructor* in the Wau Valley are *Gardenia* sp. and *Plumeria acutifolia*. Heavy infestation by this coccid was found by the Senior Author in a flower garden in the town area of Wau in July, 1963. *Plumeria* was more heavily infested than *Gardenia*; on both hostplants *Ceroplastes* was associated with sooty mould fungus.

Chrysomphalus aonidum (L.).—Forestry nursery, Bulolo, 18.IV.1965; seedlings of *Pinus* sp. severely damaged. This represents a new economic record for the Territory of Papua and New Guinea (Coll. J. Smith and Sz.).

Coccus viridis (Green).—Rapagah Estate, Wau Valley, 22.VII.1963, on *Coffea arabica,* tended by the ants *Technomyrmex* sp. and *Iridomyrmex* sp. The green scale was found by the Senior Author and B. J. Kebby in various plantations of the Wau Valley on *Coffea arabica* in 1963 associated with sooty mould. However, in most cases 90 to 95 per cent. of the scales were dead. They were killed by entomogenous fungi.

Hemiberlesia palmae (Ckll.).—Wau, VIII. 1959, on ornamental *Cocos nucifera* (leaves) (Coll. Sz.) (Szent-Ivany and Catley 1960).

Paraputo leveri (Green).—Sunshine Plantation—Snake River Valley, 12.VII.1960, on the roots of *Coffea arabica* (Coll. A. Catley). Sunshine Plantation, 2.VII.1963; on the underground stem and roots of *Coffea arabica* (Coll. Sz. and K.) same locality, II.1966, tended by the ant *Pheidole megacephala* (Fabricius) (Coll. St.) *Paraputo leveri* (Green) was described by Green from the British Solomon Islands as *Pseudococcus leveri* and then placed into the new genus *Paraputo* Laing by Williams (1960). To the best of the Authors' knowledge this species has not been found in any other area but the mainland of New Guinea and the British Solomon Islands and in Fiji (Hinckley 1963). K. S. Cole found it the first time in the Territory of Papua and New Guinea. He found *Paraputo leveri* on the roots of *Coffea canephora* in a village coffee block (Inanianene Village), in the Milne Bay District in September, 1959 (Szent-Ivany and Catley 1960). The first major damage by *Paraputo leveri* to the roots of coffee bushes was reported from Sunshine Plantation, in the Snake River Valley. In this plantation about 100 mature *Coffea arabica* bushes died as a result of the root mealybug damage in 1962-1963. The Senior Author visited Sunshine Plantation in the company of Mr. A. Ireland, the Proprietor of Sunshine Plantation, and Mr. B. J. Kebby, the resident Agricultural Officer in the Wau Subdistrict, on the 2nd July, 1963. On arrival in the coffee block most affected by the mealybug, a three and a half year old dying coffee bush was pulled out of the ground. Upon examining the roots and underground portion of the stem it was found that the bulk of the population of the pinkish white coloured mealybugs was resting under a layer of a polyporid fungus on the underground part of the stem. Samples of the fungus were forwarded to the Commonwealth Institute of Mycology (Kew, England) and the polyporid was identified by Mr. G. F. Laundon as *Diacanthodes philippinensis* (Pat.) Singer. Three ants were found associated with *Paraputo leveri* in the ground. These were identified by Professor E. O. Wilson of Harvard University as a *Paratrechina* (*Nylanderia*) sp., a *Monomorium* sp. and *Odontomachus simillimus* (Fr. Smith). One of these—the *Paratrechina* species—seems to be the main nursing ant of *Paraputo leveri.* When the tree was pulled out of the ground, workers of these ants became very active and they began to carry away individuals of the mealybug. The *Monomorium* species is also a suspected nursing ant of *Paraputo leveri.* Several queens of this ant were found under the bark of the underground portion of the stem in close vicinity of the root mealybugs. Only a few workers of the large *Odontomachus* were seen in the hole made by pulling out the dead coffee bush from the ground. These probably fell into the hole from the surface of the ground. Many more workers of this larger ant were seen running in various directions on the surface of the ground in the whole coffee block.

Dr. D. Shaw, Principal Plant Pathologist with the Department of Agriculture, Stock and Fisheries, Konedobu, made a thorough study of the literature on *Diacanthodes philippinensis* in the Plant Pathological Section of the Department of Agriculture in Ottawa (Canada) and she agreed with the Senior Author that this fungus lives in a type of symbiosis with *Paraputo leveri.* Similar observations were made on the relation of the fungus *Polyporus coffeae* and the coccid *Pseudococcus deceptor* by Donk in Java. The imperfect stage of *Polyporus coffeae* is *Bornetina corium* which, according to Singer, is identical with *Diacanthodes philippinensis.* According to Dr. Shaw "the present concensus of opinion is that the fungus does not harm the insect and that it depends on both the sugary liquid exuded by the living roots as a result of sucking activities of the coccid, and the liquid excreted by the insect itself. The coccid may thrive without the fungus, but on the other hand, the fungus seems entirely dependent on the coccid for its full development". As the coccid is protected from enemies by the thick layer of the fungus, the

Senior Author believes that the relation of *Paraputo leveri* and *Diacanthodes philippinensis* can be considered a true symbiosis. The first symptoms of *Paraputo* damage to a coffee bush is the wilting and drooping of the leaves on the top laterals of the tree which is followed by the wilting of the foliage on the next row of laterals ; then the stem begins to die and eventually the whole bush dies.

During the Junior Author's visit (February, 1966) to the coffee block of Sunshine Plantation which was so severely damaged by *Paraputo leveri* in 1962-1963, she could not find more than one coffee bush attacked by the root mealybug. As in 1963, *Paraputo leveri* was mainly found under layers of the polyporid fungus *Diacanthodes philippinensis* (Pat.) Singer.

Planococcus citri (Risso.).—There was a severe outbreak of this polyphagous mealybug in some plantations of the Wau Valley in 1956-1957. In one plantation *Planococcus citri* was associated with a few other coccids, such as *Pseudococcus adonidum* (L.), *Coccus viridis* (Green) and *Saissetia coffeae* (Walk.) and the reduction of yield in some coffee blocks of this plantation was estimated at 70 to 75 per cent. as a result of mealybug and scale insect damage. However, Mr. J. H. Ardley, who was the resident entomologist in the Morobe District in 1956-1957 visited this plantation several times and he came to the conclusion that *Planococcus citri* represented 90 to 95 per cent. of the coccid populations. Populations of the ladybird *Cryptolaemus affinis* (Crotch) were introduced to the Wau Valley from the coastal area (Markham Valley), for the control of *Planococcus citri* and this biological control trial was very successful (Szent-Ivany 1963b). During the Senior Author's comprehensive coffee insect survey in July to August, 1963, it was found that of 33 plantations visited only three had high population density of *Planococcus citri*. More than one third of the plantations had no *Planococcus citri* populations and 17 plantations had low or insignficant population density of the mealybug. *Cryptolaemus affinis* was found in 21 plantations and it was observed on several occasions feeding on *Planococcus citri*. During the Senior Author's visit to several plantations in the Wau Valley in April, 1965, *Planococcus citri* was found only in very low population density. In February, 1966, the Junior Author visited the coffee block of the Agricultural Extension Station at Wau and six plantations in the Wau Valley in the company of Mr. A. Fischle, the resident Agricultural Officer at Wau. *Cryptolaemus affinis* was observed in every plantation and the population density of *Planococcus citri* was very low. Other host plants of *Planococcus citri* observed in the Wau Valley are *Leucaena leucocephala* and *Tephrosia candida* (VII.1956, Coll. Sz. VII-VIII. 1956 ; Coll. Sz. and K.). *Planococcus citri* is tended by various ants in the Wau Valley. These are *Anoplolepis longipes* (Jerd.), *Iridomyrmex* sp., *Nylanderia* sp. (Group of *bourbonica* Forel), *Nylanderia bourbonica* Forel aff., *Pheidole megacephala* (Fabr.) *Technomyrmex* sp. *Pheidole megacephala* was observed building mud-tents above *Planococcus citri* on the stem of young coffee bushes at Kosali Plantation (Wau Valley) (3.VII.1963, Coll. Sz.).

Genus near *Perissopneumon*.—Wau, town area, 12th February, 1966. In very dense populations on *Persea gratissima*, causing death of the tree (Coll. F. and St.). This is a large fleshy mealybug, orange coloured with black markings (it changes its colour when preserved in alcohol) ; it reaches the length of 2 cm. and the width of nearly 1 cm. Apart from the gall-forming *Apiomorpha pedunculata* Full (Szent-Ivany and Womersley 1962) this is the largest mealybug so far recorded from the Territory of Papua and New Guinea. This species was previously found feeding on the branches of *Psidium guajava* at Port Moresby on 26.IX.1960 (Coll. A. Catley) and in very dense populations on *Terminalia catappa* on 10.VIII.1962 (Coll. W. Francis). This insect and most other Coccidae mentioned in this paper were identified by Dr. D. J. Williams (U.S. Department of Agriculture, Washington).

Pseudococcus adonidum (L.).—Found on coffee bushes in very low population density at Wau Coffee Estate and on Messrs. Clarke and Fry's Estate on 23rd July, 1963. The Senior Author collected this species on *Coffea arabica* more recently at Etesena Coffee Block, in the Okapa Subdistrict of the Eastern Highlands District at an approximate altitude of 6,000 ft. above sea level, on 7th January, 1965.

Pulvinaria sp.—Sunshine Plantation, Snake River Valley, IV.1965, on *Coffea arabica* foliage (Coll. Sz.).

Saissetia coffeae (Walk.).—This brown scale is found almost in every coffee plantation in the Wau Valley and also in the Bulolo-Snake River area on *Coffea arabica* in very low population density. On Rapagah Estate on the 22nd July, 1963, it was found associated with two nursing ants (*Technomyrmex* sp. and *Iridomyrmex* sp.) (Coll. Sz. and K.).

Saissetia nigra (Nietn.).—Kolega No. 2 Estate, Wau Valley, VII.1963 on *Leucaena leucocephala* (Coll. Sz. and K.). Blue Mountain Coffee Estate, 10.XI.1954, on *Crotalaria anagyroides* shade trees (Coll. R. E. P. Dwyer and Sz.).

Steatococcus samaraius Morr.—Wau, 3. VIII.1959, on *Tephrosia candida*, planted as shade tree in coffee plantation (Coll. Sz.) (Szent-Ivany and Catley 1960). McAdam Memorial Park near Wau, approximately 4,500 ft. 19.IV. 1965 ; on leaves of *Pipturus argenteus* (Coll. Sz.).

Coreidae.

Leptoglossus australis (F.).—Citrus orchard of the Bulolo Gold-Dredging Company, Bulolo, approximately 2,400 ft., July, 1956, on *Citrus reticulata* (Coll. Sz.). In a mixed grapefruit (*Citrus paradisi*) and mandarin (*C. reticulata*) orchard *Leptoglossus australis* was observed feeding on mandarin and causing severe premature fruit-fall in March, 1965, previous to the visit of the Senior Author to this orchard. *Leptoglossus* apparently left the grapefruit untouched (Szent-Ivany and Catley 1960b) ; Wau, town area, 1.VI.1957 on *Passiflora edulis* (Coll. Sz.) ; Riverside Estate, Wau Valley, 3,400 ft., IV.1965. Feeding on tender branch of *Coffea arabica* ; Vegetable Farm of Bulolo Gold-Dredging Company, approximately 2,400 ft., March, 1956, feeding on fruit of *Lycopersicum esculentum* (Observation by Mr. W. Walker) ; McAdam Memorial Park, near Wau, Morobe District of New Guinea, 19.IV.1965, on *Momordica charantia* (Coll. Sz.).

Riptortus sp.—Near *distinguendus* Blote. Poltalloch Estate, Wau Valley, 3,400 ft., 18. IV.1965. On the pods of *Tephrosia candida* (Coll. Sz.).

Riptortus linearis (F.).—D. Bonnie's Estate, near Kaisenik Village, Wau Valley, approximately 3,200 ft., 19.IV.1965, on *Tephrosia candida* (pods and branches) (Coll. Sz.).

Flatidae.

Colgar tricolor Dist.—Wau Valley and Agricultural Extension Station, Wau (several plantations) VII-VIII.1963, on leaves and branches of *Coffea arabica* (Coll. Sz. and K.). Garden near Agricultural Extension Station, Wau, VII.1963 on *Brassica chinensis*, *Brassica oleracea*, *Hibiscus manihot* (Coll. Sz. and K.) ; Yallaru Plantation, Wau Valley, 4.VIII.1963, in commercial flower garden on *Gladiolus* sp. (Coll. Sz.) ; Agricultural Extension Station, Wau and several plantations in the Wau Valley, II.1966, on *Coffea arabica* (Coll. F. and St.). The Authors wish to mention here that approximately 60 per cent. of the populations of *Colgar tricolor* were found by B. J. Kebby and the Senior Author killed by an entomogenous fungus during the comprehensive coffee insect survey in July to August, 1963.

Euphanta sp.—Agricultural Extension Station, Wau, 18.IV.1965 (Coll. Sz.).

Phymoides sp.—Bencula Estate, Wau Valley, approximately 4,300 ft., 23.VII.1963, on *Coffea arabica* (Coll. Sz. and K.) ; Bubu Estate, Wau Valley, 3,400 ft., 22.VII.1963, on *Coffea arabica* (Coll. Sz. and K.) ; Powerhouse Coffee Block (Property of New Guinea Gold-field Company), Wau Valley, 4,000 ft., 23.VIII.1963, on

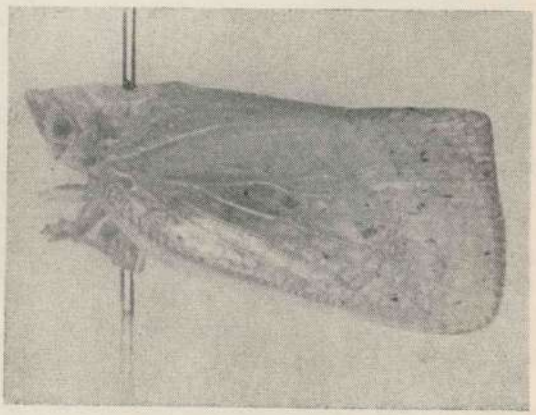

Plate II.—*Colgar tricolor* Dist.

Coffea arabica (Coll. Sz. and K.) ; Agricultural Extension Station, Wau, 18.IV.1965, on *Coffea arabica* (Coll. Sz.).

Sephena sp.—Bencula Estate, Wau Valley, approximately 4,200 ft., 23.VII.1963, on *Coffea arabica* (Coll. Sz. and K.) ; Kaisenik Village Plantation, Wau Valley, approximately 3,200 ft., 2.VIII.1963, on *Coffea arabica* (Coll. Sz. and K.).

Issidae.

Hemisphaerius sp. (*Plate* III).—Agricultural Extension Station, Wau, VII.1963 on *Coffea arabica* foliage (Coll. Sz. and K.), 18.IV.1965 on *Coffea arabica* foliage (Coll. Sz.) ; Lane's Coffee Estate, Wau Valley, approximately 3,400 ft., 25.VII.1963, on *Coffea arabica* (Coll. Sz. and K.) ; Warra-Wau Estate, Wau Valley approximately 3,400 ft., 17.IV.1963 on *Coffea arabica* Power House Coffee Block (Property of New Guinea Gold-field Company), 4,000 ft., 23.VII. 1963, on *Coffea arabica* ; Poltalloch Estate, Wau Valley, 3,400 ft., 2.VII.1963, on *Coffea arabica* (Coll. Sz.). Mr. R. G. Fennah, Assistant Director, Commonwealth Institute of Entomology (London), has kindly informed the Senior Author that this small fast jumping leaf-hopper may represent a new species. It seems to be widely distributed in the Wau Valley, but it is found in rather low population density on *Coffea arabica.*

Membracidae.

Gen. et species indet. (*Plate* IV).—This is a small species with two conspicuous processi

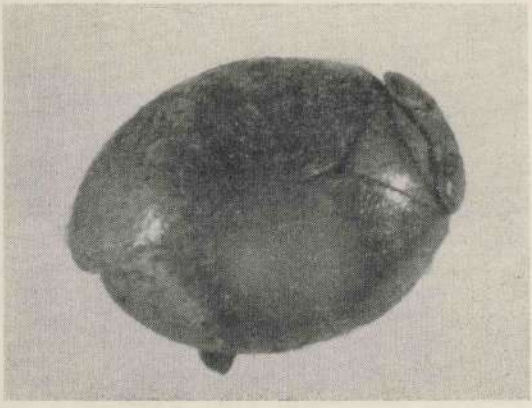

***Plate* III.—*Haemisphaerius* sp.**

(" horns ") on its head which occurs in most coffee plantations of the Wau Valley in low to medium population density, feeding near the growing point of *Coffea arabica.* Specimens with the following locality data were forwarded for indentification to the Commonwealth Institute of Entomology ; Agricultural Extension Station, Wau, 15th February, 1966 (Coll. F. and St.) ; Kaisenik Village Plantation, Wau Valley, approximately 3,200 ft., 2.VIII.1963 (Coll. Sz. and K.) ; Kunai Creek Coffee Block (Property of New Guinea Gold-field Company), Wau Valley, 4,000 ft., 23.VIII.1963 (Coll. Sz. and K.) ; Poltalloch Estate, Wau Valley, 3,400 ft., 2.VIII 1963 (Coll. Sz. and K.) ; Power House Coffee Block (Property of New Guinea Gold-field Company), 4,000 ft., 23.VII.1963 (Coll. Sz. and K.) ; Shanahan and Schuster's Plantation, Wau Valley, approximately 3,400 ft., 25.VII. 1963 (Coll. Sz. and K.) ; Wau Coffee Estate, Wau Valley, approximately 3,400 ft., 24.VII. 1963 (Coll. Sz. and K.). All the abovementioned were collected on *Coffea arabica.* This species could not be identified in the Commonwealth Institute of Entomology ; apparently neither the genus nor the species are represented in the collection of the British Museum (Natural History). It is hoped that a specialist will make further systematic studies on this membracid and will describe it if it proves to be new to science.

Terentius nubifasciatus Walk. (*Plate* V).—Kunai Creek Coffee Block (Property of New Guinea Gold-field Company), Wau Valley, 4,000 ft., 23.VIII.1963, on *Coffea arabica* (Coll. Sz. and K.).

Pentatomidae.

Agapophyta sp.—Stirling Chase Estate, Wau Valley, approximately 3,400 ft., VIII.1963, on *Tephrosia candida* and *Coffea arabica* (Coll. Sz. and K.).

Agapophyta similis Blote.—Poltalloch Estate, Wau Valley, 3,400 ft., 18.IV.1965, on *Tephrosia candida* (Coll. Sz.). This species has been also found on *Cajanus cajan* on Kar Kar Island in the Madang District.

Agapophyta viridula Blote.—Poltalloch Estate, Wau Valley, 3,400 ft., 18.IV.1965, on *Tephrosia candida* (Coll. Sz.). New economic record for the Territory.

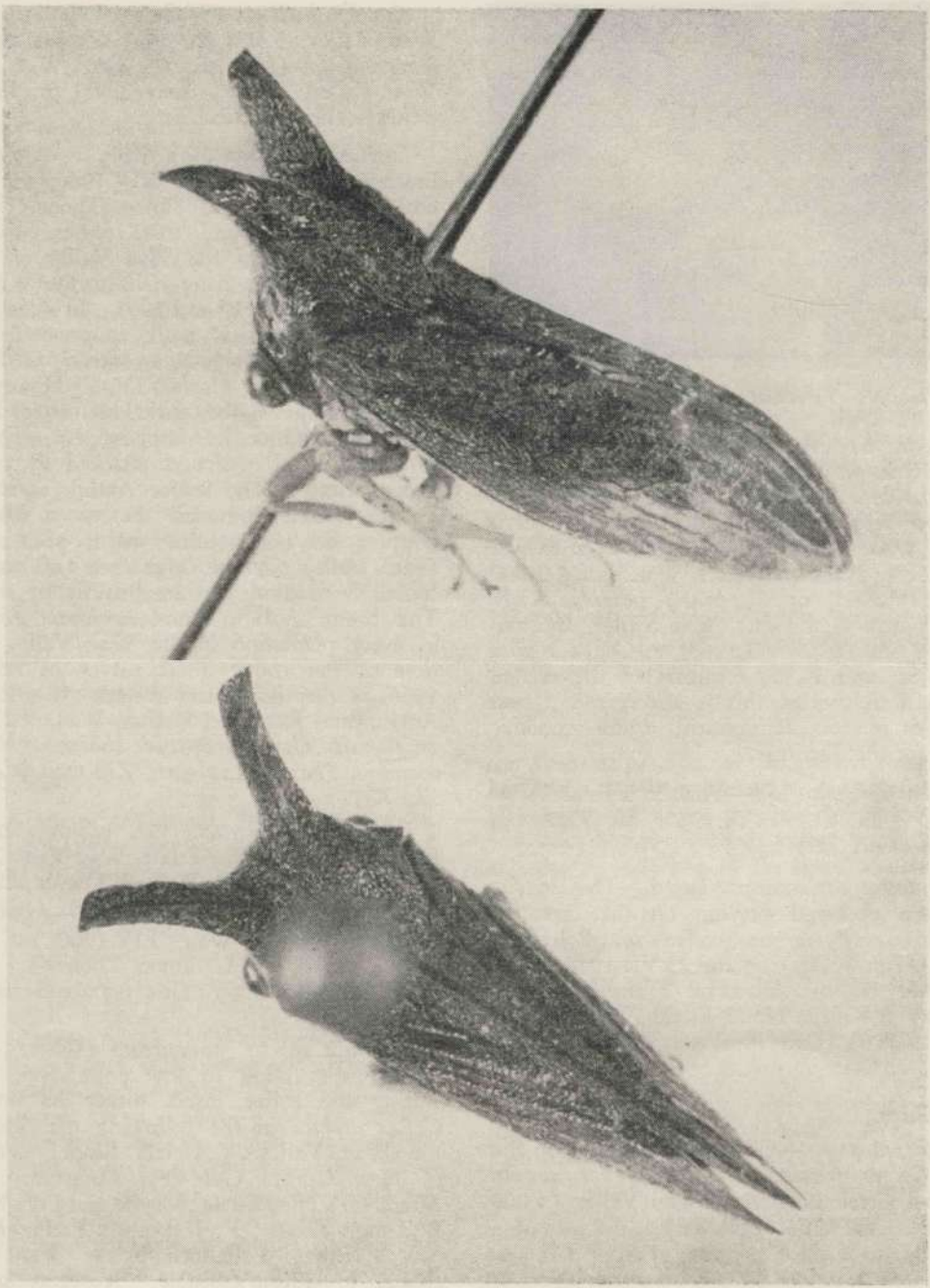

Plate IV.—A membracid, common on *Coffea arabica* in the Wau Valley (Genus et species indet). Dorsal and lateral view.

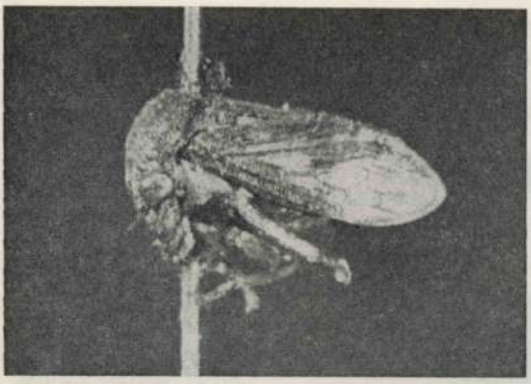

Plate V.—*Terentius mubifasciatus* Walk.

Antestiopsis semiviridis (Walk.).—Agricultural Extension Station, Wau, 24.VIII.1963, on *Coffea arabica* (Coll. Sz. and K.), 17.IV.1965, on *Piper nigrum* (Coll. Sz.) ; Clarke and Fry's Estate, Wau Valley, II.1966, on *Coffea arabica* (Coll. St.) ; Poltalloch Estate, Wau Valley, 3,400 ft., 18.IV.1965, on *Tephrosia candida* (Coll. Sz.) ; Warra-Wau Estate, Wau Valley, approximately 3,400 ft., 24.VII.1963, on *Coffea arabica* (Coll. Sz. and K.). Contrary to the related East African species, this is a very minor pest of *Coffea arabica*. It represents a new economic record for the Territory.

Nezara viridula (L.).—Poltalloch Estate, Wau Valley, 3,400 ft., 18.IV.1965, on *Tephrosia candida* (Coll. Sz.).

Platynopus melacanthus Boisd.—This species has been observed preying on the larva of *Heliothis armigera* on coffee on Poltalloch Estate (Wau Valley) on the 23.VII.1963 (Coll. Sz.) and on the larva of *Tiracola plagiata* (Walk.) at Kolega No. 2 Estate (Wau Valley) on 17.IV.1963 (Coll. Professor J. I. Balogh and Sz.).

Reduviidae.

Pristhesancus sp.—Observed preying upon the flatid *Colgar tricolor* Dist. on *Coffea arabica* at Kunai Creek Plantation, Wau Valley (4,000 ft.), on 23.VII.1963 (Coll. Sz.).

Ricaniidae.

Armacia sp.—Bubu Estate, Wau Valley, approximately 3,400 ft., VII.1963, on *Coffea arabica* (Coll. Sz. and K.).

Armacia basigera (Walk.).—Poltalloch Estate, Wau Valley, 3,400 ft., IV.1965, on *Leucaena leucocephala* (Coll. Sz.), Warra-Wau Estate, Wau Valley, approximately 3,400 ft., IV.1965, on *Coffea arabica* (Coll. Sz.).

Euricania discigutta (Walk.).—Agricultural Extension Station, Wau, 5.IV.1960, on *Coffea arabica* (Coll. R. T. Simon Thomas). The Senior Author found this species in almost every plantation of the Wau Valley on *Coffea arabica* during his many visits to the Wau Subdistrict between 1954 and 1965. In some plantations this species is more common than the cicadellid *Batrachomorphus blotei* Ghauri or the flatid *Colgar tricolor* Dist. However, in most plantations the flatid seems to be the commonest minor leaf-hopper pest. *Euricania discigutta* is often found attacked by entomogenous fungi. The Senior Author agrees with Dr. F. J. Simmonds that the reason why leafhoppers do not become major pests in the Wau Valley, is the high rate of mortality caused by natural enemies, mainly by diseases. The Junior Author found *Euricania discigutta* in every plantation in the Wau Valley at the time of her coffee insect survey in February, 1966. Other host plant records : Garden near Agricultural Extension Station, Wau, VII.1963 ; on *Brassica oleracea*, *Brassica chinensis*, *Hibiscus manihot*, *Phaseolus vulgaris*, *Zea mais* (Coll. Sz. and K.).

Euricania disciguttata var. *villica* (Stal.).—Blue Mountain Coffee Estate, Wau Valley, 3,400 ft., 10.XI.1954 (Coll. R. E. P. Dwyer and Sz.).

Ricanula trimaculata (Guer.).—Agricultural Extension Station, Wau, 5.IV.1960, on *Coffea arabica* (Coll. R. T. Simon Thomas) ; 17.IV. 1965, on *Coffea arabica* (low population density) (Coll. Sz.).

Ricanula sp. nr. *puncticosta* (Walk.).—This species was found in low population density during the coffee insect survey in 1963 on *Coffea arabica* in the following plantations of the Wau Valley : 'Albizia Block' (Property of New Guinea Gold-field Company) ; Blue Mountain Coffee Estate ; Clarke and Fry's Estate ; L. Lane's Estate ; P. J. Leahy's Farm ; Kolega No. 1 Estate, Poltalloch Estate, Wau Coffee Estate, J. Wilson's Estate. It seems to have invaded the coffee plantations in recent years. The Senior Author has not found it on *Coffea arabica* in the Wau Valley before 1963.

Ricanula sp.—Wau, 31.V.1957 ; 15.II.1957, on *Coffea arabica* (Coll. Sz.).

Tarundia sp.—Clarke and Fry's Estate, Wau Valley, approximately 3,400 ft., II.1966, on *Coffea arabica* (Coll. St.).

LEPIDOPTERA.

Arctiidae.

Creatonotus gangis (L.).—Vegetable Farm of Bulolo Gold-Dredging Company, approximately 2,400 ft., VII.1956, larva on *Zea mais* (Coll. Sz.) ; Garden near Agricultural Extension Station, Wau VII.1963 ; larva on *Zea mais* (Coll. Sz.). This arctiid must have various indigenous host plants of the family Gramineae. It appears at electric lights, both white light and mercury vapour lamps, in large numbers in the Wau area.

Cossidae.

Zeuzera ? coffeae Nietn.—A minor pest of *Coffea arabica* in the Wau Valley. There was a slight outbreak at New Guinea Gold-field Farm in 1956-1957. The borer holes were individually treated with creosote.

Gelechiidae.

Phthorimea operculella (Zell.).—Wau, home garden, reared from larvae in tuber of *Solanum tuberosum* (Coll. J. H. Ardley).

Geometridae.

Cleora sp.—Agricultural Extension Station, Wau, 18.IV.1965. Reared ex larva on *Coffea arabica* (Coll. Sz.).

Ectropis sabulosa Warr.—Reared from larvae on *Coffea arabica* and *Leucaena leucocephala* by the Junior Author at Clarke and Fry's Estate (Wau Valley), and at Sunshine Plantation (Snake River Valley) in February, 1966.

Hyposidra talaca (Walk.).—Waramouli Estate, Wau Valley, VII.1963 young larvae feeding on *Coffea arabica* leaves (Coll. Sz.). Poltalloch Estate, Wau Valley, 3,400 ft., 18.IV. 1965, reared from larva on *Coffea arabica* (Coll. Sz.). Warra-Wau Estate and Clarke and Fry's Estate (Wau Valley) and Sunshine Plantation (Snake River Valley), II.1966, larvae found in low population density feeding on *Coffea arabica* (Coll. St.).

Milionia isodoxa (Prout).—This species was recorded as a pest of hoop pine (*Araucaria cunninghamii*) in the Eastern Highlands (Szent-Ivany and Catley 1960). Adult moths were observed by the Senior Author not far from Department of Forests' Pine Plantation ('Andersons Logging Area'), at McAdam Memorial Park in April, 1965. Larvae have not been recorded so far from hoop pine needles in the Wau-Bulolo area.

Limacodidae.

Chalcocelis alboguttata Snellen.—This species was found on *Coffea arabica* in the following plantations : Agricultural Extension Station, Wau, July, 1963 (Sz. and K.), 17.IV. 1965 (Coll. Sz.) ; Blue Mountain Coffee Estate, Bubu Estate, Clarke and Fry's Estate, Kosali Plantation, Poltalloch Estate, Riverside Estate, Rousey Estate, Warra-Wau Estate, Wau Coffee Estate, J. Wilson's Estate, all in the Wau Valley in July to August, 1963 (Coll. Sz. and K.). This slug caterpillar is a minor pest of *Coffea arabica* which never causes major defoliation.

Parasa sp.—Blue Mountain Coffee Estate, Wau Valley, VII.1963. Reared from larva on *Coffea arabica* (Coll. Sz. and K.).

Scopelodes dinawa B. Bak.—This species was found on two occasions causing almost complete defoliation of *Mangifera indica*, the first time at Blue Mountain Coffee Estate in November, 1954, by the late R. E. P. Dwyer and the Senior Author (Szent-Ivany 1955), and the second time in the town area of Wau in 1965 by J. Sedlacek.

Lymantriidae.

Dasychira sp.—Wau, 10.XI.1954, some leaf damage by the larva of this species was found on *Cassia fistula* in an ornamental garden (Coll. Sz.).

Euproctis sp.—This and possibly another species is commonly found on *Coffea arabica* plantations in the Wau Valley. Its population density is always low.

Orgyia postica (Walk.).—The Senior Author found this species causing damage to the leaves of *Cassia fistula* at Wau on 10.XI.1954. Similar to the *Euproctis* species, it occurs in low population density on *Coffea arabica* in all plantations in the Wau Valley and at Sunshine Plantation in

the Snake River Valley (Coll. Sz., Coll. St.). The Senior Author found *Orgyia postica* on one occasion feeding on *Leucaena leucocephala* (Poltalloch Estate, Wau Valley, April, 1965).

Noctuidae.

Achaea janata (F.).—Agricultural Extension Station, Wau, 3.VII.1963, reared from larva on *Coffea arabica* (Coll. Sz.). Riverside Estate, Wau Valley, 3.VII.1963. Bred from larva on *Coffea arabica.*

Agrotis interjectionis Guen.—This species appears in medium population density at the light source of 'Insecta Flash' Electrocutors and at Mercury Vapour Lamps in the Wau Valley. The Senior Author reared this species from garden lawn in Goroka in the Eastern Highlands District. It most likely causes damage to garden lawns also in the Wau Valley.

Heliothis armigera (Hbn.).—A severe outbreak of *Heliothis armigera* was found by the Senior Author in the vegetable farm of the Bulolo Gold-Dredging Company at Bulolo in July, 1956. In a block of maize at least 40 per cent. of the corn cobs were attacked by *Heliothis* larvae. In the same block *Heliothis armigera* larvae were also found damaging tomatoes, together with the larvae of *Spodoptera litura* F. Other observations on *Heliothis armigera* in the Wau-Bulolo area: (1) A few larvae were observed feeding on coffee cherries (*Coffea arabica*) at Poltalloch Estate on 23rd July, 1963 (Coll. Sz.). (2) Adults were observed flying round cabbage heads at Biangi Farm and round ornamentals in a commercial flower garden at Yallaru Farm (Coll. Sz.). (3) *Heliothis armigera* appears at Wau in medium population density at Mercury Vapour Lamps or white light (Coll. Sz.).

Othreis fullonia (Clk.).—Bishop Museum Field Station, Wau, 4,000 ft., IV.1965, reared from larvae on *Erythrina indica* (Coll. J. Sedlacek).

Pericyma cruegeri (Butl.).—This noctuid appeared the first time on ornamental legume trees (*Delonix regia* and *Pelthophorum ferrugineum*) in the Territory of Papua and New Guinea in 1958. The first serious outbreak was in the Port Moresby town area in February to May, 1958. In subsequent years it invaded the areas of many other towns and townships in several districts of the Territory (Szent-Ivany 1959, 1960, 1963b) (Szent-Ivany and Catley 1960a). Adult moths appeared in medium population density at the light source of an 'Insecta Flash' Electrocutor during a demonstration in March, 1964, at Poltalloch Estate. At the same time adult moths were also collected at Mercury Vapour Lamps at the Bishop Museum Field Station in Wau (Coll. Sz.). The first larvae were found by the Senior Author feeding on *Delonix regia* during a short visit to the Bishop Museum Field Station in March, 1966. Some branches of the tree in the Station's Garden were severely defoliated.

Spodoptera exempta (Walk.).—This common and widely distributed grass-moth appeared in very dense populations at Mercury Vapour Lamps at the Bishop Museum Field Station at Wau in March, 1964. It was also attracted by the light source of the 'Insecta Flash' Electrocutor at Poltalloch Estate. Damage to garden lawns was apparent in various parts of the town area, most likely caused by this species. The appearance of *Spodoptera exempta* in vast numbers in 1964 was not confined to the Wau area only. Severe outbreaks were reported from the Yoda Valley (Kokoda, Northern District of Papua), Port Moresby and Tapini (Central District of Papua) and Mendi (Southern Highlands District of New Guinea).

Spodoptera litura (F.).—For some years vegetable farmers in the Wau Valley were suffering severe losses as a result of the damage by this noctuid to cabbage and other garden crops. The Senior Author observed *Spodoptera litura* damaging the following cultivated plants in the Wau area: *Brassica chinensis*, *Brassica oleracea*, *Hibiscus manihot*, *Lactuca sativa*, *Lycopersicum esculentum*. Damage to tomato fruit at the Vegetable Farm of the Bulolo Gold-Dredging Company in July, 1956, was also quite severe.

Tiracola plagiata (Walk.).—During the coffee insect survey in 1963 the Senior Author and B. J. Kebby found the larvae of this moth in small pockets at Blue Mountain Coffee Estate and some larvae were found also in other plantations in the Wau Valley. The damage caused to coffee foliage was insignificant. During a visit to the Wau Valley in April, 1965, *Tiracola plagiata* was observed on both *Leucaena* shade trees and coffee bushes at Warra-Wau Estate and at Kolega No. 1 Estate. The population density at Kolega No. 1 Estate was slightly

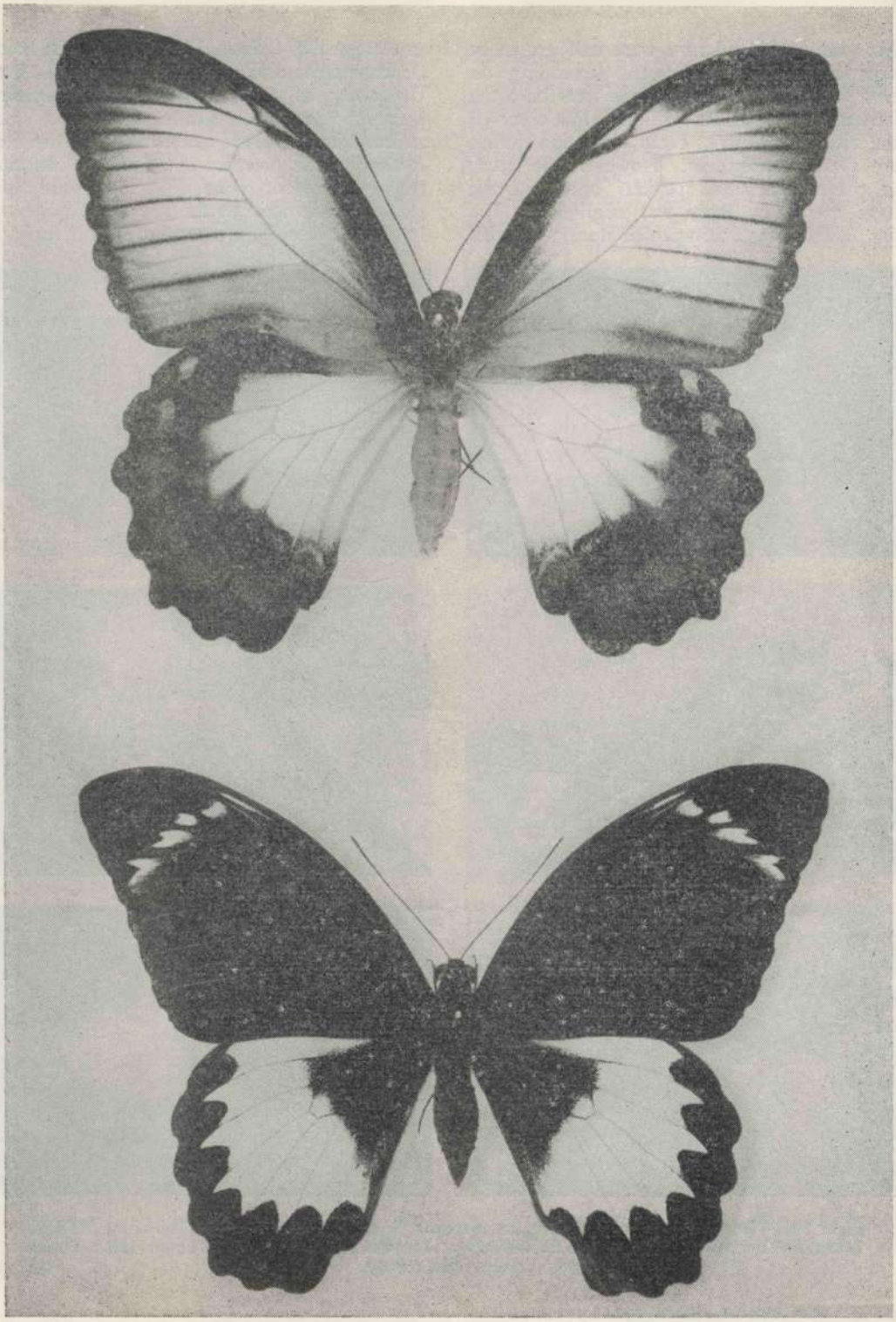

Plate VI.—Bottom : *Papilio aegeus ormenus* Guen. (Male). Top : *Papilio aegeus ormenus* Guen (Albino Female).

higher ; most of the larvae were half grown or smaller and many were seen descending on threads from the *Leucaena* shade trees onto the coffee bushes in a similar fashion to that observed in the Northern District cacao plantation during severe *Tiracola* outbreaks. However, the larvae were present in small pockets only and the damage caused by them was negligible. The Senior Author was accompanied during his visit to Kolega No. 1 Estate by Professor J. I. Balogh, Arachnologist, and soil zoologist of the L. Eotvos University of Science (Budapest). Professor Balogh, whose main aim was to collect spiders and soil insects, drew the attention of the Senior Author to the presence of an almost continuous large canopy of webs of an argiopid spider (*Epeira* sp.) between the *Leucaena* shade trees. In these webs large numbers of phytophagous

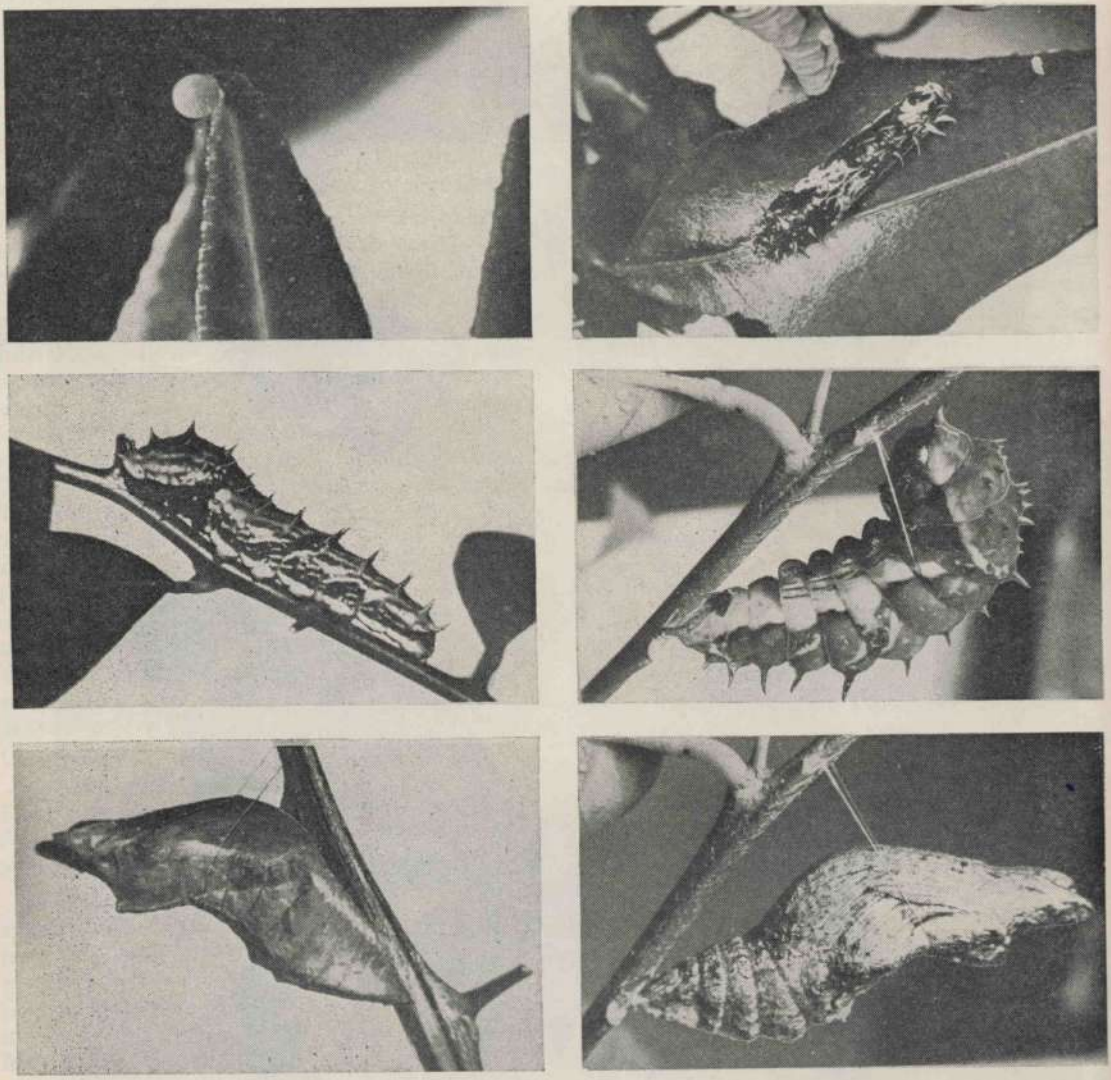

Plate VII.—Early stages of *Papilio aegeus ormenus* Guen. Top left : Egg. Top right : Third Instar larva. Middle left : Fifth Instar larva. Middle right : Prepupa. Lower left : Pupa. Lower right : Pupa.

Plate VIII.—Severe defoliation of *Citrus* tree by *Papilio aegeus ormenus* Guen.

and other caterpillars were caught. Thus, this *Epeira* species must have contributed a great insects, such as leaf-hoppers, leaf-roller larvae and adults, younger instars of *Tiracola plagiata* deal in this plantation to the control or reduction of the population density of phytophagous insects, including that of *Tiracola*. The Junior Author, during her survey in February, 1966, found *Tiracola plagiata* on *Coffea arabica* at Clarke and Fry's Estate in the Wau Valley and at Sunshine Plantation in the Snake River Valley. Both Authors collected adult moths of *Tiracola plagiata* at Mercury Vapour Lamps at the Bishop Museum Field Station and at the light source of 'Insecta Flash' Electrocutors at Poltalloch Estate (the Junior Author also at Sunshine Plantation), always in low population density.

Papilionidae.

Papilio aegeus ormenus Guen. (*Plate* VI.).—This swallowtail, commonly known as 'citrus' or 'citrus orchard butterfly' in Australia and in Papua and New Guinea, is very common in the Wau-Bulolo area. However, it rarely causes severe defoliation, and usually only single trees are affected in ornamental gardens. Complete defoliation of a *Citrus* tree by *Papilio aegeus* was observed by the Senior Author in November, 1954, in a home garden in the Wau town area (*Plate* VIII). The ichneumonid *Echthromorpha insidiator* Sm. was observed as a larval parasite and the mantid *Hierodula* (*Tamolamica*) *tamolama* (Branes.) was observed preying on the larva of *Papilio aegeus* in the Wau Valley (Coll. Sz.).

Pieridae.

Catopsilia pomona pomona (F.).—Commonly known as 'cassia butterfly' in the Territory of Papua and New Guinea. It has a Territory-wide distribution (from sea level up to about 6,000 ft.) and it causes severe defoliation in some years to *Cassia fistula* and *Cassia alata* in the Wau-Bulolo area. Such a severe defoliation was observed by the Senior Author in November, 1954 (*Plate* X). There were large numbers of adult butterflies present in the town area. Most of them were damaged females which indicated that they had emerged from their pupae some time ago and they had most likely migrated to Wau from an area where the cassia trees were completely defoliated (Szent-Ivany 1956 (1959)). *Catopsilia pomona pomona* has many individual colour varieties. The most important ones are *f. crocale* Cr. and *catilla* Cr. (*Plate* IX). For a long time the *f. crocale* was considered a distinct species.

Plutellidae.

Plutella maculipennis Curt.—Biangi Vegetable Farm, Wau Valley, approximately 3,400 ft., VII.1963; larvae attacking cabbage heads (Coll. Sz. and K.).

Psychidae.

Crematopsyche pendula Joannis.—Wau Coffee Estate, Wau Valley, approximately 3,400 ft., 21.VII.1963. Reared from larva on *Coffea arabica* (Coll. Sz.).

Pteroma sp.—Poltalloch Estate, Wau Valley, 3,400 ft., 23.VII.1963; cases hanging by threads on *Leucaena leucocephala* shade trees (Coll. Sz. and K.). Agricultural Extension Station, Wau, IV.1965; dense populations on *Leucaena leucocephala* shade trees (Coll. Sz.) same locality, II.1966; feeding on *Coffea arabica* and *Vanilla planifolia* (Coll. F. and St.).

Pyralidae.

Hymenia recurvalis (F.).—Vegetable Farm of Bulolo Gold-Dredging Company, Bulolo, approximately 2,400 ft., July, 1956, on *Beta vulgaris* (Coll. Sz.).

Sphingidae.

Agrius convolvuli (L.).—Wau, town area, 10.XI.1954, larva found on sweet potato. This moth commonly known in the Territory as

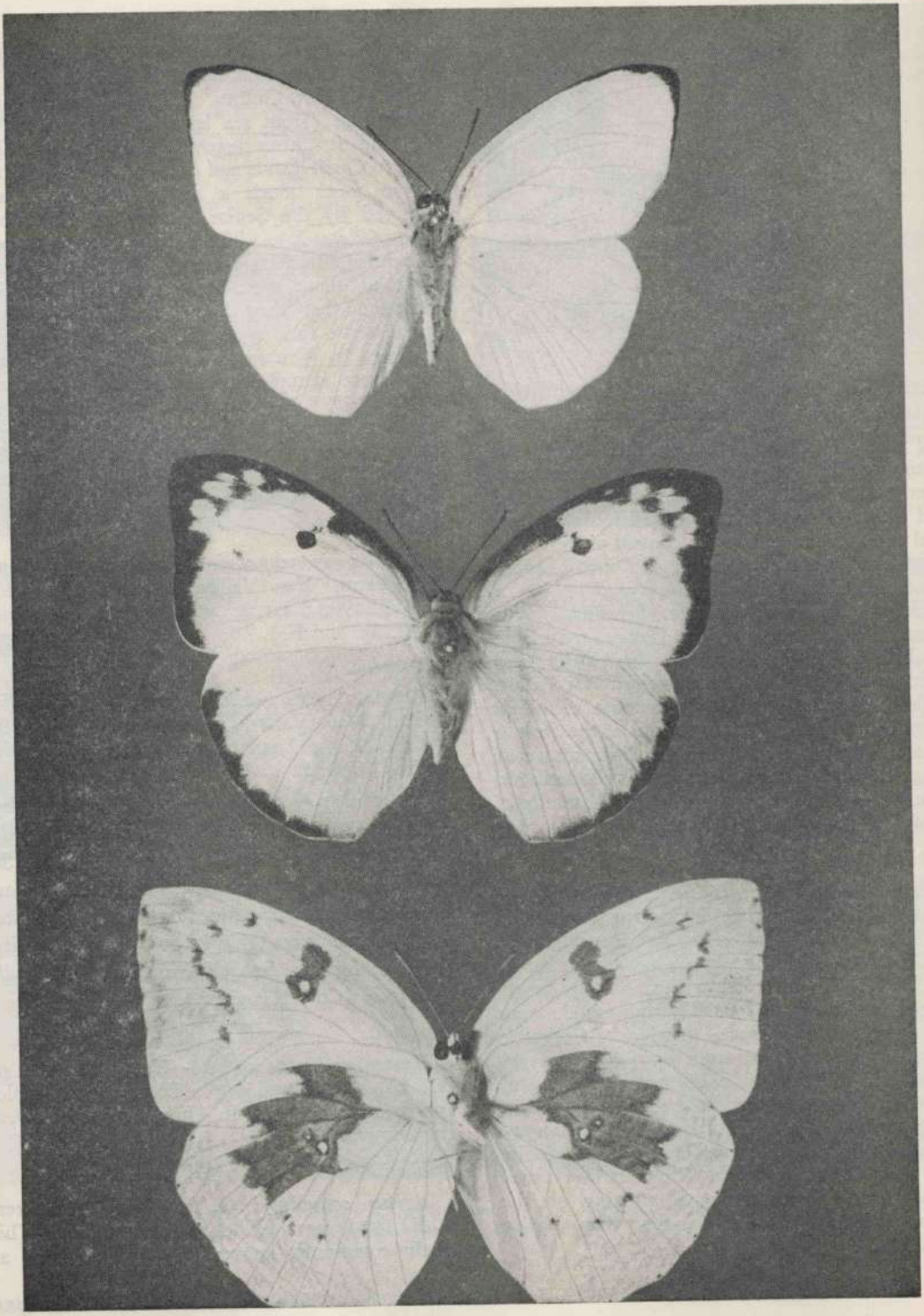

Plate IX.—Top : *Catopsilia pomona pomona* (F.). Centre : *Catopsilia pomona pomona* (F.) f. *crocale* Cr. Bottom : *Catopsilia pomona pomona* (F.) f. *catilla* Cr.

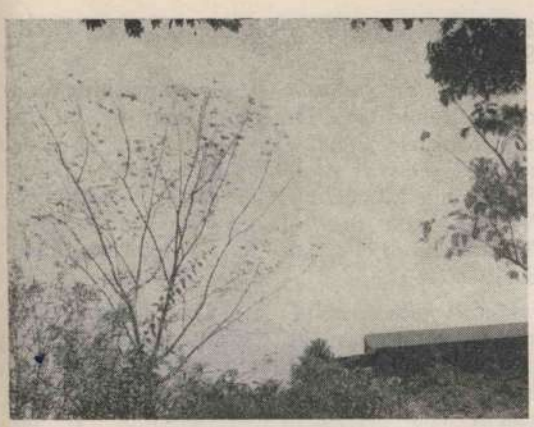

Plate X.—Severe defoliation of *Cassia fistula* tree by *Catopsilia pomona pomona* (Fabr.) at Wau.

'sweet potato hawkmoth', sometimes causes considerable damage to *Ipomoea batatas* in the Territory, mainly in the lowland areas (Szent-Ivany 1961). It is of no importance as a pest of sweet potato in the Wau Subdistrict. It must have alternate indigenous host plants as it is one of the commonest hawkmoths round electric lamps in the Wau town area. It is also strongly attracted by Mercury Vapour Lamps and the light source of the 'Insecta Flash' Electrocutor.

Hippotion celerio (L.).—Wau, town area; larvae feeding on *Vitis vinifera* (Coll. Sz.). It has been recorded as a pest of sweet potato, and taro in the Territory (Dumbleton 1954; Froggatt 1938). The Senior Author found it on *Colocasia* in various districts in recent years and A. Catley collected the larvae of *Hippotion celerio* on *Caladium* at Plant Industry Centre, Bubia, near Lae. An alternate weed host plant is *Boerhavia erecta* (Family Nyctaginaceae) (Szent-Ivany and Carver 1967 in press).

Tineidae.

Setomorpha ridella Zell.—Bulolo, VII.1964. Seed borer of klinki pine (*Araucaria hunsteinii*) reared by G. S. Dun.

Tortricidae.

Homona coffearia (Nietn.).—Ubureng Plantation, Wau Valley, VII-VIII.1963. Leaf-roller on *Coffea arabica* (Coll. Sz. and K.). Agricultural Extension Station, Wau, and Warra-Wau Estate, 17.IV.1965, on *Coffea arabica* in low population density (Observation by Sz.). The 'coffee leaf-roller moth' or 'tea-tortrix' as it is called in Ceylon, seems to be even less important as a pest of *Coffea arabica* in the Wau Valley than in the coffee growing areas of the three Central Highlands Districts.

DIPTERA.

Agromyzidae.

Agromyza ? coffeae Nietn.—Agricultural Extension Station, Wau, VII.1963, on *Coffea arabica* (Coll. Sz.). This leafminer was observed on *Coffea arabica* by Mr. B. J. Kebby and the Senior Author in July to August, 1963, at the Agricultural Extension Station in Wau and at Becula Estate in the Wau Valley. Some leaves with typical *Agromyza* damage were also found by the Senior Author at the Agricultural Extension Station, Wau, on the 18th April, 1963.

Melanagromyza phaseoli (Tryon).—Bubu Estate, Wau Valley, 10.XI.1954; severe damage to the roots of *Phaseolus vulgaris* (Coll. N. White Snr. and Sz.).

HYMENOPTERA.

Ichneumonidae.

Echthromorpha insidiator Sm.—Stirling Chase Estate, Wau Valley, VII.1963. Reared from pupa of *Papilio aegeus ormenus* Guer. found on *Citrus* tree (Coll. Sz.).

Megachilidae.

Megachile frontalis (F.).—The Homestead Coffee Estate, 10.XI.1954, constructing nests in the garden lawn in the ground (Coll. Sz.); Bishop Museum Field Station, Wau, Morobe District, New Guinea, IV.1965; cutting leaves of *Cassia* sp. in ornamental garden.

COLEOPTERA.

Cetoniidae.

Glycyphana sp.—McAdam Memorial Park, near Wau, approximately 4,500 ft., 19.IV.1957. On *Crotalaria anagyroides* and *Crotalaria striata* (Coll. J. I. Balogh, J. Sedlacek and Sz.).

Glycyphana incerta (Wall.).—McAdam Memorial Park, 19.IV.1957, on *Crotalaria anagyroides* and *Crotalaria striata* (Coll. J. I. Balogh, J. Sedlacek and Sz.).

Lomaptera annae Hell.—Bishop Museum Field Station, Wau, 4,000 ft., 18.IV.1965, on the flowers of *Spathodea campanulata* ('african tulip') (Coll. J. Sedlacek and Sz.).

Coccinellidae.

Cryptolaemus affinis Crotch. (*Plate* XI).—Introduced from the Markham Valley in 1957.

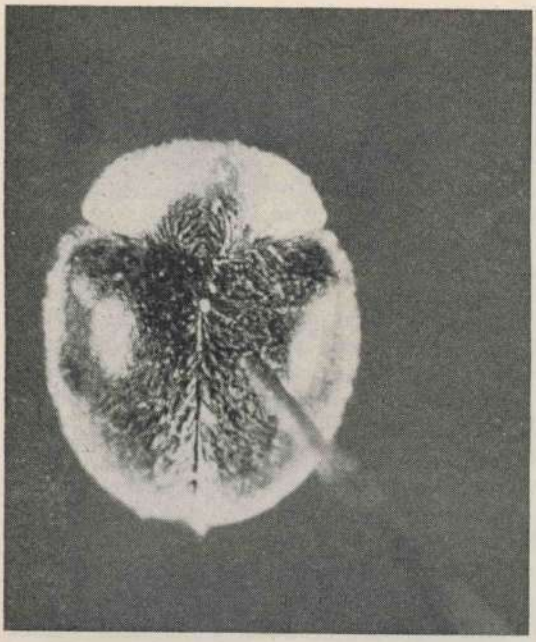

Plate XI.—*Cryptolaemus affinis* Crotch.

It is now well established in the Wau Valley and it seems to be one of the main controlling factors of *Planococcus citri* (Risso) on *Coffea arabica*. The Senior Author also found the larvae preying on *Ceroplastes destructor* Newst. feeding on *Plumeria acutifolia* in an ornamental garden in the Wau town area in July, 1963.

Henosepilachna signatipennis (Boisd.).—Wau town area, XI.1957, feeding on *Cucurbita pepo* (Coll. Sz.). Vegetable Farm of the Bulolo Gold-Dredging Company, Bulolo, approximately 2,400 ft., VII.1956, on *Beta vulgaris* (Coll. Sz.). Bubu Estate, Wau Valley, 10.XI.1954, on the flowers of *Cucurbita pepo* (Coll. Sz.).

Menochilus 4-plagiatus Switz.—Wau, town area, 31.V.1957, preying on aphid on *Crotalaria anagyroides* (Coll. Sz.).

Orcus sp. Predacious on Coccidae.—The Senior Author found this species in every coffee plantation in the Wau Valley in July to August, 1963. The Junior Author also found this *Orcus* sp. in most areas visited.

Curculionidae.

Alcidodes sp.—Vegetable Farm of the Bulolo Gold-Dredging Company, Bulolo, approximately 2,400 ft., July, 1955, on *Beta vulgaris* (Coll. Sz.).

Apirocalus cornutus Pasc.—Vegetable Farm of the Bulolo Gold-Dredging Company, Bulolo, approximately 2,400 ft., July, 1955, on *Beta vulgaris*, *Daucus carota*, *Ipomea batatas* (Coll. Sz.). Blue Mountain Coffee Estate, Wau Valley, VII.1963, on the foliage of *Coffea arabica*, Mount Kaindi, IV,1965, on *Bambusa* sp. (Coll. Sz.).

Cylas formicarius (F.).—This species, commonly known as the 'sweet potato weevil' caused very severe damage to large sweet potato blocks at Wau in 1954 and in 1956, resulting in almost 100 per cent. loss of crop. It was observed in the Wau Valley and in the Eastern Highlands that the most serious damage by *Cylas formicarius* was caused to sweet potato when is was repeatedly planted in larger blocks throughout several growing periods. However, extreme drought also brings about medium to severe outbreaks of *Cylas formicarius*.

Gymnopholus weiskei Hell.—Kunai Creek Coffee Block (Property of the New Guinea Goldfield Company), 4,000 ft., 16.II.1957; on *Tephrosia candida* (Coll. Sz.); Bishop Museum Field Station, Wau, 4,000 ft., IV.1964, in orna-

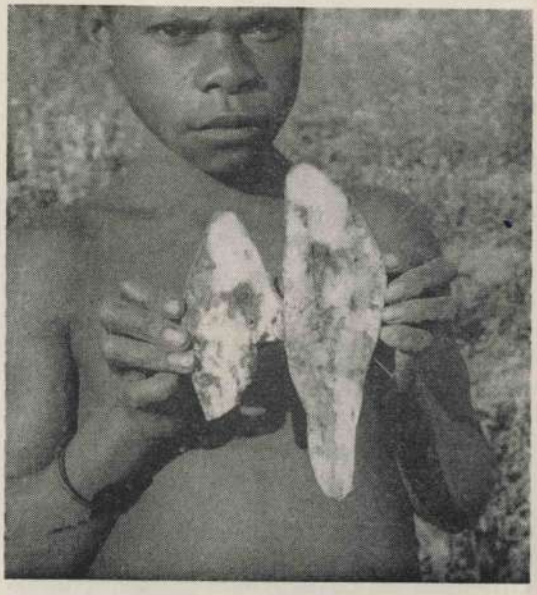

Plate XII.—Damage to Sweet Potato tuber by *Cylas formicarius* F. at Wau.

Plate XIII.—*Gymopholus weiskei* Hell.

mental garden on *Melia azedarach*, *Pipturus argenteus* and *Trema amboinensis* ; Mr. Sedlacek has kindly informed the Authors that *Gymnopholus weiskei* sometimes completely defoliates *Melia azedarach* (Szent-Ivany 1965 ; Gressitt, Sedlacek and Szent-Ivany 1965).

Oribius sp.—Kasangara village, Wau Subdistrict, 22.I.1962, on *Coffea arabica* foliage (Coll. K.).

Oribius cinereus Mshl.—Bishop Museum Field Station, Wau, 4,000 ft., 17.IV.1965, on the leaves of *Hibiscus rosa sinensis* (Coll. Sz.) ; Kaisenik Village Plantation, Wau Valley, approximately 3,200 ft., 19.IV.1965, shot-hole damage caused to *Citrus* foliage (Coll. Sz.) ; Power House Coffee Block (Property of New Guinea Gold-field Company), Wau Valley, 4,000 ft., feeding on the leaves of *Coffea arabica* (Coll. Sz.). This species was described as a new species by Sir Guy A. K. Marshall (1959), based on specimens collected on *Coffea arabica* foliage in the Saidor Subdistrict (Madang District) in 1958. This is the only previous record of *Oribius cinereus*.

Vanapa oberthuri Pouill.—This large weevil has been known as a major stem borer pest of *Araucaria cunninghamii* in the Goroka and Kainantu Subdistrict of the Eastern Highlands and in Bulolo for many years (Szent-Ivany and Womersley 1958).

Eumolpidae.

Rhyparida sp.—Agricultural Extension Station, Wau, 17.IV.1965, on *Coffea arabica* (Coll. Sz.).

Rhyparida coriacea Jac.—Wau, town area, 31.V., 1.VI.1957, 26.IV.1958 causing severe defoliation to *Eucalyptus deglupta* ; feeds at night, rests during the day in dense populations under loose bark of the main stem and on the under-surface of the leaves (Coll. Sz.) (Gressitt 1963).

Galerucidae.

Aulacophora pallidifasciata Jac.—Bubu Estate, Wau Valley, 10.XI.1954, on *Cucurbita pepo* (Coll. Sz.).

Melolonthidae.

Genus et species indet.—Larvae of an unknown cockchafer were found attacking klinkii pine (*Araucaria hunsteinii*) seedlings in a nursery of the Department of Forests at Wau on 29.IV. 1965. A scoliid larva was found associated with the larvae (Coll. J. Smith).

Genus et species indet.—Larvae were found damaging the roots of *Delonix regia* in an ornamental garden at Wau on 10.XI.1954 (Coll. R. E. P. Dwyer and Sz.).

Scolytidae.

Hylurdrectonus araucariae Schedl.—This is a major pest of hoop pine (*Araucaria cunninghamii*) in the Wau-Bulolo area. It is a needle-borer and it was described by Professor K. E. Schedl as a new species in 1964 (Schedl 1964).

SUMMARY.

At the time of writing this paper *Coffea arabica* has no major pests in the coffee growing area of the Wau Valley. There was a severe outbreak of the semicosmopolitan, polyphagous mealybug *Planococcus citri* (Risso) in 1956-1957 in some coffee plantations where it caused up to 75 to 80 per cent. reduction of yield. After the introduction of the predacious Lady Bird *Cryptolaemus affinis* Crotch from the Markham Valley, the population density of *Planococcus*

has rapidly decreased. Young coffee trees are still affected by mealybug damage especially where there are nursing ants building 'mud-tents' above the mealybug populations on the mainstem of the young coffee bushes and in the area of ramification.

The almost complete absence of *Celeuthetini* weevils in most coffee plantations is remarkable in contrast to the situation in the Eastern Highlands (Szent-Ivany and Barrett 1960).

Leaf eating caterpillars (mainly *Ectropis sabulosa*) were only causing severe damage to *Coffea arabica* in recent years in one plantation in the Snake River Valley. The cicadellid *Batrachomorphus blotei* Ghauri and the flatid *Colgar tricolor* Dist. are found sometimes in very dense populations on coffee trees; fortunately they are kept under control by entomogenous fungi. Some years ago *Spodoptera litura* appeared as a major pest of cabbage, lettuce and other vegetables in the Wau valley. Giant Toads (*Bufo marinus*) were introduced by the farming community to reduce the noctuid populations.

At the present the only major economic pests in the Wau-Bulolo area are three pests of hoop pine (*Araucaria cunninghamii*), the termite *Coptotermes elisae* Desneux, the curculionid *Vanapa oberthuri* Pouill, and the scolytid *Hylurdrectonus araucariae* Schedl.

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The Authors are indebted to Mr. E. O. Pearson, Director, Commonwealth Institute of Entomology, Mr. R. G. Fennah, Assistant Director and to the scientific staff of the Commonwealth Institute of Entomology and the British Museum for the identification of many insects listed in this paper; to Dr. J. L. Gressitt (Bishop Museum, Honolulu) for the indentification of leaf beetles; to Dr. E. O. Wilson (Harvard University, Cambridge, U.S.A.) for the identification of ants; to Dr. D. J. Williams (U.S. Department of Agriculture, Washington, D.C.) for the identification of Coccidae; to Mr. Brian J. Kebby and Mr. Alan Fischle for their helpful assistance in the collecting of insects and accompanying the Authors to the various plantations; to Professor Balogh (Budapest) for his advice on spiders as important predators of certain coffee pests and for helping in the collecting of some insects; to Mr. John Smith (Department of Forests, Lae) for assisting the Senior Author in the collecting of forest pests; to Mrs. N. White (formerly of Bubu Estate), Mr. A. Ireland (Sunshine Plantation), Mr. B. J. Kebby, Mr. and Mrs. J. Sedlacek (Bishop Museum Field Station, Wau) for their kind hospitality; to the Department of Information and Extension Services and to Mr. R. A. Carver for the preparation of the photographs.

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Diffuse Yellow Leaf Spot of Arabica Coffee in Papua and New Guinea

DOROTHY E. SHAW *

ABSTRACT.

A diffuse yellow leaf spot whose cause is unknown is recorded on Arabica coffee in Papua and New Guinea. It is somewhat similar to " weak spot " of Arabica coffee in Kenya, although apparently there are some dissimilarities. It is of no known economic importance.

A DIFFUSE yellow leaf spot of Arabica coffee has been recorded in Papua and New Guinea since 1958 ; it could, of course, have occurred earlier than this but been undetected.

It is found on both Typica (*Coffea arabica* L. var. *arabica* (syn. *C. arabica* var. *typica* Cramer) and on Bourbon (*C. arabica* var. *bourbon* (B. Rodr.) Choussy) in all the Arabica coffee growing areas in the Territory. It is inconspicuous and can be easily overlooked, especially as the number of spots per plant is usually small.

The spots on the upper surface of the leaf are pale yellow with a diffuse edge grading into the deep green of the normal leaf tissue. They are usually roughly circular in outline, from 1 mm. to 8 mm. in diameter, but sometimes covering larger areas when the spots are confluent. On the lower surface the spots are not so distinct because of the paler green of the underside of the leaf. On the under-surface of each spot, minute pimples from one to many occur, the maximum number counted to date being 34. The pimples are opaque under the stereomicroscope, and are up to 0.2 mm. in diameter. Although these raised areas do not occur on the upper surface, their position is usually indicated by a minute pale spot about 0.1 mm. wide. The plates show the appearance of four yellow diffuse spots on the upper surface (A) and the appearance of the same spots on the under surface of the leaf (B).

Sections through a pimple parallel to the lower surface reveal that the white opaque core extends from the lower epidermis at least through the spongy mesophyll.

The condition was investigated when first encountered, and at various times since, in case the spots indicate the infection courts of fungal invasion, especially, perhaps, a resistant reaction to rust. This, however, has not been demonstrated. Miscellaneous fungal spores are often found on the upper leaf surface, but no appressoria which might account for the reaction of the plant cells have been detected in the region of the spots. No mycelium has been detected microscopically in sections of the spots, but leaf tissue with spots cultured on potato dextrose agar after surface sterilization with mercuric chloride usually yielded *Gloesporium* sp. One of these isolates produced the perfect state in culture, and was confirmed by Dr. Mordue of the Commonwealth Mycological Institute, England, as *Glomerella cingulata* (Stonem.) Spauld. & Schrenk. The isolate, however, did not produce diffuse yellow spots when inoculated on to young Arabica coffee leaves. If the fungus were not the cause of the condition, it is possible that it was present as a latent infection, such as Rayner (1948) reported in coffee in Kenya. In his experiments he obtained species of *Colletotrichum*, *Phoma* and *Phomopsis* from practically every piece of healthy coffee tissue cultured on prune agar after surface sterilization, but found that the isolates from leaves never appeared to cause disease symptoms. He concluded that the fungi were present in healthy leaves at latent infections.

The spots are somewhat similar to the illustration of ' weak spot ' of Arabica coffee in Kenya described in the Atlas of Coffee Pests and Diseases (Anon. 1965). The cause of ' weak spot ' is unknown, although it is suspected that

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the spots contain fungal mycelium. No minute pimples, however, have been described for " weak spot ".

Mr. J. H. Barrett, formerly coffee entomologist in the Highlands, did not consider that the spots were the result of insect attack, although he thought that the possibility of damage by Collembola had not been completely eliminated.

The spots on New Guinea coffee leaves do not develop into necrotic areas, and as far as can be ascertained, do not cause any debilitation of the plant or premature defoliation, and are of no known economic importance.

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ACKNOWLEDGEMENTS.

Dr. Mordue of the Commonwealth Mycological Institute, England, is thanked for the identification of the culture. The photographs were taken by the Department of Information and Extension Services.

REFERENCES.

ANON. (1965). *Atlas of coffee pests and diseases.* Coffee Board, Kenya. Page 101.

RAYNER, R. W. (1948). Latent infection in *Coffee arabica* L. *Nature.* 161 : 245-246.

Plate A.—Diffuse yellow leaf spot (upper surface). (x5)

Plate B.—Diffuse yellow leaf spot (lower surface) showing minute raised areas. (x5)

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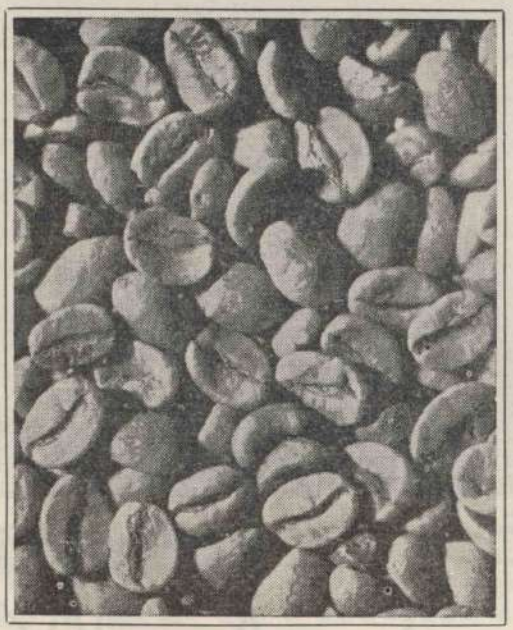

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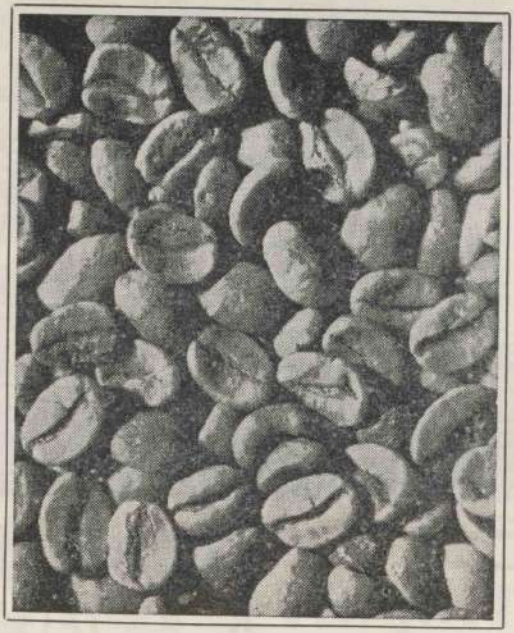

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