# INSECT PESTS OF THEOBROMA CACAO IN THE TERRITORY OF PAPUA AND NEW GUINEA*

By J. J. H. Szent-Ivany †

*In this paper, an attempt is made to give a general picture of cacao insect problems in the Territory of Papua and New Guinea. To the best of the author's knowledge, all insects recorded in association with* Theobroma cacao *are listed, besides several new unpublished records.*

*In the chapter, "Major Pests", three mirids (capsids), one coreid, three curculionids and two cerambycids are mentioned as major or important pests of cacao. More than* 140 *minor pests are listed, representing the orders: Collembola, Isoptera, Orthoptera, Hemiptera, Lepidoptera, Coleoptera and Hymenoptera. Some of the minor pests are only identified to the genus. Twenty insect species are mentioned as parasites or predators of cacao pests in the Territory;* 28 *of the* 41 *references refer to cacao pests in Papua and New Guinea.*

## INTRODUCTION

As far as can be ascertained, the first printed records of insects associated with *Theobroma cacao* in the Territory of Papua and New Guinea were published more than 22 years ago by J. L. Froggatt (1938*a*, 1938*b*). Two new stem borer weevils were mentioned in the first publication (1938*a*) and some other insects (pests of the trunk, branches, pods and foliage) in the second paper (1938*b*). These and other papers written on cacao pests in Papua and New Guinea between 1938 and 1954 were recorded in a comprehensive list of insects of cultivated plants of the South Pacific Region by L. J. Dumbleton (1954).

As a result of investigations carried out during the past six years by the entomologists of the Department of Agriculture, Stock and Fisheries, many more insect pests became known from *Theobroma cacao* in the Territory of Papua and New Guinea. Some of these are mentioned in publications of E. B. Britton (1957), E. S. Brown (1958*a*, 1958*b*), G. S. Dun (1954*a*, 1954*b*, 1955), Sir Guy A. K. Marshall (1957), C. D. Michener and J. J. H. Szent-Ivany (1960), N. C. E. Miller (1957), J. J. H. Szent-Ivany (1954, 1956*a*, 1956*b*, 1959), J. J. H. Szent-Ivany and A. Catley (1960*a*, 1960*b*, 1960*c*) and D. J. Williams (1960). Szent-Ivany, in co-authorship with J. H. Ardley, presented a short paper on the main cacao insects of the Territory of Papua and New Guinea at the Ninth Pacific Science Congress, held in Bangkok in November, 1957.

Many cacao pests found in the Territory of Papua and New Guinea since the end of the last war have represented new genera and species. Some of these have been described and named (Britton 1957, Brown 1958*a*, China and Carvalho 1951, Marshall 1957, Miller 1957). Others, including a new genus of Limacodidae (Szent-Ivany, 1954), are still awaiting description by specialists.

So far no serious regional insect pest has been found in the Territory of Papua and New Guinea. In comparison with other parts of the world, such as West Africa with its *Pseudococcus*

* This paper was first presented at the First F.A.O. Technical Conference on Cacao, held in Accra (Ghana) in February, 1959. It has now been amended to include results of investigations carried out since that time.

† Senior Entomologist, Department of Agriculture, Stock and Fisheries, Port Moresby.

*njalaensis* Laing, the main vector of the swollen shoot disease, or South America with its leaf-cutting ants, this Territory is in a very favourable position. There are a few major or important cacao pests in the Territory of Papua and New Guinea, but most of them are restricted to relatively small areas.

The population density of some minor local pests has been kept under the level of economic injury by natural enemies for many years. However, it happens in some years that unusual weather conditions or some unknown density-regulating factors cause upsets in the balance of host and parasite sequences, and this results in sudden serious outbreaks. In most cases these outbreaks are restricted to relatively small areas, often to one or two plantations only, and usually they are of short duration.

Nearly all cacao pests found in the Territory of Papua and New Guinea are indigenous species of the coastal rain-forest zone. Most plantations were established in the coastal area by clearing of the virgin forest and many of them are still more or less surrounded by primary or secondary forest. Most plantations were abandoned during the last war, and for years no measures of plantation hygiene were carried out in them. Trees and shrubs of the neighbouring forest invaded the plantations. Tall grasses and undergrowth, consisting of various weeds, grew up in a short time and some cacao plantations have almost reverted to secondary forest. Simultaneously, with the spread of the forest plants into the abandoned cacao blocks, members of the forest insect associations appeared in the plantations and some of these became adapted to *Theobroma cacao* as a host plant. This is how a number of species of Curculionidae, Miridae and Cerambycidae invaded the cacao plantations and became the most important pests of *Theobroma cacao* in the Territory of Papua and New Guinea. Recently, the coreid, *Amblypelta theobromae* Brown, was observed causing severe damage to cacao pods (Brown, 1958*b*), and this also has to be considered a major pest.

To the best of the author's knowledge, all recorded cacao pests of the Territory of Papua and New Guinea are mentioned in this paper. It also includes many new unpublished records. The bibliography contains all publications on Territory cacao insects which are known to the author.

## I. MAJOR PESTS

### A. PANTORHYTES SPP.

### (" STEM BORER WEEVILS ")

Curculionidae of the apterous genus *Pantorhytes* (subfamily Pachyrhynchinae) have to be considered major pests of cacao in Papua and New Guinea. This weevil genus has more than 20 known and probably another 15 to 20 undescribed species in the Papuan Zoogeographical Subregion, but so far only five species have been found causing injury to *Theobroma cacao*. The brightly-coloured species, *Pantorhytes plutus* Oberth. (Plate 1A), was first recorded more than 20 years ago (Froggatt, 1938*a*). The adult weevils feed on the leaves and on the bark of cacao trees. The main damage is caused by the larvae. The females lay their eggs in cracks and crevices on the bark of the trunk or branches and the larvae bore into the sapwood. They prefer to tunnel in the area of the jorquette, but they also attack laterals, some distance away from the jorquette. According to Froggatt (1938*a*), a fork between the branches is much favoured by the larvae of *Pantorhytes plutus*. The holes are easy to find because of the presence of frass or greyish-white, gummy exudate at the entrances of the tunnels. The tunnels are usually straight, but sometimes the larvae ring-bark the branch and in such cases the tissues of the section above the injury die (Henderson, 1954). In healthy trees, the gumming may be effective because it may stop the development of the larvae. Diptera larvae are often found in the gum, but they are apparently scavengers (Froggatt, 1938*a*). A thorough study of the bionomics of *Pantorhytes plutus* was carried out by B. A. O'Connor and G. S. Dun shortly after the war (Dun, 1955).

The chemical control of *Pantorhytes plutus* is rather difficult. Banding experiments carried out by Dun in the 1940s were quite successful. Bands of Ostico [1] mixed with a 10 per cent. D.D.T. dust, spread for a distance of about six inches along the stem, resulted in a high mortality of adult weevils walking over the bands up to a year after treatment (Dun, 1955). For economic reasons, banding experiments were recently abandoned and a series of new experiments with various modern insecticides was commenced at Lowlands Agricultural Experiment Station, Keravat, New Britain.

[1] " Ostico " is the trade name for a sticky banding material.

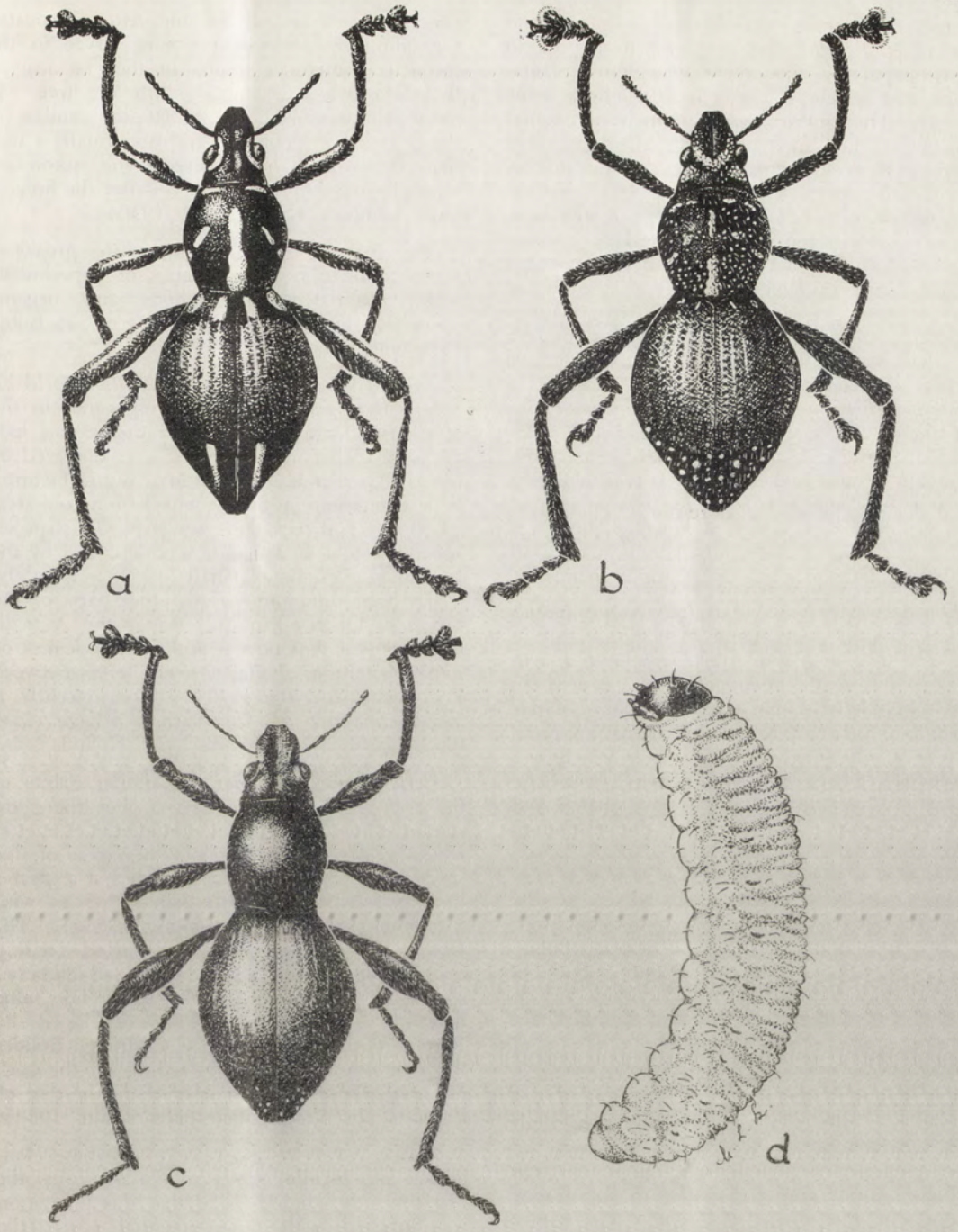



PLATE 1. [Drawings by M. L. Szent-Ivany]

(4 x Nat. Size)

a. *Pantorhytes plutus* Oberth. (adult).
b. *Pantorhytes szentivanyi* Mshl. (adult).
c. *Pantorhytes proximus* Fst. (adult).
d. *Pantorhytes proximus* Fst. (larva).

It has been noted that *Pantorhytes plutus* and the other *Pantorhytes* spp. tend to appear in dense populations in somewhat neglected plantations, and better plantation hygiene effects some relief. The author visited the experimental blocks at Lowlands Agricultural Experiment Station, Keravat, almost every day during his five-month stay at the station in 1954, but he was unable to find more than one adult specimen. In response to a request by the late Dr. F. I. van Emden, who intended to study the morphology of the larvae of *Pantorhytes plutus*, the author had to visit an old, entirely neglected cacao block (established in 1913) in the Bainings area of New Britain to collect sufficient number of larvae for study. However, there must be a certain fluctuation of population density of this curculionid in the Gazelle Peninsula of New Britain, because Dun (1954*a*) reported considerable numbers of *Pantorhytes plutus* on old cacao in 1951 and 1952 at Keravat, where plantation maintenance is always adequate. There was also a marked increase in populations since 1956 in some plantations of the Gazelle Peninsula.

During the past six years, four other species of *Pantorhytes* were found damaging cacao in the Territory of Papua and New Guinea. In 1955, *Pantorhytes proximus* Fst. appeared in mass populations in the Markham Valley (Morobe District of New Guinea). It appeared first in a very neglected plantation which was abandoned during the war and in which no plantation hygiene measures were carried out for many years. Many trees in this plantation were killed as a result of borer damage caused by *Pantorhytes proximus* and by various cerambycids. *Pantorhytes proximus* spread very rapidly into other plantations, including a cacao block at the Agricultural Experiment Station, Bubia. The borer damage caused a serious setback in growth and a reduction in yield at Bubia and in parts of some other cacao blocks in the Markham Valley.

*Pantorhytes proximus* (Plate 1C) is a more simply coloured weevil than *Pantorhytes plutus*. Its larva (Plate 1D) is a creamy-white grub with a reddish-brown head. The larvae of the other four species found damaging cacao trees in New Guinea are very similar in appearance to those of *Pantorhytes proximus*. The habits of *Pantorhytes proximus* are very similar to those of *Pantorhytes plutus*. It rarely attacks trees under three years of age. Most larvae are found in and around the jorquette. Repeated tunnelling by a dozen or more larvae in the jorquette sometimes results in the cracking of the stem, which eventually kills the tree. If there is a large quantity of gummy exudate at the entrance of a borer hole, this is usually a sign that the weevil has emerged and secondary saprophagous Diptera larvae colonize the hole in large numbers (Szent-Ivany, 1956*a*).

The chemical control of *Pantorhytes proximus* seems to be difficult. A series of experiments with chlorinated hydrocarbons and organic phosphate insecticides is in progress at Bubia Experiment Station.

A third species, *Pantorhytes szentivanyi* Mshl. (Plate 1B), was found damaging cacao in the Northern District of Papua in the second half of 1955. The first specimens were observed by Mr. F. C. Henderson and Mr. W. I. Fielding in a plantation in the Mount Lamington area, 1,000 to 1,100 feet above sea level. This species appeared to be new and it was described by the late Sir Guy A. K. Marshall (1957). Recently, it has been found in various other parts of the Northern District (in the area of the Agricultural Station, Popondetta, and in the vicinity of some plantations, lying at lower levels between Popondetta and the coast). More recently it has been found also in various village cacao blocks between Popondetta and Kokoda.

*Pantorhytes szentivanyi* has similar habits to the two aforementioned species, but there are certain differences in their ethological characteristics. A larger proportion of the larvae of this species can be found in the branches at a greater distance from the jorquette than is the case with the other species (Szent-Ivany, 1956*a*). The larvae of *P. szentivanyi* were observed feeding in cacao pods and the adults were observed chewing the surfaces of the pods. The same habit has also been recently developed by *P. proximus* in the Morobe District. Besides this, the adults were seen feeding on the bark of young shoots, as was observed in the case of *P. plutus* in New Britain (Henderson, 1954).

During a visit to the plantation, where Henderson and Fielding observed *P. szentivanyi* the first time, the author found that this plantation was infested with three potential pests (the mirid, *Helopeltis clavifer* Walk.; the coreid, *Amblypelta theobromae* Brown; and the curculionid, *P. szentivanyi*). The last was found in

such dense populations in the plantation that 12 to 15 adults could be easily collected on one tree. Several cacao trees were killed as a result of the boring by this curculionid. Many adults were seen feeding on the pods. Their feeding marks were large, brownish scars (with a diameter up to an inch) usually found in rows on the longitudinal ridges of the pods. The scars were very different from the feeding marks caused by some other pod-eating insects (Lymantriidae, Noctuidae, Rutelidae).

The chemical control of *Pantorhytes szentivanyi* is probably as difficult as that of the closely related *P. proximus*. During the outbreak of *P. szentivanyi* and the two mirids, *Helopeltis clavifer* and *Pseudodoniella laensis*, at Sangara Estate (Northern District) in 1955-1956, Mr. W. A. van den Berk, the manager of the plantation, several times applied B.H.C. dust ("Gammexane 20 Powder") against the three potential cacao pests. It was easy to control the two mirids, but the relatively high concentrate of B.H.C. never had any effect on the populations of *Pantorhytes szentivanyi*. A plantation owner in the Northern District paid a fairly high premium to his employees for collecting *Pantorhytes szentivanyi*. At the same time, he cleared his plantation of *Pipturus argenteus*, a plant which was found by Ardley (personal communication) to be an indigenous host plant of *P. szentivanyi* in the Northern District and of *P. proximus* in the Morobe District. B. A. O'Connor had earlier found *Pipturus argenteus* to be an indigenous host plant of *Pantorhytes plutus* in New Britain. It is believed that the *Pantorhytes* spp. have more indigenous host plants in their original habitats. *Pantorhytes stanleyanus* White, an Australian species of the genus (also recorded from New Guinea), was observed defoliating *Hibiscus tiliaceus* at Cairns, North Queensland (Szent-Ivany, 1956*a*). It should be mentioned here that the above-described control measures against *Pantorhytes szentivanyi* (elimination of the indigenous host plant, collecting and killing of adult weevils) were very successful. During a subsequent visit of the author to the plantation where the mechanical and cultivation methods were carried out, the cacao blocks were found almost free of this pest. However, the mechanical control methods are too troublesome, and in the case of serious outbreaks, they are uneconomical. The chances of biological control are very small [2]. Experiments for the chemical control of *Pantorhytes szentivanyi* in the Northern District will be undertaken in the near future.

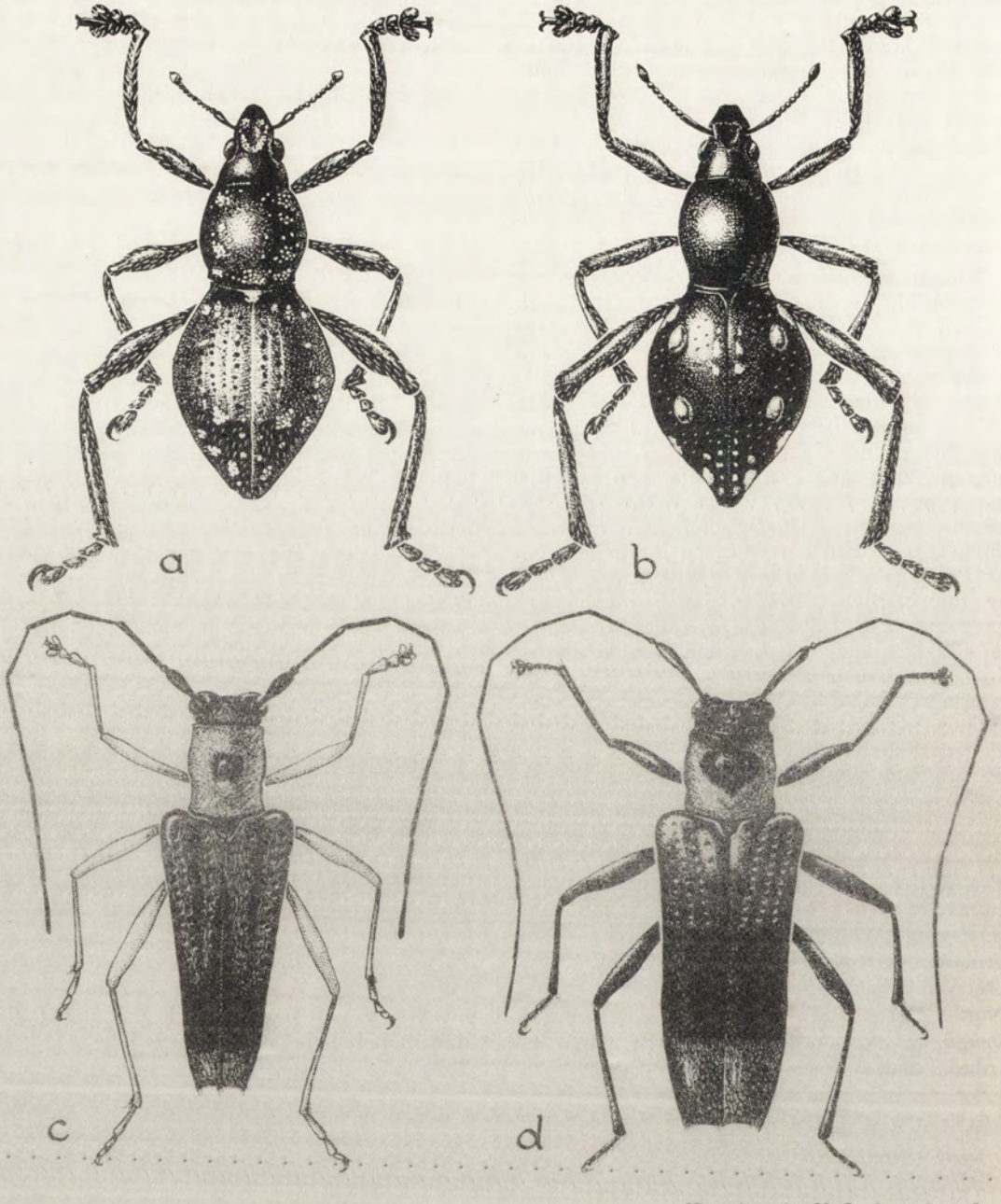
The two other *Pantorhytes* species found causing injury to cacao trees are of minor importance only. One of them, *Pantorhytes biplagiatus* Chevr. (Plate 2A), a species known earlier from the British Solomon Islands as a pest of cacao (personal communication by Mr. E. S. Brown), appeared to cause some damage to cacao trees in the Kieta Subdistrict of Bougainville. The fifth species (*P. quadripustulatus* Gestro) (Plate 2B) was found in dense populations in a small, abandoned cacao grove near Wewak in the Sepik District. The plantation was so badly damaged by the weevil that the trees had to be cut out. It should be mentioned here that the Sepik District is not a cacao-growing area. There are only about 18,000 trees planted in the whole district.

## B. MIRIDAE (CAPSIDAE)

The second important group of cacao pests in the Territory of Papua and New Guinea consists of certain species of the family Miridae (earlier known as Capsidae, Heteroptera). The first observations on mirid damage to *Theobroma cacao* were made at Kabeira plantation near Rabaul in New Britain in 1949 (Dun, 1954*b*). Further investigations in the Gazelle Peninsula of New Britain resulted in the finding of three distinct species of Miridae damaging cacao trees. They were forwarded for identification to the

[2] A braconid (genus and species unidentified) was observed parasitizing the larva of *Pantorhytes szentizanyi* Mshl. The observation was made by Dr. F. J. Simmonds and the author at Sangara Estate in August, 1959. Ardley found a large elaterid larva preying upon the larvae of *Pantorhytes szentivanyi*. Small curculionids, such as *Oribius* and *Paratactus* spp. (defoliators of cacao) are often seen attacked and carried by Green Tree Ants or "Kurukums" [*Oecophylla smaragdina* (F)]. Mr. W. J. Fielding mentioned to the author that he threw a large adult of *Pantorhytes szentivanyi* into a group of Kurukum Ants. The ants immediately attacked the weevil, grasping its head and its extremities with their strong mandibulae, but the *Pantorhytes* was able to free itself.

In the Gazelle Peninsula of New Britain (Vunapau Plantation), A. Catley observed *P. plutus* being attacked by Kurukum Ants on a cacao tree. The ants immobilized the weevil by seizing its extremities and it was carried off to the nest where it was presumably eaten.




[Drawings by M. L. Szent-Ivany]

PLATE 2.

(4 x Nat. Size)

a. *Pantorhytes biplagiatus* Chevr. (adult).
b. *Pantorhytes quadripustulatus* Gestro (adult).
c. *Glenea aluensis* Gah. (adult).
d. *Glenea lefebueri Guer.* (adult).

Commonwealth Institute of Entomology, and were examined by W. E. China at the British Museum. When Dr. China saw these insects, he first thought that some of the West African cacao mirids had been accidentally introduced to New Britain, but after closer study of the morphology with J. C. M. Carvalho it was found that they represented two new genera, closely related to some West African Bryocorinae. The two new genera were described by Dr. China and Dr. Carvalho (1951) as *Parabryocoropsis* and *Pseudodoniella*. The new species were named *Parabryocoropsis typicus* [3], *P. duni* and *Pseudodoniella pacifica*. A fourth species found in the collection of the British Museum, obtained earlier by Miss Evelyn Cheesman at Kokoda (Northern District of Papua), was added to the material and was described as *Parabryocoropsis cheesmanae* (China and Carvalho, 1951). A fifth species, collected by G. S. Dun and W. J. Hughes in the Markham Valley in 1951 was first thought to be a variety of *Pseudodoniella pacifica* China and Carv., but later it was described by N. C. E. Miller as *Pseudodoniella laensis* nov. spec. (Miller, 1957) (Plate 3B).

Of the aforementioned species, *Parabryocoropsis typicus* China and Carv. (known as Black Capsid in New Britain) (Plate 3A) appeared to be the most important pest. However, *Pseudodoniella pacifica* China and Carv. was found to be also quite numerous in some plantations, especially at somewhat higher levels (approximately 500 feet and above) (Dun, 1954*a*).

The bionomics of *Parabryocoropsis typicus* was thoroughly studied by Dun (1954*b*). The duration of the life cycle of this species is even shorter than that of the West African cacao mirids, *Sahlbergella singularis* (Hagl.) and *Distantiella theobroma* (Dist.) (Taylor, 1954).

The cacao mirids of New Britain feed mainly on pods, but *Parabryocoropsis typicus* was also observed attacking young shoots. Dun (1954*b*) recorded severe shoot and branch die-back in two plantations in New Britain. However, this type of damage by *Parabryocoropsis* is much less important than the injury to pods, and it is not connected with the attack of such serious pathogens as *Calonectria rigidiuscula*, which appears as a secondary fungus after the injury by *Sahlbergella singularis* and *Distantiella theobroma* in West Africa. The appearance of mirid damage in pockets of about 50 trees, as it is commonly observed in West Africa (Williams, 1953), is not so marked in the case of *Parabryocoropsis typicus* (Dun, 1954*b*).

The adults and neanides (nymphs) of *Parabryocoropsis typicus* and other New Britain cacao mirids suck the juice of the pods. Roundish black lesions appear on the surfaces of the pods as typical signs of dying tissue. This is apparently caused by a toxin injected into the plant tissues through the stylets of the insects (Henderson, 1954) (see figure 1). According to Dun (1954*b*) a large proportion of the damage is caused by the entry of a secondary fungus (*Gleosporium*, sp. ?) which is found in the punctures caused by the mirids.

Mirids, like most Heteroptera, are voracious feeders and a small number of individuals is sufficient to cause severe damage to a relatively large number of plants. According to Dun (1954*b*) the number of feeding scars per insect (in the case of *P. typicus*) varies from 40 to 80 a day. Thus, a population of 10 to 40 insects of *P. typicus* per tree is able to cause considerable damage. Reduction of yield in neglected and untreated blocks can be as much as 60 to 70 per cent. Fortunately *P. typicus* and all other cacao mirids of the Territory of Papua and New Guinea are susceptible to chlorinated hydrocarbon insecticides.

B.H.C. gives good control of *Parabryocoropsis typicus* (in the form of "Gammexane 10 Dust") and it can be applied with hand dusters or small hand power dusters because the trees are not very tall in New Britain. Such control would be impossible on West African cacao trees, but could be applied in some plantations in the Congo Republic (formerly Belgian Congo), where all chupons are removed above the first jorquette so that the trees very seldom exceed 12 feet in height. "Solvexane", an insecticide containing 2.2 per cent. of gamma isomer benzene hexachloride, is very effectively applied with hand dusters against *Sahlbergella singularis* Hagl. at Lukolela Plantations in the Congo Republic (Nicol and Taylor, 1956). *Distantiella theobroma* (Dist.), another African relative of the New Guinea cacao mirids, is also susceptible

[3] Recently G. S. Dun found this species on the Sogeri Plateau, in the Central District of Papua.

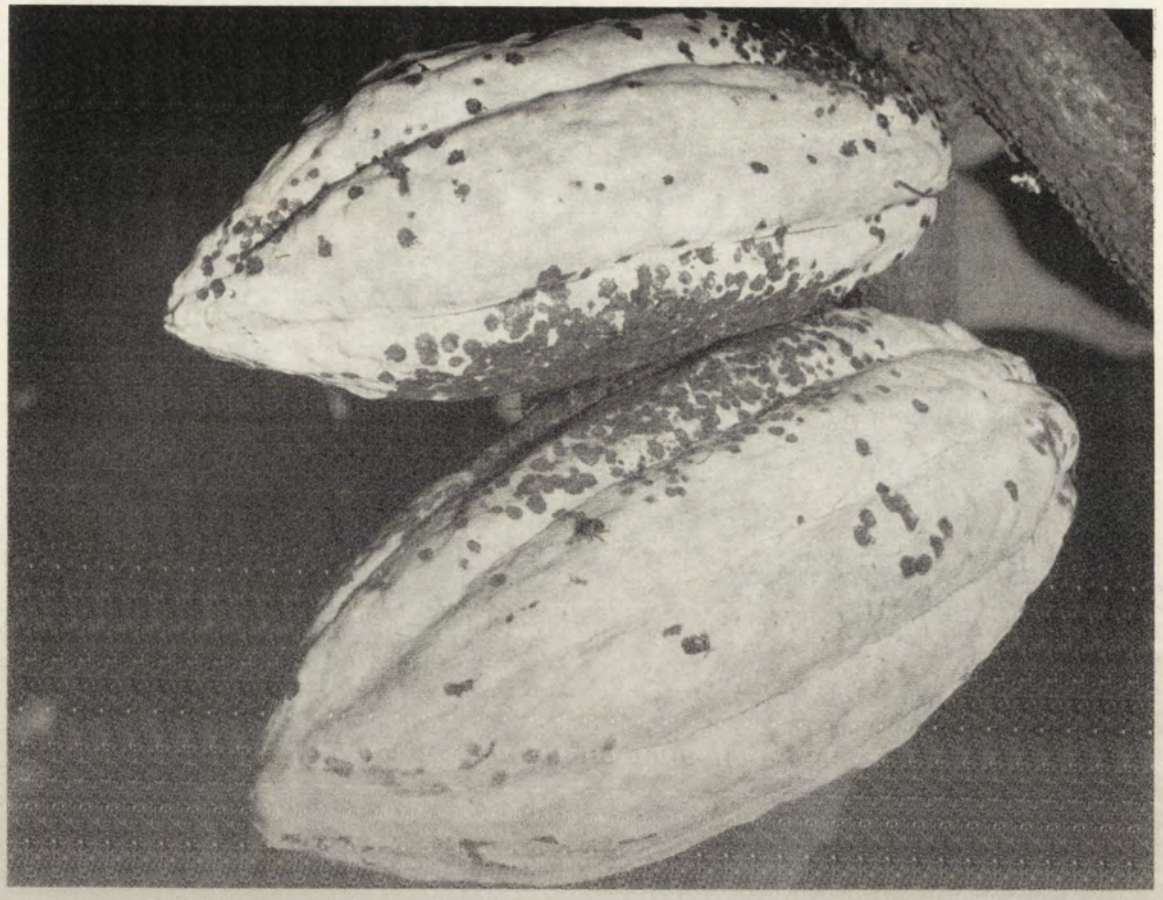
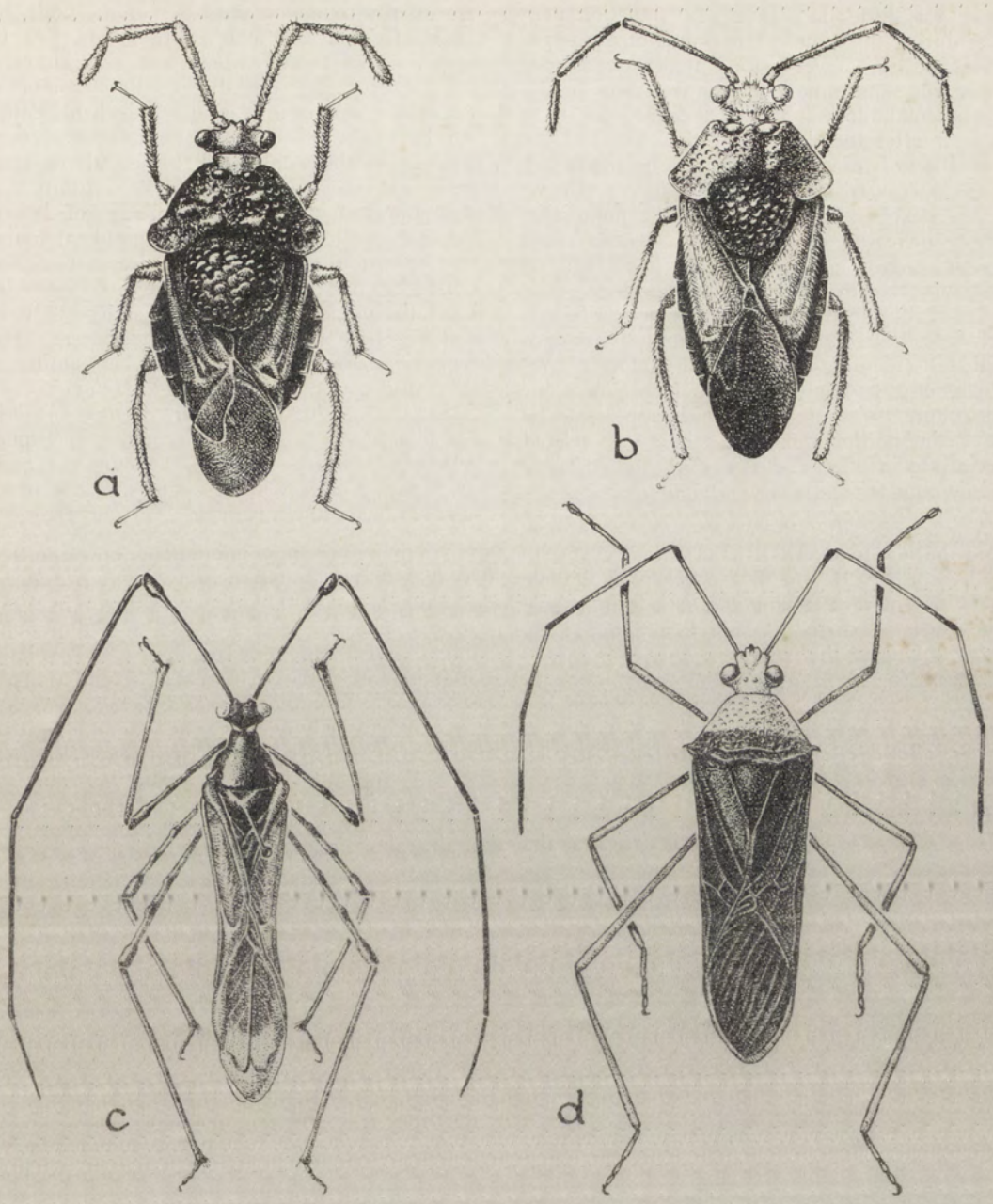


FIGURE 1.—*Injury to cacao pods by* Parabryocoropsis typicus *China & Carv.*
[Photograph L. Smee.]

to B.H.C., as was proved by field experiments carried out in 1955 and 1956 at the West African Cocoa Research Institute (Raw, *et al.*, 1956).

Dun experimented with the application of D.D.T. against *Pseudodoniella pacifica* (Dun, 1954*b*). A thrice-repeated application of 0.2 per cent. water-dispersible D.D.T. emulsion gave good control. Under Territory conditions, because of the rough terrain, the use of insecticides in the form of sprays is difficult. As mentioned above, B.H.C. is very effective against *Parabryocoropsis typicus* [4]. A dusting programme was worked out at Keravat during the past few years and this is regularly adhered to. The insecticidal treatment of the cacao blocks has no serious effect on the cacao flower-visiting insects, especially if the dusting is carried out in sections. This was proved by L. A. Bridgland and the author in an experiment at Lowlands Agricultural Experiment Station, Keravat (August, 1954). Regular counts of the populations of flower-visiting insects were carried out on a number of cacao trees in an experimental block for several days prior to the treatment of this block with B.H.C. against *Parabryocoropsis typicus*.

[4] As a result of more recent investigations in West Africa, it is suspected that B.H.C. causes a taint to cacao beans. No such observations were made in New Britain or any other part of the Territory of Papua and New Guinea. Investigations into this problem are in progress at Lowlands Agricultural Experiment Station, Keravat.




[Drawings by M. L. Szent-Ivany]

PLATE 3.

a. *Parabryocoropsis typicus* China. & Carv. (adult).*
b. *Pseudodoniella laensis* Mill. (adult).*
c. *Helopeltis clavifer* Walk. (adult).†
d. *Amblypelta theobromae* Brown (adult).‡

* 6 x Nat. Size. † 9 x Nat. Size. ‡ 4 x Nat. Size.

There was little fluctuation of population densities during this time. The counts of the populations of the flower-visiting insects were continued for some time after the treatment of the experimental block. The first count was made an hour after the dusting of the trees and the population of insects was found to be almost nil. There was a remarkable increase in populations on the next day, and after this the population density increased rapidly, so that within seven days it reached a slightly higher level than on the day before the treatment of the block. The flower-visiting insects at Keravat, amongst others, include a *Forcipomyia* sp. (Family Ceratopogonidae) (identification, courtesy of Dr. W. W. Wirth of the United States Department of Agriculture, Washington), which appears to be the main pollinating insect there, as related species are in other cacao-growing areas (Trinidad, West Africa, Java)[5].

A few years after the appearance of the new cacao mirids in New Britain, another species of Bryocorinae, *Helopeltis clavifer* Walk. (Plate 3c), was found attacking cacao pods in Papua. The damage occurred at Paili Plantation (Dun, 1954*b*). During the past four years, this species has been found in many other plantations in the Central and Northern Districts of Papua and it was also found feeding on sweet potato at higher altitudes (up to 3,400 feet) in the Morobe District of New Guinea.

In 1955, *Pseudodoniella laensis* Mill. appeared in very dense populations in a plantation in the Northern District of Papua, where it caused serious injury to cacao pods. The specimens of *P. laensis* collected in this area were first considered to represent a new species which has been named *Pseudodoniella szentivanyi* (Miller, 1957)[6]. Recent investigations by T. Odhiambo (1960) showed that *P. szentivanyi* is conspecific with *P. laensis*. The damage caused by *P. laensis* in the above-mentioned plantation resulted in a 70 to 80 per cent. crop reduction.

*Pseudodoniella laensis* has feeding habits similar to those of the other cacao mirids of the Territory of Papua and New Guinea. Neanides are usually found on the bases of the pods, but adults feed on any part of the pods. At the beginning of 1957, Ardley made some interesting observations on the feeding habits of *Pseudodoniella laensis* in the Markham Valley. Adults and various instar neanides were found feeding on the trunks and the laterals of cacao trees and they were capable of causing considerable damage. In the initial stage of damage the trees reacted by forming longitudinal lesions and by exuding gum from the deeper punctures caused by the adults and the late instar neanides. Later the gummy exudate dried and crystallized, and the bark became rough and pitted. This type of damage appears somewhat similar to the injury caused by the mirid, *Helopeltis ceylonensis* De Silva. However, as mentioned by De Silva (1957) this species (like its Papuan relative, *Helopeltis clavifer*) favours the pods, and feeding on leaves and stems is usually associated with insufficient shade over the trees.

There was a serious joint attack on cacao trees by *Helopeltis clavifer* and *Pseudodoniella laensis* at Sangara Estate (Northern District) in 1955-1956. The whole cacao block was thoroughly dusted with B.H.C. ("Gammexane 20 Powder") and the treatment was repeated several times at six-week intervals. *Pseudodoniella laensis* appeared to be more susceptible to B.H.C. than *Helopeltis clavifer*. Its populations decreased rapidly and no specimens could be found in the cacao block after the second application of B.H.C. When the dusting programme was completed, no more *Helopeltis* could be seen in the plantation, but after some months small populations began to re-enter the cacao block from the neighbouring rain forest. There was no sign of *Pseudodoniella laensis*. However, in 1959 this species appeared in another plantation in the Northern District, where it caused damage to pods. It was found in pockets similar to *Parabryocoropsis typicus* and *Pseudodoniella pacifica* in New Britain. The application of dieldrin spray was quite successful against *Pseudodoniella laensis* and the coreid, *Amblypelta theobromae*, which was attacking the pods simultaneously with the mirids (see paragraph D

[5] Other insects found in cacao flowers which might be of minor importance in pollen carrying are the aphid *Cerataphis* sp. near *rappardi* (H.R.L.), the chloropids *Botanobia* (?) sp. and *Gaurax* (?) sp., the braconid *Lipolexus* sp. (?), the ceraphronid *Ceraphron* sp. and a springtail of the subfamily Paronellinae (Family Entomobryidae).

[6] In this paper Miller revised the genera *Parabryocoropsis* and *Pseudodoniella* and transferred *Parabryocoropsis duni* China & Carv., and *Parabryocoropsis cheesmanae* China & Carv. to the genus *Pseudodoniella*.

of this paper). In 1959 *Pseudodoniella laensis* appeared in dense populations in a plantation in the Madang District, where it caused severe damage to pods and to the growing points of laterals. This outbreak occurred in association with an attack by an *Amblypelta* sp. More recently (June, 1960) Mr. R. T. Simon Thomas (Hollandia) kindly informed the author that he found *Pseudodoniella laensis* in the Manokwari District of Netherlands New Guinea, where it caused serious injury to the pods of *Theobroma cacao*.

Mirids have various enemies amongst predacious insects, but none of these are host specific. Dun (1954*b*) mentioned an attid spider, a reduviid (*Pristhesancus* sp.) and the Green Tree Ant [*Oecophylla smaragdina* (F.)] as the most important predators of *Parabryocoropsis typicus*. The author found the reduviid *Aulacagonia cheesmanae* Mill. preying upon the neanides of *Parabryocoropsis typicus* at Keravat. Four predacious insects, the formicid *Oecophylla smaragdina*, the pentatomid, *Amyotea reciprocus* Walk., the reduviid, *Euagorus* sp. and the asilid *Maira* sp. were found preying upon *Pseudodoniella laensis* Mill. and *Helopeltis clavifer* Walk. in the Northern District.

There is some indication that the ants, *Oecophylla smaragdina* F. and *Anoplolepis longipes* Jerd., have a controlling effect on the populations of *Pseudodoniella laensis* on cacao pods. They mainly act as disturbing factors against the flying adults, but there is no doubt that neanides are sometimes caught by *Oecophylla smaragdina*.

Several species of *Ficus* were found to be indigenous host plants of cacao Bryocorinae in New Guinea.

## C. CERAMBYCIDAE

Many species of the cerambycid subfamily Lamiinae ("Longicorn Beetles") invaded the cacao plantations of New Guinea from the surrounding rain forest during the last war. Some species attacked the stems of mature cacao trees, some smaller species were found as borers in the branches. The following species were identified by specialists of the Commonwealth Institute of Entomology, the British Museum and by Dr. J. L. Gressitt of the Bernice P. Bishop Museum: *Batocera nebulosa* Bates, *Batocera* sp., *Dihammus* sp. near *trigonus* Gressitt, *Dihammus strandiellus* Brng., *Dihammus* sp., *Glenea aluensis* Gah., *Glenea lefebueri* Guer., *Heteroclitomorpha punctata* Guen., *Monohammus* sp., *Oxymagis vitticollis* Fairm., *Pelargoderus arodensis* Thoms., *Sphingonotus* sp., *Tmesisternus yorkensis* Fairm. and *Tmesisternus* sp. The following species were collected on cacao trees and they are likely to be stem borers of *Theobroma cacao*: *Dihammus australis* Boisd., *Prosopus acuminipennis* Blanch, *Prosopus intermissus* Page, *Pterolophia mediochracea* Brng., *Tmesisternus bizonatus* Blanch and *Tmesisternus politus* Blanch.

Some years ago, Dr. J. L. Gressitt (Bernice P. Bishop Museum, Honolulu) began to study the taxonomy and distribution of Lamiinae in the Papuan Zoogeographical Subregion. Large collections were made by him and his field associates between the years 1955 and 1960 in the Territory of Papua and New Guinea. Another valuable collection of Lamiinae, obtained by the entomologists and other officers of the Department of Agriculture, Stock and Fisheries, was forwarded in 1959 to Dr. Gressitt for systematic study, and it is hoped that at the conclusion of his studies much more will be known of the taxonomy of the longicorn borers of Papua and New Guinea.

Serious damage by Lamiinae (especially by *Glenea aluensis*) was observed after the war in some cacao plantations in the Gazelle Peninsula of New Britain. The lack of plantation sanitation measures during the war resulted in the thickening of the shade. The Lamiinae are shade-loving species of the virgin rain forest. Most of the lamiid damage was found in cacao blocks, densely shaded by the foliage of fast-growing shrubs and trees of the rain forest, which rapidly invaded the plantations when they were abandoned by their owners.

Detailed observations on the damage by *Glenea aluensis* were made in the years after the war by Dun in New Britain. According to these, the larva of *G. aluensis* ringbarks the cacao branch, which dies or breaks off. On younger trees, borer damage occurs at the point of ramification. The end result is the complete collapse of the upper portion of the young tree, if subjected to light winds or heavy rain (Dun, 1951*b*).

Conditions similar to those found in the Gazelle Peninsula also occurred in some parts of the mainland of New Guinea. However, the general improvement of plantation sanitation after the war rapidly changed the whole picture.

With the gradual cleaning of the cacao blocks, the population density of Lamiinae in the plantations decreased from year to year and with the exception of *Glenea aluensis* (Plate 2C) in the Bismarck Archipelago and *Glenea lefebueri* (Plate 2D)[7] in the mainland of New Guinea many species of Lamiinae became minor pests of *Theobroma cacao* in the Territory. Odd specimens of the larger lamiids invade the plantations here and there; trees are attacked in small pockets on the borders of the plantations close to the rain forest and the secondary forest, causing setbacks in growth and even killing some trees if the symptoms are overlooked by the planter. Most plantation owners keep a close watch on the cacao trees near the edges of the plantations, and if they find trees attacked by Lamiinae they apply mechanical and chemical control measures.

## D. AMBLYPELTA THEOBROMA BROWN

During the past five years some species of the coreid genus *Amblypelta* Stal. appeared as pests of various cultivated plants in the Territory of Papua and New Guinea. Five of them (*Amblypelta theobromae* Brown, *Amblypelta costalis szentivanyi* Brown, *Amblypelta ardleyi* Brown, *Amblypelta cocophaga* China and *Amblypelta* sp. near *ardleyi* Brown) were found feeding on cacao pods. The New Guinea subspecies of *Amblypelta costalis* Van Duzee (the name form is only known from the small island of Bellona in the British Solomon Islands Protectorate), *Amblypelta theobromae* and *Amblypelta ardleyi*, were described by E. S. Brown (Commonwealth Institute of Entomology) in a comprehensive monograph of the genus *Amblypelta* Stal. (Brown, 1958*a*).

*Amblypelta costalis szentivanyi*, although common in cacao-growing areas of New Britain and the Northern District of Papua, rarely feeds on *Theobroma cacao* and nothing is known about the effect of injury by this species to the surface tissues of cacao pods. It is more often found feeding on *Manihot utilissima* (cassava), but the damage caused to this plant is not as extensive as it is in the case of *Amblypelta lutescens papuensis* Brown (Szent-Ivany and Catley, 1960*a*).

*Amblypelta theobromae* (Plate 3D and Figure II) is considered by E. S. Brown (1958*b*) to be a potentially serious pest of cacao pods. Fortunately, it has not a very wide area of distribution (parts of the Morobe District of New Guinea and of the Northern District of Papua) and it is susceptible to B.H.C. in the form of Gammexane 20 Dust, as was proved by W. A. van den Berk at Sangara Estate in 1956. It is also susceptible to dieldrin spray which is usually applied at present against *A. theobromae* in some plantations in the Northern District. E. S. Brown studied the feeding habits of this coreid in two plantations in the Morobe District in 1956 and the author had the chance to investigate a major outbreak in November, 1958. The symptoms of damage were described by Brown in a comprehensive paper dealing with the feeding habits and host plants of the species of the genus *Amblypelta* (Brown, 1958*b*).

The injury caused by *Amblypelta theobromae* to cacao pods is similar to that caused by *Parabryocoropsis typicus* and *Pseudodoniella* spp. but the brown scars on the surface of the pods in the case of *Amblypelta theobromae* appear to be larger and they are more evenly distributed. In contrast, the lesions, caused by mirids, especially by the neanides, are mainly found on and around the base of the fruit, where the insects seek shelter from the various predatory insects. In cases of severe pod damage by *Amblypelta theobromae*, scars may run together, forming large necrotic areas and according to Brown (1958*b*) a secondary fungus (*Gleosporium* sp. ?) may enter the lesions. If younger pods are severely attacked, they may become distorted (Figure III). Similar damage to pods is sometimes caused by the mirids *Bryocoropsis laticollis* Schum. and *Helopeltis bergrothi* Reut. in West Africa (Williams, 1953).

[7] These two species are sometimes found in plantations where sanitation measures are adequate. During a visit to a cacao block in the Sepik District in March, 1960, the writer found a large percentage of 3½-year-old cacao trees ringbarked by the larvae of *Glenea lefebueri* Guer. At least every third tree showed recent or earlier signs of ringbarking near ground level on the main stem. Only a few trees died but many showed a setback in growth. The *Leucaena* shade was healthy, not too thick, and the undergrowth was cut short. Similar conditions were found by the writer in a cacao block in the Bougainville District in 1956. The damage there was caused by *Glenea aluensis* Gah.

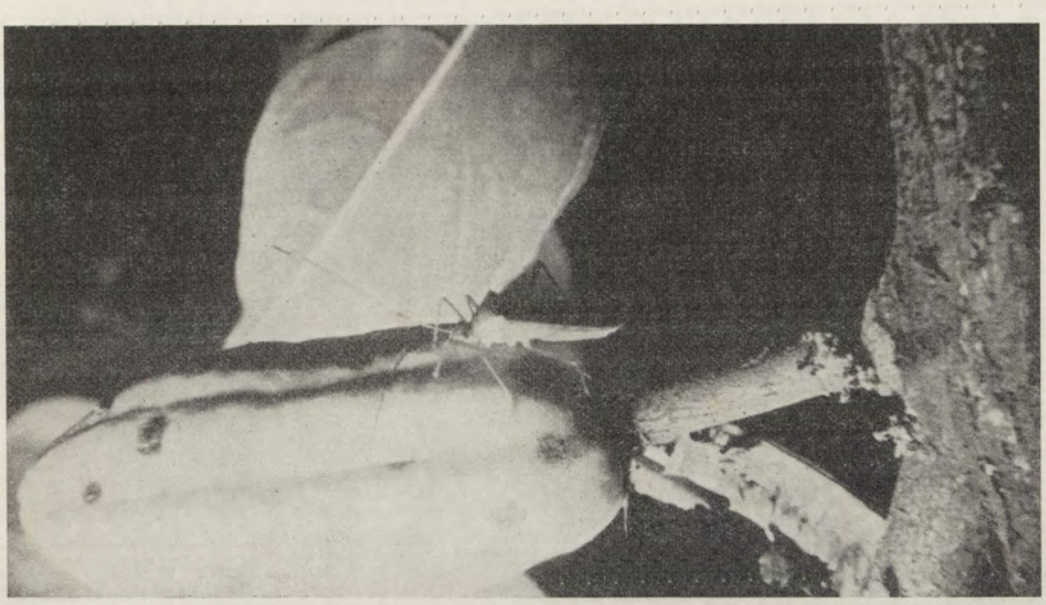


FIGURE II.—*Injury to cacao pod by* Amblypelta theobromae *Brown (with feeding adult).*

[Photograph C. S. Edwards.]

FIGURE III.—*Distortion of young cacao pods following attack by* Amblypela theobromae *Brown, with adult resting on the pod.*

[Photograph J. Stackhouse.]

Similar observations to those of Brown (1958*b*) regarding the protection of cacao trees by *Oecophylla smaragdina* against *Amblypelta theobromae* were made during a visit by the author to the Northern District in 1958. In the plantation where the above-mentioned major outbreak of *Amblypelta theobromae* occurred, only a very small percentage of cacao trees had *Oecophylla* populations. Most trees were occupied by the smallish, black, inoffensive ant, *Technomyrmex detorquens* (Wlk.). It was found that the few trees which were overrun by *Oecophylla* had healthy pods; they had very little or no *Amblypelta* damage.

*Amblypelta theobromae* did not appear in pockets in the above-mentioned plantation, as is the habit of certain mirids in Africa and in New Guinea; the species was fairly evenly distributed in the whole plantation. Both neanides and adults were feeding on cacao pods. Up to four adults were found feeding on one pod. Many copulating pairs were seen on pods. It was found that *Amblypelta theobromae*, being a native of the rain forest, is a heliofugus, shade-loving species. Thus, too thick shade can promote the increase of populations in cacao blocks. The outbreak described here was partly due to the excessive shade in the plantation. The owner recognized this fact at an early stage of the outbreak, because the thinning of the shade was in progress during the time of the author's visit.

In 1959, the author found a joint outbreak of *Pseudodoniella laensis* and an *Amblypelta* sp. at Amele village plantation in the Madang District. The latter was identified by Dr. Ghauri (Commonwealth Institute of Entomology, London) as a species near *Amblypelta ardleyi* Brown, which represents a new species. Thorough spraying of the plantation with dieldrin eliminated both the mirid and the coreid from the plantation area.

Recently (March, 1960) J. H. Ardley observed a specimen of *Amblypelta ardleyi* feeding on a cacao pod and G. S. Dun (June, 1960) found *Amblypelta cocophaga cocophaga* China feeding on cacao pods in a plantation in the Bougainville District (personal communication by Mr. Ardley and Mr. Dun). *A. cocophaga cocophaga* appeared on cacao pods in a plantation where cacao is planted under the shade of coconut palms. The palms showed symptoms of severe premature nutfall. Similar observations were made by E. S. Brown in the British Solomon Islands (Brown, 1958*b*).

## II. LOCAL OUTBREAKS AND MINOR PESTS

### A. COLLEMBOLA

The entomobryid, *Salina celebensis* Schaf., was observed causing some leaf shedding in New Britain (Dun, 1951*b*, 1954) and in the Markham Valley. According to Dun (1951*b*) both mature and immature stages feed on the under surfaces of the leaves. They etch away the lower epidermis and the leaves become yellow and may die. Similar observations were made by the author in the Markham Valley.

Two unidentified dolichopodids were observed preying upon this springtail at Keravat.

### B. ORTHOPTERA

The polyphagous cricket, *Cardiodactylus novaeguineae* Haan, is a minor pest of the foliage of young cacao trees and a mole cricket (*Gryllotalpa* sp. near *borealis*) sometimes causes injury to seedlings. The phasmid, *Anchiale maculata* Oliv., is a widespread minor pest of cacao foliage in the Gazelle Peninsula of New Britain (personal communication by Mr. Dun). Recently, the acridiid, *Dermopterella onplicata* Kairsch, *Stenocatantops angustifrons* Walk. and *Valanga papuasica* Finot., were found defoliating cacao trees in a plantation in the Gulf District. The cacao trees were simultaneously attacked by the larvae of the limacodid, *Pinzulenza kukisch* Hering.

### C. ISOPTERA

A large termite, *Calotermes papua* Desneux, was recorded 20 years ago by Froggatt (1938*b*) as attacking the trunks of mature trees (See also Hill, 1942). *Microtermes biroi* (Desn.) was found on one occasion attacking a cacao branch. This was most likely a secondary attack following *Pantorhytes* borer damage. At least two species of *Neotermes* were found in New Britain, New Ireland and in the Morobe district attacking cacao as primary pests; the taxonomy of these species is still under investigation by overseas specialists. These termites are the cause of considerable damage over quite extensive areas in the Bismarck Archipelago, but again their control is largely a matter of plantation hygiene and regular inspection and treatment.

## D. HEMIPTERA

A few Heteroptera were recorded as minor pests of cacao. These are : the coreid, *Priocnemicoris flaviceps* Guer., the lygaeids, *Astacops flavicollis* Walk. and *Lygaeus pacificus* Boisd., and the pentatomids, *Austromalaya* sp. and *Nezara viridula* L. (Dun, 1951*a*). All of these feed only occasionally on cacao, mainly on young trees : they all have some other more important host plants. The coreids, *Brachylybas inflexus* Blote, *Acanthotyla* sp. and *Sciophyrus* sp., were frequently observed on the stems of cacao pods, attacked by *Amblypelta theobromae* and by mirids, but the damage caused by these three coreids is insignificant. The pentatomid, *Brachyplatys translineatus* Walk. (Subfamily Plataspidinae), was found by the author in very dense populations on cacao pods in a plantation on Lihir Island (New Ireland District) but the species has not caused serious damage to pods. The coreid, *Leptoglossus australis* (F.), is an occasional feeder on young shoots, leaves and stems of seedlings, but it has never been found on pods (Szent-Ivany and Catley 1960*b*).

Amongst the Homoptera, many species of various leafhopper families (Cercopidae, Cicadellidae, Delphacidae, Derbidae, Membracidae, Flatidae, Ricaniidae, etc.) are found feeding on the leaves, branches and pods of cacao trees in the Territory of Papua and New Guinea, but so far none of these have caused significant damage. Only a few were identified. Such are : *Armacia basigera* Walk., *Armacia* sp., *Clovinia fasciata* Lall., *Colgar tricolor* Dist., *Colgar* sp., *Euphanta pokiana* Dist., *Euricania splendida* F., *Euricania* sp., *Paratella miniata* Mcl., *Paratella nivosa* Wath., *Ricania integra flavida* Mel., *Selenocephalus* spp., *Zoraida punctipennis* Walk. and *Zoraida* sp. Many more species were collected on cacao and these are awaiting identification by specialists.

It should be mentioned here that careful observations should be made on the spread and growth of the populations of these and other leafhoppers (especially Cicadellidae) in the cacao plantations in the Territory of Papua and New Guinea, because some species in other parts of the world (West Indies, South America, etc.) are major pests of cultivated plants, and recently one or two species of the genus *Selenocephalus* appeared to cause quite severe damage to the tissues of *Coffea arabica* plants in the Eastern Highlands of New Guinea.

Among the aphids, *Toxoptera aurantii* B. de Fons. was recorded by Dun (1954*a*) as a common and widely distributed species in New Britain on cacao foliage, but it never caused any serious damage. *Toxoptera aurantii* was found as a pest of cacao in other parts of the South Pacific region. Laing (1927) recorded it on cacao leaves from Apia, Western Samoa. The author found it on *Camellia sinensis* in the Eastern Highlands of New Guinea. Other aphids found on cacao are *Cerataphis* near *rappardi* (H.R.L.) and *Cerataphis variabilis* H.R.L.

Scales and mealy bugs (Coccidae) were recorded from various parts of the South Pacific region (Wallis, Tonga, Fiji) as minor pests of cacao leaves and pods (Cohic, 1950 ; O'Connor, 1949 ; Lever, 1946). The first mealy bug record in the Territory of Papua and New Guinea was by Froggatt in 1938 (a species feeding on cacao pods in New Britain). A few more species were found recently by entomologists of the Department of Agriculture, Stock and Fisheries (Szent-Ivany, 1956*b*).

*Planococcus citri* (Risso) and *Ferrisiana virgata* (Ckll.), known as vectors of the swollen shoot disease in West Africa (Strickland, 1951) and as vectors of a strain of this disease in Ceylon (Newton and Peiris, 1953 ; Carter, 1956), were found on *Theobroma cacao* in the Territory of Papua and New Guinea, but neither these nor any other species appeared to be virus carriers in the Territory. In a few isolated spots, *Planococcus citri* and *Planococcus lilacinus* (Ckll.) were observed causing some injury to the tips of laterals of cacao trees (Szent-Ivany and Catley, 1960*c*). The main predator of *Planococcus citri* in the Markham Valley (Morobe District) seems to be the coccinellid, *Cryptolaemus affinis* Crotch. The damage caused by mealy bugs to the growing points perhaps allows the entrance of secondary fungi. Investigations into this are being undertaken by the plant pathologists of the Department of Agriculture, Stock and Fisheries.

Other Coccidae, found in recent years in the Territory of Papua and New Guinea on cacao, are : *Ceroplastodes chiton* Green (mainly on stem of pods ; Northern District, coll. F. J. Simmonds and J. J. H. Szent-Ivany), *Criniticoccus theobromae* Williams (Williams, 1960), *Eriochiton* sp. (Bainings, New Britain, coll. J. H. Ardley), *Maconellicoccus hirsutus* (Green)

(growing point of young trees ; Northern District, coll. J. J. H. Szent-Ivany), *Mutabilicoccus* sp. (on pods tended by *Oecophylla smaragdina*) *Planococcus* sp. (on pods ; Bainings, New Britain, coll. J. J. H. Szent-Ivany) and *Pseudococcus* sp. (on pods ; Bougainville, coll. J. H. Barrett).

*Maconellicoccus hirsutus* was associated with an *Iridomyrmex* sp. as a nursing ant. A *Planococcus* sp., covering cacao pods in a plantation in the Bainings Area of New Britain, was tended by large numbers of very offensive Kurukum Ants (*Oecophylla smaragdina*). The surfaces of some pods were completely covered with the mealy bugs, but, when opened, the pods were found to be perfectly healthy. *Iridomyrmex nitidus* Mayr. was found as a nursing ant on an unidentified pseudococcid in the Maprik Subdistrict of the Sepik District.

## E. LEPIDOPTERA

### A. Limacodidae (Local Outbreaks)

Some species of Limacodidae ("Cupmoths", "Nettle Caterpillars") at times cause serious defoliation of cacao trees in Papua and New Guinea. Fortunately, they appear as pests in relatively small areas and the outbreaks are usually of short duration. Control is achieved by the application of chlorinated hydrocarbon insecticides (most species are susceptible to D.D.T.) or the population density of the pest is kept below the level of economic importance by natural enemies.

A joint attack by a cassidid (*Aspidomorpha testudinaria* Montr.) and by the caterpillars of a minute limacodid, which appeared to represent a new genus (as yet undescribed), resulted in the complete defoliation of a 100-acre block of cacao trees (see figure IV). When the author visited the plantation in November, 1954, the cacao trees were leafless. Most larvae of the limacodid were killed by a D.D.T. spray applied by the owner one day earlier ; many larvae were dying because of lack of food and concretions of 12 to 15 cocoons were found on the tips of the dry branches. Two hymenopterous parasites (*Brachymeris salomonis* Cam. and *Eurytoma albotibialis* Ashm.) were bred from cocoons collected on the cacao trees at the edge of the plantation. The outbreak lasted a few months only and the species has not been reported from the Bogia Subdistrict during the past six years.

Figure IV.—*Complete defoliation of mature cacao tree by Limacodid larvae.*

[Photograph J. J. Szent-Ivany.]

Another small limacodid, *Pinzulenza kukisch* Hering, appeared in the second half of 1958 as a serious defoliator of cacao trees in plantations at Kar Kar, a volcanic island near the coast of New Guinea in the Madang District. This species appeared also in vast populations in a plantation in the Gulf District of Papua where it attacked cacao foliage jointly with three acridiids (see also under "Orthoptera"), causing almost complete defoliation (Szent-Ivany, 1959). In December, 1959, *Pinzulenza kukisch* was found attacking cacao trees in a plantation on the North Coast of the mainland of New Guinea, opposite Kar Kar Island, in the Madang District. On Kar Kar and in this plantation, the cacao trees were planted under the shade of coconut palms. At the plantation on the North Coast of New Guinea there was a definite positive correlation between the high population density of *Pinzulenza kukisch* and inadequate shade conditions. The main foci of the outbreak were along the main road passing through the plantation, where the shade was insufficient and in a few areas where many coconut palms were killed by lightning, resulting in complete lack of shade. *Pinzulenza kukisch* is susceptible to dieldrin as was proved in this plantation, where it was applied with knapsack sprays and swing fog machines. The main parasite of *Pinzulenza kukisch* in the Madang District is the chalcidid, *Brachymeris salomonis*.

It is believed that *Pinzulenza kukisch* and the species found in the Bogia Subdistrict—similar to many other limacodids of the Indo-Australian Region—feed as a rule on coconut fronds, and at times dense populations of gravid females swarm down from the crowns of the palms to the cacao trees, covering almost every leaf with eggs.

The local outbreaks of two other larger limacodids (*Scopelodes* sp. and *Parasa lepida* Cr.) were earlier recorded by Froggatt (1940) and Dun (1953).

In recent years the limacodid, *Mambara inconspicua* B. Bak., appeared to cause defoliation of cacao trees in some plantations in the Markham Valley (Morobe District). The caterpillars virtually skeletonized the leaves. However, the damage seemed to have appeared in smaller or larger pockets and various predacious insects were observed by Ardley keeping the population density almost under the level of economic importance. The two main predators were the pentatomid, *Platynopus melacanthus* (Boisd.), and the pyrrhocorid, *Dindymus pyrochrous* (Boisd.).

### B. Other Lepidoptera

The xyloryctid, *Pansepta teleturga* Meyr. (see damage figure V), and the cossid, *Zeuzera coffeae* Nietn. (and probably some other unidentified species of this genus), are found at times as minor pests of *Theobroma cacao* (feeding on the bark and boring in the branches). Dun (1951*b*, 1955) and the author found that *Pansepta teleturga* Meyr. mainly attacks cacao in insufficiently shaded plantations. It is recorded from the New Britain, Madang and Milne Bay Districts. The author found the braconid, *Ipobracon* sp., as a parasite of this species.

G. S. Dun and A. Catley found two aegeriid stemborers at Keravat in 1958. The species were identified in the British Museum as *Conopia theobroma* Brad. and *Conopia* sp. near *chrysophanes* Meyr., both representing new economic records for the Territory of Papua and New Guinea. A parasite associated with the two species was identified in the British Museum as *Apanteles* sp. near *abdominalis* F.

Various leaf and pod-eating caterpillars were recorded from cacao in the Territory of Papua and New Guinea. These are the geometrid, *Boarmia bhurmitra* Wlk. ; the noctuids, *Achaea janata* L., *Earias citrina* Saalm., *Heliothis armigera* Hb., *Prodenia litura* F. and *Tiracola plagiata* Wlk. ; the eucosmid, *Laspeyresia* sp. (recorded by Froggatt, 1938*b*, boring into the shells of pods); the lithosiid, *Lithosia* sp.; the lymantriids *Dasychira horsfieldi* Saund. (Subsp.?), *Euproctis* spp. and *Orgyia postica* Walk.; the tortricid, *Cacoecia* sp.; the olethreutid *Olethreutes* sp.; the lithocolletid, *Acrocercops cramerella* Smith, and a number of unidentified psychids.

*Achea janata* L. was found by Dun (1951*b*) defoliating young trees 18 to 36 months old. This, and most other leaf-eating caterpillars of cacao, can be controlled with D.D.T.

### F. COLEOPTERA

Beetles were found damaging almost every part of the cacao plant in the Territory of Papua and New Guinea. The most important stem and branch borers were mentioned amongst the major pests. Froggatt (1938*a*, 1938*b*) recorded the curculionid, *Orthorhinus patruelis* (Pasc.), as an occasional borer in the branches of

FIGURE V.—*Injury to cacao branches by* Pansepta teleturga *Meyr.*

[Photograph L. Smee.]

*Theobroma cacao.* This species was also found as a borer in the branches and stems of *Coffea canephora.* Larvae of the curculionid, *Meroleptus squalidus* Mshl., were found as borers in the branches of mature cacao trees, severely attacked by *Pantorhytes szentivanyi.* Adults of this species are often found chewing the surface tissues of cacao pods, but both larva and adult can be considered minor pests only. The curculionid, *Nechyrus notatus* Pasc., has been bred from a dead cacao branch by B. A. O'Connor at Keravat.

The dynastids, *Oryctes rhinoceros* (L.), introduced about 1943, and *Xylotrupes* spp., were recorded feeding on the bark of cacao trees. A scoliid, *Scolia ruficornis* F., was introduced from Zanzibar in 1953 for the control of *Oryctes rhinoceros* (L.) which is a major pest of coconuts in some areas of the Bismarck Archipelago. Suspected indigenous parasites of *Oryctes* and *Xylotrupes spp.* are *Triscolia sausserei* Grib. and *Scolia schlechteri* Betrem. (identified by J. van der Vecht). Another suspected indigenous parasite is *Scolia pulchripennis* Cam.

Roots of young cacao trees are sometimes attacked by the larvae of Melolonthidae. Eighty per cent. of one-year-old seedlings in a cacao block in the Northern District of Papua were killed in a relatively short time by the root-eating larvae of a cockchafer in 1956. The melolonthid represented a new species and it was described as *Dermolepida noxium* Brit. (Britton, 1957). A *Campsomeris* sp. (Scoliidae) was found as an ectoparasite. The chemical control of this beetle is very difficult because the larvae of *Dermolepida noxium* can be found as deep as three feet under the surface of the ground. On account of the great loss, the above-mentioned

cacao block had to be abandoned. Fortunately, this was a local outbreak, restricted to a small area and the damage by *Dermolepida noxium* to cacao roots has never been observed again. However, the species was collected recently in the Madang District. A. Catley found another *Dermolepida* sp. damaging cacao roots in a plantation near Abau (Central District, Papua) in March, 1959.

Beetles of various families are found feeding on the surfaces of pods. The rutelids, *Parastasia inconstans* Fairm. and *Parastasia marmorata* Gestro, were mentioned by Froggatt (1940), chewing the surface tissues of cacao pods. The curculionids, *Mecopus doryphorus* Quoy and Gaim. and *Pantorhytes* spp., and some unidentified anthribids, bruchids and curculionids were observed feeding on the surfaces of pods, in many cases as secondary pests after mirid (capsid) damage (Dun, 1954*b*).

Many beetles attack the foliage of *Theobroma cacao* in the Territory of Papua and New Guinea, but they are all minor pests which can be easily controlled with chlorinated hydrocarbon insecticides. These are the curculionids, *Apirocalus cornutus* Pasc., *Balaninus* sp., *Exophthalmida glauca* Fst., *Elytrocheilus coeruleatus* Pasc., *Eupholus browni* Bates, *E. schonherri* Guer. (var.), *Idiopsis coerulea* Fst., *Idiopsis grisea* Fst., *Oribius cruciatus* Fst., *Paratactus lihirensis* Mshl., *Paratactus* sp., *Platyachus papuana* Oberth., *Platyachus ruralis* Fst., *Pseudoporopterus* sp., *Rhinoscapha bifasciata* Chev., *Rhinoscapha schmeltzi* Fairm. and *Rhinoscapha thomsoni* Waterh.; the cetoniid, *Glycyphana* sp.; the rutelids, *anomala aenotincta* Fairm., *Parastasia inconstans* Fairm. and *P. marmorata* Gestro; and the chrysomelids, *Rhyparida basalis* Baly, *Rhyparida coriacea* Jac., *Rhyparida impressipennis* Bry., *Rhyparida impuncticollis, Rhyparida obscuripennis* Bry., *Rhyparida* sp. near *quadraticollis* Arrow, *Stethotes* sp. (Subfamily Eumolpinae), *Microlepta* sp., *Monolepta semiviolacea* Fauv., *Prasyptera antennata* Jac. (Subfamily Galerucinae), *Podagrica* sp. near *psyche* Baly, *Sutrea* sp. (Subfamily Alticinae), *Aspidomorpha socia* Montr. and *Aspidomorpha testudinaria* Montr. (Subfamily Cassidinae.)

The tortoise beetle, *Aspidomorpha testudinaria* Montr., and other Cassidinae in the Territory of Papua and New Guinea prefer *Ipomoea batatas* and other *Ipomoea* species as host plants. In some years there is competition between the large caterpillars of the sphingid *Herse convolvuli* L. and the larvae and adults of Cassidinae in areas where sweet potato is grown. The Cassidinae are forced to look for subsidiary host plants. This was observed in 1953 and 1954 in some parts of the Madang District (personal communication by Mr. R. Vicary). The adults of *Aspidomorpha testudinaria* Montr. found their way to *Theobroma cacao* as a subsidiary host plant and they caused quite severe defoliation (Szent-Ivany, 1954).

The celeuthetin weevil, *Apirocalus cornutus* Pasc., one of the most polyphagous and eurythermous curculionids on the mainland of New Guinea, is able to cause severe setback in growth to young cacao and coffee trees by feeding on the growing points. A very extreme case was observed by Fielding, Henderson and the author in a cacao block in the Northern District of Papua. A joint attack by *Apirocalus cornutus* Pasc. and by two other unidentified celeuthetin weevils caused a very serious setback in growth to one-year-old cacao trees in this plantation. The area under the growing point was simultaneously attacked by the mealy bug, *Maconellicoccus hirsutus* (Green). The portion of the top shoot underneath the dying growing point was completely distorted as a result of the damage by the pseudococcid. Similar damage to the growing points of young cacao trees by the curculionid, *Platyachus ruralis* Fst., was recorded from New Britain (Dun, 1951*b*).

*Paratactus lihirensis* Mshl. appeared in very dense populations in cacao blocks on Lihir Island (New Ireland District) in 1955, causing considerable damage to the foliage of young trees.

Many more leaf-eating chrysomelids and curculionids found on the foliage of *Theobroma cacao* in the Territory of Papua and New Guinea are awaiting identification and description by specialist taxonomists.

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The Leafcutter Bee, *Megachile frontalis* F., was observed causing damage to cacao foliage in a plantation on Lihir Island in the New Ireland District (Michener and Szent-Ivany, 1960).

A small ant (*Pheidologeton* sp.) was found feeding on cacao seeds in the ground in the Northern District of Papua. The role of ants in the control of Heteroptera and their activities as "Nursing Insects" of Coccidae was mentioned in other paragraphs of this paper.

## SUMMARY

The intensive study of insect pests of cacao in the Territory of Papua and New Guinea began after the last war, although a few records were published some years earlier.

There is no serious regional pest of *Theobroma cacao* in the Territory. Some insects have to be considered major or important pests, but their occurrence is restricted to certain limited areas. All these are indigenous species of the lowlands rain forest and many of them invaded the cacao blocks during the war, when the plantations were abandoned and there was complete lack of plantation hygiene.

The most important cacao pests of the Territory of Papua and New Guinea are three Stem Borer Weevils, species of the Pachyrrhinchine genus *Pantorhytes* (*P. plutus* Oberth., *P. proximus* Fst. and *P. szentivanyi* Mshl.). *Pantorhytes plutus* Oberth. was recorded from various parts of the Territory, but, as a pest, it is restricted to New Britain. *P. proximus* Fst. is restricted to the Morobe District and *Pantorhytes szentivanyi* Mshl. to the Northern District. The *Pantorhytes* spp. have no known effective parasites and their chemical control is difficult. Experiments with chlorinated hydrocarbon and organic phosphate insecticides are in progress at two experiment stations of the Department of Agriculture, Stock and Fisheries. The species of the genus *Pantorhytes* are inclined to build up large populations in somewhat neglected cacao blocks and improvement in plantation sanitation helps greatly to reduce their population densities.

Another group of important pests consists of four species of Miridae (Capsidae) of the subfamily Bryocorinae. These mainly attack cacao pods. Some of these, under certain conditions, are able to cause up to 70 to 80 per cent. reduction in yield. One species (*Helopeltis clavifer* Walk.) is known from various parts of Papua and it was found on host plants other than cacao in the Morobe District of New Guinea up to an altitude of 4,000 feet above sea level. The species, *Pseudodoniella pacifica* China and Carv., is restricted to New Britain. *Pseudodoniella laensis* Mill. was found in the Northern, Morobe and Madang Districts and recently it was also reported from the Manokwari District of Netherlands New Guinea. *Parabryocoropsis typicus* China and Carv. is the main cacao mirid of New Britain, but recently it was found also in the Central District on a native host plant. All cacao mirids of Papua and New Guinea are susceptible to B.H.C. and their population density can be kept under the level of economic injury by regular dusting of the affected plantations. *Pseudodoniella laensis* was proved to be susceptible to dieldrin and *Pseudodoniella pacifica* to D.D.T.

Cerambycidae of the subfamily Lamiinae appeared in dense populations in many cacao plantations during the last war, causing severe damage to stems and branches. Their appearance was mainly connected with the increasing shade as a result of lack of plantation hygiene. Better sanitation measures, however, changed the conditions during the years after the war and at present only two species can be considered major pests. These are *Glenea aluensis* Gah. in the Bismarck Archipelago and Bougainville and *Glenea lefebueri* Guer. in the mainland of New Guinea.

In recent years, a coreid, *Amblypelta theobromae* Brown, became adapted to *Theobroma* cacao as a host plant, and it appears to be quite troublesome in the Morobe District of New Guinea and in the Northern District of Papua. It attacks the pods. *Amblypelta theobromae* is susceptible to B.H.C. and dieldrin and the Green Tree Ant or "Kurukum" (*Oecophylla smaragdina* F.) gives some protection to cacao trees against this pest.

All other cacao insects found in the Territory of Papua and New Guinea can be considered minor pests. Some of them (Limacodidae, Melolonthidae, Curculionidae) appear at times in sudden severe outbreaks, but these outbreaks are usually of short duration and they are restricted to small areas, often to one or two plantations only.

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