INSECTS ASSOCIATED WITH THE COCO-NUT PALM.

PART II.

By John L. Froggatt, B.Sc. and B. A. O'Connor, B.A., B.Sc.Ag.,
Department of Agriculture, Rabaul.

In this series of articles it is intended to deal with all insects which have been found in direct association with the coco-nut palm in this Territory. Part I. dealt with the coco-nut tree-hopper, *Sexava* spp. In this part, the major pests of the coco-nut are continued with species of *Hispidae* (Coleoptera), the one of greatest importance to this Territory being *Promecotheca papuana,* Csiki.

PROMECOTHECA PAPUANA, CSIKI.

Damage by this pest is twofold. The grubs, being true leaf miners, feed in between the two layers of the leaf causing large areas of dead tissues and the adult beetles feed on the surface tissue, which leads to the destruction of appreciable areas of leaf tissue when the beetles are numerous. With a heavy infestation, the palm fronds appear brown, as if scorched by fire, especially when viewed from a distance.

Palms of any age may be attacked by this pest, and although the attack in most cases is relatively mild, there are places where the damage caused has been of particular economic importance, causing loss of palms. There are always contributing factors in such cases. For instance, at the end of 1937 there was a heavy infestation over areas which received deposits of volcanic dust from the eruption in Blanche Bay in May, 1937. Torrential rain followed the eruptions, and caused heavy washaways of the pumice soils in the hills. The washed dirt smothered the butts of palms along the foreshores to a depth of several feet and in these places in particular, a large number of palms failed to survive the eruption damage followed by severe *Promecotheca* infestation. The pest was brought under control by parasites in from three to four months, varying with the intensity of the attack; areas outside those affected by the eruption dust and wash had little more than the usual pest population, and on the fringes, where the population was somewhat greater, the indigenous parasites quickly controlled the infestation.

This pest is known in the New Britain, New Ireland and Manus Districts of the Territory, but is more generally marked in the Manus areas than elsewhere. In New Ireland it has never been reported, to date, in plague proportions, parasites apparently affording a high degree of control, as they do in most parts of New Britain.

Native hosts of *P.papuana* are the sago palm, *Metroxylon sagu,* and the nipa palm, *Nipa fruticans.* Although these are not generally attacked as heavily as the coco-nut palm, they undoubtedly act as a focus of reinfestation wherever found adjacent to plantations.

In one case, where the beetle population was extremely large, eggs were laid on the foliage of oil palms, *Elaeis guineensis,* and, although larvae emerged and penetrated the leaf tissue, they only survived for one day.

Life History and Habits.

A considerable amount of research has been done on this pest in the Manus, Rabaul and Gasmata areas, as well as observations made in the field in other areas.

The Eggs.

The eggs are brown with a thick "skin", and measure about 2.5 to 3mms. in length. They are laid flat on the undersurface of the foliage usually two or three together, although in some localities four and even five have been not uncommon in the one egg mass. The eggs are covered with a dome shaped mass of frass, the whole measuring from three to four mms. in diameter; the eggs always lie parallel to one another. The egg covering is too thick to permit of observations of the developing embryo.

The egg stage has been found to occupy eleven to seventeen days, the average for all localities being sixteen days.

The Larvae.

The larva is light yellowish in colour with the head brown; the anterior portion of the body is the widest, the posterior segments tapering off; the adult larvae measure 12 mm. in length.

On emergence the larvae penetrate the leaf surface, and feed on the tissue between the upper and lower surfaces of the leaf, thus causing these two layers to separate and die, forming a brown "blistered" area on the leaflets where feeding has taken place. Feeding takes place along the veins of the leaves.

Development of the larvae takes place in three stages, or instars, with a resting period between the first and second instars, and second and third instars, and between the mature third instar larva and the formation of the pupa, known as the pre-pupal period.

The age of the foliage in which the larvae feed appears to influence the length of time passed in the three developing stages, as shown in the following table, in which the periods are given in days, and represent the average for a number of observations made in the Manus District; figures for feeding in mature foliage in New Britain are given in column 4.

—	Young Foliage.	Manus— Mature Foliage.	New Britain— Mature Foliage.
First instar	5.0	8	7.5
Rest	2.6	3	2.5
Second instar	2.8	5	9.2
Rest	2.75	3	3.0
Third instar	6.8	10	8.6
Prepupal and pupal periods	15.75	15	15.0

During the "rest" periods, the larvae retreat from the head of the mine to cast the skin ("moult"); during this time the edge of the area where feeding has been taking place shrivels and hardens, and when feeding recommences this is marked on the wall of the mine as a distinct transverse line, providing a ready means of determining at what stage of development the larvae in the mine have

reached at any time. Due probably to this hardening of end tissue, larvae that have just transformed into the second instar are often unable to penetrate this tissue and die.

The larval stages occupy an average of 27 days, with a range of seventeen to thirty days.

The Pupa.

The pupa is brown in colour, and may be present anywhere in the wider portions of the mine; it exhibits a degree of free movement if disturbed.

The prepupal and pupal period occupies fourteen to fifteen days.

A complete life cycle, from laying of egg to emergence of adult, occupies 52 to 63 days; average 60 days.

The Adult.

The adult beetle measures about 1 c.m. in length and .3 c.m. in width at the widest part over the folded elytra (wing covers); the posterior third of the elytra and the thorax and head are dark blue-black in colour, the remainder of the wing covers varying from yellow to orange in colour. In the Manus District, a colour variant has been noted in which practically the whole body is brownish yellow. The thorax in some cases shows a lighter brownish black in colour. The basal half of the antennae is brown with the apical half black.

After emerging from the pupae, the adults remain in the mine for a time during which the tissues harden; they then make a semi-circular cut in the upper wall of the mine, and emerge through this onto the surface of the leaf. Feeding commences very soon after emergence, and is done by eroding the surface tissue on the underside parallel to the veins of the leaf. When the beetle population is large, and the feeding heavy, these lines may coalesce and cause the leaf to curl due to the shrinking of the dead tissue.

The life of the adults has been taken in field-breeding cages, and has been from 115 to 160 days. Copulation was first observed 14 to 22 days after emergence (average nineteen days), after which it takes place frequently. The first egg masses were noted six to ten days after the first act of copulation; oviposition continued from then on throughout the life of the females, but was greater in the earlier period of life. On the average, two egg masses were laid every three days during the earlier period of egg laying, and subsequently at a slower rate.

The period of one complete generation, from egg laying to egg laying, has averaged 106 days with a range of 71 to 138 days.

Control.

Biological Measures.

In the course of the study of the habits of this pest, particular attention has been paid to indigenous parasites present in the various localities where it occurs; notes are appended on several parasites and one predator that have been bred from the eggs and larvae in the case of the former, and which has been observed attacking the adults in the field in the case of the latter.

Parasites of the Eggs.

The following parasites have been bred from egg masses *Promecotheca papuana* collected on palms in the field.

Fam. *Eulophidae—Closterocerus splendens,* Kow.

Fam. *Eupelmidae—Anastatus* sp.

Closterocerus splendens, Kow. measures 1.7 mm. in length, and is a metallic irridescent colour with two dark bands across each forewing. It was first bred in this Territory in the Manus District in 1932, and was later bred from material collected in various parts of New Britain; an egg parasite of *Promecotheca* was known to be present on New Britain in 1930, but was not bred out prior to the above-mentioned date.

Anastatus sp. is a small black wasp measuring 1.5 mm. in length and was first bred in this Territory from material collected in the Manus District in 1932, and later was recorded from the Gasmata District, and from the Rabaul-Kokopo District, both on New Britain.

On one occasion in Rabaul, a species of *Scelionidae, Telenomus* sp. was bred from eggs of *Promecotheca*, but no other data are available on its relationship with this host; it is an extremely minute wasp.

Parasites of the Larvae.

The following parasites have been bred from the larvae of this beetle:—

Fam. *Eurytomidae—Eurytoma promecothecae*, Ferr.

Fam. *Eulophidae —Derostenus* sp.

Eurytoma promecotheca, Ferr. is a small black wasp, the female measuring 3.7 mm. long and the male 1.6 mm. long. It is an external parasite of second and third instar larvae of *Promecotheca*, several parasite larvae often being present on the one host.

This species was first bred from *Promecotheca* larvae collected from several centres in the Gasmata sub-district by the Senior Author in 1930, and was later bred from material collected in other localities on New Britain; to date it has not been recorded from other parts of the Territory.

In Rabaul the life cycle of this parasite ranged from twelve to twenty days, with a maximum emergence of sixteen to eighteen days (av. 16.9 days). In Gasmata the Junior Author found the life cycle to average twenty days.

When fed on honey, the adults have lived for as long as 24 days, but when used in the breeding tubes they were only kept for about eight days and then liberated in the field.

Derostenus sp. is a small metallic blue wasp with white legs; the adults measure 1.2 mm. in length.

This parasite has been bred from the larvae of *Promecotheca* second and third instar collected in the Rabaul-Kokopo and Gasmata areas of New Britain, the Namatanai area of New Ireland, and from various parts of the Manus District.

It is an internal parasite of the grubs, with a life cycle avergaing 16.5 days, with a range of fifteen to nineteen days.

Under normal conditions, a combination of the parasites mentioned above maintains a very good measure of control of the pest, and even in such an extreme case as that referred to previously, they ultimately secured control, and no further major infestation has occurred in this area since.

With both native hosts referred to, *Eurytoma promecothecae* and *Derostenus* sp. have been present with the pest larvae.

On one plantation in the Gasmata sub-district, observations carried out over a period of months by the Junior Author showed that an infestation of *Promecotheca,* which had persisted for a considerable period, was prolonged owing to the fact that in the beginning of a generation, the egg parasites were 98 per cent. to 100 per cent. effective for a short time, and this broke the continuity of the generation and prevented the larval parasites from carrying through in sufficient numbers to take their share in the combined measures of control until very late in the generation, thus permitting sufficient adult beetles to mature as to form a succeeding generation. In this case, the introduction of another parasite, *Pleurotropis parvulus,* Ferr. enabled a more satisfactory carry over of the parasites and a natural equilibrium was obtained.

Introduction of Pleurotropis parvulus, Ferr.

In view of the very great success met with in Fiji and the New Hebrides with the introduction of *Pleurotropis parvulus* from Java, attempts were made to introduce this wasp into the Territory of New Guinea. On two occasions, the colony forwarded, once from the New Hebrides and once from Fiji, failed to survive the journey. A further attempt was made from Fiji, and on this occasion it was suggested that the package should be despatched to Sydney in a ship's cooler. Due to the courtesy and co-operation of Messrs. W. R. Carpenter & Co. Ltd., this was done and on the trip from Sydney to Rabaul, they were carried on ice on the airliner; this colony opened up in excellent condition, about 160 adults being alive. The initial breeding up of stocks for liberation was carried out in Rabaul by the Senior Author, and later the Junior Author took stocks to the Gasmata sub-district, where head-quarters were made on Lindenhafen, where this pest had been bad for a considerable time. Through the courtesy of Messrs. Burns Philp & Co. Ltd. and the Manager of the estate, every assistance was given in developing large stocks for liberation on this and other coco-nut areas where the pest was present in that district.

In Rabaul, the life cycle averaged 20.5 days with a range of 17 to 25 days and in the Gasmata centre the range was 19 to 21 days with third instar larvae and 21 to 23 days with second instar larvae.

The best results in the laboratory breeding work with this parasite were obtained by using fully mature third instar larvae or prepupae.

Colonies of *Pleurotropis parvulus* have been distributed to other parts of New Britain, particularly the Talasea area, to the Manus District and to Namatanai District, New Ireland. In most areas where liberations of this parasite have been made, it has been established with comparative ease.

Ants attacking Egg-masses and Larvae in Mines.

The following species of *Formicidae* (ants) have been recorded attacking the egg masses of *P. papuana*:—

Technomyrnes detorquens, Wlk.
Pheidole megacephala, F.

The following species of ants have been recorded in association with *Promecotheca* mines and attacking the larvae:—

Tapinoma melanocephalum, Fab.
Monomorium minutum, Mayr.
Monomorium floricolor, Jerd.
Tetramorium guineense, F.
Pheidole megacephala, F.

P. megacephala is probably the most important of these species.

Resulting from a large series of counts on Lindenhafen, it was found that 13.7 per cent. of the mines were attacked by ants.

Predator on adults.

A *Pentatomid* bug, *Amyotea reciprocus,* Walk var., has been observed, in the Kokopo district of New Britain, to attack and kill adult *Promecotheca* but it is by no means common, and cannot be considered as more than a minor factor in the control of the pest.

MECHANICAL CONTROL MEASURES.

On small palms, hand collection of eggs and adults, and crushing the larvae inside the mines will often enable an infestation to be checked in the beginning.

On the larger palms, flares made by fastening a half coco-nut husk onto the end of a bamboo pole, impregnating it with kerosene or waste oil and setting it alight can be used to flame the undersurface of fronds, thus killing large numbers of adults, and, if done with care, without harm to the foliage.

Spraying and Dusting.

Experimental tests with various dusts against adults of *Promecotheca* showed that arsenate of lead gave the highest percentage of kill, and derris and pyrethrum dusts gave very poor results.

Spraying with arsenate of lead also gave a high percentage of kill, but was relatively slow in action. Nicotine and lime sulphur spray fluids gave a high percentage of kill relatively quickly, but acted entirely as a contact insecticide.

A combined spray of arsenate of lead and "Black leaf 40" (nicotine sulphate) was the most satisfactory, the former remaining toxic on the foliage, while the nicotine content gave a quick kill of beetles present on the foliage at the time of spraying.

It has been a common practice, when *Promecotheca* is noticed in a plantation, to cut off and burn all fronds on which eggs or larvae are seen. Although this will undoubtedly kill all stages of the pest present, it may also destroy numbers of the parasites, and thus retard the rate of increase of these useful insects. In such cases it would be better to cut off any leaflets showing the presence of grubs, and hang them in wire gauze containers so that, any beetles emerging from the mines will be caught, but any parasites present will be able to escape through the meshes of the gauze; later, this material can be burnt if desired.

BRONTISPA FROGATTI, SHARP.

This species is distributed generally throughout the Territory and, with the exception of the Kieta District, it is not generally a serious pest of coco-nuts; in that district, it is more prevalent than elsewhere in the Territory. It attacks palms of all ages, although it is worse in young palms in the nurseries, and for the first year after planting out in the field. Where an area of young palms is neglected and becomes overgrown with vines, &c., palms up to three years or even more have been found to be strongly attacked, but after the area has been cleaned of all vines and undergrowth, the incidence of the pest decreases very markedly.

The Eggs.

The eggs are oval, brown, chitinised bodies, flattened dorsoventrally, and measure approximately 1½ mm. in length; they are laid end to end, two to four together in a slight groove made in the surface of the leaf tissue; they are usually covered with a slight amount of frass.

The egg period is 4 to 5 days.

The Larvae.

The larva when full grown is pale yellow in colour, and measures about 1 c.m. in length; development takes place in four instars, the periods of which average, 9, 6, 7 and 14 days respectively—the range of the full larval period has been from 30 to 40 days.

The larvae feed on the surface tissue of young leaflets in the unexpanded new shoot ("spear") of the palm, giving rise to an area of dead tissue where feeding has taken place.

The Pupae.

The pupa is slightly darker in colour than the larva, and has the cast larval skin attached to the anal end of the body; it is slightly shorter in length than the larva.

Pupation takes place in between the leaflets, and occupies about six days.

The Adults.

The adult beetle measures 7 to 9 mm. in length and 2 mm. across the widest part (just behind the thorax), tapering slightly towards the anal end of the elytra (wing covers).

The elytra are completely black except for a small portion adjoining the thorax, which is yellow; the thorax is yellow with the head and antennae black.

The adults also feed on the surface tissue of the young leaflets in the opening spear, and have a life of 200 to 220 days. It has been noted that the first eggs were deposited 22 to 23 days after emergence.

Control.

Mechanical Measures.

By pouring a spray fluid of "Black-leaf 40" (nicotine sulphate) down the opening central shoot ("Spear"), the larvae and adults are usually easily killed, but it has been found in some particularly susceptible hosts that arsenate of lead spray has had to be forced in with a spray pump to obtain control of the pest.

Biological Measures.

Two species of indigenous parasites have been bred from host material collected in the neighbourhood of Rabaul, namely:—.

Trichogrammatidae, Thrichogrammatoidea nana, Zehntner.

This is an extremely minute wasp, measuring approximately .5 mm. in length, which parasitises the eggs. The period from egg-laying to emergence of adult is ten-eleven days.

Eulophidae, Achrysocharis sp.

This is a minute wasp measuring approximately 1 mm. in length which parasitises the larvae; the life cycle (from deposition of egg to emergence of adult) is nineteen days.

Advice has been received that the former sp. had been bred by R. W. Paine from Brontispa eggs in the British Solomon Islands.

Through the courtesy of Messrs. Levers Pacific Plantations Ltd., a colony of pupal parasite, *Tetrastichodes brontispae,* was sent to us from the British Solomon Islands. It has been bred through a large number of generations in the laboratory in Rabaul, and colonies have been liberated on various plantations in the Rabaul-Kokopo district, and others distributed to other districts of the Territory.

This parasite has been recovered from the field in the Rabaul area from a plantation where liberations have been made for several months, but the numbers collected have not been large.

Other Host Plants of B. Froggatti.

Areca catechu is a very common bush host of both *Brontispa froggatti* and *Oxycephala papuana.*

Metroxylon sagu (Sago palm) is another indigenous host of *B. froggatti.*

In the Botanic Gardens, Rabaul, the following palms have been found to be hosts of *B. froggatti*; *Oreodoxia regia* (Royal palm), *Elaeis guineensis* (Oil palm) and *Washingtonia filifera.* The last mentioned palm was found to be particularly susceptible to the attack of this pest.

OTHER SPECIES OF HISPIDAE ATTACKING THE "SPEAR".

There are three other species of *Hispidae* recorded from this Territory attacking the opening "spear" of the coco-nut palm.

Brontispa simmondsi, Mlk. has been collected in the Manus District (Admiralty Islands). This species is slightly longer than *B. froggatti,* and has the thorax and elytra brown, usually with a dark marking down the middle of the elytra pointed towards the thorax, widening in the middle, and tapering towards the anal end; the head and antennae are black.

Brontispa longissima, Gestro, has been collected in the Wewak District of the mainland of New Guinea. This species is practically the same size as the former species, and has the elytra brown with darker colouring over anal half; the thorax and head are brown, with the antennae black.

Oxycephala papuana, Gerst. has also been collected in the Manus District on both coco-nut palms and *Areca catechu*. It is markedly larger than the other spp. referred to, measuring slightly more than 1 c.m. in length and 3 mm. in width.

The elytra are deep black, the head and thorax yellow to orange-brown with the basal portion of the antennae brown, and the apical portion black.

REFERENCES TO PREVIOUS PUBLICATIONS ON COCO-NUT HISPIDAE.

Entomological Bulletin No. 1, 1931, Department of Agriculture, New Guinea.
New Guinea Agricultural Gazette, 2, 1, 10-12
" " " " , 3, 2, 21-22
" " " " , 4, 1, 51-55
" " " " , 5, 1, 3-10
" " " " , 6, 2, 20-30.

REVIEW.

In an article by A. G. Van Veen (Geneesk. Tijdschr. Nederland.—Indië, 1938, 78, 2548-2552), it is shown that the food value of young cassava (tapioca) leaves, either steamed or boiled, is uncommonly high. The average composition is—water 77 per cent., soluble carbohydrates 3.3 per cent., fat 1.2 per cent., crude protein 8.2 per cent., crude fibre 7.8 per cent., ferric oxide .01 per cent., lime .28 per cent., and phosphoric acid .3 per cent. The leaves contain less hydrocyanic acid (.02 per cent.) than the roots and cooking completely removes it.

It is shown that the vitamin content of cassava leaves is also high. The sample studied contained 72 per cent. moisture and 8.5 per cent. crude protein: 100 g. raw leaf gave 116 g. steamed and 136 g. boiled. In steaming about 1/7th and in boiling about 1/4th of the dry matter was removed by extraction. Chromatographic analysis showed that almost all the carotene of the leaves was β-carotene: 100 g. fresh leaf gave in the raw state 13,000 I.U. vitamin A; 100 to 110 I.U. vitamin B_1; 145 to 185 mg. vitamin C and 430 γ-lactoflavin: after boiling, 16,000 I.U. vitamin A, about 50 I.U. vitamin B_1, 24 to 36 mg. vitamin C; after steaming, 15,000 I.U. vitamin A, about 100 I.U. vitamin B_1 and 52 to 75 mg. vitamin C. The value of 13,000 I.U. vitamin A is possibly too low on account of difficulty of extraction from the raw leaf.

Analysis showed that about 75 per cent. of the crude protein is true protein and feeding experiments with rats showed that the feeding value is high, although not quite as high as that of the protein of soya beans.