THE COCO-NUT LEAF-MINER, *PROMECOTHECA PAPUANA*, CSIKI., AND ITS PARASITES.

(*B. A. O'Connor, B.A., B.Sc.Agr., Department of Agriculture.*)

In various parts of the Territory of New Guinea, chiefly on the island of New Britain, the Coco-nut Leaf-Miner has caused extensive damage to plantations and native groves. The two most serious outbreaks in recent years were those in the Rabaul district following the volcanic eruption of May, 1937, and at Lindenhafen in the Gasmata district, on the south coast of New Britain, in 1936. In the main, the pest appears to be controlled by native parasites, and the mortality among these during the eruption is believed to have been responsible for the Rabaul outbreak. The reasons for the severity of the attack at Lindenhafen are obscure, but a study of the conditions there has brought to light some interesting data.

In a severe infestation, the extent of the damage to the palms can be very great. The leaflets are completely destroyed, turning a greyish-brown colour, and giving the palms the appearance of having been scorched by fire, while in some cases the central shoot may be extensively damaged, leading to the death of the palm. Recovery is slow, and there may be a cessation of nut-production for as long as two years, the immature nuts falling to the ground as a result of the debility of the palm. Where attack is less severe, drying and curling of the tips of the fronds is noticeable, together with the elongated, brown patches due to mining of the larvae within the leaflets.

Data relating to the life history and habits of the beetles and its parasites have been compiled during the course of investigations at Manus in 1938, and at Lindenhafen, New Britain, in 1938-39. The method of rearing and observation was as follows:—

One or more pairs of newly-emerged adults were placed in wire sleeves attached to a growing palm in such a way as to contain several leaflets. The wire sleeves were cylindrical, about 18 inches long and 4 inches in diameter, and at each end were continued into cloth cylinders about 6 inches long, which served to close the wire cylinder, and render it beetle-proof. Palms of from six months to a few years old were used, as their foliage is more easily accessible. When the palm used was only a few feet high, a stake was placed in the ground a few feet away, and one end of the cylinder attached to a piece of twine coming from the end of the stake. Thus the weight of the cylinder was supported largely by the stake. When older palms were employed, a piece of tie-wire was passed along one side of the cylinder, and was attached to the mid-rib of the frond. Cotton-wool wrappings were always used to ensure that the cloth fitted tightly over the leaflets, as otherwise the beetles were able to escape. When food became exhausted, or when several egg-masses had been laid on the leaflets, the beetles were moved to fresh leaflets. Egg-masses were marked, and the development of the eggs and larvae followed up. Life histories of larvae were worked out also in the laboratory, where larvae could be carried through in leaflets kept in water, being put into mines in fresh leaflets whenever necessary.

Bionomics of *P. papuana*.

The Eggs.—The eggs, which are dorso-ventrally flattened, oval objects, are laid almost invariably on the underside of the leaflet, very occasionally on the upper surface, and are covered with excrement by the female beetle. The mound thus formed is oval, about ⅛ inch long, with a rough, biscuit-coloured surface. Egg-laying takes place in the evening, during the last hour before sundown, and the number of eggs per egg-mass is from one to six, averaging about three. In Manus, the usual number is three, and five is an extremely uncommon total, while at Lindenhafen four is the usual number, five is not uncommon, and six is very rarely met with. Before laying the eggs, the female beetle chews a furrow in the leaf surface in the spot where the eggs are to be laid, so that the young larva, on emerging, is able to enter the interior of the leaflet. The larva is unable to penetrate an undamaged leaf surface, as its head is very strongly flattened dorso-ventrally, the pincer-like mandibles working in a horizontal plane.

The Larva.—The larva is a cream-coloured grub, with strongly chitinized head and mouth-parts, golden-brown in colour. On hatching from the egg, it immediately works its way inside the leaflet, using the furrow made by the female beetle, and normally feeds straight ahead, cutting a wide track through the green matter of the leaflet, which it tears away by the pincer-like action of the jaws. Only the epidermis of the leaflet is left above and underneath the mine, and before this begins to dry, the larvae can clearly be seen feeding when a mine is held up to the light. Regular swathes of excrement are left behind in the mine as the larva advances. The average number of larvae per mine is about three, but during severe infestations twenty or thirty egg-masses may be laid on one leaflet, and several mines made by young larvae may run into one another. As many as thirteen larvae have been seen by the writer feeding abreast in a single mine. In such cases, of course, usually only a few larvae reach maturity, the majority perishing of starvation.

There are three larval instars, and at the end of each of the first two, a larval skin is cast. The fully-fed first-instar larva retires backwards down the mine, and a quiescent period of two or three days follows, during which the old larval skin is cast. Feeding then continues until the end of the second instar, when the process is repeated. On the completion of the third instar, no skin is cast, but the larva ceases feeding, and spends about three days as a resting prepupa, the latter differing only slightly in external appearance from the fully-fed larva.

The places at which feeding for each instar has ceased can often be seen in an external view of the mine. At the end of each instar, the green tissue of the leaf which the larva has been attacking dries hard, leaving a visible mark after the larva has again begun to feed, which it does by first biting through the dried tissue. The position of the larva in the mine can best be called "lying on its back", the dorsal portion of the body always being towards the ground. This position is maintained by the pupa, so that normally the newly-hatched adult beetle is placed with its mouth-parts in proximity to the upper surface of the mine, and hence it bites its way out through this surface. When a larva is being examined outside the mine, the dorsal surface can always be distinguished from the ventral, as the larva bows itself backwards, the inner portion of the curve being formed by the dorsal surface.

Prepupa and Pupa.—When the resting stage of the prepupa is completed, the old skin splits along the dorsal portion of the thorax, and the pupa forces its way out. A series of convulsive movements by the pupa sloughs off the old skin until it comes to rest at the dorsal end of the pupa, forming a small attached lump, the most noticeable portion being the chitinized head and mouth parts of the old larval skin. Later on, this lump falls off the pupa, leaving it quite free.

The colour of the pupa, when it is first formed, is creamy-white, but it quickly darkens until it reaches a golden-brown tint. Later, eyes, mouth-parts and elytra become black. It is armed with rows of spines on the dorsal surface of the abdominal segments, and these enable it to move freely within the mine by gripping the epidermis of the leaf as it progresses by alternately doubling and straightening itself.

Adult.—The newly-emerged adult is pale yellow in colour, with dark patches on the distal portion of the elytra. The colour gradually deepens, until finally the general colouration is golden-brown, with the prothorax and distal third of the elytra a deep bluish-black. A colour variation occurs in Manus, the beetles in that locality having much paler colouration and markings.

After emergence from the pupa, the adult remains for about two days in the mine before biting its way out. It lies on its back in the mine, with its feet grasping the cast pupal skin. When emerging from the mine, it bites a semi-circle in the epidermis, almost invariably in the upper surface of the leaflet, and forces its way out.

The beetle feeds mainly on the distal third of the leaflets, preferring the older fronds to the younger. Almost all the feeding takes place underneath the leaflets, the green tissue being eaten in fine lines running parallel with the mid-rib. The beetle rests on the leaflets with the long axis of the body parallel to the mid-rib, and turns its head sideways for each bite, so that the mandibles can grasp a portion of the green tissue of the leaf from between the fibres. The damage caused by adult feeding is much more extensive than that due to the larvae. The distal portions of the leaflets become dry and curled, and, where infestation is severe, the whole palm has a brown, scorched appearance.

Copulation occurs frequently, and copulating pairs show a tendency to be gregarious. Pairs of beetles which have been kept under observation have been seen to copulate almost daily over a period of two to three months. Seven to ten days after the first copulation, the females begin egg-laying, and continue for some months. They do not lay more than one egg-mass per day, the usual rate being about two egg-masses in three days for the first month or two, after which it is lower.

Adult beetles can live as long as five months, and probably more. Of those kept in captivity, none was kept until it died of natural causes. They either escaped, or were still living when observation had to be discontinued. One female was kept at Lindenhafen for 160 days and a male and female for 140 days. Copulation was noticed with beetles 135 days old.

It would appear that the female can lay about 80-100 eggs, that is about 30 egg-masses at Manus, and 25 at Lindenhafen. The pre-oviposition period is commonly about four weeks or a month, 24 days being the shortest period noted. At Manus, life-history observations were interrupted before oviposition was

completed, but the average oviposition by four females was 22 egg-masses in 41 days. At Lindenhafen it appeared that there was a break in the continuity of egg-laying. Thus, two females under constant observation laid eggs as follows:—

Emergence of adult from mine.	First oviposition period began.	First oviposition period ended.	Second oviposition period began.	Second oviposition period finished.
	16 Egg-masses		4 Egg-masses.	
A.—10th to 11th February	10th March	6th April	8th May	22nd May.
	28 days	27 days	32 days	14 days
	13 Egg-masses.		11 Egg-masses.	
B.—14th February	14th March	15th April.	27th May	27th June
	28 days	32 days	42 days	31 days

It will be seen that the total period of oviposition for A is 73 days, with a break of 32 days, and for B 105 days, with a break of 42 days.

Figures for the developmental period of eggs, larvae and pupae are given below:—

Eggs.—At Manus, the incubation period varied from 13½ to 16 days, with an average of 15 days. At Lindenhafen, the range was 13 to 15 days, with an average of 14 days.

Larvae and Pupae.—Data are presented in the following table (the figures are in days):—

——	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
First stadium ..	9	8	8	5	5	5½	5	6	6	6	6
Rest	3	2	3	2½	2	3	3	3	3	3	3
Second stadium ..	5	5	5	3	3	2½	3	8	8	8	13
Rest	3	3	3	2½	3	3	2½	2	2	2	3
Third stadium ..	8	10	10	7½	6	6	4	6	7	8	12
To emergence of adult ..	16	15	15	15	15	15	15	15	15	15	15
Total, egg to adult	44	43	44	35½	34	35	32½	40	41	42	52

Mines A to G inclusive were under observation on growing palms at Manus. Mines A to C were in mature leaflets, while mines D to G were in leaflets of a palm about six months old. It will be noticed that there is a marked difference in the developmental period of larvae from these two sets of mines. H to K are single larvae from the same mine at Lindenhafen. These were reared in the laboratory on leaflets kept in water. Larva K, it will be noticed, had a very much longer developmental period than larvae H to J. The period of 15 days from the end of the third stadium to emergence of the adult from the mine is very consistent, and is made up normally of a prepupal period of 3 days, pupal 10 days, and resting adult two days.

At Lindenhafen, where in certain localities there was a definite break in the normal overlapping of life-history stages, field observations indicated that the length of a generation was three months. This was the period which elapsed

between first appearance of adults in one generation and first appearance in the next. However, the average length of a generation would be longer, calculating from the middle of one oviposition period to the middle of the next. On this basis, the average length of a generation could be estimated as follows:—

	Manus.	Lindenhafen.
	Days.	Days.
Incubation period	15	14
Larval period	28	30
To emergence of adult	15	15
Pre-oviposition	45–50	60–70
Total	103–108	119–129

Hence there would be between three and four complete generations each year. If we put 28 days as the pre-oviposition period (i.e., the period from emergence of adult to first egg-laying), we have just under three months for the generation.

The break in overlapping of generations at Lindenhafen has been mentioned above, and a similar state of affairs appears to exist in the Rabaul district. Having regard to the long period during which oviposition takes place, complete overlapping would be expected to prevail, as, even after a temporary setback, this condition could be produced in one generation. In the beginning of December, 1938, when the writer first went to Lindenhafen, only eggs and adults were present. Later on, only larvae were to be found, then larvae, pupae and adults, then again adults only, and finally adults and eggs only. This was roughly the position during the eight months during which work was carried out at Lindenhafen, and apparently it had been so for a considerable time previously. The break was not absolutely complete, as a very occasional larva might be found during the adult and egg period, but generally speaking, it is true to say that overlapping covered a period of only a month. In other words, it would be possible to have all stages of larvae in the field at one time, or pupae and adults, or adults and eggs, &c., the least advanced stage commonly found being only one month's development behind the most advanced stages. Hence it seems that the longevity of adults in the field may be much shorter than in wire sleeves, as otherwise adults would have been present in considerable numbers at all times. The activities of predators and fungi in reducing the adult population appeared by no means sufficient to bring about the observed conditions. In the case of the eggs, larvae and pupae, the destruction of eggs by internal parasites and by ants is thought to be the main factor in reducing overlapping. This subject will be mentioned later.

Host-plants of *P. papuana*.—Apart from the coco-nut palm, only two other plants have been noted as hosts of *P. papuana*, namely, the sago palm, *Metroxylon sago*, and the oil palm, *Elaeis guineensis*. On the former, the insect can go through all stages of its life-history, but this is apparently not so on the latter. Eggs are laid on it during severe infestation, but the larvae die after the first day or two of feeding.

Parasites and Predators of *P. papuana*.

Pleurotropis parvulus.—This Eulophid had been introduced from Java to Fiji and the New Hebrides to control other species of *Promecotheca*, and had been outstandingly successful. Hence it was decided that it should be imported into the Territory. In October, 1938, a colony arrived in good condition from Fiji, coming from Sydney by mail-plane, Messrs. W. R. Carpenter & Co. Ltd. having given every assistance with the introduction. The parasites were bred up in Rabaul, and distributed in the Rabaul district, Manus, Talasea, Pondo and other localities. At the end of November, the writer was sent with a colony to Lindenhafen, where *P. papuana* was present in very large numbers at the time. Breeding and distribution of the parasite were carried out in this district (Gasmata) until the end of July, 1939, by which time *P. parvulus* was firmly established at Lindenhafen. Daily collection of *Promecotheca* was carried out, so that a check could be kept on the progress of the parasites in the field. It was found that two weeks after the initial liberations, parasitized larvae and pupae could be found on the site of liberation, and even as much as 200 yards away from this point. A gradual increase was discernible in percentage of parasitism in the field, as is shown by the figures given below. Percentages were based only on mines which contained healthy larvae, pupae or adults of *Promecotheca*, or larvae and pupae containing *P. parvulus*, all those from which *P. papuana* or *P. parvulus* had emerged being excluded. Data are appended—

——	Mines containing Parasitized Individuals.	Total Mines.	Percentage of Mines containing Parasitized Individuals.
			Per cent.
6th to 22nd June, 1939 ..	18	414	4.3
23rd to 30th June, 1939 ..	10	451	2.2
6th to 30th June, 1939 ..	28	865	3.2
1st to 14th July, 1939 ..	33	872	3.8

Accurate counts are not available for the latter half of July, but judging from the results obtained from the inspection of several hundred mines, the percentage of parasitism appeared to have jumped rather sharply to the vicinity of 7 per cent. Mines were very few at this period, the average being probably only one or two per palm. In October, counts of mines sent to Rabaul from Lindenhafen showed a 50 per cent. parasitism of mines.

In the Rabaul district, possibly due to the generally drier and finer weather, *P. parvulus* seems to have multiplied much more rapidly than at Lindenhafen. Most of the liberations around Rabaul and Kokopo were made early in 1939, and by August parasitized larvae and pupae could be found in numbers by most casual inspection. At Wangaramut Plantation, for instance, between 200 and 300 mines were opened, and every one of these contained one or more parasitized larvae and pupae. Other plantations on which the parasites are well established are Ralabang, Ulatava, Keravat and Pondo, showing that its distribution is wide.

Method of Breeding of *P. parvulus*.—A very satisfactory method for bulk breeding is as follows:—

Into a large mine, from 20 to 40 prepupae or newly-formed pupae are placed. The ends of the mine are cut and closed with wire clips, and the mine is then placed in a glass tube about 8 inches by 1½ inches with 100 to 200 *P. parvulus* (i.e.

five P. *parvulus* per individual *Promecotheca*) and left for two days. Food is provided in the form of honey very slightly diluted with water, which can be placed on a small piece of blotting paper stuck to the side of the tube, or on the upper surface of the mine in very small droplets. At the end of two days, the prepupae and pupae are removed, and stored in a glass tube 6 inches by 1 inch. If the climate is moist, the tube should be lined with blotting-paper, and adult beetles emerging from unparasitized pupae should be removed daily, otherwise there is a risk of sweating, and consequent fungus attack on the parasitized individuals. The same individuals of *P. parvulus* can be used three or four times for oviposition in fresh lots of *Promecotheca*. Prepupae and pupae are preferred to larvae, as the latter have to be fed before and after parasitism, a process which occupies a great deal of time. These methods were used at Lindenhafen, and produced from 1,000 to 1,500 well-grown wasps per day. Superparasitism was found to be negligible. The developmental period of *P. parvulus* from parasitism to emergence of wasps, was found to be 17 days in Rabaul and 19 days at Lindenhafen, the difference being due to higher mean temperatures at the former locality.

In this connexion it was calculated that the developmental zero for *P. parvulus* was approximately 55° F. (12.8° C.). To determine this figure, parasitized larvae and pupae of *P. papuana* were placed in a refrigerator where the temperature varied from 56° F. to 70° F., averaging between 61° F. and 62° F. Temperatures were taken every three hours in the refrigerator and in the laboratory, and the developmental period for *P. parvulus* in these two situations was noted. From these data the figure for developmental zero was calculated, the results of three trials conducted at different times being 55.5° F., 54.7° F. and 56.7° F.

Description of *P. parvulus*.—The adult wasp is a black, robust insect, about 1/16th inch in body-length. The three proximal tarsal joints on each leg are white, the fourth joint, like the tibia and femur, being black. Males are smaller than females, and have a greenish sheen on the ventral portion of the thorax, which is not present in the female.

Bionomics.—The egg of the wasp is laid, from outside the mine, into the larva, prepupa or pupa of *P. papuana*, the ovipositor of the female penetrating the epidermis of the leaflets in order to reach the host. Oviposition is usually carried on from the under-surface of the leaflet. Where the host is a well-grown, third-instar larva, a prepupa or a pupa, the developmental period of the parasite is shorter than when a first-instar or second-instar larva is the host. At Lindenhafen, 19 to 21 days was the usual period, but some individuals occupied as much as 27 days even in large third-instar larvae. In the second-instar larvae, the period was from 21 to 23 days, with some individuals occupying up to 30 days. At Rabaul, 17 to 19 days was the usual period when large larvae were the hosts. When the life-cycle covers 19 days, the larval period is about eight to nine days, and the pupal period 10 to 11 days. The pupae, when first formed, are white, but darken quickly, until they are finally quite black. The skin of the host turns black about six or seven days after oviposition, in the case of third-instar larvae. When prepupae are attacked by the parasite, they almost invariably reach the pupal stage before dying, and when the pupa darkens it does not become black, but a greyish-brown. Parasitized larvae always feed more voraciously after eggs of the parasite have been laid into them, and in the case of first or second instar

larvae, the subsequent feeding period may be as long as 14 days. Feeding by the parasite larvae goes on entirely within the host, and when prepupation occurs, the pupae are packed inside the dried larval or pupal skin.

When fully developed, the adult parasites cut holes in the dry skins of the host, and emerge into the mine, where they then cut holes in the upper epidermis of the leaflet, and escape into the open air. If the portion of the host skin in which the hole is made is pressed against the epidermis, the parasites bite their way straight out, and do not enter the body of the mine. The number of holes made in host and mine varies from one to six.

Superparasitism.—This has seldom been observed in nature by the writer, but in laboratory breeding, when parasites are placed in a tube with an insufficient number of hosts, it is of common occurrence. If the degree of superparasitism is moderate, the parasites complete their development, but emerge as stunted adults. If it is extreme, development is not completed, parasite larvae and host shrivelling up completely. In one shrivelled third-instar larva, 180 *P. parvulus* larvae were counted. It appears that up to 40 good-sized wasps can develop in a prepupa, pupa or mature larva.

Eurytoma promecothecae.—This parasite was recently described by Ferrière from specimens collected in the Rabaul and Gasmata districts. It is a black wasp, about 1/10th of an inch in body-length, with the distal ends of the tibia yellow, and the tarsi white. The antennae of the male differ from those of the female, the funicle joints of the former being hairy and irregular in shape, while those of the latter are smooth and rounded.

E. promecotheca has been so far recorded only from New Britain, and it appeared to be the main factor in controlling the outbreak of *P. papuana* which occurred along the north-coast road in the Rabaul district subsequent to the volcanic eruption of May, 1937. It would appear that the outbreak was due largely to destruction of a great proportion of the local parasites by the deposits of ash which fell on the plantations in this area, followed by torrential downpours of rain. It was noticeable that those plantations which had suffered most from the ash and the cloudburst were subsequently the most severely attacked by *P. parvulus*.

E. promecotheca is an external parasite of the larva of *P. papuana*, each of the three instars being attacked. The parasite larvae are voracious feeders and, attaching themselves to the sides of the *Promecotheca* larva, they suck its body-fluids until they are fully fed. Feeding is especially heavy during the last day, when the host larva shrinks from almost normal size to a shrivelled husk. The host larvae are paralysed by the adult wasp when the latter lays its eggs, so that they are unable to rid themselves of the parasite larvae.

When the larva of the parasite is fully fed, it moves along the mine and pupates, the pupa being attached to the wall of the mine by a drop of excreta and the cast larval skin. Its colour is at first light yellow, later becoming black. The developmental period, from oviposition to emergence of the adult wasp, is 19–21 days at Lindenhafen, 17–20 days at Rabaul. The adult cuts a hole in the epidermis of the leaflet, usually on the upper surface, and emerges. Maximum longevity of adults in the laboratory was 60 days when not provided with hosts, and 35 days when permitted to oviposit into larvae.

Derostenus sp.—This parasite of the larvae of *P. papuana* occurs widely throughout the Territory, having been recorded from Lindenhafen, Rabaul and Manus. It has not yet been specifically determined, but belongs to the family *Eulophidae*. The adult is of a metallic-green colour, with coxae, tibia and tarsi of all three pairs of legs white. Body-length is about 1/16th of an inch. The adult has a very characteristic habit of running rapidly sideways and of standing on the leaf swaying its body to and fro.

This insect is an internal parasite of the larvae of *P. papuana*. The host does not feed after oviposition by the parasite, and the parasite larvae develop inside the body of the host, which gradually assumes the appearance of a transparent envelope enclosing the parasite larvae. When fully fed, these latter bite their way out of the skin, and pupate in the mine, the pupae being attached to the walls of the mine by a drop of excreta and the cast larval skin. The skin of the host remains distended and transparent. The parasite pupae gradually become black in colour, and normally, the adults emerge and bite their way out of the mine 18–21 days after oviposition by the parent generation. Larval and pupal periods at Lindenhafen were approximately equal.

In the laboratory, *Derostenus* failed to oviposit in prepupae and pupae, and no larvae parasitized by it ever reached the pupal stage. However, in the field it was not uncommon to find pupae parasitized by this species, their appearance being very similar to that of pupae attacked by *P. parvulus*. Three adult females, supplied regularly with food and host larvae for oviposition, lived 25, 26 and 32 days in the laboratory, laying eggs until a day or two before death. When *Derostenus* and *P. parvulus* females were allowed to oviposit into a host larva at the same time, *Derostenus* always won in the competition for food, and only *Derostenus* adults later emerged from the parasitized larva.

Closterocerus splendens, Kow.—This Eulophid is about 1/25th inch long, with brilliant metallic-green body and banded wings. It was originally described by Kowalski from the New Hebrides as a parasite of the larva of *Promecotheca opacicollis*, Gestro., but in New Guinea, where it has been found in the Manus, Rabaul and Gasmata districts, it is an egg-parasite. The bionomics of this species have not been extensively studied, but the developmental period from egg-laying to emergence of adult is about 21 days. One parasite develops in an egg of *P. papuana* and an egg-mass may have one or more parasitized eggs. When the parasite is fully developed, it cuts a small hole through the covering of the egg-mass, through which it emerges.

As has been mentioned earlier, *C. splendens*, and to a lesser degree the egg-parasite *Anastatus* sp., are deemed the main factors causing the break in over-lapping of generations in Gasmata and Rabaul districts. At the beginning of egg-laying in one generation of the beetle at Lindenhafen, an attempt was made to estimate the percentage of parasitism of the eggs at different periods. Egg-masses were collected from widely separated portions of the plantations, and the leaflets on which they were laid were kept in water for ten days to allow any parasites which might be in the eggs to develop to a point where they were easily distinguishable. Laying of eggs in the field by this generation of beetles began about 20th May, 1938, and hatching of parasites from these eggs began about 9th June, 1938.

Results of the examinations of eggs collected at three different times are as follows:—

Collected 6th June	30 per cent. eggs parasitized.
Collected 20th June	80 per cent. eggs parasitized.
Collected 3rd July	100 per cent. eggs parasitized.

Hence we see that about six weeks after egg-laying began, 100 per cent. of the eggs were parasitized, and this could explain the restriction of over-lapping of generations to about that period.

Anastatus sp.—This Encyrtid is about the same size as *C. splendens*, and is of a brilliant blue-black colour. It has been hatched from the eggs of *P. papuana* in the Manus and Gasmata districts.

Other Internal Parasites.—One other parasite of the larva, whose habits are similar to those of *P. parvulus*, has been found in Manus, and from the same district and Rabaul, two species of minute hyperparasites of *C. splendens* have been recovered.

Predators.—The pentatomid bug, *Amyotea reciprocus*, Wek., has been recorded as a predator of the adults of *P. papuana* in the Rabaul and Gasmata districts. The adult bug impales the beetles on the end of its extended proboscis, and sucks up the body fluid at leisure.

Ants.—These destroy large numbers of eggs and larvae, and a few adult beetles. Vast numbers of eggs are eaten by *Pheidole megacephala*, Fabr., a small, reddish ant, whose workers have greatly enlarged heads. *Technomyrmex detorquens*, Walk., a black, active ant, with somewhat heart-shaped abdomen, which builds protective galleries under the palm leaflets, using earth-coloured fluff from the crown of the palm, has also been seen to devour eggs.

Various species of ants also attack the larvae and pupae, biting holes to gain access to the mines, or entering through holes previously made by earwigs. *Pheidole megacephala* is again one of the invaders, and other species which attack larvae and pupae in the mines are *Tetramorium guineense*, F., *Monomorium floricola*, Jerd., *Monomorium minutum*, Mayr., and *Tapinoma melanocephalum*, Fab. *M. minutum* frequently forms its nest within the mine of *P. papuana*. At times, as many as 50 per cent. of the mines collected in the field had been attacked by ants, and up to 30 per cent. of the larvae and pupae destroyed.

The Kurukum Ant.—There has been much discussion in the Territory as to the value of the Kurukum Ant, *Oecophylla smaragdina*, var. *virescens*, F., as a controlling agent for *Promecotheca papuana*. Some planters claim that this ant, if present in sufficient numbers, will prevent extensive attacks by the pest. The writer's observations at Lindenhafen provide no support for this view, as the Kurukum was present on the plantation in very large numbers, but was unable to prevent or control the depredations of *P. papuana*. On no occasion has the ant been observed to attack eggs, larvae or pupae of the beetles, and the latter have been observed laying eggs freely on the leaflets of fronds which carried hundreds of Kurukums. The ants have occasionally been seen attacking the adult beetles, and carrying them off to their nests, but these activities are negligible from the point of view of control. It has, however, been noted that certain palms which

have an exceptionally large number of the ants are sometimes less severely attacked than the surrounding palms. A point of importance regarding the habits of *O. smaragdina* is that it exerts a harmful influence by cultivating and protecting aphids, scale-insects and mealybugs.

Earwigs.—There is a species of earwig commonly found in the crown of coco-nut palms in this Territory, which has not yet been identified. At Lindenhafen, it was found that this earwig commonly entered mines of *P. papuana*, usually making longitudinal slits in the upper surface, and at other times chewing openings in the upper or lower surface. Observation in the laboratory gave no indication that the earwigs attack larvae or pupae of the beetle, and it is thought that they enter the mines for scavenging purposes. Holes made by them provide points of entry for ants.

Fungi.—During the south-east season in the Gasmata district, from April to October each year, the rainfall is very heavy, up to 70 inches in one month having been recorded, and there are many dull, cloudy days. Under these conditions, the adult beetles are freely attacked by a fungus which has been identified as *Synnematium jonesii*, Speare. Many adults were found dead and fixed to the upper or under surface of leaflets by the white mycelium of the fungus, which also radiates out in all directions from the dead beetle, and covers the body with weblike hyphae. The fungus is not considered to be of great economic importance, as its controlling effect on *P. papuana* appears to be slight.

Bacteria.—Third-instar larvae of *P. papuana* are frequently found dead in mines, and have the appearance of having been killed by bacterial attack. Their coloration is black, and they lie extended in the mine, the body contents being a black slime. Like the fungus, this bacterial attack is apparently of little economic importance.

Death of Larvae from Unknown Causes.—During heavy infestations at Lindenhafen, it has been noticed that there is often a high mortality among first-instar larvae. The larvae are found at the head of the mine, in the feeding position, their bodies being flattened and extended, and normal in colour, showing no sign of bacterial or fungal attack, though there is frequently a blue-mould on the surface of the mine. The cause of this mortality is not known.

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