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ABSTRACTS

PANULIRUS POLYPHAGUS—A NEW SPINY LOBSTER RECORD FROM PAPUA NEW GUINEA

REX R. PYNE. *Papua New Guinea agric. J.*, 22 (2) : 149-150 (1971)

A female spiny lobster taken in the Gulf of Papua and identified as *Panulirus polyphagus* (Herbst, 1793), is described and illustrated as a new record for Papua New Guinea.

EFFECT OF PROLONGED SPRAYING WITH TRICHLORPHON ON BLOOD CHOLINESTERASE LEVELS OF SPRAYERS

T. V. BOURKE, W. B. MORRISON AND BETTY MACARTNEY.
Papua New Guinea agric. J., 22 (3) : 151-164 (1971)

Two series of trials to study the effect of prolonged application of the organophosphorus insecticide trichlorphon (dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate to cacao trees through motorized portable misting machines on the whole blood cholinesterase levels of sprayers were carried out at Popondetta, Northern District in 1968-69.

In the first series 1.5 lb of trichlorphon (as an 80 per cent wettable powder formulation) in 30 gallons of water per acre was applied to the cacao trees.

There was steady reduction in whole blood cholinesterase of approximately 12 per cent between readings for the first 2 weeks, whereupon the readings levelled off and fluctuated between 70 and 90 units for a period of 6 weeks. They then dropped sharply to a predetermined 'safety' level of 40 to 50 units whereupon the sprayers were removed from exposure. This level was reached some 9½ weeks after spraying commenced. The safety level set was still well above the level (25 per cent of normal) at which clinical symptoms of poisoning are said to become evident.

Recovery of blood cholinesterase was rapid and had risen to 80 per cent of normal within 4 weeks of removal.

In the second series, 2 lb of trichlorphon (as a 70 per cent w/v Low Volume Concentrate formulation) in 2 gal of water per acre was applied through the same misting machines which had been modified for Low Volume Concentrate application. The opportunity was also taken to study the effect of protective clothing—long-sleeved overalls, polythene gloves, hats and agricultural respirators—on whole blood cholinesterase levels of protected sprayers.

Results showed that there was a steady reduction in blood cholinesterase of approximately 16 per cent per week over the first 2 weeks. There was no difference between protected and unprotected sprayers during the first 3 weeks, but for the remaining 7 weeks there was a difference of from 12 to 23 per cent in blood cholinesterase levels, the protected and unprotected sprayers remaining at an average of 20 to 33 per cent and 32 to 48 per cent below normal respectively. The lowest reading obtained was a reduction of 53.1 per cent for an unprotected sprayer, still well above the safety level.

Following the introduction of trichlorphon spraying on both European and smallholder plantations in the Northern District during November-December, 1968, a monitoring system was established in December to monitor whole blood cholinesterase levels of plantation spray team personnel. From its establishment and up until the introduction of LVC trichlorphon in August-September, 1969 approximately 118 sprayers were removed from exposure with levels ranging from 50 down to 22 units.

[*continued overleaf*]

With the introduction of LVC trichlorphon, however, 106 sprayers had to be removed from exposure during the first 4 weeks with blood cholinesterase levels ranging from 60 down to 30 units (normal range: 90 to 150 units). This was contrary to what one would have expected from the results of the second series of controlled trials.

In an attempt to simplify the blood sampling procedure and obviate the need to forward the blood samples to Port Moresby, a portable cholinesterase field test kit was tested in the field at Popondetta. However, the kit gave highly variable results which were often quite misleading and field use of the kit was abandoned.

No differences were recorded in whole blood cholinesterase levels for 101 Europeans and 103 Papua New Guineans sampled at Port Moresby General Hospital.

USE OF RAW SWEET POTATO, RAW PEANUTS AND PROTEIN CONCENTRATE IN RATIONS FOR GROWING PIGS

G. L. MALYNICZ. *Papua New Guinea agric. J.*, 22 (3) : 165-166 (1971)

Twenty-seven weaner Berkshire cross pigs were used in an experiment with three replicates to study the performance of three diets:

(1) A control ration based on ground sorghum and protein concentrate,

(2) Raw sweet potatoes and raw whole peanuts,

(3) Raw sweet potatoes and 55 per cent crude protein concentrate.

Diets (2) and (3) were fed according to a modified Lehmann system. There were significant differences between treatment means for weight gain and food consumption for the three diets. Average daily gain (lb), average daily voluntary food consumption (lb of dry matter) and feed efficiency (dry matter basis) for the three treatments were (1) 1.246, 4.561, 3.662; (2) 0.208, 1.726, 8.533; (3) 0.7193, 3.538, 4.911. One of the pigs on the peanut, sweet potato ration died.

FURTHER STUDIES IN COCONUT SEEDLING ESTABLISHMENT

J. H. SUMBAK. *Papua New Guinea agric. J.*, 22 (3) : 167-173 (1971)

In a volcanic ash soil that had previously been cropped and had shown a response to nitrogen and sulphur, complete weed control led to superior growth compared with the normal plantation practice of periodical slashing. Complete weed control was also much superior to merely clean-weeding a limited area around seedlings. Seedlings fertilized with ammonium sulphate in any of the clean-weeding treatments were more heavily attacked by *Helminthosprorium incurvatum* than unfertilized seedlings and the growth of the latter was superior in all cases up to about one year after transplanting. At the end of the experiment fresh weight determinations showed that fertilized seedlings which had been subjected to limited clean-weeding were slightly heavier (despite the initial *H. incurvatum* damage) than unfertilized seedlings but that fertilized seedlings under complete clean-weeding remained inferior. There was an indication that under complete weed control a light mulch was beneficial.

[*continued overleaf*]

Under slashing maintenance the fertilizer effect was reversed, with fertilized seedlings being more than twice as heavy at the end of the experiment. Increased susceptibility to *H. incurvatus* is apparently related to high nitrogen availability and it is postulated that severe weed competition in the slashed plots prevented nitrogen availability from becoming excessive when fertilizer was used.

It is suggested that lower nitrogen rates or possibly the use of sulphur alone may result in lowering of *H. incurvatum* damage.

PRELIMINARY RESULTS OF A TWO-YEAR SORGHUM TRIAL ON A GRUMUSOL, WAIGANI, PAPUA NEW GUINEA

R. L. PARFITT AND D. P. DROVER. *Papua New Guinea agric. J.*, 22 (3) : 174-176 (1971)

Grain sorghum was grown on a grumusol at Waigani. One pot trial and a two-year field trial were carried out to test the response of the crop to nitrogen fertilizer. The yield was more than doubled with use of fertilizer. The pot trial showed that phosphorus and potassium were prerequisites for response to nitrogen.

RADOPHOLUS SIMILIS, THE BURROWING NEMATODE IN NEW GUINEA

J. M. FISHER AND DOROTHY E. SHAW. *Papua New Guinea agric. J.*, 22 (3) : 177-178 (1971)

Radopholus similis (Cobb, 1893) Thorne, 1949 is recorded on three occasions on unthrifty bananas at two sites at Lae and in the Lower Markham Valley, these being the first records of this nematode in New Guinea.

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PANULIRUS POLYPHAGUS—
A NEW SPINY LOBSTER RECORD FROM PAPUA NEW GUINEA

REX R. PYNE*

ABSTRACT

A female spiny lobster taken in the Gulf of Papua and identified as Panulirus polyphagus (*Herbst,* 1793), *is described and illustrated as a new record for Papua New Guinea.*

INTRODUCTION

COMMERCIAL exploitation of spiny lobster resources in Papua New Guinea has evolved around one species, the 'ornate spiny lobster' or *Panulirus ornatus* Fabricius. Four other species, viz., *P. versicolor* Latreille, *P. penicillatus* (Olivier), *P. homarus* Latreille, and *P. longipes femoristriga* (Von Martens), are also known to occur in Papua New Guinea waters (Pyne 1970; Rapson 1962).

A privately operated commercial prawn trawler, the M.V. *Claire, M,* fishing in Freshwater Bay, Gulf of Papua, took from the trawl catch a different species of spiny lobster, later identified by the author as *Panulirus polyphagus* (Herbst, 1793).

MATERIAL

One adult female of 244.3 mm total length, carapace length 85.2 mm, weight 292.2 g (see *Plate*) was taken at a depth of 13 metres by the prawn trawler M.V. *Claire M* on 23rd September, 1970, in Freshwater Bay (Lat. 8°10' S., Long. 146° E.).

DESCRIPTION

The antennular plate has two principal spines only, set well forward, the remainder of the plate being unarmed and smooth; colour is blue-green with a cream median longitudinal stripe. Antennular flagella have alternate bands of reddish-brown and cream.

Cephalothorax is divided into an anterior hepatic region with few spines and posterior branchio-cardiac region with many spines and tufted setae. Cervical groove is deep and smooth; hepatic groove shallow and smooth; cardiac and branchial grooves shallow with numerous tufted setae. Hepatic region blue-green in colour, has spines with a green-brown base and cream tip. The tufted setae, reddish-brown in colour, obscure the blue-green colour of the branchio-cardiac region.

The specimen has a row of six cream spots on each side of the lateral regions of the carapace, the anterior spot being the largest; a small spine arises from each spot. From the posterolateral corner of the carapace to the region of the mouth parts runs a white stripe, terminating in a broad white patch. Another white stripe commences at the same place, running along the base of the legs. Walking legs are patched; joints cream with remainder cream, green or brown patches.

Each abdominal somite is smooth, with a black transverse band on the hind margin, and a narrow horizontal cream stripe which is broken on the first abdominal somite. Colour is blue-green pitted with cream spots.

Anterior third of telson and uropods are blue-green in colour with pitted white spots; remainder is reddish-brown.

ACKNOWLEDGEMENT

I wish to thank Captain I. Ellem, M.V. *Claire M,* for making this specimen available to me.

REFERENCES

PYNE, R. R. (1970). Tropical Spiny Lobsters, *Panulirus* spp. of Papua and New Guinea. *Search, ANZAAS Sydney,* 1(5):248-253.

RAPSON, A. M. (1962). The Tropical Crayfish (*Panulirus ornatus* Fabricius) in southern Papuan waters. *Fish. Bull. Papua,* No. 2.

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*Biologist, Department of Agriculture, Stock and Fisheries, Kanudi

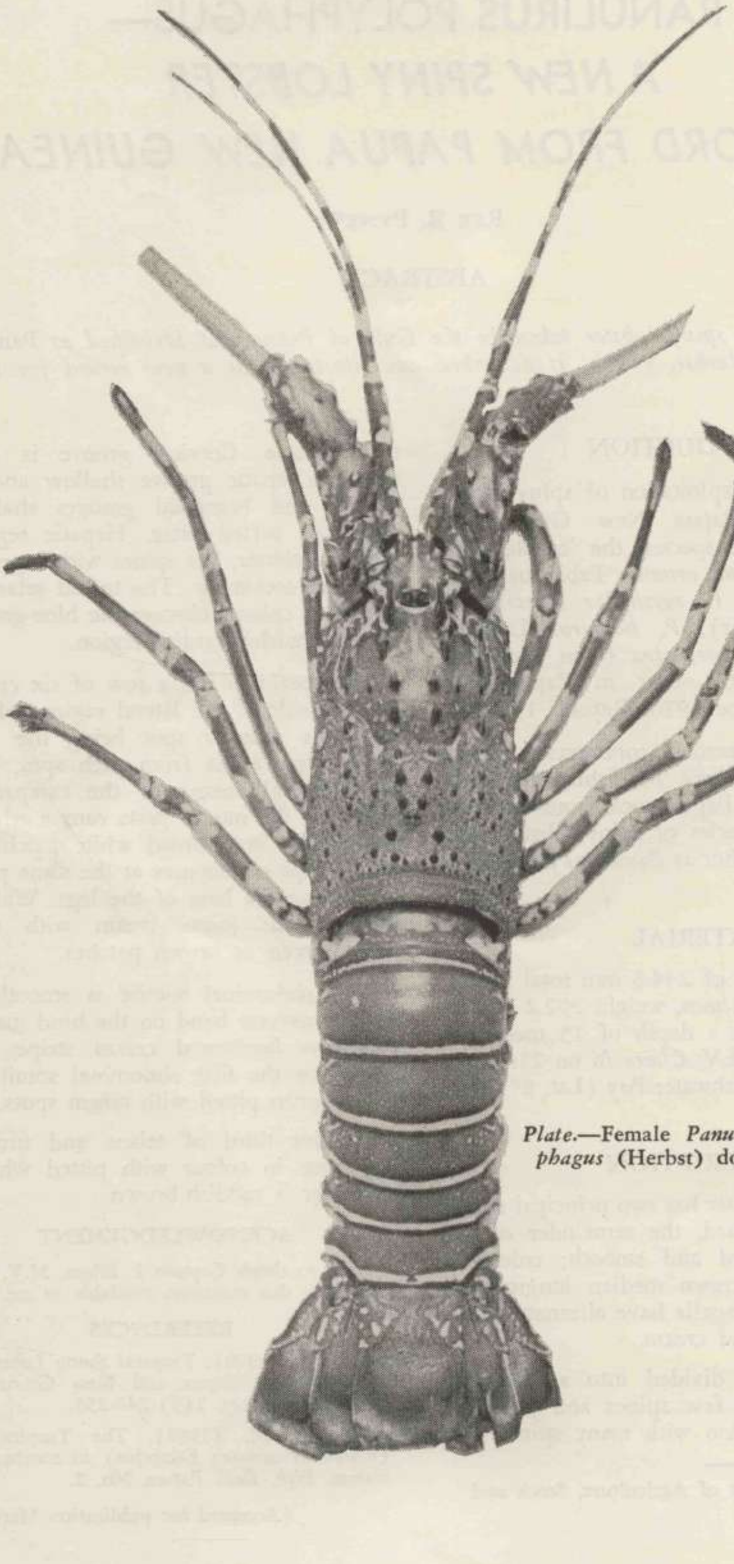

Plate.—Female *Panulirus polyphagus* (Herbst) dorsal view

EFFECT OF PROLONGED SPRAYING WITH TRICHLORPHON ON BLOOD CHOLINESTERASE LEVELS OF SPRAYERS

T. V. BOURKE,[1] W. B. MORRISON[2] AND BETTY K. MACARTNEY[3]

ABSTRACT

Two series of trials to study the effect of prolonged application of the organophosporus insecticide trichlorphon (dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate) to cacao trees through motorized portable misting machines on the whole blood cholinesterase levels of sprayers were carried out at Popondetta, Northern District in 1968-69.

In the first series 1.5 *lb of trichlorphon (as an* 80 *per cent wettable powder formulation) in* 30 *gallons of water per acre was applied to the cacao trees.*

There was steady reduction in whole blood cholinesterase of approximately 12 *per cent between readings for the first* 2 *weeks, whereupon the readings levelled off and fluctuated between* 70 *and* 90 *units for a period of* 6 *weeks. They then dropped sharply to a predetermined 'safety' level of* 40 *to* 50 *units whereupon the sprayers were removed from exposure. This level was reached some* 9½ *weeks after spraying commenced. The safety level set was still well above the level* (25 *per cent of normal) at which clinical symptoms of poisoning are said to become evident.*

Recovery of blood cholinesterase was rapid and had risen to 80 *per cent of normal within* 4 *weeks of removal.*

In the second series, 2 *lb of trichlorphon (as a* 70 *per cent w/v Low Volume Concentrate formulation) in* 2 *gal of water per acre was applied through the same misting machines which had been modified for Low Volume Concentrate application. The opportunity was also taken to study the effect of protective clothing—long-sleeved overalls, polythene gloves, hats and agricultural respirators—on whole blood cholinesterase levels of protected sprayers.*

Results showed that there was a steady reduction in blood cholinesterase of approximately 16 *per cent per week over the first* 2 *weeks. There was no difference between protected and unprotected sprayers during the first* 3 *weeks, but for the remaining* 7 *weeks there was a difference of from* 12 *to* 23 *per cent in blood cholinesterase levels, the protected and unprotected sprayers remaining at an average of* 20 *to* 33 *per cent and* 32 *to* 48 *per cent below normal respectively. The lowest reading obtained was a reduction of* 53.1 *per cent for an unprotected sprayer, still well above the safety level.*

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3. Medical Technologist in Charge of Biochemistry, Pathology Department, Department of Public Health, Taurama General Hospital, Port Moresby.

ABSTRACT

Following the introduction of trichlorphon spraying on both European and smallholder plantations in the Northern District during November-December, 1968, *a monitoring system was established in December to monitor whole blood cholinesterase levels of plantation spray team personnel. From its establishment and up until the introduction of LVC trichlorphon in August-September,* 1969 *approximately* 118 *sprayers were removed from exposure with levels ranging from* 50 *down to* 22 *units.*

With the introduction of LVC trichlorphon, however, 106 *sprayers had to be removed from exposure during the first* 4 *weeks with blood cholinesterase levels ranging from* 60 *down to* 30 *units (normal range:* 90 *to* 150 *units). This was contrary to what one would have expected from the results of the second series of controlled trials.*

In an attempt to simplify the blood sampling procedure and obviate the need to forward the blood samples to Port Moresby, a portable cholinesterase field test kit was tested in the field at Popondetta. However, the kit gave highly variable results which were often quite misleading and field use of the kit was abandoned.

No differences were recorded in whole blood cholinesterase levels for 101 *Europeans and* 103 *Papua New Guineans sampled at Port Moresby General Hospital.*

INTRODUCTION

REGULAR spraying of foliage, branches and trunks of cacao trees with the organo phosphorus insecticide trichlorphon by motorized portable misting machines was one of the Department of Agriculture, Stock and Fisheries' recommendations introduced in October, 1968 as a part of an overall programme financed by the Administration of Papua New Guinea to control *Pantorhytes szentivanyi* in the Popondetta-Sangara area of the Northern District. In the first instance a wettable powder formulation of trichlorphon was used and applied at 4-weekly intervals at the rate of 1.5 lb trichlorphon in 30 gallons of water per acre. One per cent superior white oil was added to act as a spreading agent.

In August-September, 1969 a 70 per cent w/v Low Volume Concentrate formulation of trichlorphon was introduced to replace the wettable powder formulation. Unfortunately, the lowest application rate that could be achieved with the motorized spraying units fitted with LVC adaptors was 0.5 gal per acre. As this would have resulted in 3.5 lb of trichlorphon being applied per acre, the LVC trichlorphon was diluted one in seven with water and applied at the rate of 2 gal per acre, equivalent to 2 lb trichlorphon per acre.

In Papua New Guinea, cacao forms a dense interlocking canopy at from 6 to 7 ft above ground level some 5 to 6 years after planting (see *Plate* I). It was thought that the spraying of cacao would present the same toxicological hazards as presented by spraying in a semi-enclosed environment, in that spray team personnel would be in an insecticide-saturated atmosphere for 6 to 8 hours per day 5 to 6 days per week.

Whilst trichlorphon is considered to be a relatively safe insecticide, having oral and dermal LD_{50} values in rats of 650 and 2800 mg per kg body weight respectively, no information was available on the effects of continued exposure of sprayers to trichlorphon under Papua New Guinean conditions. It was therefore thought necessary to run controlled trials to study the effect of prolonged spraying with trichlorphon on the blood cholinesterase levels of sprayers.

The opportunity was also taken (by B.K.M.) at a later date to determine the blood cholinesterase levels and range of personal variation in samples of Europeans and Papua New Guineans as we had been led to believe that Papua New Guinean levels would be lower than those for Europeans.

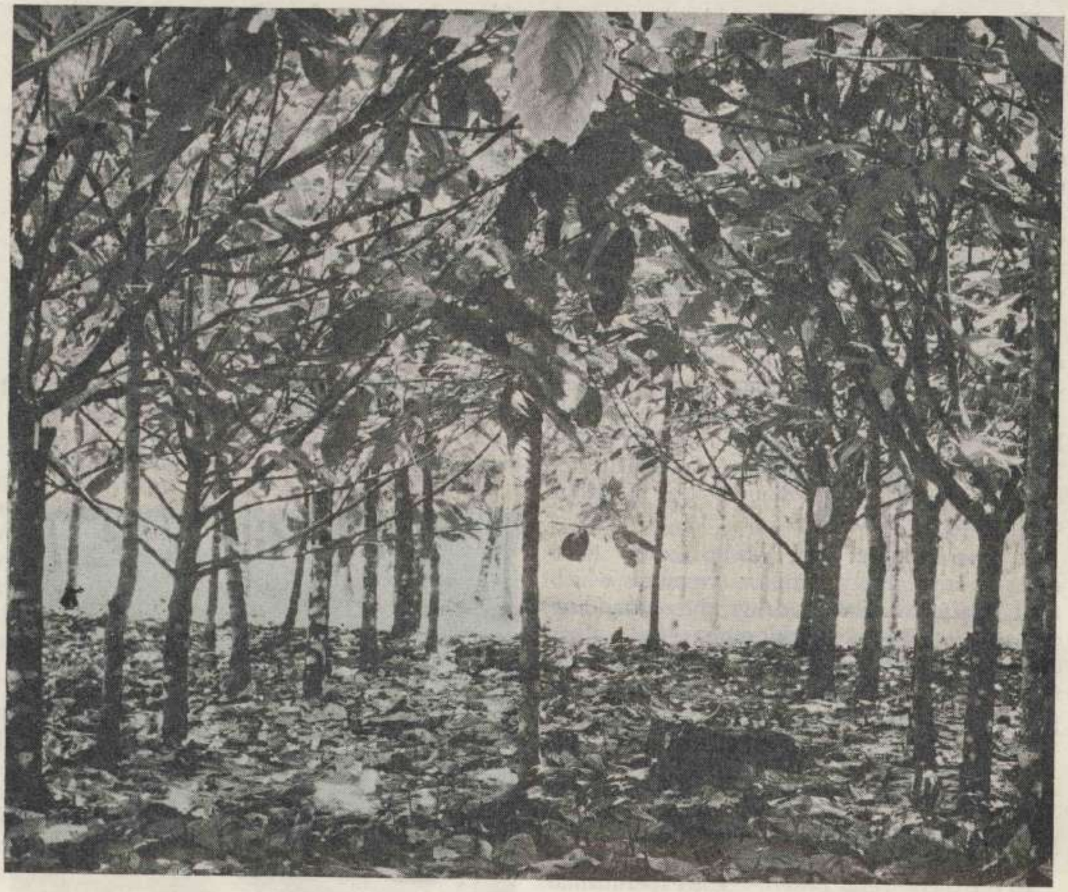

Plate I.—Five to six year old cacao showing dense interlocking canopy

(Photo; A. E. Charles)

METHODS AND MATERIALS

Trichlorphon

Trichlorphon (dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate) is a non-systemic, organophosphorus insecticide which acts mainly as a contact and stomach poison. Its solubility in water at 25 deg C is 15.4 g per 100 ml (Martin 1968). It is stable at room temperature but is decomposed by water at higher temperatures and at a pH greater than 5.5 to form dichlorvos (Muhlmann and Schrader 1957). Its activity in insects is attributed to its metabolic conversion to dichlorvos (Metcalf, Fukuto and March 1959).

Earlier work by Arthur and Casida (1957), however, failed to demonstrate the presence of dichlorvos in either *Musca domestica* L., *Periplaneta americana* (L.) or *Leucophaea maderae* (Fab.) adults poisoned with trichlorphon.

Trichlorphon has been shown to have a relatively low mammalian toxicity and to exert an anti-cholinesterase action *in vitro* and *in vivo* (Dubois and Cotter 1955). These same authors showed that rapid detoxification of trichlorphon was at least partially responsible for its low toxicity. When sublethal doses were administered to rats by intraperitoneal injection, trichlorphon disappeared from the serum rapidly and only a small percentage was excreted unchanged in the urine.

These findings were supported by the work of Robbins, Hopkins and Eddy (1956) who studied the metabolism and excretion of P^{32} labelled trichlorphon in a lactating cow following oral administration of the material at the rate of 25 mg per kg. They found that trichlorphon was rapidly metabolized by the cow and eliminated via the urine, with the peak of elimination occurring $2\frac{1}{2}$ to $5\frac{1}{2}$ hours following administration. No dichlorvos was detected in the blood, milk or urine of the cows.

Following the injection of 150 mg per kg of trichlorphon into a 9.2 kg female dog, general anticholinergic symptoms first appeared 15 minutes after administration and were followed by a marked diminution of symptoms 30 minutes later and apparent complete recovery 6 hours after administration (Arthur and Casida 1957).

It would appear that whilst acutely toxic doses of trichlorphon produce symptoms which are typical of cholinergic drugs, the outstanding difference between trichlorphon and other organophosphorus insecticides is that its duration of action is extremely brief and complete recovery of affected animals occurs within a few hours of poisoning (Dubois and Cotter 1955; Robbins *et al.* 1956; Arthur and Casida 1957; Metcalf *et al.* 1959).

Spray Team Personnel

(*a*) *Experimental Teams*.—The experimental spray teams consisted of indigenous labourers from the Northern, Chimbu and Western Highlands Districts.

(*b*) *Plantations*.—Composition of plantation spray teams varied from plantation to plantation and even between sampling dates on each individual plantation. However their composition was similar to that of the experimental teams.

Most plantation labourers had minimal formal education and very little instruction in the use of spray equipment, techniques of spray application or the dangers of pesticide application. The experimental spray teams had a slightly higher educational standard and received some instruction in the use of spray equipment and techniques of spray applications. They were also instructed in the simple safety procedures when handling or spraying pesticides—do not smoke when spraying or before washing hands; wash thoroughly after spraying; avoid gross contamination from spillage, leaking sprays, etc.

Clothing worn by sprayers varied, but generally consisted of a pair of shorts or a pair of shorts plus short-sleeved or sleeveless shirt. A typical sprayer is shown in *Plate II*.

Spraying Methods

The spraying method employed by plantations varied. The method used by the experimental spray teams was as follows:

Five sprayers were lined up at the edge of the block of cacao to be sprayed as shown in *Figure* 1. Each sprayer then proceeded down between two lines of cacao as shown (lines 1

Plate II.—Typical plantation sprayer showing spray machine and clothing usually worn under Papua New Guinea conditions

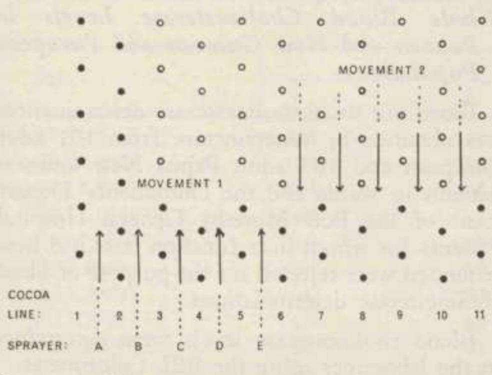

Figure 1.—Illustrates spraying method employed by experimental spray team

and 2 for sprayer A, 2 and 3 for sprayer B, etc.), spraying the half trees facing him and the canopy in between the trees as he moved. After completing the downward run (Movement 1), the sprayer then moved over five lines of cacao and sprayed rows 6 to 11 (Movement 2), and so on until the block was sprayed.

The spray units used in the controlled trials were either Solo Junior 410 or Solo Port 423 Misting Machines. All spraying on European owned/managed plantations, with the exception of one plantation, was carried out using Solo Port 423s. On the one plantation which did not use Solo Port 423s, a tractor mounted PTO misting machine was used.

Controlled Trials

1. *First Series.*—In the first series using the wettable powder formulation, 1.5 lb of trichlorphon in 30 gal of water per acre was applied through misting machines. A blood sample (1 ml venous blood) was taken from each sprayer on Mondays, Wednesdays and Fridays, and forwarded to Port Moresby for whole blood cholinesterase determinations. The Monday samples were taken before spraying commenced for the week and followed 2 days' (Saturday and Sunday) rest from spraying.

A second trial was started when it became apparent that the sprayers in the first trial were not continuously exposed. In the second trial, the sprayers were continuously exposed for 6 to 8 hours per day for 5 days a week. However there were two breaks during the exposure period—5 days between 25th and 29th December, 1968, and 1 day on 1st January 1969.

2. *Second Series.*—In the second series of trials 2 lb of trichlorphon (as a 70 per cent w/v Low Volume Concentrate formulation)* in 2 gal of water per acre was applied through the same misting machines which had been modified for Low Volume Concentrate application. Blood samples (1 ml of venous blood) were teaken as before and forwarded to Port Moresby for whole blood cholinesterase determinations.

Only one trial was conducted in this second series, and besides studying the effect of trichlorphon LVC on blood cholinesterase levels, the opportunity was taken to study the effect of protective clothing versus no protective clothing on blood cholinesterase levels. Accordingly three of the seven sprayers were outfitted with protective clothing consisting of long-sleeved overalls buttoned at the neck and wrists; elbow-length, heavy duty polythene gloves; plastic, brimmed hats; and an agricultural type respirator fitted with replaceable canisters. The unprotected sprayers were dressed in short-sleeved shirts and shorts.

Cholinesterase Determination

1. *Port Moresby Laboratory Method.*—The method used to determine blood cholinesterase in the Port Moresby laboratory was that outlined by Biggs, Carey and Morrison (1958) as modified by Varley (1962). This method relies on measuring the colour change of the indicator bromthymol blue in an EEL Colorimeter. Units of cholinesterase activity are expressed in micromoles of acetic acid liberated from acetylcholine by 1 ml of serum for 30 minutes at 37 deg C. Venous blood samples which had previously been taken into vials (at Popondetta) containing the anticoagulant lithium heparin were used.

2. *The Lovibond Comparator and Portable Kit Method.*—In an attempt to simplify the blood sampling procedure and obviate the need to forward samples to Port Moresby, a chol-

*This formulation was later replaced by a 59 per cent w/v LVC formulation, although the experimental team used the 70 per cent w/v formulation throughout.

inesterase test kit based on that developed by Gerarde (1964) and described by Simpson (1965, 1966a) using 0.01 ml of blood obtained from a finger prick, was used. The method is reported to give a combination of speed, convenience and reasonable precision for emergency or routine determinations. It relies on colour change of bromthymol blue due to the liberation of acetic acid from acetylcholine by the enzyme cholinesterase. It measures the change occurring in an 'unknown' blood sample in the time taken by a normal sample to reach the 100 per cent activity colour change. The change in colour, which is a measure of a change in pH over a fixed time, is therefore a measure of cholinesterase, reflecting the measure of exposure to the organophosphorus insecticide.

The kit was set up and tested in the Biochemistry Department of the Port Moresby Hospital. The indicator, substrate, and carbon-dioxide-free distilled water were checked each day prior to a batch of samples being tested. The kit proved quite satisfactory and was therefore taken to Popondetta to be used in the field. The first batches were run in the laboratory at Popondetta and were also fairly satisfactory.

However, as mentioned later, under both field and experimental conditions, no correlation could be obtained between the blood cholinesterase readings obtained via the kit and via the Port Moresby laboratory method, and field use of the kit was abandoned.

Whole Blood Cholinesterase Levels in Papuan and New Guinean and European Populations

Blood for these cholinesterase determinations was obtained by venepuncture from 101 adult European and 103 adult Papua New Guinean patients in wards and the Outpatients' Department of the Port Moresby General Hospital. Patients for whom liver function tests had been requested were rejected for the purpose of blood cholinesterase determinations.

Blood cholinesterase levels were determined in the laboratory using the EEL Colorimeter.

RESULTS

Controlled Trials

First Series.—The results of the first two trials are shown in *Tables* 1 and 2. It can be seen from both tables that there was steady reduction in blood cholinesterase of approximately 12 per cent between readings for the first 2 weeks, whereupon the readings levelled off. It actually rose in the first experiment because of the decreased daily exposure period, as explained previously. There was also a period during the second experiment when it appeared that cholinesterase levels had settled down at levels between 70 and 90 units for a period of 6 weeks. They then dropped sharply to a predetermined safety level of 40 to 45 units whereupon the sprayers were removed from exposure. This level was reached some 9½ weeks after spraying commenced. The safety level set was still well above the level

***Table* 1.—Effect of trichlorphon (wettable powder) on blood cholinesterase levels of sprayers —Trial 1**

Date	Units of Whole Blood Cholinesterase				
	A	B	C	D	E
18.9.1968 (pre-exposure)	150	148	146	145	124
24.9.1968	128	128	114	134	115
26.9.1968	110	109	99	104	106
1.10.1968	104	90	92	90	93
3.10.1968	92	88	75	72	91
9.10.1968	87	88	85	80	92
10.10.1968	93	103	103	96	92
16.10.1968	108	111	112	102	103
22.10.1968	98	100	104	84	94
29.10.1968	104	105	101	96	104

Table 2.—Effect of trichlorphon (wettable powder) on blood cholinesterase levels of sprayers —Trial 2

Date	Units of Whole Blood Cholinesterase				
	F	G	H	J	K
18.11.1968	140	136	136	128	125
20.11.1968	126	128	135	110	128
25.11.1968	114	106	90	103	112
27.11.1968	80	92	97	85	97
29.11.1968	80	80	74	70	84
2.12.1968	n.d.	80	72	63	74
4.12.1968	n.d.	89	87	74	92
6.12.1968	84	89	98	81	90
9.12.1968	92	92	97	92	99
12.12.1968	64	86	88	70	91
16.12.1968	64	73	83	58	74
19.12.1968	52	n.d.	60	54	54
23.12.1968	51	69	69	48	48
30.12.1968	78	72	n.d.	n.d.	60
2.1.1969	54	64	58	48	n.d.
6.1.1969	66	64	64	66	76
8.1.1969	52	78	74	88	76
9.1.1969	70	78	72	66	76
14.1.1969	71	82	81	71	80
16.1.1969	84	71	69	71	n.d.
20.1.1969	74	82	83	74	79
22.1.1969	44	54	62	48	44
23.1.1969*	44	48	57	40	44
28.1.1969	50	86	n.d.	60	60
31.1.1969	54	80	74	68	60
10.2.1969	98	108	106	100	72
13.2.1969	100	115	86	98	95
17.2.1969	n.d.	117	110	68	117
20.2.1969	106	104	100	98	104
25.2.1969	112	114	100	106	98

*Team taken off spraying at completion of spraying on 24th January, 1969.

(25 to 30 per cent of normal) at which clinical symptoms of poisoning are said to become evident (Simpson 1966b).

Second Series.—The results of the trichlorphon LVC are shown in *Table* 3. It can be seen that there was a steady reduction in blood cholinesterase of approximately 16 per cent per week over the first 2 weeks. There was no difference between protected and unprotected sprayers during the first 3 weeks, but for the remaining 7 weeks there was a difference of from 12 to 23 per cent in blood cholinesterase levels, the protected and unprotected sprayers remaining at an average of 20 to 33 per cent and 32 to 48 per cent below normal respectively. The lowest reading obtained was a reduction of 53.1 per cent for an unprotected sprayer, still well above the safety level. This information is summarized in *Table* 4.

Use of Field Kit

A comparison between the results obtained by using the field kit and from the laboratory method for both trichlorphon wettable powder and LVC formulations is shown in *Tables* 5 and 6 respectively. The kit was used by two different operators to obtain the results presented in *Tables* 5 and 6.

Table 3.—Effect of trichlorphon on blood cholinesterase levels of protected and unprotected sprayers

Week	Units of Whole Blood Cholinesterase						
	Protected			Unprotected			
	L	M	N	P	Q	R	S
16.6.1969 (pre-exposure)	125	121	101	145	142	125	121
20.6.1969	120	116	107	125	130	118	116
27.6.1969	78	82	73	95	107	78	82
30.6.1969	80	91	78	93	107	76	n.d.
4.7.1969	70	99	73	70	84	70	87
7.7.1969	70	85	85	n.d.	79	73	88
9.7.1969	91	97	90	86	91	79	83
11.7.1969	73	83	75	75	73	73	79
14.7.1969	92	92	92	n.d.	90	87	n.d.
16.7.1960	81	88	85	83	92	83	81
18.7.1969	83	100	85	95	85	83	73
21.7.1969	77	104	95	95	85	85	73
23.7.1969	79	79	92	n.d.	85	73	75
25.7.1969	88	81	79	73	85	58	68
28.7.1969	93	97	97	85	92	75	66
30.7.1969	90	95	97	87	90	87	79
1.8.1969	87	87	99	68	81	81	68
4.8.1969	92	97	83	87	93	87	79
6.8.1969	90	93	93	77	86	75	67
8.8.1969	96	86	77	70	66	59	59
11.8.1969	98	91	95	93	70	82	70
13.8.1969	82	88	75	75	75	75	65
15.8.1969	82	90	75	73	75	68	70
20.8.1969	82	93	82	70	86	63	65
22.8.1969	70	84	80	75	70	88	65
25.8.1969	109	110	91	98	104	90	82
29.8.1969	77	82	82	70	86	68	61

Table 4.—Percentage reduction in weekly cholinesterase levels of sprayers exposed to trichlorphon LVC

Week	Protected Sprayers				Unprotected Sprayers				
	L	M	N	Average	P	Q	R	S	Average
2	37.6	32.2	28.7	32.8	34.5	24.6	37.6	32.2	32.2
3	41.6	31.4	25.7	32.9	48.3	35.4	41.6	34.7	40.0
4	33.6	17.4	15.8	22.3	34.5	43.8	33.6	39.7	37.9
5	29.6	33.1	8.9	23.9	49.7	34.6	55.4	34.8	45.9
6	30.4	28.1	2.0	20.2	53.1	34.6	35.2	43.8	41.7
7	23.2	28.9	23.8	25.3	51.7	37.7	52.8	51.2	48.4
8	34.3	25.6	25.7	28.6	49.7	49.2	45.6	42.1	46.7
9	44.0	30.6	20.8	31.8	48.3	46.2	30.6	46.3	42.9
10	38.4	32.2	18.8	29.8	51.7	33.8	45.6	49.6	45.2

Table 5.—Comparison between results for trichlorphon wettable powder using laboratory methods (column 1) and field kit (column 3)

Date	Cholinesterase Readings														
	A			B			C			D			E		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
17.9.1968 (pre-exposure)			100			86.5			70			78.5			70
18.9.1968 (pre-exposure)	150			148			146			145			124		
24.9.1968	128	83.3	87.5	128	86.5	87.5	114	78.1	68.5	134	92.4	81.3	115	92.8	50
26.9.1968	110	73.3	87.5	109	73.6	87.5	99	67.8	75	104	71.7	68.8	106	85.5	67.5
1.10.1968	104	96.3	93.8	90	60.7	81.5	92	63	68.8	90	62.1	75	93	75	56.3
3.10.1968	92	61.3	81.8	88	59.5	75	75	51.4	75	72	49.7	68.8	91	73.4	62.5

1 = units of cholinesterase as determined by laboratory method

2 = laboratory readings as a percentage, taking the pre-exposure level (column 1) to equal 100 per cent

3 = percentage cholinesterase as determined by test kit

Table 6.—Comparison between results for trichlorphon LVC using laboratory methods (column 1) and field kit (column 3)

Date	Cholinesterase Readings																				
	L			M			N			P			Q			R			S		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
16.6.1969 (pre-exposure)	125	100		121	100		101	100		145	100		142	100		125	100		121	100	
20.6.1969	120	96	100	116	95.9	100	107	105.9	100	125	86.2	100	130	91.5	100	118	94.4	100	116	95.9	100
25.6.1969			43			59			50			78			100			66			59
27.6 1969	78	62.4	75.5	82	67.8	94	72	71.3	78.5	95	65.5	43	107	75.4	91	78	62.4	91	82	67.8	75.5
30.6.1969	80	64	49.5	91	75.2	72	78	77.2	44	93	64.1	43	107	75.4	62.5	76	60.8	69			
4.7.1969	70	56	79.5	99	81.8	75	73	72.3	65.5	70	48.3	81	84	59.2	90	70	56	78	85	71.9	78.5
16.7.1969	81	64.8	65.5	88	72.7	100	85	84.2	37.5	83	57.2	72	92	64.8	75	83	66.4	62.5	81	67	37

1 = units of cholinesterase as determined by laboratory method

2 = laboratory readings as a percentage, taking the pre-exposure level (column 1) to equal 100 per cent

3 = percentage cholinesterase as determined by test kit

Table 7.—Blood cholinesterase levels, in units of cholinesterase, for European and Papuan and New Guinean populations, Port Moresby

	Male			Female			All		
	Number sampled	Range	Mean	Number sampled	Range	Mean	Number sampled	Range	Mean
European	51	89-150	110.5	46	94-133	107.1	101	89-150	109.1
Papuan and New Guinean	46	99-138	111.3	26	89-124	107.2	103	89-138	109.6

From both tables it can be seen that the kit gave highly variable results which in many instances bore no resemblance to those obtained by the laboratory method. In fact some of the results obtained with the kit were quite misleading.

Following the first lot of results (*Table* 5), the use of the kit for estimating blood cholinesterase levels under field conditions was abandoned.

Whole Blood Cholinesterase Levels in European and Papuan and New Guinean Populations

The results of this survey are given in *Table* 7. Contrary to expectations, there was no difference between the cholinesterase levels of Europeans and Papua New Guineans.

DISCUSSION

From the first series of trials it became evident that the use of trichlorphon on a field scale to control *Pantorhytes* spp. would have to be watched closely. In fact a monitoring programme whereby regular blood samples (each of 1 cc of venous blood) were taken from plantation spray team personnel was commenced in early December, 1968. Sampling of individual spray teams was carried out at approximately 2-weekly intervals, and the samples were forwarded to Port Moresby for blood cholinesterase determination.

From the time the monitoring programme began and up until the introduction of LVC trichlorphon, approximately 118 sprayers were removed from exposure and one sprayer whose blood cholinesterase level fell to 22 units was admitted to hospital. However he did not exhibit any clinical symptoms of poisoning and was discharged after observation.

Following the introduction of LVC trichlorphon, however, the field position assumed rather alarming proportions, and in the first 4 weeks' use 106 sprayers were removed from exposure, with blood cholinesterase levels ranging from 60 down to 30 units (normal range: 90 to 150 units). Depletion of cholinesterase was rapid and occurred mainly within the first two weeks. It was obvious that gross contamination of sprayers was occurring and investigation showed that this was mainly from leaking spray machines. However with the introduction of the more concentrated spray (10 per cent versus 0.5 per cent for the wettable powder formulation) contamination of skin and clothing could also have been important.

Accordingly, a plea was made to planters (see *Appendix*) to ensure that the correct safety precautions were adopted by both sprayers and planters. This led to a marked improvement in the field position.

Absorption of organophosphorus insecticides may occur through the lungs, gastrointestinal tract, or skin (Batchelor and Walker 1954, Culver, Caplan and Batchelor 1956, Durham and Wolfe 1962, Simpson 1966). Absorption is more rapid and complete through the first two routes although skin contamination with small amounts of the more toxic compounds has frequently proved fatal.

Respiratory exposure may be of importance wherever there is a sufficient concentration of small droplets fine enough to inhale, and this may, in part, be responsible for the increased 'poisoning' of sprayers following the introduction of trichlorphon LVC. However it is usually contamination of the skin which is responsible for the lowering of cholinesterase levels.

It is also known that multiple exposures to organophosphorus insecticides over a brief period are partially cumulative in effect (Durham and Hayes 1962). However small multiple exposures over an extended period are not indefinitely cumulative in their effects but the cholinesterase level reaches a plateau (Hayes and Durham 1954, Sumerford *et al.* 1953). This may in part explain the levelling off of cholinesterase levels obtained in our trials. The reason for the further decrease in *Table* 2 is not known.

Recovery of cholinesterase levels as shown in *Table* 2, following removal from exposure, agreed well with that recorded in the literature. Durham and Hayes (1962) reported that following cessation of exposure to organophosphates plasma enzyme activity is increased by about 13 per cent of original activity during the first day, and more slowly thereafter, so that 30 to 40 days are required to reach the normal pre-exposure level. This would appear to be at variance with the statement by Simson, Simpson and Penney (1969) that plasma levels usually return to normal in 1 or 2 days, although the data presented by them (their Table 1) showed that a period of 32 days was necessary in the case of a person acutely poisoned with monocrotophos.

With erythrocytes, once fully inhibited, the enzyme content of a particular erythrocyte is not regenerated, and it would appear that the rate of regeneration of red blood-cell cholinesterase reflects the replacement of red corpuscles in the circulation and thus requires 90 to 100 days to return to normal after near complete depression (Durham and Hayes 1962). Ganelin (1964) quotes a recovery period of from 70 to 182 days, whilst Simson *et al.* (1969) quote a maximum figure of 42 days.

Use of Field Kit

As mentioned earlier, the results obtained when using the field kit were very disappointing, even though many attempts were made to use it and all reagents and apparatus were thoroughly rechecked. Possible reasons for its failure under field conditions are:—

1. The blood sample used with the field kit is only 0.01 ml. This is an extremely small amount to measure accurately under difficult conditions.

2. The people to be tested were often called direct from spraying. Their hands may have been improperly washed or fingers unsatisfactorily cleaned with spirit prior to sample collection, thus introducing a small amount of insecticide into the test.

3. The test is dependent upon change in pH and requires scrupulously clean glassware. This is difficult to achieve if the tubes and pipettes have to be rinsed between batches in the field.

4. The incidence of high temperatures.

The only other study of the effect of spraying with organophosphorus insecticides on blood cholinesterase levels of sprayers under tropical conditions is that reported by Marchart (1970). He studied the effects on five sprayers of routine mistblower application to cacao of 2 oz of monocrotophos per acre. Monocrotophos is reported to have oral and dermal LD_{50}s of 13 to 21 and 122 to 350 mg per kg respectively (Shell International Chemical Company Limited, London, unpublished report, 1967). Twenty-seven acres were sprayed per day and the sprayers were all fitted with protective

***Table* 8.—Mistblower application of monocrotophos: blood cholinesterase activities of spray men (from Marchart 1970)**

Sprayer	Cholinesterase Activity				
	Pre-exposure (average)	Exposure (days) 1	2	3	10 Days Post-exposure
A (Control)	123	118	140	120	127
B	114	109	90	62	87
C	102	73	85	33	80
D	111	108	61	32	134
E	146	137	134	97	132
F	110	63	85	29	81

clothing (overalls, broad-brimmed felt hats). The spray gang was cautioned that they were handling a more toxic material than usual. Results are shown in *Table* 8 (after Marchart). Although no clinical symptoms of poisoning became evident the trial was stopped on the third day. Marchart concluded that the results demonstrated the risk with heavy insecticide exposure to mistblower operators working in the confined space under dense cacao canopy.

Monocrotophos has also received some attention in Papua New Guinea where it has been aerially applied to coconuts on Lihir Island to control a complex of coconut insects. The insecticide (a 60 per cent w/v emulsifiable concentrate) was mixed with oil and water and applied at 13.5 fl oz per acre, equivalent to 0.5 lb of active ingredient per acre. The spray was mixed in bulk in closed drums, hoses and pumps being used to introduce the various components of the mixture into the drums. However, it was necessary to pour concentrated monocrotophos through a filter, and under field conditions minor spillage was probably unavoidable. All personnel wore Protector Toxiguard agricultural respirators and rubber gloves. Towels and water were available and freely used to wash any concentrate off the skin immediately. Loading of the plane was from closed drums via hose using either gravity feed or pumps. Masks and gloves were also worn throughout this operation.

Blood samples were collected before any handling of monocrotophos and immediately after spraying was completed (Lauer, unpublished data). Results of the whole blood cholinesterase determinations are shown in *Table* 9.

The levels of all the indigenous mixers subjects A to D) fell. Subject A's level fell drastically, and it was thought that this was due to his being much more active in the mixing process.

Subjects E and F were exposed in the treated area while spraying was in progress. There was virtually no change in their cholinesterase levels.

Subject G, who showed little change, had almost no contact with the spray, whilst subjects H and J were directly concerned with handling the monocrotophos concentrate.

The pilot (subject K), showed a fall of 35 per cent.

With an increasing use of organophosphorus insecticides in Papua New Guinea, some of which must be looked upon as hazardous materials for general use on plantations, it is obvious that we need to know more about the toxicological hazards for each insecticide formulation when used on specific crops. We have already had reports of methomyl (oral and dermal LD_{50}s of 17 to 23.5 (rats) and 1500 (rabbits) mg per kg respectively) producing vomiting attacks in a spray gang spraying cacao and they were apparently so severe that spraying with the application rate used had to cease.

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Table 9.—**Effects on blood cholinesterase levels of exposure and posible exposure to monocrotophos (after Lauer, unpublished data)**

Subject	Units of Blood Cholinesterase	
	Pre-spray Level	Post-spray Level
A	108	40
B	103	75
C	95	79
D	82	68
E	106	117
F	111	114
G	108	103
H	107	106
J	112	95
K	103	68

sprayers and for assisting in compiling the records used in the preparation of the paper.

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REFERENCES

ARTHUR, B. W. AND CASIDA, J. E. (1957). Metabolism and selectivity of 0,0-dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate and its acetyl and vinyl derivatives. *J. agric. Fd Chem.*, 5: 186-192.

BATCHELOR, G. S. AND WALKER, K. C. (1954). Health hazards involved in use of parathion in fruit orchards of North Central Washington. *A.M.A. Arch. Ind. Hyg. & Occup. Med.*, 10: 522-529.

BIGGS, H. G., CARLEY, SHIRLEY AND MORRISON, D. B. (1958). A simple colorimetric method for measuring activities of cellular and plasma cholinesterase *Amer. J. Clin. Pathol.*, 30: 181-186 (as quoted in Varley, H. (1962) in "Practical Clinical Biochemistry", 3rd Ed. p. 689 (Heinemann: London)).

CULVER, D., CAPLAN, P. AND BATCHELOR, G. S. (1956). Studies of human exposure during aerosol application of malathion and chlorthion. *A.M.A. Arch. Ind. & Occup. Med.*, 13: 37-50.

DUBOIS, K. P. AND COTTER, G. C. (1955). Studies on the toxicity and mechanism of action of Dipterex. *A.M.A. Arch. Ind. Hyg. & Occup. Med.*, 11: 53-60.

DURHAM, W. F. AND HAYES, W. J. (1962). Organic phosphorus poisoning and its therapy. *A.M.A. Arch. Ind. & Occup. Med.*, 5: 27-53.

DURHAM, W. F. AND WOLFE, H. R. (1962). Measurement of the exposure of workers to pesticides. *Bull. Wld Hlth Org.*, 26: 75-91.

GANELIN, R. S. (1964). Measurement of cholinesterase activity of the blood. *Ariz. Med.*, 21: 710.

GERARDE, H. W. (1964). Unopette Manual of Clinical Laboratory Procedure (Esso Research and Engineering Co.: Lindon, New Jersey, U.S.A.).

HAYES, W. J. AND DURHAM, W. F. (1954). Studies of organic phosphorus insecticide poisoning. *Congr. int. Path. comp VI*, II, 1952, Acta 1954, p. 231.

MARCHART, H. (1970). Monocrotophos mistblower application. Effect on blood cholinesterase. *Rep. Cocoa Res. Inst. Ghana* 1968-69, pp. 82-83.

MARTIN, H. (Ed.) (1968). *Pesticide Manual British Crop Protection Council*, 464 pp.

METCALF, R. L., FUKUTO, T. R. AND MARCH, R. B. (1959). Toxic action of Dipterex and DDVP to the house fly. *J. econ. Ent.*, 52: 44-49.

MUHLMANN, VON R. AND SCHRADER, G. (1957). Hydrolyse der insektiziden Phosphorsaureester. *Ztschr. Naturforschung*, 126: 196-201.

ROBBINS, W. E., HOPKINS, T. L. AND EDDY, G. W. (1956). The metabolism of P^{32}-labelled Bayer L13/59 in a cow. *J. econ. Ent.*, 49: 801-806.

SIMPSON, G. R. (1965). Cholinesterase testing and organo-phosphate pesticides. *Med. J. Aust.*, 1: 269-271.

SIMPSON, G. R. (1966a). A simple cholinesterase testing method for suspected organic phosphate pesticide poisoning. *Med. J. Aust.*, 1: 270-271.

SIMPSON, G. R. (1966b). Organic phosphate spraying exposure. *Med. J. Aust.*, 2: 906-907.

SIMSON, R. E., SIMPSON, G. R. AND PENNEY, D. J. (1969). Poisoning with monocrotophos, an organophosphorus pesticide. *Med. J. Aust.*, 2: 1013-1016.

SUMERFORD, W. T., HAYES, W. J., JOHNSTON, J. M., WALKER, K. AND SPILLANE, J. (1953). Cholinesterase response and symptomatology from exposure to organic phosphorus insecticides. *A.M.A. Arch. Ind. Hyg. & Occup. Med.*, 7: 383-398.

VARLEY, H. (1962). *Practical Clinical Biochemistry* 3rd Ed. p. 689 (Heinemann: London).

APPENDIX

SAFETY PRECAUTIONS TO BE OBSERVED WHEN SPRAYING TRICHLORPHON LVC FOR THE CONTROL OF PANTORHYTES SPP.

1. The concentrate is poisonous. Avoid contact with the skin and avoid breathing the vapour. If spilled on the skin, wash thoroughly with soap and water.
2. Sprayers should spray for a 2-week period and then be rested for 4 weeks.
3. AT THE COMPLETION OF EACH DAY'S SPRAYING, SPRAYERS SHOULD WASH OR BATHE THOROUGHLY, USING PLENTY OF SOAP AND WATER.
4. Any clothing worn during spraying should be removed at the completion of each day's spraying and WASHED THOROUGHLY. AT NO TIME SHOULD THE SPRAYER SLEEP IN CLOTHING IN WHICH HE HAS SPRAYED.
5. EVERY PRECAUTION SHOULD BE TAKEN TO ENSURE THAT THE SPRAY MACHINE DOES NOT LEAK INSECTICIDE OVER THE SPRAYER, ESPECIALLY FROM THE TAP, NOZZLE OR INSECTICIDE TANK. This is very important AS IT LEADS TO GROSS CONTAMINATION, and besides, it is very wasteful of spray.
6. SPRAYERS SHOULD NOT EAT OR SMOKE WHILE SPRAYING OR IMMEDIATELY AFTER SPRAYING WITHOUT FIRST WASHING THOROUGHLY WITH SOAP AND WATER.
7. Spillage of the concentrate or mixed spray should be avoided.

8. AT NO TIME SHOULD HANDS BE USED TO MIX THE SPRAY.
9. The SECOND SMALLEST flow restrictor hole in the ULV flow restrictor slide is used.

If large holes are used, the sprayer is being exposed to higher rates of insecticide and will therefore run a higher risk of being poisoned. Use of larger restrictor holes also leads to wastage of spray mixture without any increase in kill of *Pantorhytes* adults.

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USE OF RAW SWEET POTATO, RAW PEANUTS AND PROTEIN CONCENTRATE IN RATIONS FOR GROWING PIGS

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ABSTRACT

Twenty-seven weaner Berkshire cross pigs were used in an experiment with three replicates to study the performance of three diets:

(1) *A control ration based on ground sorghum and protein concentrate,*

(2) *Raw sweet potatoes and raw whole peanuts,*

(3) *Raw sweet potatoes and* 55 *per cent crude protein concentrate.*

Diets (2) *and* (3) *were fed according to a modified Lehmann system. There were significant differences between treatment means for weight gain and food consumption for the three diets. Average daily gain (lb), average daily voluntary food consumption (lb of dry matter) and feed efficiency (dry matter basis) for the three treatments were* (1) 1.246, 4.561, 3.662; (2) 0.208, 1.726, 8.533; (3) 0.7193, 3.538, 4.919. *One of the pigs on the peanut/sweet potato ration died.*

INTRODUCTION

INADEQUATE nutrition and low genetic potential for commercial productivity among the native pigs are the major technical problems facing the development of a pig industry in Papua New Guinea. The large population of native pigs subsists by scavenging and a little hand-feeding with sweet potatoes (Malynicz 1970). The utilization of locally grown feedstuffs has been considered of fundamental importance in the development of commercial pig production (Iverson 1964) and the main objective of this experiment was to evaluate sweet potato and peanuts, two local foods, in pig rations.

Most of the readily available foods in Papua New Guinea such as sweet potato, cassava, taro and sago, are high in water and carbohydrate but low in protein. Lehmann of Gottingen in Germany devised a feeding system for growing pigs based on the use of a similar starchy staple, the potato. The system consists in feeding a fixed amount of protein supplement from weaning to slaughter, in addition to which a starchy staple is fed to appetite. The system, with modifications, has been examined by Anon. (1930), Braude and Foot (1941), Butterworth and Houghton (1963) and Devendra (1963). The following paper describes an experiment based on the Lehmann method but utilizing sweet potato as the starchy staple with whole raw peanuts or a protein concentrate as the fixed protein supplement.

MATERIALS AND METHODS

A total of 27 male and female grade Berkshire cross Tamworth weaner pigs was used in the experiment. These were taken from three replicates of nine, allocated at random on the basis of litter origin to plots of three pigs per treatment. There were thus nine groups of three pigs in the experiment. The treatment rations compared are shown in *Table* 1.

All pigs were housed in open-fronted concrete-floored pens during the experiment which lasted for 12 weeks. Water was available *ad libitum.* Food was given once daily with uneaten residues weighed to allow estimates of food consumption for each treatment group to be obtained. Pigs were weighed at weekly intervals.

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Table 1.—**Characteristics of diets based on sweet potato, peanuts, protein concentrate and ground sorghum**

Ingredient	Ration 1	Ration 2	Ration 3
Ground sorghum	80 per cent		
Protein concentrate*	20 per cent		to 1 lb daily
Raw peanut kernels		to 1½ lb daily	
Raw sweet potato		*ad libitum*	*ad libitum*

*Hutmills, Melbourne, composition-minimum crude protein 55 per cent, salt 2 per cent, per lb Vit A 34,000 I.U., Vit D3 5,800 I.U., Vit E 28 I.U., Vit B2 12 mg.

Table 2.—**Treatment effects of diets based on sweet potatoes, peanuts, protein concentrate and ground sorghum ration**

	1 Control	2 Peanut	3 Concentrate	Standard Error	Significance
Initial weight (lb)	33	26	31	3.3	Not significant
Average daily gain (lb)	1.246	0.2018	0.7193	0.1201	1-3 $P<0.01$ 1-2 and 2-3 $P<0.05$
Daily dry matter consumption (1lb)	4.561	1.726	3.538	0.1432	All differences $P<0.01$
Feed efficiency	3.662	8.533	4.919		

RESULTS

Table 2 shows treatment effects for average daily gain, daily voluntary food consumption and feed efficiency. Analysis of variance and Duncan's test were used to assess significance between treatment means (Steel and Torrie 1960). One of the pigs on the peanut/sweet potato ration died during the experiment and others after its completion.

DISCUSSION

The pigs on the ground sorghum/protein concentrate diet gained weight at the rate of 1.246 lb per day. The concentrate/sweet potato group showed significantly lower ($P<0.05$) weight gains, as did the peanut/sweet potato pigs ($P<0.01$). There were corresponding significant differences in voluntary food consumption. Feed efficiency was greatest on the control ration and least on the peanut/sweet potato ration. At Goroka prices the costs per lb of liveweight gains for the sorghum concentrate and the sweet potato concentrate rations were 22.0 and 25.6 cents respectively, which considering the present ruling price of 50 cents per lb liveweight should allow a reasonable return on either ration.

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REFERENCES

ANON. (1930). *Scot. J. Agric.*, 13 : 30.

BRAUDE, R. AND FOOT, A. S. (1941). *J. Agric. Sci.*, 32 : 70.

BUTTERWORTH, M. H. AND HOUGHTON, T. R. (1963). *Emp. J. Exper. Agric.*, 31 : 14.

DEVENDRA, C. (1963). *Malayan Agric. J.*, 44 : 26.

IVERSON, K. R. (1964). *The Economic Development of the Territory of Papua and New Guinea* (International Bank for Reconstruction and Development: Washington).

MALYNICZ, G. L. (1970). Pig keeping by the subsistence agriculturalists of the New Guinea Highlands. *Proc. ANZAAS Conf. Port Moresby.*

STEEL, R. G. D. AND TORRIE, J. H. (1960). *Principles and procedures of Statistics* (McGraw Hill: New York).

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FURTHER STUDIES IN COCONUT SEEDLING ESTABLISHMENT

J. H. SUMBAK*

ABSTRACT

In a volcanic ash soil that had previously been cropped and had shown a response to nitrogen and sulphur, complete weed control led to superior growth compared with the normal plantation practice of periodical slashing. Complete weed control was also much superior to merely clean-weeding a limited area around seedlings. Seedlings fertilized with ammonium sulphate in any of the clean-weeding treatments were more heavily attacked by Helminthosporium incurvatum *than unfertilized seedlings and the growth of the latter was superior in all cases up to about one year after transplanting. At the end of the experiment fresh weight determinations showed that fertilized seedlings which had been subjected to limited clean-weeding were slightly heavier (despite the initial* H. incurvatum *damage) than unfertilized seedlings but that fertilized seedlings under complte clean-weeding remained inferior. There was an indication that under complete weed control a light mulch was beneficial.*

Under slashing maintenance the fertilizer effect was reversed, with fertilized seedlings being more than twice as heavy at the end of the experiment. Increased susceptibility to H. incurvatum *is apparently related to high nitrogen availability and it is postulated that severe weed competition in the slashed plots prevented nitrogen availability from becoming excessive when fertilizer was used.*

It is suggested that lower nitrogen rates or possibly the use of sulphur alone may result in lowering of H. incurvatum *damage.*

INTRODUCTION

THE advantages of adequate weed control during coconut seedling establishment on volcanic ash soils of the Gazelle Peninsula, New Britain, were demonstrated by Sumbak (1970). Seedlings in plots that were weeded by hand showed superior growth to those where weeds were merely slashed periodically. Regular slashing was superior to infrequent slashing. Under conditions of infrequent slashing growth was so poor that it was doubtful whether seedlings could be brought into production without fertilizer.

Weeds undoubtedly competed for nutrients, as good response to fertilizer occurred on slashed plots while clean-weeded plots showed less response. Fertilizer increased leaf sulphur content of seedlings in slashed plots very substantially while an uptake of nitrogen was also indicated. However, as fertilizer failed to raise seedlings in either of the slashed treatments to the standard of unfertilized clean-weeded seedlings it was probable that competition for soil moisture and probably light were also of importance.

Complete weed control, which leaves the soil in sole coconut stands exposed, would at present be neither feasible nor desirable in Papua New Guinea. However, clean-weeding in a limited area around the base of the seedlings would be practicable. A trial was conducted to investigate the effectiveness of weed control over a restricted area around the base of the seedling and the usefulness of a light mulch as well as any interaction of fertilizer with various maintenance systems.

EXPERIMENTAL METHODS

Seedlings between the four-leaf and seven-leaf stage were transplanted in January, 1968. A 15ft spacing was used as it was intended to terminate the trial after two years and hence inter-seedling competition would be of little

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consequence. The trial area initially supported a cover mainly of *Sorghum propinquum* with limited amounts of kunai (*Imperata cylindrica*) and occasional plants of sweet potato (*Ipomoea batatas*) and taro (*Colocatia* sp.).

Treatments were as follows:—

T1—periodical slashing (about every 8 weeks).

T2—clean-weeding over a circle about 3 ft in diameter.

T3—clean-weeding over a circle about 6 ft in diameter.

T4—clean-weeding the entire plot.

T5—clean-weeding the entire plot and light mulching.

Clean weeding circles were increased to 4 ft and 8 ft respectively in Fedruary, 1969. Treatments involving clean weeding were carried out at intervals of from 4 to 5 weeks. For a period of 8 months (extending from June, 1968 to February, 1969) labourers used spades and bush knives to remove weeds instead of using the prescribed method of pulling weeds out by hand, shaking the soil loose and laying the uprooted weeds over the area from where they had been removed. When spades were used, weeds and some of the topsoil were thrown outside the clean-weeded circles. Aside from lessening nutrient availability it is possible that the root systems of seedlings may have suffered some mechanical damage. Hand-weeding was re-introduced in February, 1969 and strictly observed. Mulch was applied every 8 weeks and consisted of young *Sorghum propinquum* plants. About 15 lb of fresh material were applied to each seedling so that an area about 4 ft in diameter around the base of the seedling was well covered.

Fertilizer was applied to alternate seedlings, 1 month after transplanting and thereafter at 2-monthly intervals, at 4 oz ammonium sulphate per seedling. Rates were changed to 8 oz every 3 months in February, 1969.

Main plots consisted of 16 seedlings and each treatment was replicated four times.

Regular records of height and frond production were taken and fresh weights of the above-ground portion of the plants were obtained, 25 months after establishment for two replicates and 26 months after establishment for the other two. It had been intended to keep two replicates growing but increasingly severe dynastid beetle damage forced an early conclusion to the trial.

RESULTS

Fungal attack, which undoubtedly contributed to the deaths of a number of seedlings and hindered the growth of others, added a complication to the trial as severity of damage appeared to be related to treatments. In the later stages dynastid beetle damage again complicated trial interpretation with the more advanced seedlings being more liable to attack. Results were assessed on an average per seedling basis.

Fungal Damage

Severe damage was noted in November, 1968 and the causal fungus was identified as *Helminthosporium incurvatum*. Damage appeared to be worst in the slashing treatments while the use of ammonium sulphate fertilizer in association with both complete or limited clean-weeding favoured fungal attack. *Table* 1 illustrates severity of damage on an average per seedling basis scoring the five youngest fronds of each seedling in the following scale:—

0 = uninfected.

1 = up to 25 per cent leaf area affected.

2 = 25 to 50 per cent.

3 = 50 to 75 per cent.

4 = 75 to 100 per cent.

5 = no functional leaf tissue.

Table 1.—Severity of *H. incurvatum* damage per seedling recorded in November, 1968*

Treatment	Fertilized	Unfertilized	Mean
T1	7.3	13.4	10.4
T2	14.4	8.7	11.6
T3	12.3	6.5	9.6
T4	13.4	5.5	9.5
T5	14.5	6.1	10.3

*See text for details of scoring for fungal damage.

An average rating was obtained by totalling the scores for each treatment and averaging.

A further examination in December, 1968, revealed numerous old leaf spots. Conidiophores resembling those of *H. incurvatum* were still present but no spores, and many other fungi, probably saprophytes, were also recorded on the old lesions. It was thought, at that stage, that much of the speckling of the green tissue with young lesions, not then sporulating, was due to a new cycle of infection by *H. incurvatum*. However, infestations as severe as the previous ones did not recur. The age of the seedlings or perhaps climatic effects and control measures adopted precluded severe damage. Control measures consisted of the removal and burning of severely affected fronds and spraying with copper oxychloride at 1 lb of ingredient to 29 gal of water.

Fungal damage was still evident in February and March, 1969 but it was not nearly as severe as the *H. incurvatum* damage encountered previously. Older fronds were typically affected (mainly frond positions 5, 6, 7 and 8) with only occasional infections on younger fronds. Symptoms were similar to those described by Shaw (1965) and attributed to *Pestalotiopsis palmarum* and *Pestalotiopsis theae*.

Another symptom which usually affected fronds from position 2 downwards was noted. Characteristically a blotchy yellowing and browning occurred at the base of leaflets usually well down the frond and gradually extended along the leaflets. The condition appeared to spread quite rapidly and affected tissue died quickly. The only fungus planted out from these lesions was a species of *Pestalotiopsis*. It was suspected that fungicidal sprays may have had a phytotoxic effect which may have favoured fungal infection. The suggestion of phytotoxicity arose from the observation that damage was first noticed at the base of leaflets and on the lower side where accumulation of liquids could be expected. The damage disappeared after about 6 weeks.

Although the initial heavy infestation by *H. incurvatum* was positively correlated with the use of ammonium sulphate fertilizer, later outbreaks mainly ascribable to species of *Pestalotiopsis* did not show a similar correlation with fertilizer use. Indeed a subjective assessment indicated less severe fungal damage where fertilizer was used under slashing and limited clean-weeding treatments.

Aside from contributing to seedling deaths fungal infestations weakened many seedlings. Seedlings were set back further by severe pruning of infected fronds as is illustrated in *Table* 2. Infected fronds were removed and burnt.

Seedling Deaths

Table 3 shows the number of deaths from the commencement of the trial in January, 1968 to mid February, 1969 (when most of the severe fungal damage was over) and total deaths from January, 1968 to March, 1970. There was initially a total of 32 seedlings in each sub-treatment.

Table 2.—Average number of fronds per surviving seedling in March, 1969

Treatment	Fertilized	Unfertilized
T1	4.70	3.13
T2	3.70	4.18
T3	4.25	4.34
T4	4.96	6.28
T5	4.21	6.47

During the first period the poor nutrient status of unfertilized palms in the slashed plots appeared to increase susceptibility to fungal damage which resulted in the death of almost half these seedlings. Fertilized palms in the other treatments were more heavily attacked by *H. incurvatum* than unfertilized and there were many deaths amongst heavily attacked seedlings. In the second period of the trial, 31 of the 54 deaths were associated with dynastid beetle attack, with 18 of these occurring in the completely clean-weeded plots.

Growth

Measurements of seedling heights and fronds production for February, 1969 and February, 1970 are shown in *Tables* 4 and 5.

Fresh weights of the above-ground portion of seedlings are shown in *Table* 6.

Plates I and II demonstrate the marked response to clean-weeding and mulching compared with ring-weeding only.

Table 3.—Total number of missing seedlings at various intervals after transplanting

Treatment	January, 1968 to February, 1969			January, 1968 to March, 1970			Percentage
	Fertilized	Unfertilized	Total	Fertilized	Unfertilized	Total	
T1	2	14	16	7	19	26	40.6
T2	6	3	9	12	8	20	32.3
T3	4	0	4	10	3	13	20.3
T4	3	4	7	9	13	22	34.4
T5	1	0	1	7	3	10	15.6
Total	16	21	37	45	46	91	28.6

Table 4.—Average seedling heights (ft) recorded in February, 1969 and February, 1970

Date	February, 1969*			February, 1970†		
Treatment	Fertilized	Unfertilized	Average	Fertilized	Unfertilized	Average
T1	6.00	3.47	4.73	13.47	8.95	11.21
T2	5.53	4.68	5.10	13.46	10.86	12.16
T3	5.76	4.25	5.25	12.57	10.20	11.39
T4	6.19	7.14	6.66	15.35	16.36	15.85
T5	5.91	6.67	6.29	16.32	17.58	16.95

* Least Significant Difference 5% 1.19 1% 1.67 Maintenance treatment means.

Least Significant Difference 5% 1.06 1% 1.47 Same maintenance, different fertilizer levels.

† Least Significant Difference 5% 3.36 1% 4.70 Maintenance treatment means.

Least Significant Difference 5% 1.88 1% 2.60 Same maintenance, different fertilizer levels.

Table 5.—Average cumulative frond production recorded in February, 1969 and February, 1970

Date	February, 1969			February, 1970*		
Treatment	Fertilized	Unfertilized	Average	Fertilized	Unfertilized	Average
T1	8,29	6.91	7.60	16.03	13.82	14.93
T2	7.67	7.67	7.67	16.89	15.61	16.25
T3	8.34	7.84	8.09	17.12	15.38	16.25
T4	8.89	9.39	9.14	18.38	19.17	18.77
T5	9.22	9.56	9.37	19.24	20.11	19.68

* Least Significant Difference 5% 2.29 1% 3.21 Maintenance treatment means.

Least Significant Difference 5% 1.19 1% 1.64 Same maintenance, different fertilizer levels.

Table 6.—Average fresh weight (lb) of above- ground portion of seedlings

Treatment	Fertilized	Unfertilized	Mean*
T1	88.0	39.5	63.8
T2	72.3	52.8	64.0
T3	81.0	51.3	66.1
T4	128.3	169.0	148.6
T5	157.3	205.8	181.5

* Least Significant Difference 5% 73.0 1% 102.3 Maintenance treatment means.

Least Significant Difference 5% 33.8 1% 46.7 Same maintenance, different fertilizer levels.

DISCUSSION

Maintenance Effects

Early growth measurements indicated that with ammonium sulphate fertilizer, differences between maintenance treatments were largely obviated, but without fertilizer, slashing or limited clean-weeding were inferior. However, as the experiment progressed the superiority of complete weed control to either slashing or limited clean-weeding became very marked and there was an indication that light mulching may also have been beneficial. Unfertilized seedlings which had been clean weeded and lightly mulched were more than twice as heavy as fertilized seedlings and five times as heavy as unfertilized ones where maintenance consisted solely of slashing. This is in general agreement with previous observations on maintenance effects (Sumbak 1970).

Plate I.—Treatment 5, unfertilized seedling 21 months after transplanting

Plate II.—Treatment 3, fertilized seedling 21 months after transplanting

The relatively poor performance of ring-weeded seedlings was somewhat surprising. Although incorrect weeding procedures for a portion of the trial may have been of some consequence it is more likely that poaching by weeds and competition with seedling roots outside the clean-weeded areas were of more importance. That limited clean-weeding had some effect was suggested by unfertilized seedlings in these treatments showing better growth than unfertilized slashed seedlings. This finding is of little practical value as growth in both cases was still unsatisfactory.

A good response to ammonium sulphate occurred under both limited clean-weeding and slashing but in the former case increased damage by *H. incurvatum* over the first portion of the trials lessened the overall positive fertilizer effect.

Fertilizer decreased growth in the completely clean-weeded plots by increasing susceptibility to *H. incurvatum* attack, but the possibility of more appropriate fertilizer benefiting growth cannot be overruled. It is noted that a small positive response to a compound fertilizer (NPK supplemented by sulphur) was shown under clean-weeded conditions in a previous establishment trial (Sumbak 1970).

Disease Effects

H. incurvatum damage was severe to about 12 months after field planting with the intensity apparently related to the nutritional status of the seedlings. It is likely that the relatively high nitrogen availability and possibly its relation to sulphur supply influences susceptibility to this fungus. Russell (1961) noted that "excessive amounts of nitrogen give leaves with such large thin-walled cells that they are readily attacked by insects and fungus pests and harmed by unfavourable weather such as droughts and frosts." Under conditions encountered in this trial, nitrogen levels are likely to have been high where clean-weeding (to a greater or lesser extent) was combined with frequent ammonium sulphate applications. This appears to have favoured *H. incurvatum* attack.

The clear indication that fungal damage was more severe in unfertilized than in fertilized seedlings under slashing maintenance is somewhat puzzling. One would expect severe weed competition to change fertilizer effects but that an effect should be reversed is very surprising. A number of very tentative explanations are ventured.

Less severe damage to fertilized seedlings under slashing maintenance may possibly be explained by severe weed competition limiting nitrogen availability but leaving sufficient for reasonable growth. In other words nitrogen levels in seedlings were not sufficiently high to induce an increased susceptibility to fungal attack. A possible explanation for the poor performance of unfertilized seedlings is that low sulphur levels have led to unthriftiness and so increased susceptibility to fungal attack generally, and other fungi besides *H. incurvatum* may also have been of importance.

Futher studies of nutrient availability under different maintenance systems and susceptibility to fungal attack are planned. Fertilizer types and rates under slashing and limited clean-weeding maintenance will be examined and work will not be limited to one site. Varietal reaction to fungal attack will also be noted.

The amounts of nitrogen applied are likely to be of importance. In a previous seedling establishment trial (Sumbak 1970) fungal attack caused some damage but there was no evidence of fertilizer increasing susceptibility to infestation. The amount of nitrogen supplied over the first 12 months to each seedling was 2 oz as compared to 5 oz in the current trial. In another establishment trial little fungal damage was evident on coconut seedlings fertilized with nitrogen and sulphur but a large number of deaths, and virtually no growth in seedlings fertilized with nitrogen only, caused the latter treatment to be abandoned. Maintenance involved infrequent slashing or rolling so in some respects it was similar to the current trial.

Damage due to *H. incurvatum* ceased to be a major problem about 12 months after transplanting but less severe damage attributed to *Pestalotiopsis* spp. and possibly other fungi continued throughout the duration of the trial. Towards the end fungal damage in the better-developed seedlings was negligible.

CONCLUSIONS

The practical implications of these findings are various. Where *H. incurvatum* is likely to be encountered it may be advisable to forgo clean-weeding around the seedlings, restrict maintenance to slashing and use ammonium sulphate fertilizer or possibly use restricted clean-weeding and reduce nitrogen application rates. It is also possible that where restricted clean-weeding is used additions of sulphur alone may suffice. The author recorded only a small response to sulphur without nitrogen in the first 2 years after transplanting in kunai (*Imperata cylindrica*) grassland conditions, but ring-weeding around the seedlings was not practised. Perhaps limited clean-weeding would ensure an adequate nitrogen supply which when supplemented by sulphur additions would allow good growth without increasing susceptibility to fungal damage.

Where *H. incurvatum* has not posed a problem in the past the use of ammonium sulphate combined with limited clean-weeding could well result in better growth than when maintenance is limited to slashing. This possibility and perhaps a reduction of nitrogen rates (or substituting sulphur) warrants investigation.

ACKNOWLEDGEMENTS

The author is indebted to Mr A. E. Charles, Chief Agronomist, Port Moresby, for assistance rendered. The supervision provided by Mr H. Gallasch during a portion of the trial is acknowledged.

REFERENCES

RUSSELL, E. W. (1961). *Soil Condition and Plant Growth*, 9th edition (Longmans Green : London) p. 31.

SHAW, DOROTHY E. (1965). Diseases of coconut in Papua and New Guinea. *Papua New Guin. agric. J.*, 17(2) : 67-71.

SUMBAK, J. H. (1970). Coconut seedling establishment as affected by seedling development at transplanting as well as agronomic practices. *Papua New Guin, agric. J.*, 22(1) : 6-25.

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PRELIMINARY RESULTS OF A TWO-YEAR SORGHUM TRIAL ON A GRUMUSOL, WAIGANI, PAPUA NEW GUINEA

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ABSTRACT

Grain sorghum was grown on a grumusol at Waigani. One pot trial and a two-year field trial were carried out to test the response of the crop to nitrogen fertilizer. The yield was more than doubled with use of fertilizer. The plot trial showed that phosphorus and potassium were prerequisites for response to nitrogen.

INTRODUCTION

MINOR alluvial plains consisting of moderately well drained dark clay soils occupy a small proportion of the coastal hill zone around Port Moresby. Average annual rainfall at Jackson's Airport is 1150 mm (45.2 in), 85 per cent of which falls between November and April. The vegetation is Eucalyptus—Themeda savannah open woodland. Although the soils are not extensive it was thought some information as to their fertility would be desirable prior to the possible establishment of a department of Agriculture at the University of Papua New Guinea. The soils are not used extensively by native people; when done, however, a shifting type cultivation is used.

MATERIALS AND METHODS

Soil.—The soil was a black clay of the Jackson family (Mabbutt *et al.* 1965). The profile was—

Horizon	Depth (cm)	Description
A	0-20	Black (N4/0) hard fine blocky clay with occasional limestone concretions, sticky and plastic when wet; pH 6.5.
B	20-	Black (N2/0) clay, hard massive, cracking when dry, sticky and plastic when wet; pH 6.5.

Mechanical analyses and chemical data are given in *Table* 1.

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Pot trial.—In 1970, a preliminary pot trial was made, primarily as a source of teaching material.

Seven kg of the A horizon of the soil were placed in 23 cm diameter pots and the following treatments in quadruplicate applied:—

0, 110 N, 110 N+34 P, 110 N+80 K, 34 P+80 K, 55 N+34 P+80 K, 110 N+34 P+80 K, 220 N+34 P+80 K.

The figures are in kg/ha. (Multiply by 0.9 to give lb/acre.) The treatments were randomized.

Nitrogen (N) was applied as ammonium sulphate, potassium (K) as potassium sulphate and phosphorus (P) as superphosphate. The 110 N and 220 N treatments were split into two equal applications, the second being applied 20 days after planting. The initial fertilizer was placed 5 cm below the seed, sorghum seed, Texas 608, was planted at a depth of 2 cm. The soil was kept at field capacity by daily adding distilled water.

Field trial.—The treatments were P+K, 55 N+P+K, 110 N+P+K, 220 N+P+K, where P and K were 34 kg and 80 kg/ha respectively. The fertilizer was broadcast 21 days before planting in 1970 and applied as a band in 1971 at planting. In 1971, half the 110 N and 220 N were applied as a side dressing 14 days after planting.

A randomized block with four replicates was used, each plot was 6 m (20 ft) by 6 m (20 ft). Sorghum seed, Texas 608 was broadcast by hand on 6th February, 1970.

Table 1.—Physical and chemical analysis for the Jackson soil

Horizon	% particle size			% Nitrogen	pH	Exchangeable cations m-equiv/100 g				Cation exchange capacity m-equiv/100 g
	Sand	Silt	Clay			Ca	Mg	K	Na	
A	34	22	40	0.07	6.6	39.8	2.2	0.38	0.3	45.6
B	32	17	41	0.03	6.6	—	—	—	—	—

In the second year, seeding was done on 15th December, 1970 with a seed drill. Rates of seeding were 8 kg/ha (7 lb/acre). The crop was harvested on 15th May, 1970 and 8th March, 1971.

RESULTS AND DISCUSSION

The results are shown in *Tables* 2 and 3.

Pot trial.—From *Table* 2 (a) the yield of sorghum was increased 70 per cent on addition of 110 kg N fertilizer. This was not significant (P>0.05). The addition of 80 kg K with the same dressing of N however caused a further increase as did 34 kg P but to a lesser extent. When phosphorus and potassium carriers were applied together in the absence of applied nitrogen, the grain yield did not differ significantly (P>0.05) from the control.

Table 2 (*a*).—Pot trial sorghum yield (weight of head—g/head)

Treatment	Control	110 N	110 N+80 K	100 N+34 P	34 P+80 K
Yield	9.5	16.3	28.8	21.3	10.0

Table 2 (*b*).—Mean yield of grain (g/head) (all plots received 34 P + 80 K)

Treatment	0 N	55 N	110 N	220 N
Yield	10.0	28.5	29.3	35.5

L.S.D. at P<0.05 = 14.7

Table 3.—Mean yield grain (kg/ha)

Year	0 N	55 N	110 N	22 N	L.S.D.
1970	1910	2030	2780	4380	For P<0.05, 1008
1971	2430	4500	6700	5730	For P<0.05, 1749

To obtain lb/acre multiply by 0.9

The effect of P and K on N is isolated in *Table* 2 (b); the yields for all three levels of N are significantly higher than the controls (P<0.05). The increase in yield with 220 N however is not significantly greater than that with 55 N.

Field trial.—The yields of grain for the 1970 and 1971 seasons are given in *Table* 3.

In 1970, the maximum grain yield was obtained with 110 kg N/ha. This was statistically greater (P<0.05) than for any of the other treatments. The yields from the lower dressings of nitrogen did not differ statistically (P>0.05) among themselves. The small response to 55 kg N is probably explained by the heavy rain 415 mm (16.3 in) in February, 1970 which may have leached the fertilizer from the soil.

In 1971, maximum yield was obtained with 110 kg N/ha; 220 kg/ N/ha was excessive and depressed the yield. The overall yields were higher in this year due no doubt to the equal distribution of rain over the growing season and the banding of the fertilizer and seed. The yields from 110 lb N/ha and 220 lb N/ha were not statistically different (P>0.05).

No statistical comparison was made of the two years' trials.

The results of a two years' nitrogen fertilizer experiment on a dark tropical clay soil indicate that continuous cropping does not cause a rapid decline in soil nitrogen as the yield of sorghum from the 1971 control was greater than that in 1970. The results from a pot trial indicate that at least 80 kg K/ha and 34 kg P/ha are a prerequisite for response to ammonium sulphate fertilizer.

REFERENCES

MABBUTT, J. A. *et al.* (1965). Lands of the Port Moresby-Kairuku Area, Territory of Papua and New Guinea. *Lands Res. Ser. CSIRO Aust.* 14.

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RADOPHOLUS SIMILIS, *THE BURROWING NEMATODE IN NEW GUINEA*

J. M. Fisher* and Dorothy E. Shaw†

ABSTRACT

Radopholus similis (*Cobb,* 1893) *Thorne,* 1949 *is recorded on three occasions on unthrifty bananas at two sites at Lae and in the Lower Markham Valley, these being the first records of this nematode in New Guinea.*

DURING November, 1970 a banana sucker showing signs of root disease was studied at the Konedobu laboratories. The sucker came from a stool of green-bracted cooking bananas of the *Musa acuminata* type from Lae, New Guinea. The grower stated that it came from a plant which showed sickness for some weeks as evidence by production of very small leaves, premature shooting of a weak bunch, abundant production of water suckers and later collapse of the pseudostem with the inflorescence. An examination of the base showed that most of the roots were dead and rotten and were in a similar condition to the main stool and could be lifted out of the ground without any digging.

Amongst the nematodes extracted by the Baermann funnel at Port Moresby from the decaying roots and surrounding soil were various nematodes, including numerous specimens of *Radopholus similis* (Cobb, 1893) Thorne, 1949,, as identified by the senior author (TPNG 7396). The bananas surrounding the infested site have been kept under observation, but no other unthrifty plants have been noted.

A survey was then undertaken of bananas (cooking, fresh eating and non-edible) at seven localities in the lower Markham Valley. Only at one site at one locality were some unthrifty suckers found, in a stool of Dwarf Cavendish (*M. acuminata*). Extraction from roots and soil by the Baermann funnel at Port Moresby was carried out, and specimens of the nematodes were again identified by the senior author as *R. similis* (TPNG 7580 and 7581). Another extraction carried out from a further set of suckers from the same site several weeks later also included nematodes identified as *R. similis* (TPNG 7593).

Although no unthrifty bananas were found at the other six localities, extractions of soil from each were carried out as a check but no *R. similis* was recorded. The bananas included *M. acuminata* (1 area), *M. acuminata* type (1 area), *Musa* sp. with characteristics of *M. acuminata* and *M. schizocarpa* (1 area), *M. schizocarpa* (1 area) and *M. balbisiana* type (2 areas) (TPNG 7620-5 inclusive).

The nematode is regarded as a serious pest of bananas in most countries where bananas are grown, including New South Wales, Queensland, Indonesia, Fiji, West Indies and the U.S.A., and was first recorded from Fiji in 1893.

Symptoms produced by the nematode on bananas include reddish-brown lesions in the cortex of affected lateral or 'cord' roots which gradually expand, and if they coalesce they may encircle the cortex and eventually that part of the root distal to the lesion will be killed. If the population of nematodes is dense, the root system may be reduced to a few short stubs at the base of the corm such that anchorage becomes tenuous and the plants topple easily. Lesions close to the corm may extend with the roots into the superficial layers of the corm. Thus, young suckers in an infested area are likely to be affected. Therefore, new planting material should be obtained from uninfested areas.

The nematode exists in a number of races, one of which attacks citrus and is responsible for 'spreading decline' of citrus in Florida, U.S.A., on the control of which millions of

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dollars have been spent. It is not known as yet which race or races are present in Papua New Guinea.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to Dr G. Argent of the New Guinea Biological Foundation for forwarding the first specimens and for the identification of the bananas, and to the following officers of the Department of Agriculture, Stock and Fisheries: Mr P. N. Vance and Mr S. Meara for forwarding two specimens and to Mr W. A. Layton for one extraction.

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INSECT PEST SURVEY FOR THE YEAR ENDING 30th JUNE, 1968*

CONTENTS

* Compiled by Entomology Branch, Research and Surveys Division, Department of Agriculture, Stock and Fisheries.

ADDENDUM AND ERRATA TO INSECT PEST SURVEY FOR THE YEAR ENDING 30th JUNE, 1967

ADDENDUM

COCONUTS

Galela sp. (Fulgoridae)

Female adult collected from palm, Passam, East Sepik District, April, 1967.

SHADE TREES AND ORNAMENTALS

Pericyma cruegeri (Butl.) (Noctuidae)—Poinciana Looper

The exceptional intensity of the wet season at the beginning of 1967 apparently slowed down the build-up of *Pericyma cruegeri* in the Port Moresby town area (Central District).

Surveys on the incidence of the pest carried out in January and February showed that by the third week of February, late instar larvae and pupae were present in the upper parts of poinciana trees (*Delonix regia*) throughout the survey area and it was evident that the next generation would cause severe damage.

Heavy defoliation was observed in the Konedobu and Paga Hill areas in the latter part of March, and became widespread shortly thereafter. Large populations persisted until the end of May but then declined sharply. The continuation of the wet season after the end of May enabled trees to make new growth which remained substantially free from attack. As a consequence, poinciana trees in Port Moresby carried more foliage in June than at the same period in any year since 1957.

Xyleborus compactus Eichhoff (Scolytidae)

Adults bred from stems of *Gliricidia maculata*, L.A.E.S., Keravat, E.N.B., February.

ERRATA

Page 51—delete the heading "Phytophagous Insect Pests in Papua and New Guinea" and substitute "Insect Pest Survey for the year ending 30th June, 1967".

Final para., line 3, for Messers", read "Messrs".

Page 52—column 2, under *Archips spilotoma* Meyr (Tortricidae), for "cause" read "caused".

Under *Crossotarsus barbatus* Chapuis (Platypodidae) for "½ in." read "⅛ in.".

Page 55—column 1, for "*Psychidae*, gen. et sp. indet." read "Psychidae, gen. et sp. indet.".

Page 62—column 1, for "*Atractomorpha crenaticeps* Blanch. (Acrididae)" read "*Atractomorpha crenaticeps* Blanch. (Pyrgomorphidae).".

Page 66—column 1, for "*Onthophagus latenasutus* Arrow (Scarabaeidae)" read "*Onthophagus latenasutus* Arrow (Scarabaeinae)".

Page 69—column 2, for "*Brachymeria euploeae* Westw. (Braconidae)" read "*Brachymeria euploeae* Westw. (Chalcididae)".

For "*Brachymeria* sp. (Braconidae)" read "*Brachymeria* sp. (Chalcididae)".

Page 73—column 1, for "*Lagria palliata* . . . 59, 57", read "*Lagria palliata* . . . 59, 67".

INSECT PEST SURVEY FOR THE YEAR ENDING 30th JUNE, 1968

INTRODUCTION

THIS is the second annual insect pest survey to be published. As in the first surveys†, the insects are arranged alphabetically under the different hosts which have been grouped under general headings such as Commercial Tree Crops, Field Crops, Fruit, Nut and Food Trees, etc., as shown in the Table of Contents. Indices to the various insects and plants mentioned in the list are appended. Abbreviations used in the text are as follows:—

C.D.—Central District
E.N.B.—East New Britain District
N.D.—Northern District
S.H.D.—Southern Highlands District
W.N.B.—West New Britain District
W.D.—Western District
W.H.D.—Western Highlands District

Unfortunately the first survey contained some errors and omissions which were partly outside our control. These have been corrected and are given on page 180. The various family and subfamily names as listed in the CSIRO's recent text book *The Insects of Australia* (Melbourne University Press, 1970, xiii + 1029 pp.) have been used in this second survey.

The majority of identifications other than those made by our own staff were made through the Commonwealth Institute of Entomology, London. Other specialists who co-operated were Drs I. F. B. Common, K. H. L. Key and Mr T. G. Campbell, CSIRO, Canberra, Australia, Mr K. L. Taylor, CSIRO, Hobart, Tasmania, Mr R. A. I. Drew, Department of Primary Industries, Brisbane, Queensland, Professor C. H. Martin, Oregon, U.S.A., Dr S. Endrodi, Natural History Museum, Budapest, Hungary, and Dr Z. Kaszab, Natural History Museum, Budapest, Hungary.

COMMERCIAL TREE CROPS

CACAO (*Theobroma cacao*)

Acanthotyla sp. (Coreidae)

Adults very numerous on cacao, mainly on pod stems, Popondetta/Sangara area, N.D., July, 1967 to June, 1968. Its status as a pest species still remains unknown.

Achaea janata L. (Noctuidae)—Cacao False-Looper

Larval damage to cacao (flush) in the Popondetta/Sangara area, N.D., remained at a very low level during the year and the insect has virtually ceased to be a problem.

† Insect Pest Survey for the year ending 30th June, 1967. *Papua New Guin. agric. J.*, 21 (2) : 49-75 (1969).

Adoxophyes fasciculana Walk. (Tortricidae)

Larvae were found feeding on flush foliage throughout the year in the Popondetta/Sangara area, N.D.

Adoxophyes sp. (Tortricidae)

Larvae found feeding on foliage throughout the year, Gazelle Peninsula, E.N.B.

Amblypelta theobromae Brown (Coreidae)—Amblypelta

Adults and nymphs numerous on pods in cacao blocks in the Kokoda Valley (Kokoda-Ilimo) and Popondetta/Sangara area, N.D., July, 1967 to June, 1968. Isolated areas of severe damage to young pods reported from time to time.

Anchiale maculata Oliff (Phasmatidae)

Adults and nymphs present on cacao in the Northern District throughout the year. Damage slight, although increases in numbers were recorded during the main cacao flush (vegetative growth) periods.

Cerambycidae, either *Dihammus* sp. or *Monohammus* sp.

Larvae boring in stems of cacao trees, Bougainville, July. Preserved larvae collected from cacao on Goodenough Island, Milne Bay District, were received at Konedobu in December.

Dasychira mendosa Hubn. (Lymantriidae).

Larvae present on flush foliage and pods from October onwards, Popondetta/Sangara area, N.D. Larval numbers increased during the period October to December and remained at a high level during the wet season.

Ectropis sabulosa Warr. (Geometridae)—Cacao Looper

Larvae present on flush foliage from time to time during the year but damage negligible, Popondetta/Sangara area, N.D.

Elytrocheilus coeruleatus (Pasc.) (Curculionidae)

Adults observed feeding on foliage and stems in the Northern District throughout the year. Twigs were often completely ring-barked, but damage usually of minor importance only.

Euproctis sp. (Lymantriidae)

Larvae collected from cacao flush, Vunapau, E.N.B., August.

Glenea aluensis Gah. (Cerambycidae)

Larvae boring in stems of cacao trees, Bougainville, July.

Helopeltis clavifer (Walk.) (Miridae)—Cacao Mirid

This insect is by far the most widespread and damaging cacao mirid in the Northern District, especially in the Sangara/Popondetta area. Adults, nymphs and eggs were to be found in cacao blocks at any time during the year, and damage to young and old pods and growing tips were both severe and widespread, especially during dry spells. Loss of production often approached 80 per cent of the expected crop.

Homona coffearia Nietn. (Tortricidae)—Tea Tortrix

Larvae fed on foliage, Keravat, May.

Hyposidra talaca (Walk.) (Geometridae)—Cacao Looper

Larvae present on flush foliage from time to time during the year, but damage negligible, Popondetta/Sangara area, N.D.

Idiopsis coerulea Fst. (Curculionidae)

Adults reported to have fed on foliage and caused minor defoliation, Bokre, Bougainville, December.

Lobobasis niveimaculata Hamps. (Arctiidae)

Larvae collected from cacao, Keravat, E.N.B., July.

Nacaduba berenice dobbensis Roeber (Lycaenidae)

A common species feeding on flush foliage in the Sangara/Popondetta/Serovi area, N.D., throughout the year. Of no economic importance.

Neolieftinckana fuscata Spin. (Fulgoridae)

Adults collected from foliage, Sangara, N.D., March. No damage noticed.

Olethreutes sp. (Olethreutinae)—Cacao Pod Borer

Reports of larvae boring into the mesocarp of ripening pods were received from Bougainville and the Warangoi area, E.N.B., during the year, but little or no penetration of the endocarp apparently occurred.

Pansepta teleturga Meyr. (Xyloryictidae)—Cacao Web Worm

The incidence of this pest continued to increase, particularly in areas where shade had been drastically reduced or completely removed on the Gazelle Peninsula, E.N.B.

Pantorhytes chrysomelas (Montr.) (Curculionidae)—Cacao Weevil

Adults collected from cacao trees, Baturu, N.D., August. Its status as a pest species is not known.

Pantorhytes batesi batesi (Faust.) (Curculionidae)—Cacao Weevil

Adults, larvae and eggs very numerous in cacao plantations along Markham Valley and lower Wau Valley, Morobe District, July, 1967 to June, 1968. Damage to trees by larvae and adults severe where no control measures had been adopted.

Pantorhytes plutus (Oberth.) (Curculionidae) —Cacao Weevil

Continued to cause severe damage to cacao trees on the Gazelle Peninsula, particularly the Warangoi area, E.N.B.

Pantorhytes szentivanyi Marsh. (Curculionidae)—Cacao Weevil

Adults, larvae and eggs very numerous in most cacao plantations in the Popondetta/Sangara area, N.D., July, 1967 to June, 1968. Damage to older cacao particularly severe where no control measures had been adopted.

Pinzulenza kukisch Her. (Limacodidae)

A very common species in the Sangara/Popondetta area, N.D., throughout the year. Damage slight.

Larvae severely defoliated cacao under coconuts on Kulili Plantation, Karkar Island, Madang District, during August to September. The outbreak was eventually brought under control by the chalcid pupal parasite *Brachymeria salomonis* Cam.

An outbreak also occurred on cacao under coconuts at Baubauguina Plantation, Central District, during October to November. A single specimen of the tachinid? *Spogossia* sp. was reared from a large batch of pupae received at Konedobu.

Priocnemicoris flaviceps Guer. (Coreidae)

Collected from cacao, L.A.E.S., Keravat, E.N.B., November.

Pseudodoniella typica (China and Carv.) (Miridae)—Cacao Mirid

Heavy infestations throughout the year in many areas on the Gazelle Peninsula, E.N.B., but most noticeable in the Warangoi area.

Salina sp. (Collembola)

Adults and nymphs always numerous on cacao foliage, Keravat, E.N.B. Its status as a pest has not been proved.

Symphylites sp. (Cerambycidae)

A commonly encountered pest of cacao in the Sangara/Popondetta area, N.D. The larvae bore in the stems of cacao trees. Damage to date has not been extensive.

An unidentified hymenopterous larval parasite is often associated with the larvae.

Tiracola plagiata (Walk.) (Noctuidae)—Cacao Armyworm

Except for areas of cacao still shaded by *Leucaena leucocephala*, *T. plagiata* ceased to be a problem in the Northern District. However in areas shaded by *L. leucocephala*, moderate to severe damage was still experienced throughout the year.

Toxoptera aurantii B. de Fonsc. (Aphididae)—Black Citrus Aphid

Adults and nymphs present on young flush from time to time during the year, Popondetta/Sangara area, N.D., but damage insignificant.

Xyleborus destruens Blandf. (Scolytinae)

Adults bred from cacao stems forwarded from Kieta, Bougainville, April, June.

COCONUTS (*Cocos nucifera*)

Aleurodicus destructor Mackie (Aleyrodidae)

Colonies (adults and nymphs) were noted on the foliage of many palms at Hula, C.D., in August. The infestation was not heavy, and little damage was apparent.

Amarygmus hydrophiloides Fairm. (Tenebrionidae)

Adult collected from fronds, Nahavio, W.N.B., May. No damage noted.

Amblypelta cocophaga cocophaga Brown (Coreidae)

Reported to have caused premature nutfall, Bougainville (no date).

Aulacophora sp. (Galerucinae)

Adults collected from fronds, Gaungo Village, W.N.B., May. No damage noted.

Axiagastus cambelli Dist. (Pentatomidae)—Coconut Spathe Bug

Adults and nymphs reported to be responsible for continued, severe nutfall, Lihir Island, New Ireland District, during the year. There has still been no definite proof to show that *A. cambelli* is the primary causal agent of premature nutfall on Lihir Island.

Baryrrhynchus schroederi Kln. (Curculionidae)

Adults collected from fronds, Mosa Plantation, W.N.B., May. No damage noted.

Brontispa longissima Gestro (Hispinae)—Coconut Hispid

Damage to young palms widespread and serious at Hula, C.D., August.

Larvae and adults caused moderate to severe damage to young palms throughout the year, W.N.B.

Cephrenes moselyi (Butl.) (Hesperiidae)—Coconut Skipper

Larvae caused moderate leaf damage to 1 to 2 year old coconuts, Talasea area, W.N.B., April. Two species of the larval parasites, *Carcelia* sp. (Tachinidae) were bred out from samples collected.

Chariotheca sp. (Tenebrionidae)

Adults resting on fronds, Mosa Plantation, W.N.B., May.

Ectocemus decemmaculatus Montr. (Brenthidae)

Adults resting on fronds, Nahavio, W.N.B., May.

Miolispa papuana Kln. (Brenthidae)

Adults resting on fronds, Nahavio, W.N.B., May.

Oryctes rhinoceros (L.) (Dynastinae)—Asiatic Rhinoceros Beetle

Adult damage to palms reported from the Gazelle Peninsula, E.N.B., throughout the year.

Larvae were found breeding in dead standing palms on Tingwon Island, New Ireland District, and in decaying coconut trunks and stumps at Tigak, Lakuramau, Pinikindu, Namarodu, Hilalou and Manmo, New Ireland, June.

Promecotheca papuana Csiki (Hispidae)—Coconut Leaf Miner

Small pockets of this pest were reported on the Gazelle Peninsula, E.N.B., during the year.

Reports of increased activity at Lindenhafen and Linga Linga, W.N.B., were received in the last quarter of 1967-1968.

Two adults were collected from coconuts, Nahavio, W.N.B., May.

Pterolophia arrowiana Breun. (Cerambycidae)

Adults resting on fronds, Dagi, W.N.B., May.

Rhynchophorus bilineatus (Montr.) (Curculionidae)—Palm Weevil

Damage to palms continued to be severe throughout the year in the New Britain and New Ireland Districts.

An infestation at Klinwata Plantation, E.N.B., June, was associated with a condition resembling bud rot of coconuts.

Numerous adults were collected in settlement blocks at Nahavio, W.N.B., in May.

Rhynchophorus sp. (Curculionidae)—Palm Weevil

See under *Sparganobasis subcruciatus*.

Scapanes australis grossepunctatus Sternb. (Dynastinae)—New Guinea Rhinoceros Beetle

Adults damaged young palms, New Massava and Warangoi area, Gazelle Peninsula, E.N.B. throughout the year and also damaged young palms at Mosa and Gaungo Villages and Tabairikau and Lavilelo settlement blocks near Hoskins and Wandoro, Volupai and the Dagi River Settlement area, W.N.B.

Damage to young palms was also reported from Tigak, Panameko, Enuk Island, Matakuru and Manmo and Mungai Plantation, south-east New Ireland in June, and Matakwiss and Lihir Islands, New Ireland District, also in June.

Segestidea sp. ? *insulana* Will. (Tettigoniidae)—Coconut Tree Hopper

Many reports of moderate to heavy infestation were received from East and West New Britain during the year.

The outbreak at Volupai which commenced in February, 1967 ceased about the beginning of the 1967-68 dry season, probably as a result of the application of DDT/BHC dust and introduction of the parasites *Leefmansia bicolor* Waterst., *Doirania leefmansi* Waterst. and *Stethynium* sp. from New Hanover.

Oothecae were received from Volupai in March and April, 1968, but they were difficult to find and highly parasitized by *Leefmansia bicolor*.

Other reports of *S. ? insulana* infestations were received from Kalili, E.N.B., in April and Kandrian, E.N.B. in May.

Segestidea sp. (Tettigoniidae)—Coconut Tree Hopper

Specimens in alcohol were received from Malai Island, Siassi group, in December. It was reported that palms on the island had been almost stripped by the hoppers.

A "Sexava" outbreak was reported from Umboi Island, Morobe District, in May, but no specimens were received.

Moderate damage was reported from the Situm/Gobari area, Morobe District, July to October.

Sparganobasis subcruciatus Marsh. (Curculionidae)—Coconut Bole Weevil

Approximately 20 to 25 per cent of 12,000 6-year-old palms on Raihu Plantation, Aitape, West Sepik District, were severely damaged by a mixed infestation of *Sparganobasis subcruciatus* and *Rhynchophorus* sp. larvae. *Rhynchophorus* sp. adults were also present in numbers. Approximately 1500 palms had either been killed or had collapsed.

In all cases damage was to the lower bole region, from ground level to a height of 2 to 3 ft. As some palms did not show external damage to the bole, the point of entry of the weevils was not certain. However it would appear that *S. subcruciatus* was the primary insect responsible for the damage and that *Rhynchophorus* was secondary.

One adult collected from coconut palm, Sosoli Village, E.N.B., August. No damage reported.

Spodoptera litura (F.) (Noctuidae)—Cluster Caterpillar

Young larvae completely stripped the epidermis of young coconut fronds, Mosa Plantation, W.N.B., March to April; Keravat, E.N.B., May to June.

Tarundia sp. (Ricaniidae)

Adults collected from coconuts, Mosa Plantation, W.N.B., May.

Thosea sinensis (Walk.) (Limacodidae)—Coconut Cup Moth

Damage to young palms widespread and serious at Hula, C.D., August.

Tirathaba rufivena Walk. (Pyralidae)—Coconut Spathe Moth

Adults were reared from a heavily infested spathe from a dwarf coconut forwarded from Madang in August. It was claimed that palms in the town were not bearing as a result of damage by this pest.

Larvae were submitted in July from Lihir Island in samples of young button nuts from one of the premature nutfall areas. Less than 5 per cent of the young button nuts had been damaged by *Tirathaba*.

Larvae were also observed at Klinwata Plantation, E.N.B., in June, where they were found in high population density webbing together sections of male flowers.

Uropteroides gestroi Senna (Brenthidae)

Adults collected from fronds, Gaungo Village, W.N.B., May. No damage reported.

Xyleborus exiguus Walk. (Scolytinae)

Adults collected from a necrotic area on a coconut petiole, Rainau Plantation, Gazelle Peninsula, E.N.B., June.

Zophiuma lobulata Ghauri (Lophopidae)—Coconut Leafhopper

Adults and nymphs still present on palms in the Finschhafen area, Morobe District, July, 1967 to June, 1968.

The general position was reported to have improved during the year with many of the previously affected palms recovering from the diseased or unthrifty condition (see I.P.S. for year ending 30th June, 1967 for description of disease condition). The improvement appeared to be related to a general decrease in *Z. lobulata* populations throughout the affected area.

COFFEE (*Coffea arabica, Coffea canephora*)

Tiracola plagiata Walk. (Noctuidae)—Cacao Armyworm

Reports of widespread defoliation of coffee by *Tiracola* larvae were received from the Morobe District in October; Upper Bena, Eastern Highlands District, January to February; Togahau, Papoga areas in the Northern District in May to June.

Approximately 23 per cent of the pupae collected at Togahau were parasitized by the tachinid *Exorista sorbillans* Wied.

Zeuzera coffeae Nietn. (Cossidae)—Coffee Borer

Larva boring in coffee, Bunum-Wo Plantation, Banz, W.H.D., September; Kup area, Chimbu District, November.

OIL PALM (*Elaeis guineensis*)

Acanthotyla sp. (Coreidae)

Adults collected from oil palms, Saiho, N.D., January. Numerous, but no damage noted.

This is the same species that occurs on cacao in the Northern District (see under cacao).

Alcidodes sp. (Curculionidae)

Adults collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Aspidomorpha quadriradiata Boh. (Cassidinae)

Adults collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Basicryptus sp. nr *rugicollis* Westw. (Pentatomidae)

Adults collected from oil palms, Saiho, N.D., January.

Campsomeris sp. ? *manokwariensis* (Cam.) (Scoliidae)

Adult resting on oil palm, Mosa Plantation, W.N.B., May.

Cardiodactylus novaeguineae de Haan (Gryllidae)—Tree Cricket

Adults collected from oil palms, Saiho, N.D., January.

Carpophilus sp. (Nitidulidae)

Adults collected from oil palm, Kapore, W.N.B., May. No damage noted.

Cephrenes augiades Felder (Hesperiidae)

A minor pest of oil palms, the larvae chew across the pinnae of the oil palm frond, roll up the cut section to feed on it and finally pupate in this section. Collected Kapore and Mosa, W.N.B., April. The damage is similar to that caused by *Cephrenes moselyi* which attacks coconuts in the same locality.

Ceresium pachymerum Pasc. (Cerambycidae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Clania sp. (Psychidae)—Bag Moth.

Larvae responsible for defoliation of seedlings in nursery, Mosa Plantation, W.N.B., April. Damage severe.

The tachinids *Exorista* sp. and *Strobliomyia orbata* Wied. were bred from field-collected material.

Coccinella arcuata (F.) (Coccinellidae)

Adult resting on oil palm, Mosa Plantation, W.N.B., May.

? *Coelophora inaequalis* (F.) (Coccinellidae)

Adults collected from oil palm, Nahavio, W.N.B., May. No damage noted.

Coelophora inaequalis var. ? (Coccinellidae)

Adults collected from oil palm, Kapore Settlement, W.N.B., May. No damage noted.

Coelophora ripponi Crotch. (Coccinellidae)

Adults collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Diacrisia niceta (Stal) (Arctiidae)

Larvae collected from oil palms, Mosa Plantation nursery, W.N.B., April. The larvae were observed to be stripping the pinnae from fronds.

The preferred host appears to be a *Portulaca* sp. (? *oleracea*), a common weed of cultivated areas.

Dicladispa fabricii Guer. (Hispinae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Dindymus sp. ? *pyrochrous* (Boisd.) (Pyrrhocoridae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Eoporus elegans Pasc. (Cerambycidae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Eupholus schonherri Guer. (Curculionidae)

Adults collected from oil palms, Saiho, N.D., January.

Eurycania tristicula Stal (Ricaniidae)

Adult collected from oil palm, Nahavio, W.N.B., May. No damage noted.

Gryllotalpa sp. (Gryllotalpidae)

Adult collected from oil palm, Mosa Plantation, April. No damage noted.

Henosepilachna doryca Boisd. (Coccinellidae) ellidae)

Adults collected from oil palm, Mosa Plantation and Nahavio, W.N.B., May. No damage noted.

Henosepilachna guttatpustulata (F.) (Coccinellidae)

Adults collected from oil palm, Nahavio, W.N.B., May. No damage noted.

Henosepilachna sp. (Coccinellidae)

Adults collected from oil palm, Kapore, W.N.B., May. No damage noted.

? *Hypolixus* sp. (Curculionidae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Lanelater sp. (Elateridae)

Adults collected from oil palms, Saiho, N.D., January.

Leptoglossus australis F. (Coreidae)

Adults collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Lyramorpha diluta Stal (Pentatomidae)

Adults collected from oil palms, Saiho, N.D., January.

Metriona papuana Spaeth. (Cassidinae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Mezira membranaceus F. (Aradidae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Monolepta nigroapicata Bry. (Galerucinae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Nerthra laticollis (G. & M.) (Gelastocoridae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May.

Nysius villicus V.D. (Lygaeidae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Papuana woodlarkiana (Montr.) (Dynastinae)

Adults caused appreciable damage to seedlings by boring into the boles and also by feeding on the roots. In severe attacks the young seedlings died, but in most instances damage resulted in retarded growth and production of small, distorted fronds. Mosa Plantation, W.N.B., April.

? *Peribleptus* sp. (Curculionidae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Plutorectis sp. nr *boisduvali* Westw. (Psychidae)—Bag Moth

Larvae collected from oil palm seedlings, Mosa Plantation, W.N.B., April. Damage severe.

Priochirus sp. (Staphylinidae)

Adult collected from oil palm, Kapore, W.N.B., May.

Psychidae, gen. et sp. indet.—Bag Moth

Larvae collected from fronds, Saiho, N.D., January. Minor frond damage reported.

Rhinoscapha schmeltzi Fairm. (Curculionidae)

Adults collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Rhinoscapha thomsoni Waterh. (Curculionidae)

Adults collected from oil palms, Saiho, N.D., January.

Rhyparida fasciata Baly. (Eumolpinae)

Adults collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Scapanes australis (Boisd.) (Dynastinae)—New Guinea Rhinoceros Beetle

Adults collected from young oil palms, Saiho, N.D., July. Damage of no economic importance.

Sodates sp. (Cerambycidae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May. No damage noted.

Spodoptera litura (F.) (Noctuidae)—Cluster Caterpillar

Young larvae completely stripped the epidermis of the fronds of young oil palm seedlings, Mosa Plantation nursery, W.N.B., March to April.

The tachinid *Cuphocera varia* F. was bred from field-collected material.

Stenocatantops angustifrons (Walk.) (Acrididae)

Adult collected from oil palm, Mosa Plantation, W.N.B., April, and Saiho, N.D., January. No damage noted.

Sybra sp. (Cerambycidae)

Adult collected from oil palm. Saiho, N.D., January.

Tarundia boadicea Dist. (Ricaniidae)

Adults collected from oil palm, Mosa Plantation, W.N.B., May.

Tmesisternus politus Black (Cerambycidae)

Adults collected from oil palms, Saiho, N.D., January.

Tmesisternus yorkensis Fairm. (Cerambycidae)

Adult collected from oil palm, Kapore, W.N.B., May. No damage noted.

Valanga spp. (Acrididae)

Several species of *Valanga* caused minor damage to fronds of young seedlings in the nursery, Mosa Plantation, W.N.B., April.

TEA (*Camellia sinensis*)

Adoxophyes sp. nov. (Tortricidae)

Larvae caused heavy defoliation of seedlings growing in a glasshouse at Konedobu, C.D., during August to September.

Brevipalpus californicus (Banks) (Acarina: Phytoptipalpidae)—Scarlet Mite

Caused some damage to tea foliage in many parts of the W.H.D. during the year. A tea insects survey of the Mount Hagen-Minj-Banz area was carried out in February, 1968. It showed that *B. californicus* was to be found in all tea plantings in the Wahgi Valley. It was especially numerous at Nunga and on Bucknell's plantation. In fact when inspected in February the population at Bucknell's probably warranted spraying with sulphur.

Adults and nymphs were submitted from Monenga, W.H.D., and reported as damaging tea on Kudjip Tea Estate, Banz, W.H.D., July to September.

A severe infestation was observed on tea at Ialibu, S.H.D., and on a mature stand of tea on one plantation in the Western Highlands in February.

Collembola (Family ? Sminthuridae)

An unidentified collembolan was found in numbers on tea at Pugamp Plantation, W.H.D., February. It occurred on mature foliage and was associated with brittle, yellowed or whitened, mottled leaves. Its importance as a possible tea pest has not been investigated.

Hemitarsonemus latus (Banks) (Acarina: Tarsonemidae)—Yellow Mite

Present in large numbers on experimental tea seedlings in a glasshouse at Konedobu, C.D., in July, and caused heavy defoliation. A spray of 0.03 per cent dicofol completely controlled the infestation.

Homona sp. ? *coffearia* Nietn. (Tortricidae)—Tea Tortrix

Larvae present on tea plantings, Wahgi Valley, W.H.D., February. Damage negligible.

Oribius spp. (Curculionidae)

Adults numerous on tea plantings, especially on the edges of plantings adjacent to native vegetation and hedges, Wahgi Valley, W.H.D., February. Damage slight and consisted of leaf chewing.

Papuana spp. (probably *P. woodlarkiana* (Montr.)) (Dynastinae)

Tea bushes on Wurup Smallholder Blocks and on Warrowau Plantation, W.H.D., showed fresh signs of *Papuana* damage when inspected in February. Damage consisted of partial or total ringbarking of the trunk at or below ground level with subsequent stunting and chlorosis of affected plants.

Tetranychidae (? *Oligonychus coffeae* Nietn.)

A species of Tetranychidae was present on many tea plantings, Wahgi Valley, W.H.D., February, but not in any numbers.

Toxoptera aurantii B. de Fonsc. (Aphididae)—Black Citrus Aphid.

Adults and nymphs present on tea plantings, Wahgi Valley, W.H.D., February. Of no apparent economic importance.

Zeuzera coffeae (Nietn.) (Cossidae)—Coffee Borer

Larvae boring in tea, Banz and Olgaboli areas, W.H.D., in September and February and December respectively. Damage to isolated tea bushes only.

FRUIT, NUT AND FOOD TREES

AVOCADO (*Persea gratissima*)

Scolytoplatypus papuanus Egg. (Platypodinae)

Adults collected from a dying branch of avocado, Banz, W.H.D., April. Associated with the scolytine *Xyleborus potens*.

Xyleborus potens Schedl (Scolytinae)

Adults collected from a dying branch of avocado, Banz, W.H.D., April. Associated with the platypodine *Scolytoplatypus papuanus*.

BANANA (*Musa* spp.)

Nacoleia octasema (Meyr.) (Pyralidae)

Larvae caused damage to fruit, Keravat, E.N.B. throughout the year. Adults were bred out from a bunch of bananas in June.

Strumeta musae (Tryon) (Tephritidae)—Banana Fruit Fly

Adults were bred from banana fruits received from Goroka, E.H.D., January, and the Kuare area, S.H.D., in July. Minor to moderate damage was reported and it would appear that *S. musae* is a chronic problem in both areas.

CASHEW (*Anacardium occidentale*)

Oribius cruciatus Fst. (Curculionidae)

Adults damaged foliage of young trees at Bereina, C.D., January to April. Partial control was obtained by ring-weeding and spraying the bases of infested trees with dieldrin.

Selenothrips rubrocinctus (Giard.) (Thripidae)

Caused severe to complete defoliation of several 15-month old trees in an experimental planting of 4 acres at Bereina, C.D., July.

CITRUS

Agrilus occipitalis Esch. (Buprestidae)

Adults were collected from the bark of an unthrifty *C. aurantifolia* tree at Ilimo Farm, C.D., May.

Larvae boring in and just under the bark of unthrifty lime trees, P.A.T.I., Popondetta, N.D., throughout the year. Their status as a primary or secondary pest is still not known.

Elytrocheilus coeruleatus Pasc. (Curculionidae)

Adults collected from citrus, Saiho, N.D., November.

Eudecatoma sp. (Eurytomidae)

Fruit galling of *C. aurantifolia* probably caused by this wasp, Kerema, Gulf District, May.

Eurycania tristicula Stal (Ricaniidae)

Adults collected from citrus, Nahavio, W.N.B., May.

Papilio aegeus Don. (Papilionidae)—Citrus Butterfly

Larvae caused moderate to heavy defoliation of young lime trees at Bereina, C.D., June.

Papilio sp. (Papilionidae)—Citrus Butterfly

Larvae caused extensive damage to citrus, Sohano, Bougainville, June.

Phyllocnistis citrella Staint. (Phyllocnistidae)—Citrus Leaf Miner

Larvae mined young leaves at Kikori, Gulf District, May; caused severe damage to citrus, Nahavio, W.N.B., May; recorded throughout the year on citrus at Keravat, E.N.B.

Thosea sinensis (Walk.) (Limacodidae)—Coconut Cup Moth

An adult was reared from a larva feeding on *C. sinensis* foliage at Laloki, C.D., June.

EUGENIA (*Eugenia* sp.)

Idiophantis sp. nov. nr *chirodaeta* Meyr. (Gelechiidae)

Adults were reared from larvae feeding within galls on leaves, Kavieng area, New Ireland, March.

Strumeta tryoni (Frogg.) (Tephritidae)—Queensland Fruit Fly

One adult bred from *Eugenia* fruit collected at Koabu, Fly River Delta area, W.D., December.

MANGO (*Mangifera indica*)

Chunrocerus niveosparsus (Leth.) (Cicadellidae)

Adults and nymphs feeding on mango inflorescence, Rabaul, E.N.B., April to June, causing the entire infloresence to blacken. Found in association with *I. clypealis* (see below). Few, if any, trees appear to bear fruit following an attack by these leafhoppers.

Adults collected from foliage and inflorescences, Daru, W.D., November, and Konedobu, C.D., April. Heavy infestation caused chlorosis and necrosis of flowers and was accompanied by sooty mould development. Associated with *I. clypealis*.

Idioscopus clypealis (Leth.) (Cicadellidae)

Adults and nymphs feeding on mango inflorescence, Rabaul, E.N.B., April to June, causing the entire inflorescence to blacken. Found in association with *C. niveosparsus*.

Adults collected from foliage and inflorescences, Daru, W.D., November and Konedobu, C.D., April. Heavy infestation caused necrosis of flowers, and was accompanied by sooty mould development. Associated with *C. niveosparsus*.

PAWPAW (*Carica papaya*)

Ischiopsopha bifasciata Quoy and Gaim. var. *hyla* Heller (Cetoniinae)

Adults fed on ripe pawpaw fruits, Upper Musa, N.D., January.

TERMINALIA (*Terminalia catappa*)

Aiteta iridias Meyr. (Noctuidae)

Adult reared from a larva feeding on foliage, Konedobu, C.D., April.

FRUIT TREES, GENERAL

Asiadacus curvifer (Walk.) (Tephritidae)

One specimen collected resting on banana foliage, Sepi Village, Kiwai Island, W.D., December.

Strumeta bryoniae (Tryon) (Tephritidae).

A few specimens collected from "Dak Pot" male lure trap (baited with 1-(p-hydroxyphenyl)-butan-3-one and 1-(p-acetoxyphenyl)-butan-3-one), garden area, Daru; one specimen in "Dak Pot" in rainforest near Masingara Village, 30 miles west of Daru, W.D., December.

Strumeta frauenfeldi (Schiner) (Tephritidae)

Specimens taken in "Dak Pot" lures at the following Western District localities: Daru, Mabaduan Village, Dauan Island, Olmawata Village, Sepi Village (Kiwai Island), Balimo Station, December. In almost every case the trap was in or near mango trees. It would appear that *S. frauenfeldi* is associated with mango as it was taken only at locations where mangoes were present, never at sites where they did not occur.

Strumeta musae (Tryon) (Tephritidae)—Banana Fruit Fly

A single specimen was taken in a "Dak Pot" lure in primary forest near Dogono Village, Balimo area, W.D., December.

The species commonly found infesting bananas in the Western District appears to be an undescribed *Strumeta* sp., species 'C' (see below).

Strumeta tryoni (Frogg.) (Tephritidae)—Queensland Fruit Fly

One adult bred from *Eugenia* fruit collected at Koabu, Fly River delta, W.D., December.

Strumeta sp 'A' (Tephritidae)

Collected in "Dak Pot" lures at Daru and Sepi Village, Kiwai Island, W.D., December. Not abundant.

Strumeta sp. 'B' (Tephritidae)

Six specimens taken in "Dak Pot" lure, Daru town area, W.D., December.

Strumeta sp. 'C' (Tephritidae)

A very abundant species in the Western District, being taken in "Dak Pot" lures at Daru, Olmawata Village and Sepi Village, W.D., in December. At the last two sites, lures were located in banana gardens, and one at Sepi caught several hundred specimens in 1 hour. Banana fruits infested by maggots were collected at Sepi, but failed to produce adult flies.

SHADE TREES AND ORNAMENTALS

Acanthotyla sp. (Coreidae)

Adults collected from flemingia (*Flemingia* sp.), Popondetta area, N.D., March. Its status as a pest species has not been investigated.

This is the same species that occurs on cacao in the Northern District (see under cacao).

Agapophyta sp. (Pentatomidae)

A heavy population of adults produced necrotic lesions on leaves and pods of cassia (*Cassia fistula*) at Konedobu, C.D., April to June.

Cryptophlebia ombrodelta Low. (Tortricidae)

Adults reared from larvae which had damaged up to half the seed in many pods of indigofera (*Indigofera teysmani*) at Laloki, C.D., May.

Helopeltis clavifer Walk. (Miridae)—Cacao Mirid

Caused minor damage to shoots of *Flemingia strobilifera* at Bisianumu, C.D., November.

Maconellicoccus hirsutus (Green) (Pseudococcidae)—Hibiscus Mealybug

Severe infestations on hibiscus (*Hibiscus rosasinensis*), township area, Rabaul, E.N.B., throughout the year. Ornamental hedges of hibiscus were heavily infested and suffered severe damage.

Mastotermes darwiniensis Frogg. (Mastotermitidae)—Giant Termite

A *Cassia* sp. tree was found infested by *M. darwiniensis* at Lae (Hospital site), Morobe District, November.

Pericyma cruegeri (Butl.) (Noctuidae)—Poinciana Looper

The 1968 outbreak of *P. cruegeri* in the Port Moresby area, C.D., lasted for approximately 3 months, from the middle of March to mid-June. Observed rates of larval and pupal parasitism were rather low (10 to 15 per cent), but the early onset of the dry season and consequent scarcity of regrowth on defoliated poinciana (*Delonix regia*) trees led to the collapse of the outbreak.

A sample of pupae collected on 21st March yielded the following results: adults emerged 85 per cent, parasitized 11 per cent, died from other causes 4 per cent. The pupal parasites *Brachymeria euploeae* Westw. (Chalcididae) and *Echthromorpha insidiator* Smith (Ichneumonidae) were bred from the parasitized pupae.

On 19th April, 2 samples were collected—one from walls, stumps and other sites not on poinciana trees, the other from the normal site in webbed leaves. These yielded the following results: adults emerged 84 per cent (leaves), 60 per cent (other sites); parasitized 10 per cent (leaves), 15 per cent (other sites); died from other causes 5 per cent (leaves), 25 per cent (other sites). The high proportion of pupae from other sites which died from causes other than parasitism probably reflects enforced pupation by larvae which had abandoned defoliated trees and failed to find other food.

Poinciana trees at Popondetta, N.D., were completely defoliated by *P. cruegeri* larvae by the end of February. Both of the pupal parasites mentioned above were bred from field collected pupae at Popondetta.

Planococcus citri (Risso) (Pseudococcidae)—Citrus Mealy Bug

Shoots of *Flemingia strobilifera* were infested by citrus mealy bugs, causing leaf puckering and stem distortion, Bisianumu, C.D., November.

Protaetia sp. ? *fusca* Herbst. (Cetoniinae)

Adults damaged orchid flowers, Lae, Morobe District, June.

Psyllidae, gen. et sp. indet.

Psyllids infested seedlings of *Eucalyptus deglupta* at Togoba, W.H.D., in August. Another species which commonly infests *E. papuana* in the Port Moresby area was sent for specialist identification in April. Both species are considered to be new, but neither has been described.

Riptortus sp. ? *annulicornis* Boisd. (Alydidae)

Adults fed on pods of flemingia (*Flemingia* sp.) Popondetta area, March. Damage severe.

Xanthodes transversa Gn. (Noctuidae)

Larvae fed on hibiscus (*Hibiscus rosa-sinensis*) foliage, Keravat, E.N.B., July.

Xyleborus destruens Blandf. (Scolytinae)

Larvae bored in trunks of casuarina (*Casuarina oligodon*) apparently causing death of some trees in the Wandi area, Chimbu District, November.

Xyleborus fornicatus Eichh. (Scolytinae)

Boring in *Mundulea sericea*, Saiho, N.D., March, 1968.

Xylotrupes gideon (Dynastinae)

Adults numerous on poinciana (*Delonix regia*) trees, Navuvu Plantation, E.N.B., November.

Zeuzera sp. (Cossidae)

Larvae severely damaged a young silky oak (*Grevillea robusta*) tree by boring in the trunk, Mount Hagen, W.H.D., March.

FIELD CROPS

SUGAR CANE (*Saccharum officinarum*)

Atractomorpha crenaticeps Blanch. (Pyrgomorphidae)

Adults common on cane at Popondetta, N.D., throughout the year. Foliar damage only of minor importance.

Gesonula mundata sanguinolenta Kr. (Acrididae)

Adults common on cane at Popondetta, N.D., throughout the year. Foliar damage only of minor importance.

Hypolixus ritsemae Pasc. (Curculionidae)

Adults collected in numbers on young cane at Popondetta, N.D., throughout the year. Foliar damage slight.

Mulciber linnaei Thoms. (Cerambycidae)

Adults and larvae common in sugar cane stands in the Popondetta area, N.D., throughout the year. Larvae bore in the cane stems and can cause slight to moderate damage to stands.

Oxya gavisa (Walk.) (Acrididae)

Adults collected from young cane at Popondetta, N.D., throughout the year. Foliar damage slight.

TOBACCO (*Nicotiana tabacum*)

Heliothis armigera (Hubn.) (Noctuidae)—Budworm

Larvae common, feeding on foliage and flowers, Popondetta/Sangara area, N.D., throughout the year.

GRAIN CROPS

MAIZE (*Zea mays*)

Ostrinia sp. (Pyralidae)

Larvae infested 50 per cent of plants in a $\frac{1}{8}$ acre school garden at Aitape, West Sepik District, June.

RICE (*Oryza sativa*)

Cerambycidae, gen. et sp. indet.

One preserved larva was received from Dreikikir, East Sepik District, in May. It was reported to have been boring in a rice stem.

Chilo sp. (Pyralidae)

Larvae boring in rice stems, Dreikikir, East Sepik District, May.

Sesamia inferens Walk. (Noctuidae)—Pink Stem Borer

Larvae boring in rice stems, Dreikikir, East Sepik District, May.

VEGETABLES

BEAN (*Phaseolus vulgaris*)

Henosepilachna signatipennis Boisd. (Coccinellidae)

Adults common, feeding on foliage, Popondetta N.D., July to September.

Melanagromyza phaseoli (Tryon) (Agromyzidae)—Bean Fly

Larvae caused severe damage to beans, Popondetta, N.D., July to September.

Riptortus annulicornis Boisd. (Alydidae)—Pod Sucking Bug

Adults numerous, feeding on developing and ripe pods, Popondetta, N.D., throughout year. Damage severe.

CABBAGE (*Brassica oleracea* var. *capitata*)

Papuana sp. (Dynastinae)

Adults fed on stems at or below ground level, Mount Hagen, W.H.D., November.

CAPSICUM (*Capsicum frutescens*)

Plautia sp. (Pentatomidae)

Adults and nymphs fed on and caused deformation of young fruit, Keravat, E.N.B., April to June.

CUCUMBER (*Cucumis sativus*)

Aulacophora sp. ? *similis* Oliv. (Galerucinae)

Adults chewed leaves and caused extensive damage to young plants, Keravat, E.N.B., March to April.

Leptoglossus australis F. (Coreidae)

Adults fed on flowers and young fruits, Keravat, E.N.B., April to June.

POTATO (*Solanum tuberosum*)

Papuana sp. (Dynastinae)

Adults caused minor damage to tubers at Mount Hagen, W.H.D., and Aiyura, Eastern Highlands District, in November and June, respectively.

Papuana sp. ? *woodlarkiana* (Montr.) (Dynastinae)

Adults fed on developing potato tubers, Aiyura, Eastern Highlands District, June.

PUMPKIN (*Cucurbita pepo*)

Aulacophora sp. nr *similis* Oliv. (Galerucinae)

Adults fed on foliage and flowers of pumpkin vine, Kagamuga, W.H.D., December; Keravat, E.N.B., March to April.

Leptoglossus australis F. (Coreidae)

Adults observed feeding on flowers and young fruit, Keravat, E.N.B., May to June.

Paradacus sp. (Tephritidae)

Pumpkin fruit of all ages attacked by this species, Keravat and Vudal, E.N.B., April to June. Few, if any, fruits mature in areas where this species occurs.

TARO (*Colocasia* sp.)

Dermolepida noxium Britton (Melolonthinae)

Adults collected from taro garden, Laloki, C.D., October.

Papuana woodlarkiana woodlarkiana Montr. (Dynastinae)

Adults damaged tubers in an experimental taro planting at Laloki, C.D., October.

TOMATO (*Lycopersicon esculentum*)

Spodoptera litura (F.) (Noctuidae)—Cluster Caterpillar

Larvae fed on developing fruit and caused heavy loss of crop, Keravat, E.N.B., throughout the year.

Valanga spp. (Acrididae)

Adults chewed off young seedling transplants, Keravat, E.N.B., June.

YAM (*Dioscorea* spp.)

Lilioceris sp. ? *bakewelli* Baly (Criocerinae)

Adults and larvae fed on foliage of yam (*Dioscorea* sp.), Port Moresby, C.D., April.

Scarabaeidae, gen. et sp. indet.

Larvae of an unidentified scarabaeid fed on yams, Kalauna Village, Goodenough Island, Milne Bay District, January to March; 50 per cent of village yam gardens affected.

PASTURES

Austracris spp. (Acrididae)—Spur-throated Locust

Adults numerous in native grasslands, Goodenough Island, Milne Bay District, July, 1967 to March, 1968, and again in May to June, 1968.

Gastrimargus musicus (F.) (Acrididae)—Yellow-winged Locust

Adults present in native grasslands, Goodenough Island, Milne Bay District, July to September. Not plentiful.

Hedylepta diemenalis Gn. (Pyralidae)

Larvae fed on pueraria (*Pueraria* sp.), Keravat, E.N.B., August.

Locusta migratoria (L.) (Acrididae)—Migratory Locust

Phase solitarious adults were observed on Goodenough Island, Milne Bay District, during the year, but not in any numbers. No damage to either grasslands or coconuts reported. Phase solitarious females were observed ovipositing in burnt grassland areas during July to August.

Maruca testulalis Hb. (Pyralidae)

Larvae fed on pueraria (*Pueraria* sp.), Keravat, E.N.B., August.

Valanga spp. (Acrididae)

Adults common in native grasslands, Goodenough Island, Milne Bay District, July to August. At Nuatutu Plantation in July, light swarms of 4 to 8 adults per square yard were noted. Populations decreased as from July, but an increase was again noted in April to June.

WEEDS

Diacrisia niceta (Stal) (Arctiidae)

Larvae feeding on *Portulaca* sp. ? *oleracea* foliage, Mosa Plantation, W.N.B., May.

Teleonemia scrupulosa Stal (Tingidae)—Lantana Bug

Adults and nymphs present on lantana (*Lantana camara*), Wewak, East Sepik District, throughout the year. Damage to plants severe during dry season, with complete defoliation of plants in some areas.

HOUSEHOLD PESTS

Anoplolepis longipes Jerd. (Formicidae)—Crazy Ant

Heavy populations of *A. longipes* invaded houses at Gobari and Situm Land Settlement Schemes, Morobe District. They were nesting in decaying logs scattered throughout coconut plantations and nearby bush and foraging in dwellings and fowl-houses.

Lyctus brunneus (Steph.) (Lyctidae)—Powder Post Beetle

Adults and larvae were collected boring in seasoned timber of *Myristica* sp., Goroka area, Eastern Highlands District, December.

Mastotermes darwiniensis Frogg. (Mastotermitidae)—Giant Termite

The Milford Haven Road area at Lae, Morobe District, apparently remained free from infestation during 1968-1969. At the Hospital site a resurgence of activity was noted in November. This was eventually traced to a nest in a Cassia tree between two of the Hospital buildings. A total of 11 trees and 21 shrubs were removed from this area in November and June, and the area was trap posted.

The periphery of the Hospital site on the town side was trenched to a depth of 1 ft and treated with 2 gallons of 0.5 per cent dieldrin per 10 lineal feet to guard against possible subterranean movement into the town area proper.

MEDICAL AND VETERINARY PESTS

POULTRY

Hermetia illucens L. (Stratiomyidae)

Fowl droppings at a commercial poultry farm at Lae, Morobe District were heavily infested by larvae. Adults were also present in numbers either feeding or resting on the manure heaps, which were in a very liquid condition.

PARASITES AND PREDATORS

Anoplolepis longipes Jerd. (Formicidae)—Crazy Ant

Workers were observed carrying away *Pantorhytes szentivanyi* Marsh. eggs and "harassing" *P. szentivanyi* adults, Sangara/Popondetta area, N.D.

Apleurotropis lalori Gir. (Eulophidae)

Bred from *Promecotheca papuana* Csiki larvae/pupae collected from damaged coconut palms, Toriu Plantation, E.N.B., September.

Argyrophylax proclinata Crosskey (Tachinidae)

Bred ex pupa of undetermined tortricid feeding on pueraria (*Pueraria* sp.), Keravat, E.N.B., August.

Brachymeria euploeae Westw. (Chalcididae)

Parasitized 23.1 per cent, 7.7 per cent, 6 per cent and 13 per cent of samples of pupae of *Pericyma cruegeri* (Butl.) collected from foliage of *Delonix regia* in September, March and April and from other sites (trunks, walls, eaves) in April respectively, Konedobu area, C.D.

Bred from *Pericyma cruegeri* (Butl.) pupae, Popondetta, N.D., February to April.

Brachymeria salomonis Cam. (Chalcididae)

This pupal parasite was responsible for bringing under control an outbreak of *Pinzu-*

lenza kukisch larvae which were defoliating cacao at Kulili Plantation, Karkar Island, Madang District, August to September.

Brachymeria sp. (Chalcididae)

Bred ex *Pansepta teleturga* Meyr. larva, collected Tavilo Plantation, E.N.B.

Campsomeris sp. ? *manokwariensis* (Cam.) (Scoliidae)

Adults resting on oil palm, Mosa Plantation, W.N.B., May.

Carcelia spp. (Tachinidae)

Two species bred ex *Cephrenes moselyi* (Butl.) larvae collected Talasea area, W.N.B., April.

Bred ex pupae of undetermined lymantriid collected Vunapau Plantation, E.N.B., August.

Bred ex *Tiracola plagiata* (Walk.) pupae, collected Madang, August.

Coccinella arcuata F. (Coccinellidae)

Adult resting on oil palm, Mosa Plantation, W.N.B., May.

Cryptolaemus affinis Crotch. (Coccinellidae)

Adults noted feeding on *Maconellicoccus hirsutus* (Green) at Rabaul and *Planococcus citri* (Risso) at Keravat and Gela Gela Plantation, E.N.B., throughout the year.

Closteroceros splendida Kowalski (Eulophidae)

Oothecae of *Promecotheca papuana* Csiki collected from coconut plams, Toriu Plantation, E.N.B., September, yielded *C. splendida* adults.

Cuphocera varia F. (Tachinidae)

Ex *Spodoptera litura* (F.) pupae which were bred from larvae feeding on oil palm foliage, Mosa Plantation, W.N.B., May.

Dirhinomorpha sp. (Chalcididae)

Bred ex *Pansepta teleturga* Meyr. larvae collected Tavilo Plantation, E.N.B., October.

Echthromorpha insidiator Smith (Ichneumonidae)

Parasitized 2.6 per cent and 2 per cent of samples of pupae of *Pericyma cruegeri* (Butl.) collected from foliage of *Delonix regia* in March and April respectively, but was not bred from pupae of this host ex foliage (September) or ex trunks, walls and eaves (April), Konedobu area, C.D.

Bred from *Pericyma cruegeri* (Butl.) pupae, Popondetta, N.D., February to April.

Euagorus sp. nr *dolosus* Stal (Reduviidae)

Adults observed preying on early instar *Spodoptera litura* (L.) larvae feeding on oil palm foliage, Mosa Plantation, W.N.B., May.

Euagorus sp. (Reduviidae)

Adults and nymphs commonly found feeding on 1st to 4th instar larvae of *Tiracola plagiata* (Walk.) and *Ectropis sabulosa* Warr., Sangara/Popondetta area, N.D.

Exorista fallax Mg. (Tachinidae)

Parasitized 7.7 per cent, 0.8 per cent, 3 per cent and 2 per cent of samples of pupae of *Pericyma cruegeri* (Butl.) collected from foliage of *Delonix regia* in September, March and April and from other sites (trunks, walls, eaves) in April, respectively, Konedobu area, C.D.

Exorista sorbillans Wied. (Tachinidae)

Bred from *Tiracola plagiata* Walk. pupae collected from coffee gardens, Togahau, N.D., May to June.

Exorista sp. (Tachinidae)

Bred from *Clania* sp. larvae collected from oil palm seedlings, Mosa Plantation, W.N.B., April. The larvae were heavily parasitized by both this tachinid and also *Strobliomyia orbata* Wied.

Helenotus exsugiens Stal (Reduviidae)

Adults and nymphs commonly found feeding on 1st to 4th instar larvae of *Tiracola plagiata* (Walk.) and *Ectropis sabulosa* Warr., Sangara/Popondetta area, N.D.

Leefmansia bicolor Waterst. (Encyrtidae)

A small sample of *Segestidea* sp. ? *insulana* Willemse oothecae collected from the Volupai area, W.N.B., in March indicated 10 to 15 per cent parasitism by *L. bicolor*. *L. bicolor* had previously been introduced from New Hanover in July.

Monomorium floricola (Jerd.) (Formicidae)

Workers observed feeding on *Pantorhytes szentivanyi* Marsh. eggs placed on *Pipturus argenteus*, Serovi area, N.D., August.

Neoarcesius sp. (Reduviidae)

Adult female observed feeding on *Pantorhytes szentivanyi* Marsh. larva, Bisi Plantation, Sangara area, N.D., January.

Neophryxe sp. (Tachinidae)

Bred ex pupae of undetermined psychid, Navuvu Plantation, E.N.B., September.

Nerthra laticollis (G. & M.) (Gelastocoridae)

Adult collected from oil palm, Mosa Plantation, W.N.B., May.

Pediobius parvulus (Ferriere) (Eulophidae)

Bred from *Promecotheca papuana* Csiki larvae/pupae collected from damaged coconut palms, Toriu Plantation, E.N.B., September.

Pheidole megacephala (F.) (Formicidae)—Coastal Brown Ant

Workers observed carrying off *Pantorhytes szentivanyi* Marsh. eggs, Sangara/Popondetta area, N.D., throughout the year. Workers have also been observed carrying away tipulid larvae* which were living in *Pantorhytes* channels and preying on *Pantorhytes* larvae.

Platynopus melacanthus Boisd. (Pentatomidae)

Collected from oil palms, Mosa Plantation, W.N.B., May; preying on *Spodoptera litura* (F.) larvae.

Adults and nymphs commonly found feeding on 1st to 4th instar larvae of *Tiracola plagiata* Walk., *Ectropis sabulosa* Warr. and *Pinzulenza kukisch* Her., Sangara/Popondetta area, N.D.

Pristhesancus femoralis Horv. (Reduviidae)

Adults and nymphs commonly found feeding on 1st to 4th instar larvae of *Tiracola plagiata* Walk. and *Ectropis sabulosa* Warr., Sangara/Popondetta area, N.D.

Pristhesancus sp. (Reduviidae)

Collected from oil palms, Mosa Plantation, W.N.B., May.

Prosapegus atrellus Dodd (Scelionidae)

Wasp parasites bred from *Segestidea* sp. oothecae collected Kandrian, W.N.B., June.

? *Spoggosia* sp. (Tachinidae)

One specimen reared from *Pinzulenza kukisch* Her. larvae, collected from cacao, Baubauguina Plantation, C.D., October to November.

*Subsequently identified as *Nephrotoma* sp. and *Limonia sp.*

Spoggosia grandis Macq. (Tachinidae)

Bred from *Thosea sinensis* (Walk.) larvae, collected from coconut foliage, Hula, C.D., August.

Strobliomyia orbata Wied. (Tachinidae)

Bred from *Clania* sp. larvae collected from oil palm seedlings, Mosa Plantation, W.N.B., April. The larvae were heavily parasitized by both this tachinid and also *Exorista* sp.

Telenomus sp. (Scelionidae)

Bred ex eggs lymantriid (? *Euproctis* sp.), collected Vunapau Plantation, E.N.B., August.

Tetrastichus sp. (Eulophidae)

Hyperparasite bred ex cocoon of *Charops* sp. (Ichneumonidae), Vunapau Plantation, E.N.B., August.

Winthemia sp. ? *diversa* Mall. (Tachinidae)

Bred from *Tiracola plagiata* (Walk.) larvae/pupae in the Sangara/Popondetta area, N.D., throughout the year.

BIOLOGICAL CONTROL PROJECTS

A. INSECTS

Coconut Dynastines

The *Platymeris laevicollis* Dist. ditribution programme continued during the year, but on a reduced scale. In all, 550 *Platymeris* were distributed, as follows:—

Stockholm Plantation, E.N.B. Manibu Plantation, E.N.B. Kurindale Plantation, E.N.B.	250 adults (October, 1967)
Mosa Plantation, W.N.B.	300 adults (January, 1968)

Towards the end of the year stocks were being built up so as to provide a large supply of *Platymeris* for the new oil palm development area at Cape Hoskins, West New Britain. The policy of distribution of adults only has been maintained in order to provide the best chances for establishment. To date there has been little information to suggest successful establishment of the species in any of the island regions.

Maconellicoccus hirsutus (Green) (Coccidae)

Shipments of *M. hirsutus* predators, all adults, were received from India (Commonwealth Institute of Biological Control, Indian Station) during the year, as follows:—

Brumus suturalis F. (Coccinellidae)
410 shipped (4 shipments),
300 released in the field.

Pullus pallidicollis (Muls.) (Coccinellidae)
75 + shipped (4 shipments),
47 + released in the field.

Hyperaspis maindroni Sic. (Coccinellidae)
120 shipped (1 shipment),
57 released in the field.

Hyperaspis maindroni var. *brumoides* Sic. (Coccinellidae)
270 shipped (2 shipments),
213 released in the field.

All the above releases were made in Rabaul, E.N.B.

One shipment of 215 *H. maindroni* var. *brumoides* forwarded from India was also received at Popondetta, N.D., in May. 183 adults were subsequently released at Popondetta.

Telenomus sp. (Hymenoptera: Scelionidae)

Two trial shipments of *Telenomus* sp., egg parasites of a number of species of Lepidoptera including *Achaea janata* L., were forwarded to Commonwealth Institute of Biological Control, Bangalore, India, for maintenance of their stock colonies.

Unfortunately the population of *Achaea janata* and other cacao flush defoliators has continued very low during the year and it was not possible to forward further supplies.

B. WEEDS

Puncture vine—*Tribulus cistoides*

No further shipments of the stem weevil *Microlarinus lypriformis* (Woll.) were received from Hawaii. However, *M. lypriformis* has apparently established successfuly at the release site at Koki with adults and larvae being located in the area every time an inspection was made. By the end of the year, *Tribulus* had been almost eliminated in the immediate vicinity of the release site and the weevil was to be found on plants up to 1 mile away.

In October, 60 adult weevils collected in the Koki area were released in a patch of *Tribulus* at Boroko. It was later reported that the weed had died off there, but a subsequent search in the vicinity located odd plants which did not show signs of infestation.

C. GIANT SNAIL

Further collections of the predatory snail *Gonaxis quadrilateralis* Preston were made during the year in response to a request from the Department of Agriculture, Malaysia. The *Gonaxis* specimens were all collected from two of the original release sites on the Gazelle Peninsula (Tokaya and Keravat).

Live specimens of *Gonaxis quadrilateralis* were found about 2 miles from the original release site at Tokaya, indicating that the species is firmly established in this area. A relatively high population occurs at Keravat.

QUARANTINE INTERCEPTIONS

Agrotis munda Walk. (Noctuidae)—Brown Cutworm

One adult collected inside an aircraft ex Sydney and Brisbane, Port Moresby, October.

Araecerus fasciculatus (Deg.) (Anthribidae)

Adults infested a package of dried shrimps ex Singapore, Port Moresby, November.

Locusta migratoria L. (Acriridae)—Migratory Locust

A female (phase solitarious) was collected alive in a crate of lettuce ex Queensland, Port Moresby, April.

Phthorimaea operculella (Zell.) (Gelechiidae)—Potato Moth

Adults were reared from larvae infesting a cargo of potatoes ex Queensland, Samarai, April.

Strumeta tryoni (Frogg.) (Tephritidae)—Queensland Fruit Fly

Adults were bred from larvae infesting nectarines and tomatoes ex Sydney, Port Moresby, February. Both lots of fruit were in aircraft passengers' hand luggage.

APPENDIX I—INDEX OF INSECTS MENTIONED

APPENDIX II—INDEX OF PLANT HOSTS MENTIONED

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