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Department of Agriculture, Stock and Fisheries,
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TERRITORY OF PAPUA AND NEW GUINEA

Minister for External Territories :
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Papua and New Guinea agricultural Journal 21 (2)

ERRATA

Abstracts, first page of Abstracts, line 20, 'stained-cell . . .' should read 'stained cell . . .'.

Immediately preceding 'An annotated list . . .' insert the heading: INSECT PEST SURVEY FOR THE YEAR ENDING 30 JUNE 1967. *Papua and New Guinea agric. J.*, 21(2): 49-75.

Second page of Abstracts, Abstract of article by J. A. Springhall, second para., first line, '. . . bassed . . .' should read '. . . based . . .' and last para., second line 'soybean mead . . .' should read 'soybean meal . . .'.

Second page of Abstracts, add the Abstract to article 'Preliminary Studies in Vegetative Propagation of *Piper nigrum*', by B. G. Kamp which was omitted *in toto*.

Contents, in the Table of Contents, last line, for '. . . Piper Nigrum' read '*Piper nigrum*'.

Page 24, in *Table* 2, 'SHE32' should read 'SHE30'.

Page 25, line 10 of Abstract: 'stained-cell . . .' should read 'stained cell . . .'.

Page 44, column 2, lines 8, 11, 13, 24 and 28: The periods should be omitted from after the figures 4, 4, 4, 12 and 4 respectively.

Page 45, column 2, tenth line from base: 'Strips of leaves . . .' should read 'Strips of tissue . . .'.

Page 46, column 1, line 15: 'bio-essays . . .' should read 'bio-assays . . .'.

Page 47, colums 2, third last line: 'main-cacao-growing . . .' should read 'main cacao-growing . . .'.

Reference omitted: BROOKS, E. R. AND GUARD, A. T. (1952). Vegetative anatomy of *Theobroma cacao*, *Bot. Gaz.*, 113: 444-454.

Page 51, final para., line 3: For 'Messers,' read 'Messrs.'.

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

Column 2, under *Crossotarsus barbatus* Chapuis (Platypodidae): for '½ in.' read '1/8 in.'.

Page 55, column 1, for '*Psychidae*' read 'Psychidae'.

Page 66, column 1, reference *Onthophagus latenasutus* Arrow: for '(Scarabeidae)' read '(Copridae)'.

Page 79, third line below the *Table* 2, for 'Vitamin B12, 10 ug' read 'Vitamin B12, 10μg.'.

Page 88, title—'Preliminary Studies . . . Piper Nigrum' should read 'Preliminary Studies . . . *Piper nigrum*'.

Page 89, column 1, the two phographers at the top of the column should be captioned: '*Figure* 1.—Method of setting cuttings in a bushbed propagator'. Column 2, the photograph at the foot of the column should be captioned: '*Figure* 2.—Cuttings in bamboo pots, showing the wire frame used to support the plastic bags which will cover the cuttings'.

Page 90, column 2, line 2: for 'bambo' read 'bamboo'.

Page 91, column 2, caption 'Plates IV and V—Six-node cuttings' should read: '*Figure* 3.—The upper photograph shows (left) a plant with three primary shoots which developed from a six-node cutting, and (right) a plant of similar age developed from a single-node cutting. Lower photograph is a closer view of development of a six-node cutting'.

ABSTRACTS

SOY BEAN YIELDS IN THE LOWLANDS OF NEW GUINEA.

G. D. HILL. *Papua and New Guinea agric. J.*, 21 (2) : 23-24.

Four varieties of soy beans NG 4661 Batavian Yellow, NG 4662, SHE 30, and Mission were grown in the wet Lowlands at Bubia near Lae. The three best varieties yielded more than 1,500 lb. of beans per acre. The mean protein content of the beans was 43.0 per cent. and the mean oil content 17.4 per cent for all varieties. Yields compare favourably with those reported from the highlands.

GALLS OF CACAO IN PAPUA AND NEW GUINEA.

DOROTHY E. SHAW and W. M. BURNETT. *Papua and New Guinea agric J.*, 21 (2) : 25-48.

Fan and knob galls of cacao, previously recorded in Central America, are now recorded in Papua and New Guinea. Neither of these galls, the causes of which have not been determined, are of economic importance in the Territory at present.

Studies carried out on knob gall include microscopic examination of the tissues, isolations in nutrient agar of fungi present in the galls, inoculations with gall tissue (which did not result in galls), excision of galls in the field and the production of new galls from some old excision scars. The presence of knob galls could not be correlated with any nutritive state of the trees. No significant difference was found in auxin activity or in gibberellin levels in galled and normal samples and no virus-like particles were found in negatively stained-cell extracts in the electron microscope.

An annotated list of Territory phytophagous insect pests is being prepared by Dr. J. J. H. Szent-Ivany, previously Senior Entomologist, Department of Agriculture, Stock and Fisheries, Konedobu. It is expected that this list will be published in 1970, *with records extending up to June,* 1966.

To overcome delays in publishing records obtained since June, 1966, *annual insect pest surveys are to be published, commencing with this list for the year ended* 30*th June,* 1967.

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. The abbreviation N.D. in the text refers to the Northern District of Papua.

The majority of identifications other than those made by our own staff were made through the Commonwealth Institute of Entomology, London. Othe rspecialists who co-operated were Messers. I. F. B. Common and F. J. Gay, C.S.I.R.O., Canberra, Australia; Dr. M. O. de Lisle, Paris, France; Mr. R. A. I. Drew, Department of Primary Industries, Brisbane, Australia; Drs. J. L. Gressitt, Y. Kondo, N. Wilson and Mr. G. A. Samuelson, Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A.; Dr. Z. Kaszab, Hungarian Natural History Museum, Budapest, Hungary; Dr. K. E. Schedl, Forstliche Bundes-versuchsanstalt, Lienz, Austria; and Dr. J. N. L. Stibick, Catholic University of America, Washington D.C., U.S.A.

[*continued overleaf*]

THE USE OF SELECTED LOCAL INGREDIENTS FOR PIG RATIONS IN THE TERRITORY OF PAPUA AND NEW GUINEA.

J. A. SPRINGHALL. *Papua and New Guinea agric. J.*, 21 (2) : 76-86.

A soybean/maize 14 per cent. crude protein pig ration gave higher weight gains in pigs than a ration based on cooked sweet potato, with added soybean or meat meal, with a total crude protein content of 16 per cent. or 8 per cent., or a sweet potato ration without protein supplements, containing 4 per cent. crude protein.

Sorghum bassed rations supplemented mainly with passionfruit seed and copra in varying proportions produced significantly higher weight gains than a sorghum/meat meal ration with the same crude protein level.

The substitution of peanut hay (2.5 to 20 per cent.) for part of the sorghum ration did not produce significantly different weight gains when comparison was made with pigs fed the control soybean/sorghum ration.

Substitution of 10 to 30 per cent. sago for sorghum in pig rations containing peanut hay, fish meal or soybean mead did not affect weight gains. The substitution of meat meal for fish meal, however, produced significantly lower gains. Fifty per cent. sago was substituted with similar results.

The

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CONTENTS

SOY BEAN YIELDS IN THE LOWLANDS OF NEW GUINEA

G. D. HILL.*

ABSTRACT.

Four varieties of soy beans NG 4661 *Batavian Yellow, NG* 4662, *SHE* 30, *and Mission were grown in the wet Lowlands at Bubia near Lae. The three best varieties yielded more than* 1,500 *lb. of beans per acre. The mean protein content of the beans was* 43.0 *per cent. and the mean oil content* 17.4 *per cent for all varieties. Yields compare favourably with those reported from the Highlands.*

INTRODUCTION.

Because of its high protein content for stock and human nutrition, the possible importance of soy bean (*Glycine max*) for the Territory was discussed by Kimber in 1968.

For many years, farmers in the Markham Valley have been seeking a suitable crop to incorporate into a rotation or as an alternative crop to replace peanuts in the monoculture currently practised on most farms.

In 1964, two trials in the Markham Valley to assess soy bean varieties in the wet lowlands failed because of poor seed germination (Anon 1966). In 1968, a further trial using four soy bean varieties was planted at Bubia Agricultural Experiment Centre, near Lae, to evaluate the potential of this legume in the wet lowlands.

MATERIALS AND METHODS.

Four varieties selected on the basis of their results in yield trials in the Highlands were sown on 7th November, 1968. The varieties were NG 4661 Batavian Yellow, NG 4662, SHE 30 and Mission.

The trial was randomized block design with four replicates. Five rows 2 ft. apart were sown in each plot at a seeding rate calculated to give a within row spacing of 2 in. between plants. The total area of each plot was 43.5 ft. x 10 ft.

Seed had been obtained from Aiyura in August, 1968, and prior to planting was stored in a domestic refrigerator to prevent loss of viability. At planting, all seed was inoculated with *Rhizobium* strain CB 1809.

RESULTS AND DISCUSSION.

Progress of Trial.

All varieties germinated well and initial growth was excellent. 'Mission' was pale green by comparison with the other varieties under test. This appeared to be a varietal characteristic, because two months after planting, nodulation was equally effective in all varieties. 'Mission' was also shorter, and was first to flower and mature.

Harvesting of Mission began in early February and continued to the end of the month. The other three varieties were harvested between the end of February and mid March.

Rainfall, mean maximum and minimum temperatures, and average hours of sunshine for the period of the trial are shown in *Table* 1.

Pests and Diseases.

There was little evidence of attack by insect pests or plant pathogens. In particular it was noted that pods were not attacked by insects. Such attack is quite common with legumes in

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Table 1.—Meterological Data, Bubia, November, 1968-March, 1969.

	Month.					
	Nov.	Dec.	Jan.	Feb.	Mar.	Mean.
Rainfall, inches	4.34	12.79	6.42	4.79	12.68	8.20
Mean Maximum, Degrees F.	89.7	90.7	91.5	92.5	88.4	90.6
Mean Minimum, Degrees F.	71.2	72.0	71.7	73.2	73.3	72.3
Hours Sun, Average	6.0	6.9	6.3	5.1	5.8	6.0

Table 2.—Yield of Soy Beans, Crude Protein and Oil, Bubia.

Variety.	Beans lb./acre.	CP per cent.	CP lb./acre.	Oil per cent.	Oil lb./acre.
NG 4661	1,509	41.2	622	18.1	273
NG 4662	1,694	43.1	730	18.8	318
SHE 32	1,529	41.0	627	14.6	223
Mission	1,035	46.9	485	18.3	189
Mean	1,442	43.0	616	17.4	251

the lowlands and the freedom from attack in the soy beans may have been due to their hairy exterior. Retention of seed by all varieties was excellent.

Harvesting.

As each variety matured, the two guard rows of the plots were discarded as well as 21 in. at each end. Harvested pods were sun-dried and hulled to record seed yields. From each bulked variety a subsample was removed and ground for crude protein and oil determinations. The mean seed yield, and the yields of oil and protein for all varieties are shown in *Table* 2.

A Duncan multiple range test was performed on the yield data and the results are shown in *Table* 3.

Table 3.—Variety.

	NG 4662.	SHE 32.	NG 4661.	Mission.
Mean Yield lb./acre	1,694	1,529	1,509	1,035

SIGNIFICANCE : Any two means not underlined by the same line are different at the 5 per cent. level.

The three top varieties did not differ significantly from each other but Mission was clearly inferior to them all.

CONCLUSIONS.

These yields compare favourably with those quoted by Kimber (1968) for trials in the highlands. It would appear that soy beans can be grown in the lowlands and produce satisfactory yields. An advisable precaution would be to store seed for lowland plantings in a cool room store or send it to the highlands for storage between seasons.

ACKNOWLEDGEMENTS.

Miss C. A. Fowler for chemical analyses, and Mr. M. S. Meara for assistance in the field.

REFERENCES.

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KIMBER, A. (1968). Soybean in the New Guinea Highlands. *Rural Digest*, Dept. Agric. Stock and Fisheries, T.P.N.G. 10, No. 1, 13-7.

(Accepted for publication July, 1969.)

GALLS OF CACAO IN PAPUA AND NEW GUINEA

BY DOROTHY E. SHAW* AND W. M. BURNETT.†

ABSTRACT.

Fan and knob galls of cacao, previously recorded in Central America, are now recorded in Papua and New Guinea. Neither of these galls, the causes of which have not been determined, are of economic importance in the Territory at present.

Studies carried out on knob gall include microscopic examination of the tissues, isolations in nutrient agar of fungi present in the galls, inoculations with gall tissue (which did not result in galls), excision of galls in the field and the production of new galls from some old excision scars. The presence of knob galls could not be correlated with any nutritive state of the trees. No significant difference was found in auxin activity or in gibberellin levels in galled and normal samples and no virus-like particles were found in negatively stained-cell extracts in the electron microscope.

INTRODUCTION.

Of the various galls of cacao recorded overseas (Hutchins and Siller, 1961) the only ones so far identified in Papua and New Guinea are fan gall and knob gall. Occasionally trees with prolific flowering are located, but so far these have been attributed to causes other than flowery gall by the Cacao Agronomist, Mr. J. B. O'Donohue (unpublished data) who, on the senior author's recommendation, kept such trees under observation in one of the cacao-growing areas of Papua. No records of disc or green point gall have been made to date. Information on fan and knob galls as they occur in the Territory, and the work carried out on the latter, is given below.

FAN GALL.

Fan gall was described from Central America (Hutchins and Siller, 1961) as a stem-like outgrowth up to several inches in length, sometimes branched, with very short internodes and bract-like leaves ; some of the outgrowths bore flowers. Groups of such stems had a fan-like appearance, hence the name.

In the Territory a condition resembling fan gall has been noted in New Britain, in the Markham Valley (New Guinea mainland) and in the Northern District of Papua. An early stage is shown in *Plate* I and a later stage, where a cluster of such stems are forming a fan, is shown in *Plate* II. Often the accumulation of dead flowers from the small branches forms a mass of debris around the fan gall.

One tree was examined by the senior author several times a year for three years. When first noted it had apparently normal flowering on the trunk and all the branches except one. On the exceptional branch fan galls were present, not only on the thicker wood, but on thinner wood which would not usually carry flowers (*Plate* I). Apparently normal pods were being borne on other branches. Since that time the tree has continued to bear well and at the time of the last visit carried 17 pods. The incidence of fan gall on this tree seems to have fluctuated over the period of three years. It is growing on deep volcanic sand in an area where the cacao does not have symptoms of soil deficiency.

No cause has been ascribed to the condition overseas, nor has any claim been made that it is infectious.

The authors would be interested to learn of the occurrence of fan galls on Territory plantations other than those on which fans have already been noted and collections studied.

As mentioned previously, fan gall has been previously recorded on Central American cacao,

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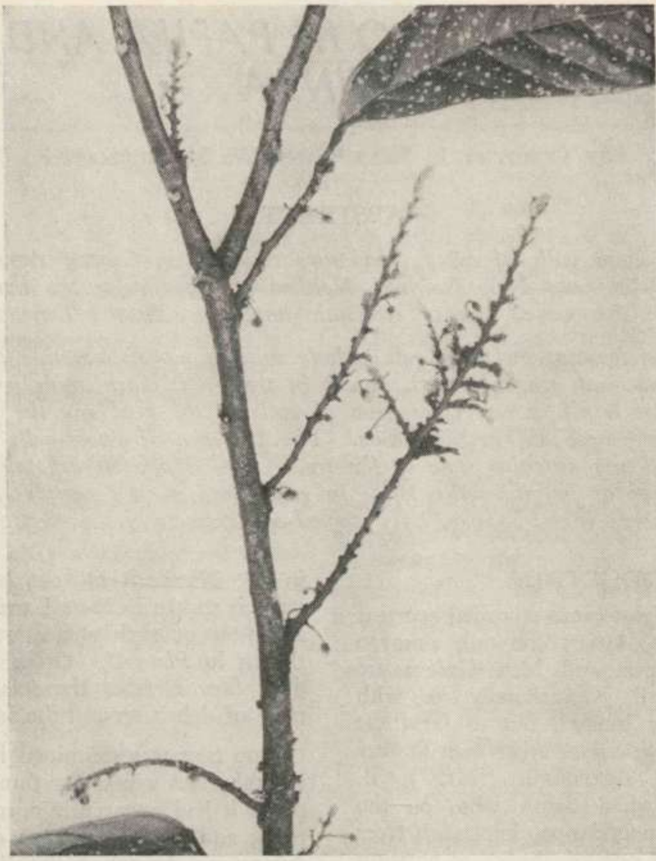

Plate I.—An early stage of fan gall of cacao. Note the flowers on the small shoots and the shortened internodes.

and now on cacao in Papua and New Guinea. It may occur in the other cacao-growing areas of the world but has not been recorded.

Trees and Collections Examined.

As well as the fan galls examined on trees in the field in New Britain, the Markham Valley on the New Guinea mainland and the Popondetta area of Papua, and later collections from these trees studied in the laboratory over a period of four years, other collections examined were as follows : TPNG 4187, C. Levy, New Britain ; 24.VI.64 ; TPNG 4188, P. G. Hicks, New Britain, 25.VI.64 ; TPNG 4238, J. Millar, Markham Valley, New Guinea, 17.VIII.64 ; TPNG 4260 and 4261, N. Robinson, Northern District, Papua, 28.VIII.64 ; TPNG 4478, A. E. Charles, Northern District, Papua, 28.II.65 ; TPNG 5493, J. B. O'Donohue, Northern District, Papua, 24.VI.65.

KNOB GALL.

Galls similar to knob gall described overseas have been recorded in the Territory in New Britain, New Ireland and on an island off the New Guinea mainland.

Knob galls were described by Hutchins and Siller (1961) as hard, woody, smooth-surfaced swellings, which may occur in the flower cushion, but which bear no flowers. The galls were said to be widely distributed * but were

* Presumably throughout the American cacao-growing areas ; no records in other countries are known to the authors.

relatively unimportant. It was stated by the above authors that an affected tree seldom showed more than 10 to 15 galls, usually less, over its entire fruiting area. Hutchins (1964) reported that knob gall developed in tissues after excision of flowery galls. Tollenaar (1966) reported that in Ecuador deficiency of boron in cacao led to vast swellings along the main trunk and often to the formation of knob galls.

Habit and morphology of knob galls in the Territory.

In the Territory knob galls have been found occurring on the main trunk, especially immediately below the jorquette (*Plate* III), on the primary branches, especially just above the jorquette, and occasionally higher up the tree. At the New Guinea island location galls often occurred in rows, on one or both sides of the fan branches (*Plate* IV, A, B and C) reflecting the $\frac{1}{2}$ phyllotaxy of these branches. At other times only one gall was found on a branch, and sometimes only one gall on the tree. In New Ireland galls were frequently found just below the forks of branches as shown in *Plate* XI, in each case examined with a slight inclination downwards. Most galls examined have been up to $1\frac{1}{2}$ in. in diameter (4 cm.), although some, especially in New Ireland, measured up to 6 in. long, 5 in. wide and 4 in. in radial cross section (approximately 15.2 by 12.7 by 10.2 cm.) and had bases as wide as the gall at the site of insertion onto the branch.

Galls were found on branches on which some cushions were flowering (*Plate* IV, A and B) and on trees which were bearing pods.

Plate II.—Fan gall on cacao. Note the accumulation of dead flowers from the small branches forming a mass of debris around the gall.

Plate III.—Tree with very large galls on trunk.

The galls were hard, woody, smooth-surfaced swellings, agreeing well with the description given by Hutchins and Siller (1961). Occasionally a tree was found with enlarged lenticels and in these cases the lenticels on the gall were also enlarged (*Plate* IV, D). The swellings were mainly hemi-spherical, that is, with a base usually or nearly as wide as the gall. Some were slightly pointed, mainly on the uppermost side, especially when the galls were on upright trunks or branches ; some galls were slightly asymmetrical. A few galls illustrating these points are shown in *Plate* V.

Dissections of Galls.

Notes on the dissection of individual galls are as follows :

A gall just over 1 in. (2.8 cm.) long, $1\frac{1}{2}$ in. (4 cm.) wide and 1 in. (2.5 cm.) in radial section is shown in *Plate* VI, A. The same gall is shown in profile in *Plate* VI, B ; the wood still attached to the specimen when received was approximately 1 cm. thick. In *Plate* VI, C, a portion of the reverse of the block is shown ; the position of the gall is marked by the vascular trace at a depth of 1 cm. in the wood.

In *Plate* VII, A, the same gall is shown with the bark cut away, revealing the bulbous outthrust of wood protruding from the normal circumference of the branch. In *Plate* VII, B, the bulbous outthrust has been pushed through the bark, leaving a hole, as clearly shown in the illustration. Although the longest axis of the gall was the horizontal, the longer axis of the opening in the bark through which the gall protruded was the vertical axis. The peeled excised gall, attached to the paper by a pin in *Plate* VII, B, can be seen to have grain forming concentric circles around the horizonal axis of the gall tangential to the trunk. A third centre of grain also occurred near the top, slightly off centre. Strips of tissue resembling thick irregular, slightly shredded strands of stiff cotton could easily be stripped off the gall at this stage.

In *Plate* VII, C, a cut across the gall near one of the ends clearly shows the concentric circles of tissue.

Microscopic examination revealed that :—

1. No pith or lysigenous cavities were present in the wood of the gall ;
2. The tissue was composed of secondary xylem, i.e., ray parenchyma, fibres and xylem vessels, forming the grain lines discernible macroscopically with the bark peeled away ; starch grains were few in number and solitary druses of calcium oxalate were noted only occasionally ;
3. At the two horizontal extensions of the gall, the secondary xylem elements formed concentric circles, as shown in *Plate* VIII ; and
4. Where the grain from the two ends met the grain encircling the third centre, the elements were mainly continuous but with a change of direction, the angle of change often being quite acute.

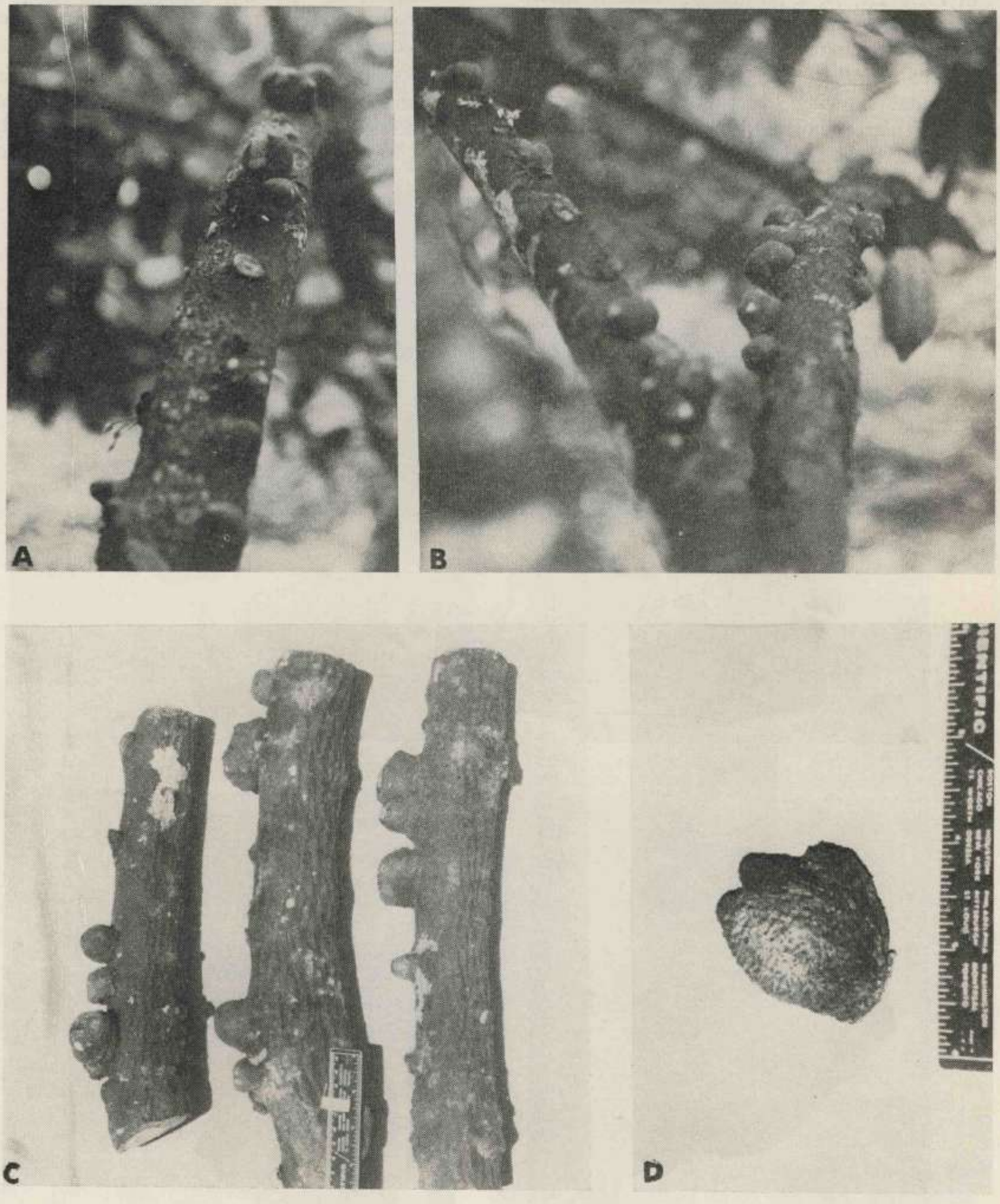

Plate IV.—A, B. Galls *in situ* on branches. C. Profile view of some galls. D. Gall with enlarged lenticels on the surface.

In *Plate* IX, A, a portion of trunk is shown with a longitudinal radial cut made through a gall so young as to be hardly discernible above the bark. In *Plate* IX, B, the two halves are opened out showing the young gall in profile and particularly showing the horizontal line of the trace at right angles to the bark leading into the interior of the branch—only this portion of the wood was still attached to the specimen when it was received at the laboratory.

The wood supporting one of the galls originally shown in *Plate* IV, C, was exposed by transverse section and as is shown in *Plate* X, A, the gall is directly opposite to the sector formed of

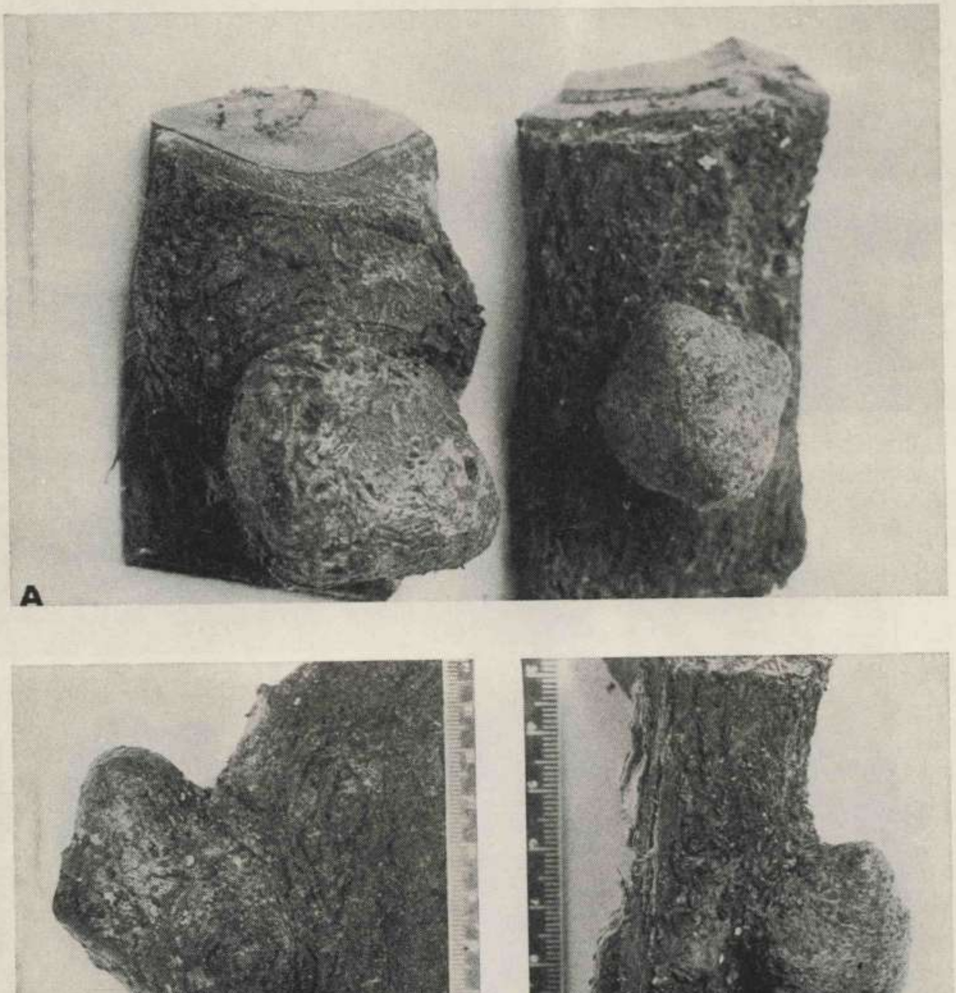

Plate V.—A. Two galls on cacao trunks. B, C. Two galls in profile. (Scale in cm.).

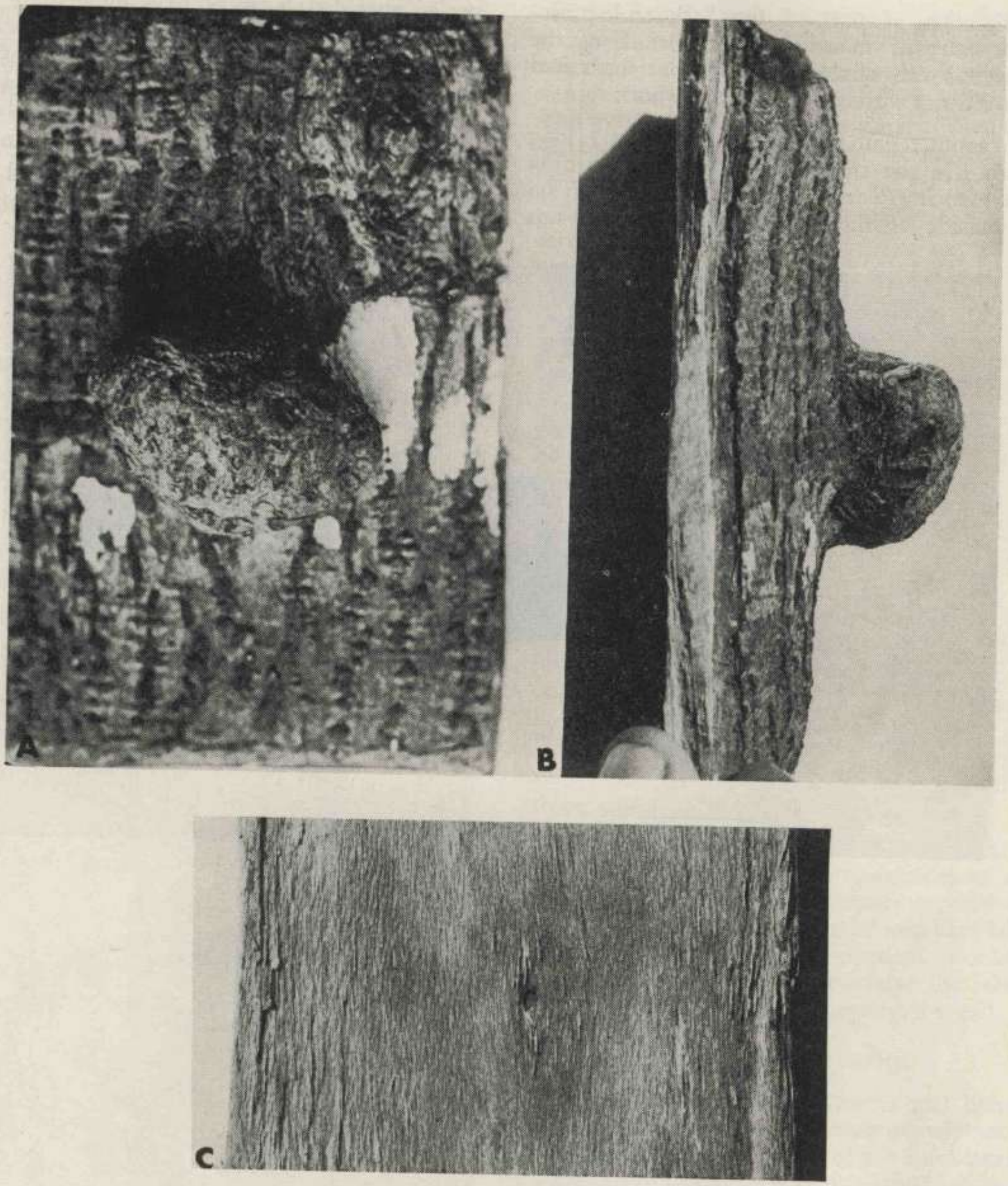

Plate VI.—A. Gall on cacao trunk. B. Same gall in profile. C. Reverse of A, with the position of the gall indicated by the ' core ' in the wood.

gap parenchyma commencing at the edge of the eccentric pith ; this is shown microscopically in *Plate* X, B.

In one large gall, 6 in. long, 5 in. wide and 4 in. in radial cross section (15.2 by 12.7 by 10.2 cm.) whorls of grain were visible on the outside of the wood when the bark was peeled off. The pattern was particularly evident because some of the parenchyma between the xylem and fibres had disintegrated due to deterioration of part of the bark and consequent entry of moisture. The surface of the wood was very slightly knobbly, but the raised areas did not correspond with the whorls.

In another gall nearly 3 in. (7.5 cm.) long growing in the crease below the junction of a large branch (*Plate* XI) the pattern of grain on the outside of the wood when the bark was peeled consisted of wavy lines integrading and some intermixing with whorls. Nine crests were counted along 1 in. of surface, the distance between crests and troughs being about $\frac{1}{8}$ in. Sections at and parallel to the surface are shown microscopically in *Plate* XII. It will be noted that the arrangement of continuous angled and whorled elements on the surface of this gall was

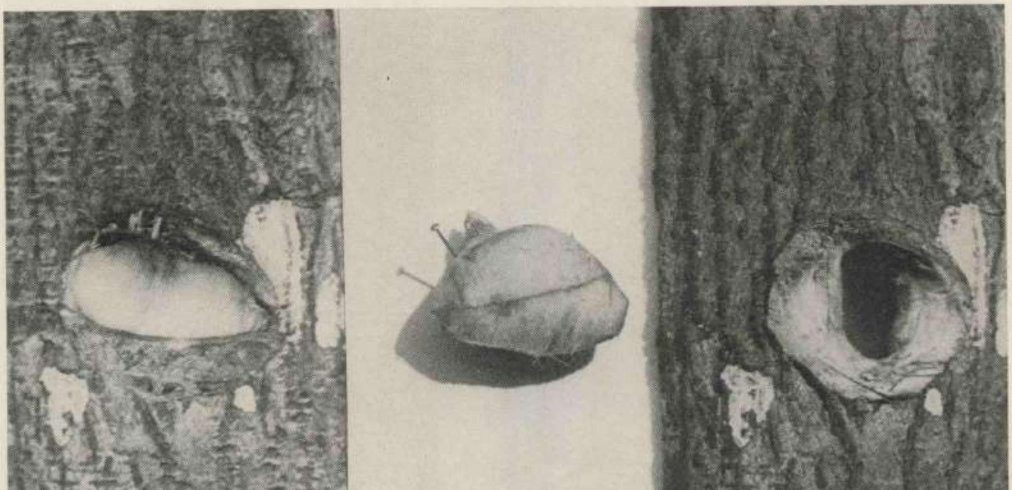

Plate VII.—A. Same gall as in Plate VI ; bark peeled from gall. B. The peeled gall excised from the underlying wood and removed from the -hole in the bark. (The straight line is a scalpel cut.) C. The concentrically-zoned wood of the gall revealed after the removal of the end. Note the grain running around the peeled gall.

of a type similar to the continuous angled and whorled elements from the interior of the gall shown microscopically in *Plate* VIII, which had straight grain on the surface except at the ends and one other centre.

The pattern of wavy lines and whorls was also impressed on the inside of the bark. Sections through the cambium zone of the gall did not reveal anything which could be recognized as abnormal when examined microscopically. Sections through the bark, however, revealed that the triangularity of the fibre bundles of the cortex and the reverse triangularity of the parenchyma capping the rays were greatly distorted. The bark of this gall could be fairly easily pulled apart by the fingers, mainly into irregular layers, a week or so after harvest. This ease of disintegration of the tissues was no doubt due to the disorganization of the elements of the cortex—the bark of the normal branch was still quite firm at that stage. During the dissection of the wood bearing the gall, no vascular trace or parenchymatous gap arising from the centre

Plate VIII.—Section through one end of a gall showing whorled secondary xylem.

of the branch was recognized. As the gall occurred in the crease below the junction of the branch, in a region of complex tissue, the trace and gap may have been missed during dissection. The wood of this gall, unlike some of the others, was particularly compact even weeks after harvest.

In all except one of the dissections of galls carried out to date, the position of the gall has corresponded with a right-angled parenchymatous gap in the wood supporting the gall ; the vascular traces were no doubt present but were difficult to identify. Brooks and Guard (1951-1952) stated that the flowering cushion is derived from the solitary axillary bud of a leaf ; the parenchymatous gap and trace opposite a gall is no doubt the trace and gap complex of the original leaf and axillary bud.

The linear orientation of many of the galls on fan branches, especially on cacao from the New Guinea island location, also supports the contention that vascular traces and parenchymatous gaps subtending galls were probably originally those of the leaf and axillary bud at that site.

On some occasions it was difficult to determine by external visual examination whether galls, especially those on trunks, occurred at cushion sites ; internal dissection would be necessary in these cases.

In some cases galls seemed to occur near but not at cushions. While the eccentricity of some of the cacao stems and perhaps repositioning caused by haphazard excising by unskilled labour may account for these, dissections would be necessary in each case to determine the internal condition of the wood supporting the gall.

Possible Associated Abnormality.

In sections of wood of trunks and branches bearing galls it was occasionally noted that collapse of the ray parenchyma of the outer layers of the secondary xylem occurred in wood adjacent to the galls. When such wood was examined even with a hand lens about one week after collection, minute wedges of holes were present. This collapse of the outer ray parenchyma may have only taken place with differential drying in the immediate vicinity of the gall of the excised wood block and may never be manifested in the growing tree.

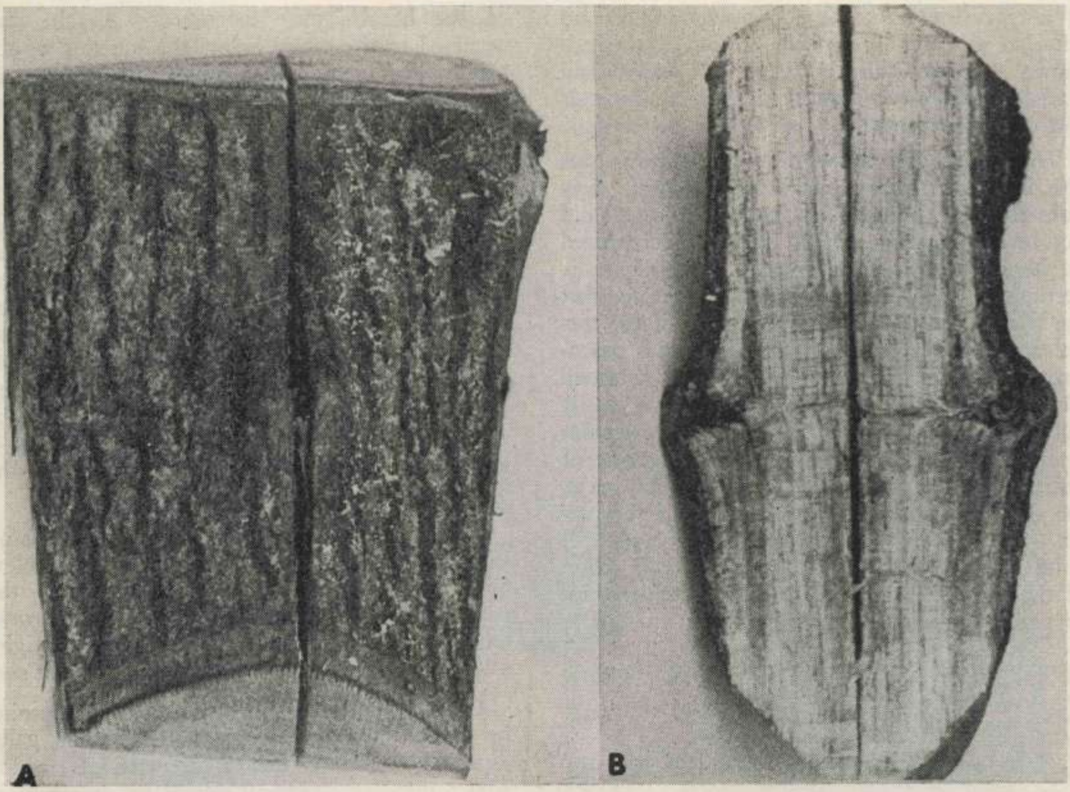

Plate IX.—A. Portion of cacao trunk with a radial cut through a young gall. B. Same block opened out to show young gall in half profile. Note horizontal black line running from centre of gall deep into the wood.

Galls and underlying wood with vertical traumatic lysigenous canals.

Some of the wood of trees with galls were found to have vertical traumatic lysigenous canals (*Plate* XIII, A and B). The wood of seven galls chosen at random by a field officer in New Ireland was examined to determine whether the canals always occurred in wood of the trunk or branch on which galls were found. The results are shown in *Table* 1.

From the Table it will be seen that some galls arose from wood in which no v.t.l. canals occurred. Since Shaw (1968) examined other specimens of wood with v.t.l. canals from which no galls arose, it appears as if the occurrence of galls and v.t.l. canals is coincidental.

Table 1.—Presence or Absence (—) of Traumatic Vertical Lysigenous Canals in Trunk or Branch Bearing Galls.

Size of gall. (tangential axis). cm.	Examination of wood.
14	One ring * of canals deep in wood.
7	Several rings of canals, possibly relating to previous injury (Plate XIII, A).
4	Two rings of canals (Plate XIII, B). (At the time this illustration was taken, the bark had been peeled and the gall excised from the wood; the position of the gall, however, is still evident.)
0.5	One ring of canals on one side only.
2.5	—
1.5	—
1.5	—

* One ring visible macroscopically—each ring may be composed of several rows of lysigenous canals.

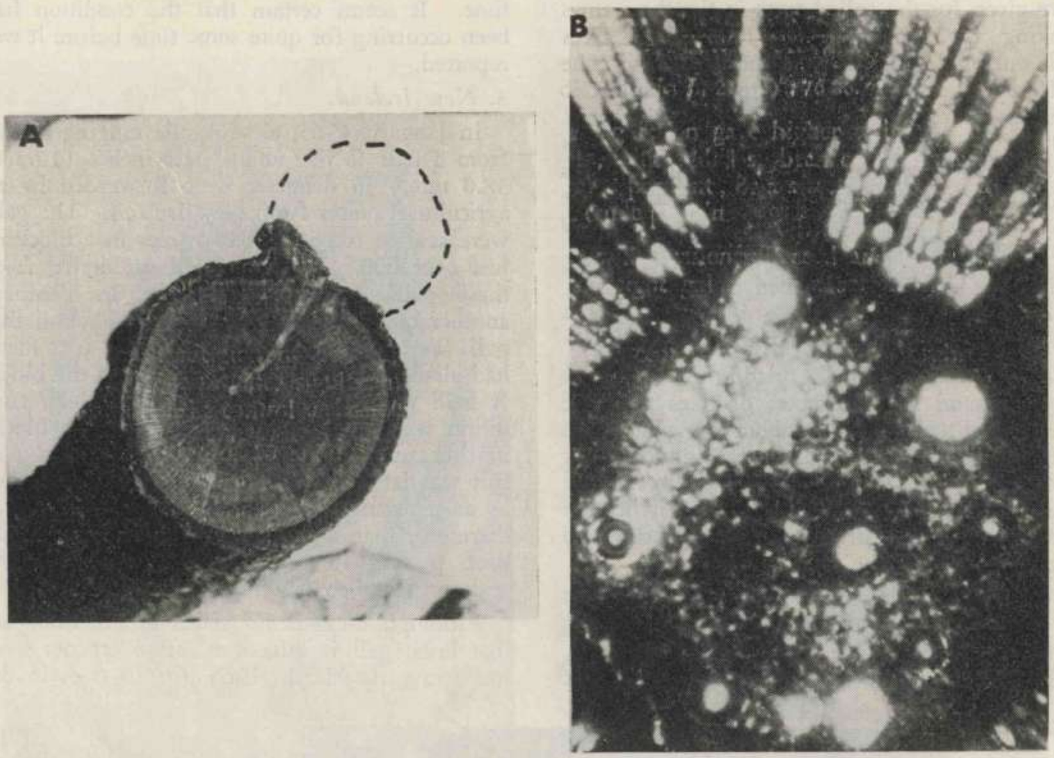

Plate X.—A. Transverse cut showing parenchymatous sector in the wood subtending gall which was previously removed. B. Transverse section through same stem showing pith and the beginning of the parenchymatous sector issuing north of the pith, 33x.

History of the occurrences.

1. *New Britain.*

One gall was received from a plantation in a relatively isolated area of New Britain in August, 1963. It was a typical knob gall. The planter was advised to destroy the tree, and, despite subsequent inquiry, no further notification of galls has been received from this plantation.

2. *Island off the New Guinea mainland.*

In November, 1966, a plantation owner and the agricultural officer at the above locality advised that one tree with galls had been located. One gall forwarded to Port Moresby, however, was very old, and had obviously been present for some time. As a precautionary measure, the planter was advised to destroy the tree and to report any further occurrence immediately.

In early January, 1967, another tree with galls was found and destroyed. The planter was requested to provide information on the position of the second tree in relation to the first.

In early February he advised that the second tree was about 150 yards (137 m.) from the first. He also reported that during his inspections he had found another area of 21 trees with galls and a third area of two trees with galls. The larger area was about one mile (1.6 km.) from the first tree found on the plantation, with the smaller area about 250 yards (228.5 m.) further away. The trees were mainly eight years old, with a small proportion five to ten years old.

The relative positions of the affected trees in the larger area are shown in *Figure* 1, the planter's assessment of the number of knobs per tree also being shown. No positions, however, were given for the galled trees in the three rows flanking the most affected row. Two trees had one old gall each ; one tree had one gall only on a branch ; other trees had from two galls to more, and three trees were said to be 'covered'. The concentration of galled trees around two trees with one old gall each is suggestive of distribution around a centre. The area shown in *Figure* 1 is at sea-level about 250 yards (228.5 m.) from the shore.

Some of the galls examined in the laboratory at Port Moresby were up to $1\frac{1}{2}$ in. (nearly 4 cm.) in diameter, and two were confluent.

By middle February the planter reported that he had found large numbers of trees with the gall well distributed throughout the plantation. This was confirmed by the agricultural officer who stated that 'many dozens' of trees were found with the condition, and that "it became apparent that the gall was much more common than at first thought".

It is stressed, therefore, that it is not known for how long galls had been occurring on trees on the plantation before the report of November, 1966, or how many trees were affected at that time. It seems certain that the condition had been occurring for quite some time before it was reported.

3. *New Ireland.*

In January, 1965, eleven galls ranging in size from a half to one and a half inches (12.5 to 38.0 mm.) in diameter were forwarded by an agricultural officer from New Ireland. The galls were said to come from two trees in a block of just over 600. Isolations were attempted from these galls, as reported later. In February another officer checked the area and found that galls were present on some trees but that many had already been cut off other trees in the block. A field worker also claimed that a similar condition was occurring on cacao on other blocks in the same general area of New Ireland and this was later confirmed in a survey carried out by an assistant pathologist. It must be stressed, therefore, that the condition must have already been present for some time and was already widespread when first reported.

Although there is no claim in the literature that knob gall is infectious, arrangements were made in early March, 1965, for all trees in the

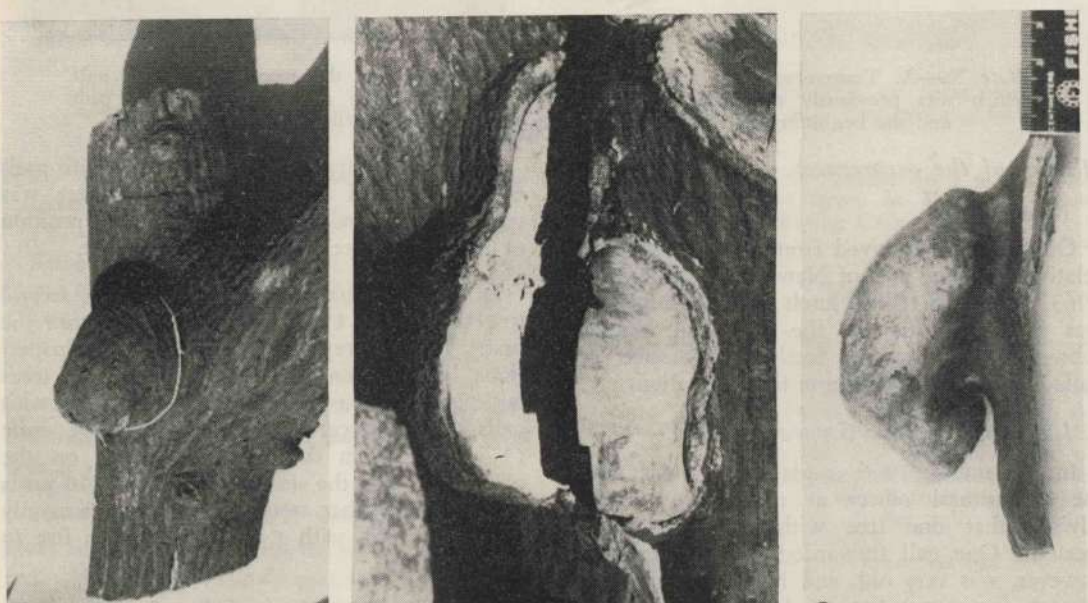

Plate XI.—A. Gall below junction of branch, $\frac{1}{4}$x. B. Gall split longitudinally and bark peeled from one half, $\frac{1}{2}$x. C. Gall in profile, bark removed, $\frac{1}{2}$x.

Plate XII.—Sections at and parallel to the surface of fall shown in *Plate* XI.

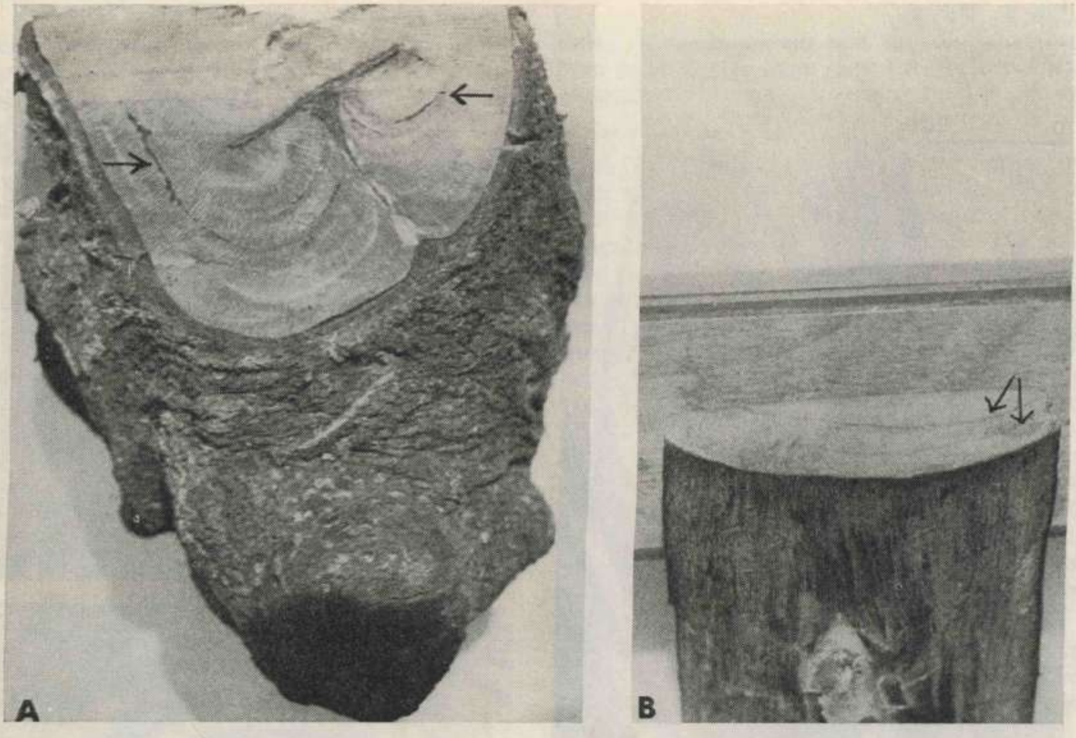

Plate XIII.—A. Cross section of portion of trunk above a large gall, showing deep-seated probable wound and partial rings of vertical traumatic lysigenous canals, indicated by arrows. B. Wood block with bark peeled and gall excised, showing two rings of vertical traumatic lysigenous canals, indicated by arrows.

block to be inspected, and any trees with galls were marked on the trunk with paint. Trees with galls were counted and marked by the local staff during the following year to try and determine whether any spread was occurring. However, continual difficulty was experienced with the labourers who persisted in cutting off galls during the regular removal of water shoots, despite instructions to the contrary ; reliable results were, therefore, not obtained.

Occurrence of galls on cacao at two readings six months apart.

In May, 1966, each tree in the block of 600 in New Ireland was examined by the senior author who noted the presence or absence of galls, scars, and galls from scars. Similar readings were taken approximately six months later. The position and type of tree is shown in *Figure* 2, and the numbers of trees in each class are shown in *Tables* 2 and 3.

When reading the Tables and Figure, it should be kept in mind that before and during this six month period the trees, which were about 15 ft. high and interplanted with *Leucaena leucocephala* (Lam.) de Wit to provide shade and which were growing on shallow soil derived from coral, were subject to normal plantation procedure. This involved harvesting of mature pods by cutting with unsterilized knives and the removal of water shoots using unsterilized knives ; also, despite instructions to the contrary, the labourers still apparently cut off galls from time to time, also with unsterilized knives.

From *Table* 2 it will be noted that at the first inspection 235 trees had galls but scars were plainly evident on 75 other trees, making 310 trees which had had or then had galls.

At the inspection six months later 181 trees had galls, with a cutting mark evident on one other tree, making 182 trees which obviously had galls or had had galls.

Table 2.—Numbers of Normal and Galled Cacao Trees at Two Readings Six Months apart.

Condition of tree.	May, 1966. No.	May, 1966. Per cent.		November, 1966 No.	November, 1966 Per cent.	
Normal	258	43.0		382	63.7	
Galled	160	26.7	51.6	152	25.3	30.3
Gall scars	75	12.5		1	0.2	
Galls and gall scars	39	6.5		0	0.0	
Galls, some at least from scars	36	6.0		29	4.8	
Missing	32	5.3		36	6.0	
	600	100.0		600	100.0	

These figures show that 128 more trees had or had had galls at the first reading than was evident six months later. *Table* 3 shows the detailed analysis of the tree readings. It seems that many of the galls had been removed, and scars had healed sufficiently to be unnoticeable, especially those at the higher levels which were more difficult to see in the deep shade under the cacao and *Leucaena* trees. In some cases at least, however, the removal of galls did not prevent a new gall from arising from the old scar.

During the readings every care was taken to try and distinguish cuts caused by the removal of water shoots and those caused by the removal of galls, which mainly occurred higher up the trunk above and below the jorquette. While some errors may have occurred, scars scored as having arisen from galls comprised only 8.3 per cent. of the total and even if all the scars had arisen from water shoot scars the general position is not affected. It will also be noted that out of the 258 normal trees at the first readings, 227 or 88.7 per cent. were still normal at the end of six months. This was despite the continual harvesting of pods and removal of water shoots with unsterilized knives, and the probable removal of galls themselves from other trees during this period, also with unsterilized knives. Only 5 per cent. of new trees acquired galls during the six months' period.

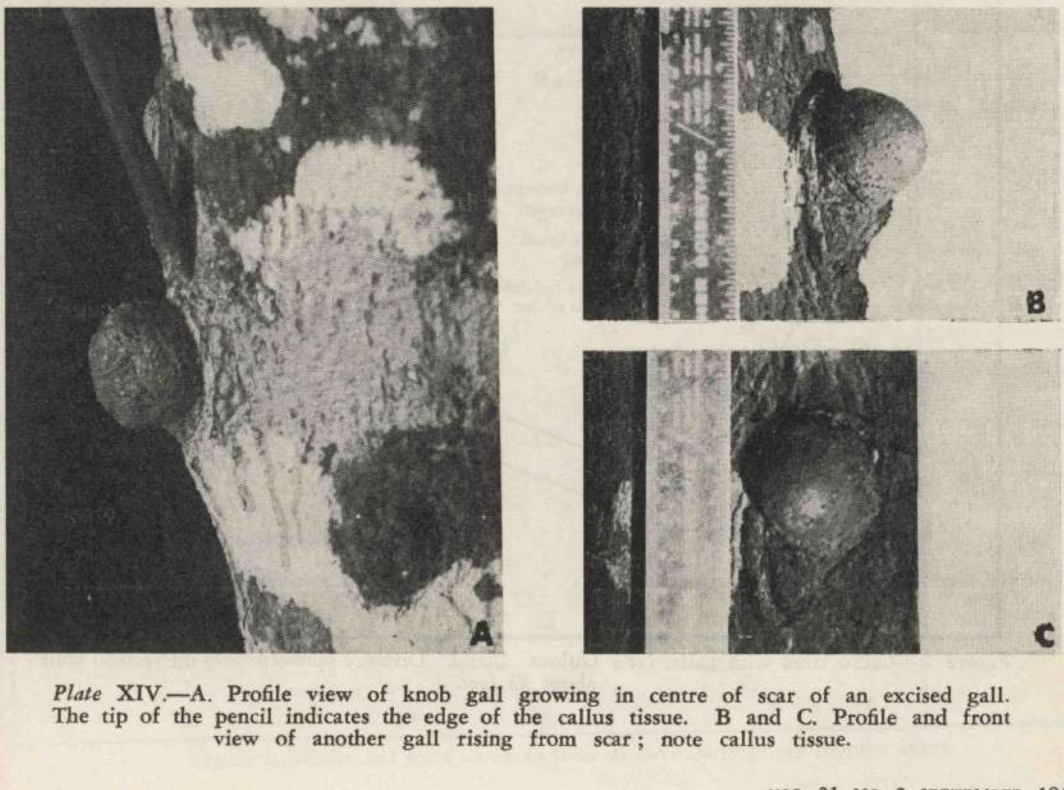

Plate XIV.—A. Profile view of knob gall growing in centre of scar of an excised gall. The tip of the pencil indicates the edge of the callus tissue. B and C. Profile and front view of another gall rising from scar; note callus tissue.

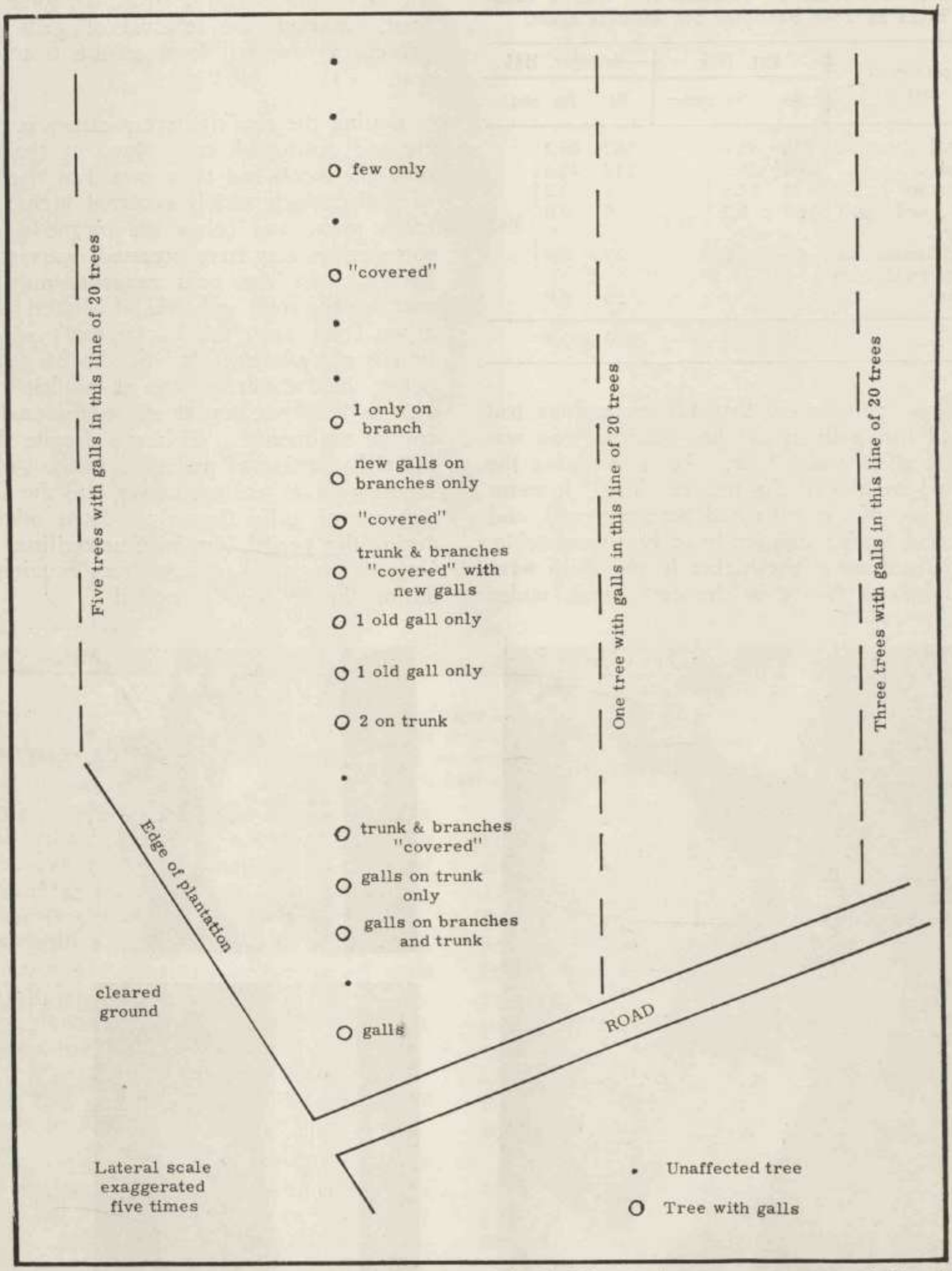

Figure 1.—Cacao trees with galls, New Guinea island. Distance between trees on vertical scale about 12 feet.

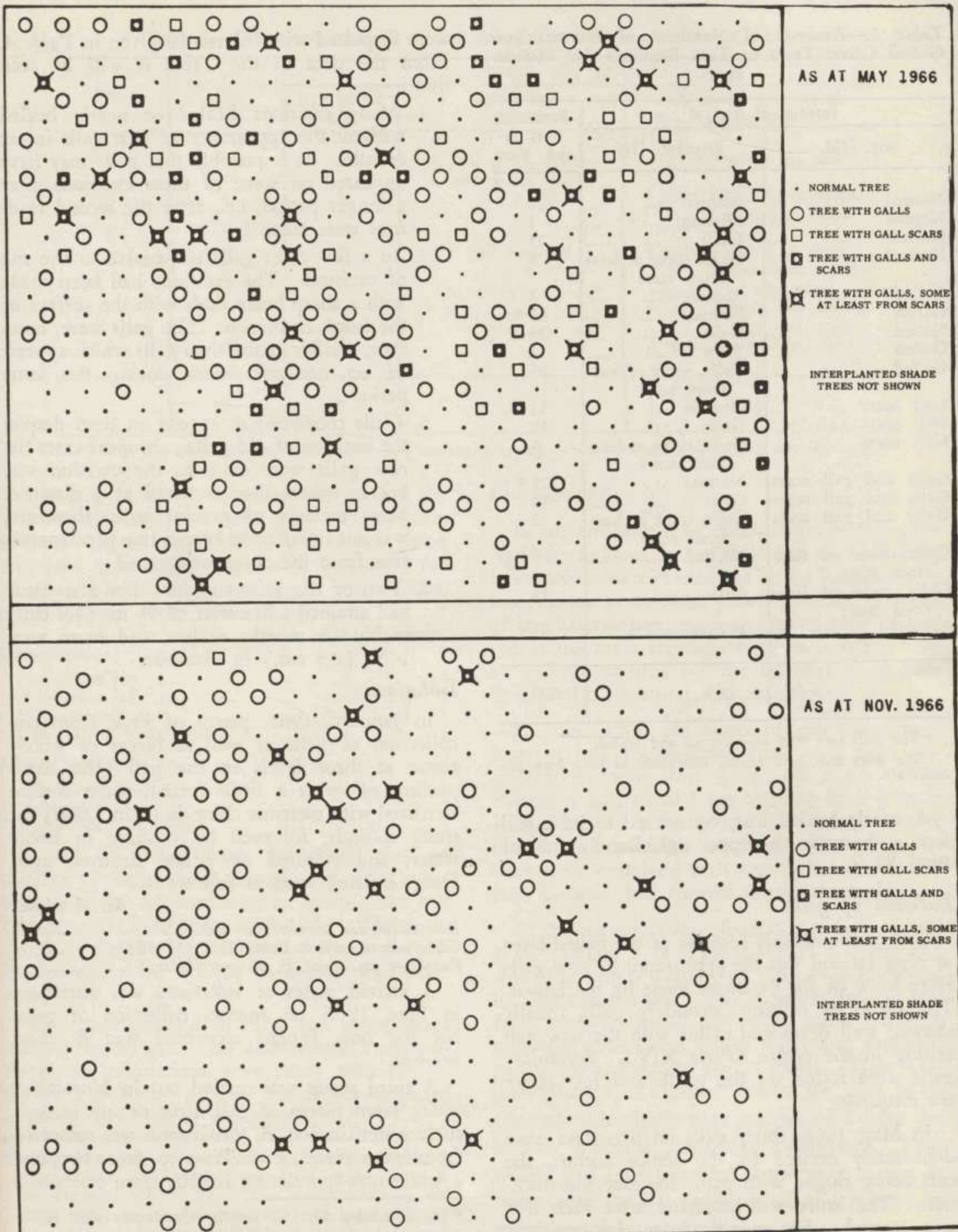

Figure 2.—Galls and scars on cacao trees at two readings six months apart.

Table 3.—Analysis of Numbers of Normal and Galled Cacao Trees at Two Readings Six Months apart.

Condition of trees at May, 1966.	Condition of trees at November, 1966	Number of trees in each class.
Normal	Normal	227
Normal	Missing	1
Normal	Galls	25
Normal	Galls, some at least from scars	5
Galled	Missing	3
Galled	Normal	65 *
Galled	Galls	78
Galled	Scars	1
Galled	Galls, some at least from scars	13
Gall scars	Normal	51
Gall scars	Galls	19
Gall scars	Galls, some at least from scars	5
Galls and gall scars	Normal	23 * †
Galls and gall scars	Galls	12
Galls and gall scars	Galls, some at least from scars	3
Galls, some at least from scars	Normal	15 * †
Galls, some at least from scars	Galls	18
Missing	Missing	32
		600

* The galls may have been cut off and healed.

† The scars may have healed sufficiently to have been unnoticeable.

A nearly healed scar, considered to be a gall scar, is shown in the upper right hand corner of *Plate* VI, C.

Excision of galls.

One of the notable features of the galled trees in New Ireland was the appearance of new galls from some of the excisions made by the labour. The excisions bearing secondary galls usually showed well developed callus with the new gall arising in the centre (*Plate* XIV). Secondary galls were found on the trunk and just above the jorquette.

In May, 1966, thirty galls on five trees were deliberately excised by the senior author, the cuts being ringed with paint for easy identification. The knife was sterilized after each tree was treated. Six months later the excisions were inspected with the results given in *Table* 4. From the data in the Table it will be seen that :—

1. Many excisions healed or nearly healed without the appearance of new galls in six months. It is possible that galls may have appeared on some of these excisions after a longer period, i.e., after the second readings were taken ;
2. In a few cases galls reappeared at the site of excision. The excisions had been made with a sharp knife flush with the surface of the trunk or branch. The galls were, however, smaller in size than galls which appeared on non-scar tissue during the same period ;
3. Galls continued to appear on trees despite the excision of old galls. In some cases the new galls were close to the excision scar but in others they occurred at a distance. Mere excision of present galls, therefore, was not sufficient to keep a tree permanently free from the outgrowths ; and
4. Two of the galls from the non-scar tissue had attained a diameter of $1\frac{1}{2}$ in. (3.8 cm.) within six months or less, and seven were 1 in. (2.5 cm.) in diameter.

Isolations.

In January, 1965, pieces of bark from one collection of galls as well as pieces of woody tissue at three levels in the gall (the layers peeling off with a little force), were surface sterilized with mercuric chloride (1 in 1,000) for thirty seconds, followed by washing in sterile water, and cultured on potato dextrose agar. Fungi isolated were as follows :—

	No. of colonies.
Botryodiplodia theobromae Pat.	18
Gliocladium roseum Bain (IMI 112160)*	4
Fusarium sp. (not *F. decemcellulare*)	4

A second series of isolations was attempted in June, 1966, on another collection of galls, but the only fungus recovered was *B. theobromae*.

A third series was carried out in November, 1966, from pieces of gall after twenty seconds surface sterilization. *B. theobromae* was recovered from seven pieces, *Penicillium* sp. from two, and a white non-sporulating fungus from one piece.

* Identified by Dr. C. Booth, Commonwealth Mycological Institute, England.

Table 4.—Occurrence of Galls on and near Excision Scars after Six Months.

Tree.	No. of galls excised.	Readings after six months.		
		Scars without galls.	Scars with galls.	No. of new galls not on excision scars.
1	9	7	1 gall ½ in. diam. 1 gall ¼ in. diam.	4 galls each 1 in. diam.
2	3	3		2 galls, 1 with 1½ in. diam. 1 with ½ in. diam.
3	6	6 *		
4	6	5	1 gall forming	5 galls, 3 with ½ in. diam. 1 with 1½ in. diam. at scar edge 1 with 1 in. diam. near scar edge
5	6	6		2 galls each 1 in. diam.
	30	27	3	13

* Very big edges on callus tissue, some cuts completely healed, others with unhealed opening into the wood.

A fourth series of isolations was carried out in February, 1967, on three galls. From tissue without surface sterilization and from tissue immersed in mercuric chloride (1 in 1,000) for 20 seconds, followed by washing in sterile water, the following were obtained :—

	No. of colonies.
Unsterilized—	
Penicillium sp.	14
Aspergillus sp.	1
Pestalotiopsis sp.	1
Unidentified white colony	1
Surface sterilized—	
Penicillium sp.	8
Aspergillus sp	2
Unidentified (4 types)	5

It will be noted from the above that no colonies of *Fusarium decemcellulare,* which has been shown to be implicated in green point gall (Brunt and Wharton, 1961-1962 ; Hutchins, 1965), were obtained in any of the isolations. No bacteria were isolated in any of the above tests.

As it was decided to carry out inoculations with macerated gall tissue and extracts from gall tissue, no inoculations were made with any of the above isolates,* none of which was suspected of being the cause of the galls.

* In another study of fungi isolated from cacao, many inoculations into cacao have been made with *B. theobromae* isolated from this host, although not from galls, but to date no galls have been recorded from any of the inoculations.

Inoculations.

In an endeavour to determine whether galls could be induced in healthy trees, the following inoculations were carried out at the Port Moresby laboratories or in cacao planted within 12 miles of the laboratories ; no inoculations were carried out in the main cacao-growing areas either with or without records for the occurrence of galls in case the condition was infectious.

In June, 1966, six pieces of gall tissue were inserted into young cacao trees with stem diameters of more than ¼ in. (6 mm.). The slivers of gall tissue were about ¼ in x ⅛ in. x ⅛ in. (6 x 3 x 3 mm.) and after insertion were bound with adhesive bandage. Thereafter the trees were examined each month but 12 months later no galls had formed anywhere on them.

In November, 1966, fresh tissue from a gall ¾ in. (nearly 2 cm.) in diameter was cut and shredded with a scalpel and the pieces immersed in de-ionized water. Eight newly peeled and four seeds unpeeled but with some mucilage removed were added to the water and shredded gall tissue and soaked for 21 hours. They were then planted in crushed quartz, the pots being covered with plastic bags and watered from the bottom until the seeds had germinated. Four peeled and four unpeeled seeds were soaked in water only for the same period and planted in separate pots as controls.

The emerging seedlings were examined weekly but six months later no galls had formed on the cotyledons or on the stems or petioles.

In February, 1967, a third series of inoculations was made on trees about seven years old near Port Moresby as follows :—

Gall extract inoculum—Four cuts about three inches (7.6 cm.) long by approximately one half inch (1.3 cm.) deep were made on the limbs about two feet (0.6 m.) above the jorquette in each of four trees, the knife being run through a gall still attached to a portion of the branch before each cut. Eight of the cuts were covered with adhesive bandage for five weeks until the first readings were taken ; eight cuts were left uncovered ;

Controls—As above, but the knife was drawn through healthy cacao tissue instead of through gall tissue prior to inoculation ;

Gall tissue inoculum—Pieces of gall tissue about ½ in. (1.3 cm.) square and one sixteenth inch (1.5 mm.) deep were inserted at four sites in each of four trees, eight of the insertions being covered with adhesive bandage for five weeks ; eight insertions were left uncovered ; and

Controls—As above, but healthy cacao tissue was inserted instead of gall tissue.

No galls or malformed tissue was observed on or near the inoculation sites on any of the trees during the succeeding four months.

In February, 1967, 48 seeds were obtained from two healthy pods from trees in a non-gall area, and treated as follows :—

12 seeds. Peeled ; soaked in macerated gall tissue in water for 24 hours ; planted in soil in pots at the laboratory ;

12 seeds. Peeled ; each seed punctured with a needle three times on each side ; soaked in macerated gall tissue in water for 24 hours ; planted in soil in pots as above ;

12 seeds. Peeled ; soaked in water without gall tissue for 24 hours ; planted as above (controls) ; and

12 seeds. Peeled ; punctured with a needle as above ; soaked in water only for 24 hours ; planted as above (controls).

Four months later no galls or malformations had occurred on any part of the seedlings grown from the above seeds.

In April, 1967, a further series of inoculations was carried out on two-month-old seedlings as follows :—

Inoculum of macerated gall tissue suspension—

4. plants. Inoculum introduced per hypodermic syringe at three different positions into each seedling.

4. plants. Inoculum introduced per hypodermic syringe into base of seedlings.

4. plants. Inoculum introduced per hypodermic syringe at tip of seedlings.

Inoculum of gall tissue—

8 plants. Inoculum consisting of piece of gall tissue approximately one sixteenth inch (1.5 mm.) square by one quarter inch (3 mm.) thick inserted into each stem.

Inoculum of macerated gall tissue—

4 plants. Soil around seedlings watered with a suspension of macerated gall tissue.

Controls—

12. plants. Inoculated with water only per syringe.

8 plants. Inoculated with slivers of healthy cacao wood.

4. plants. Seedlings watered with tap water only.

All the injections and insertions were covered with adhesive bandage for at least four weeks, but some bandages were not removed at all.

Seven months later no galls or malformations were present on any of the above seedlings.

From the four series of inoculations carried out no galls were obtained in any of the test material. Further inoculations using different methods will be required before it can be stated firmly that the condition cannot be transferred by inoculation.

Sowing of seed from a tree with galls.

Seeds from two pods from a tree with galls in New Ireland and seeds from two pods from a tree in a non-gall area were dipped separately in 95 per cent alcohol for five seconds, washed in de-ionized water and sown in soil in pots in the Port Moresby laboratory. Seven months after sowing no galls had appeared on the 16 seedlings raised from the pods from galled trees or on the 20 seedlings raised from seeds from normal trees.

It seems unlikely to the authors that a genetical factor is involved causing the production of knob galls on some trees but not on others.

Reported association overseas of knob gall with boron deficiency.

Tollenaar (1964) reported that in Ecuador deficiency of boron led to vast swellings along the main trunk and often to the formation of knob galls in cacao.

The Senior Chemist of the Department of Agriculture, Stock and Fisheries, Mr. P. J. Southern, kindly made available to the authors the results (unpublished) of analyses carried out on cacao leaves from the gall area in New Ireland and from non-gall cacao in many other parts of the Territory. The figures are shown in *Table* 5.

Table 5.—Range and Average p.p.m. of Boron in Cacao Leaf Samples from Gall and Non-Gall Areas in New Guinea.

Location.	No. of Samples.	Boron in p.p.m.	
		Range.	Average.
Gall area, New Ireland	15	32-44	38
Gall area, New Guinea island	1		45
Non-gall areas, various sites throughout the Territory	103		39

As is evident from the Table, both the range and average boron in p.p.m. of cacao leaves from the two gall areas are similar to those from the non-gall areas in the Territory.

Tollenaar considered that boron deficiency could be induced on soils with high calcium. While the gall area in New Ireland is on soil containing high amounts of available calcium, other non-gall areas in the Territory with similar leaf boron content are on soils with a similar or higher calcium status. Also, no other symptoms such as those described by Maskell *et al.* (1953), Lockard *et al.* (1959) or by Loue (1961-1962) for boron deficiency in cacao seedlings under controlled conditions were present on the galled cacao, nor were there any of the other symptoms described by Tollenaar for cacao with boron deficiency in the field. It would seem, therefore, that the knob galls in this Territory cannot be attributed to deficiency of boron.

Mr. Southern summarized the position regarding the general nutrient status of the soils as follows :—

> " One of the areas where galls occur is situated on fertile volcanic soil and soil and cacao leaf analysis do not indicate likely mineral deficiencies or toxicities. The other area is limestone derived soil of lower fertility but which still has a relatively high nutrient availability, as judged by both soil and leaf analysis. Many other cacao growing areas where galls are not occurring are chemically poorer. There is thus no evidence of mineral deficiency or toxicity associated with the production of galls in this Territory and in particular little possibility of an association with borin deficiency, as reported by Tollenaar (1964) in Equador."

Electron microscope check for virus particles.

In April, 1967, Dr. Adrian Gibbs of the Australian National University, Canberra, kindly examined in the electron microscope sap extracts from the sources listed below, the material having been mounted on grids and negatively stained with potassium phosphotungstate in Port Moresby using the methods described by Hitchborn and Hills (1965) :—

Unaffected cacao—

Strips of tissue from the underside of leaves ; and

Cambium zone and bark of stems.

Cacao with knob gall—

Strips of leaves from the underside of leaves ;

Cambium zone and bark of gall ;

Stem of young shoot from tree with galls ; and

Water shoot of three eighth in. (0.9 cm.) diameter arising from gall.

Gibbs (personal communication) found no virus-like particles in the preparations, though extracts of *Crotalaria anagyroides* leaves showing mosaic symptoms, mounted in the same way and at the same time, contained filamentous virus-like particles. These results suggest that there is little likelihood of a virus with elongated particles being present in the trees with galls. A virus with isometric particles whose concentration is lower than about 10^{11} per ml. might be present, however, because small isometric virus particles are not easily distinguished from sound plant sap constituents in the electron microscope, unless they are abundant.

Check on giberellin and auxin content.

In 1967 arrangements were made with one of the English laboratories of Imperial Chemical Industries Ltd. to undertake bio-essays on cacao gall material in order to determine whether gibberellins or auxins occurred in gall tissue in excess of that found in normal cacao tissue. Samples were obtained from both New Ireland and from the island of the New Guinea mainland and were sent to England by air. Each consignment consisted of the following :—

1. Galls of various sizes freshly cut from branches or trunks ;
2. Portion of branch from a tree with galls ; and
3. Portion of branch from a tree never known to have had galls.

Dr. D. Broadbent of the Biochemical Research Department of Imperial Chemical Industries Ltd. reported (personal communication) that the method used by Mr. G. W. Elson for the assay of growth substances, and the results, were as follows :—

" Samples of sawdust produced from the wood were weighed and extracted by stirring with 70 per cent. methanol for 12 hours at 2 degrees C. Each sample was extracted twice. The two extracts were bulked and the methanol removed by vacuum distillation at 35-40 degrees C. The aqueous residue was divided into two equal fractions A and B.

Fraction A.—adjusted to pH2 with dilute hydrochloric acid and extracted three times with equal volumes of diethyl ether. The solvent extract was dried over anhydrous sodium sulphate, evaporated to dryness and assayed for indole auxin.

The dried extract was taken up in ethanol/ether/water (50 : 40 :10 v/v/v) and strip loaded on to Whatman No. 1 chromatography paper. The chromatograms were developed with water/isopropanol (95 : 5 v/v) at 2 degrees C. in the dark. The strips were cut at 0.1.R.F. intervals and each segment eluted with 5 ml. of a solution containing 0.05 m. glucose and 0.0025 m. potassium dihydrogen phosphate at M4.8. Ten 5 mm. oat coleoptile segments were placed in each dish. The segments were measured after four hours incubation at 25 degrees C. in the dark.

Oat coleoptiles were grown for 96 hours at 25 degrees C. in continuous red light. Coleoptiles 25 mm. to 35 mm. in length were selected, the 3 mm. apical segment removed and the next 5 mm. segment used in the assay.

Each extract was made up from 8 gm. of material, as below :—

Extract 1 : from separated galls ;

Extract 2 : from branch of tree with galls ; and

Extract 3 : from branch of tree without galls.

There was some activity in each extract but only in Extract 3 was there much activity ; the overall pattern was very similar for all three extracts. Further tests would be desirable on more samples.

Fraction B.—adjusted to pH2 with dilute hydrochloric acid and extracted three times with one third volumes of ethyl acetate. The aqueous phase was discarded and the solvent phase extracted three times with equal volumes of 1 per cent. sodium bicarbonate. The solvent phase was discarded and the aqueous phase adjusted to pH2 and extracted three times with equal volumes of ethyl acetate. The ethyl acetate extract was dried over anhydrous sodium sulphate and the solvent removed by vacuum distillation. The residue was assayed for gibberellins. All extracts were stored at 20 degrees C. between operations.

Gibberellin assay.—The residue was dissolved in ethyl acetate and replicate aliquots of this solution equivalent to 20 gm. of the fresh weight were pipetted into assay vials containing the aqueous assay substrate. The ethyl acetate was removed under vacuum and the assay was carried out using barley endosperm assay (Jones and Varner, 1967).

The total gibberellins content of all three samples was equal to 10^{-3}ug/kg fresh weight. There was no significant difference between galls, gall-infected- or gall-free wood."

Economic importance.

To date knob gall has not been of economic importance in the Territory. If many galls occur on flower cushions, however, yields may be affected. It was because of this possible contingency that observations and experimental work were commenced on the condition several years ago.

Collections examined.

Apart from the knob galls studied in the field by the senior author and those studied in the Laboratory, other collections examined were as follows : TPNG 3985, R. Kelly, New Britain, 9.VIII.63 ; TPNG 4434, J. Cox, New Ireland, 26.I.65 ; TPNG 5324, G. R. Forbes, New Guinea island, 2.II.67, TPNG 5427, R. Burnett, New Ireland, 13.IV.67 ; TPNG 6161, D. Brown, New Ireland, 10.IX.68 ; TPNG 6401, J. Owen-Turner, New Ireland, 7.II.69 ; TPNG 6408, J. Owen-Turner, New Ireland, 13.II.69.

DISCUSSION.

Galls on plants can be caused by nematodes, mites and insects (Mani 1964), but dissection of knob galls in the Territory has not revealed any direct evidence of the above, although this itself cannot, of course, rule out these organisms as possible causes of knob gall.

The failure to transmit the condition from macerated gall tissue after inoculation into peeled cacao beans, seedlings and trees, and the lack of virus particles in sap extract preparations in the electron microscope examined by Dr. Gibbs would seem to indicate little likelihood of a viral cause, unless a virus with isometric particles in low concentration which is not easily transmitted by the methods used is present.

Certain bacteria and fungi can cause galls in cacao, for example *Agrobacterium tumefaciens* (Brunt and Wharton, 1961) and *Fusarium decemcellulare* (Brunt and Wharton, 1961, 1962 Hutchins, 1965). Although no bacteria or *F. decemcellulare* have been isolated in the tests carried out to date, and although no transmission was obtained in the inoculation experiments, neither bacteria nor fungi can be ruled out as possible causal organisms without further tests.

The galls occur in one area which is minerally relatively rich and in another area which, although on poorer soil derived from coralline rock, nevertheless is not chemically poorer than other soils of a similar composition in the Territory which are growing cacao without galls. It would seem therefore, that a mineral deficiency or toxicity is not involved. There is especially no evidence that deficiency of boron, which Tollenaar (1964) found associated with knob gall in Ecuador, is causing this condition in the Territory.

Cushions with flowers or pods were found adjacent to or interspersed with galls. If the cause is a nutritional or physiological one, considerable selectivity of action must be operating at these sites on the same tree.

Hutchins (1964) reported that knob gall developed in tissues after excision of flowery galls. No prolific flowering such as occurs with flowery gall has been reported from the New Guinea island, and no flowery galls occurred at the site in New Ireland where the senior author carried out the tree inspections and gall excisions, although a few trees did occur with profuse flowering.

It has been demonstrated in this paper that excision of all knob galls on a tree does not prevent the tree from continuing to produce new galls both on or near the scars or on other parts of the tree. Some excision scars healed apparently completely in the period of six months during which they were under observation.

It seems unlikely to the authors that a genetical factor is involved causing the production of knob galls on some trees but not on others, although normal seedlings raised from seed from a tree with galls are probably too young yet for this negative evidence to be conclusive.

The present studies have been handicapped because of the distance of the condition from the Port Moresby laboratories (approximately 400 miles) and the resulting inability to keep close surveillance on experiments in the field. Care had to be taken that no material with knob gall was taken to the other main-cacao-growing areas at present free from the condition, in case an infectious agent was present.

ACKNOWLEDGEMENTS.

Grateful thanks are extended to the following: Dr. Adrian Gibbs, John Curtin School of Medical Research, the Australian National University, Canberra, for checking sap extract preparations in the electron microscope; Dr. C. Booth, Commonwealth Mycological Institute, England, for the identification of one of the fungal isolates; Dr. D. Broadbent and Mr. G. W. Elson of Imperial Chemical Industries Ltd., England, for gibberellin and auxin analyses; Mr. P. J. Southern, formerly Senior Chemist of the Department of Agriculture, Stock and Fisheries, Port Moresby, for making available his data on boron analyses; officers of the Department who assisted in any way with these studies including Mr. A. W. Charles for critically reading the manuscript; the collectors who forwarded material for examination and the planter who kindly made available the photographs used in *Plates* III and IV, A and B, and for the information he supplied on the occurrence of galls on his plantation.

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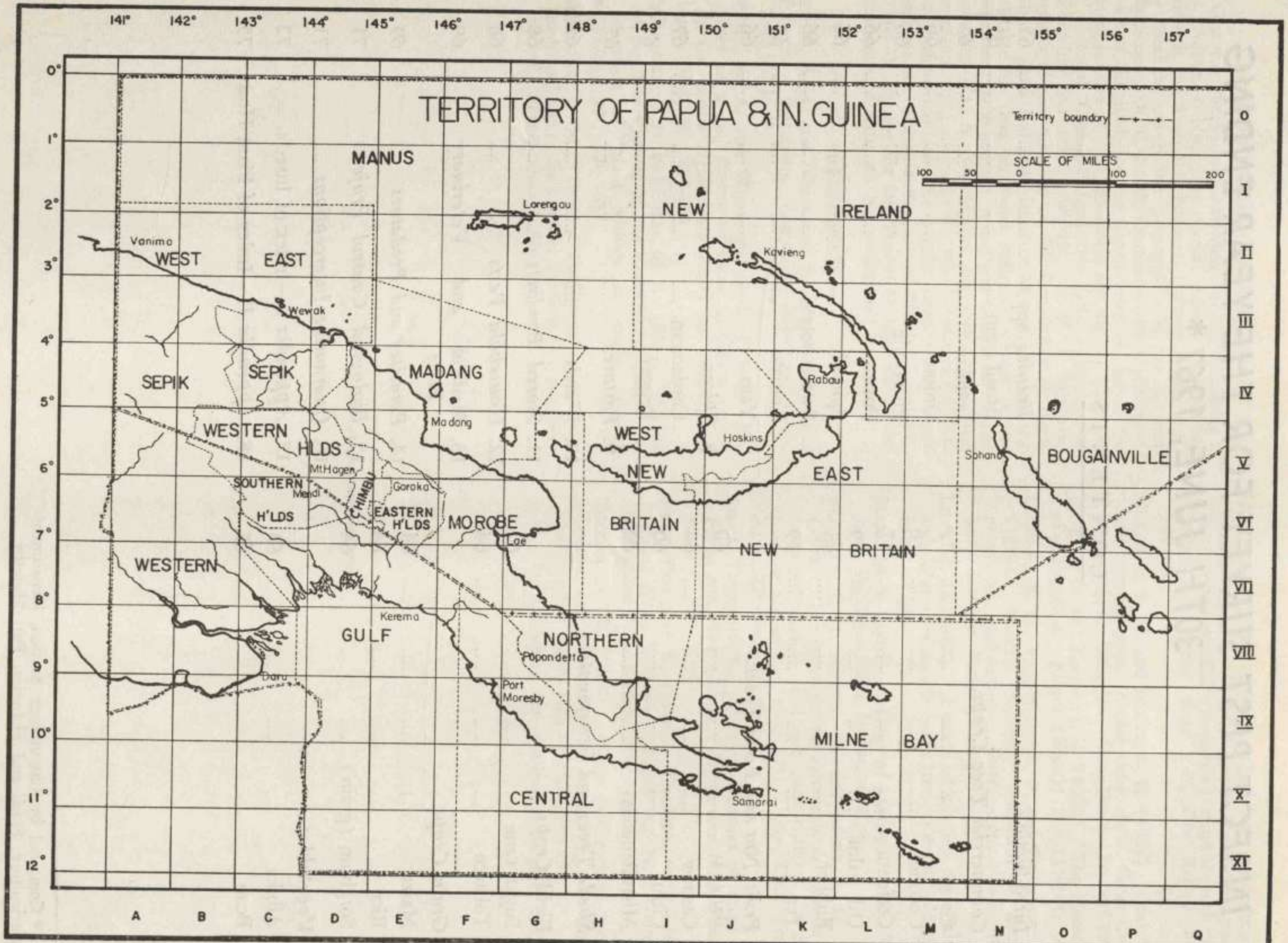
INSECT PEST SURVEY FOR THE YEAR ENDING 30TH JUNE, 1967 *

CONTENTS

* Compiled by Entomology Section, Department of Agriculture, Stock and Fisheries, Port Moresby.


TERRITORY OF PAPUA & N. GUINEA
Territory boundary
SCALE OF MILES
100 50 0 100 200
141° 142° 143° 144° 145° 146° 147° 148° 149° 150° 151° 152° 153° 154° 155° 156° 157°
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A B C D E F G H I J K L M N O P Q
MANUS
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Kavieng
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WEST SEPIK
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Wewak
MADANG
Madang
Rabaul
WESTERN HLDS
Mt Hagen
SOUTHERN H'LDS
Mendi
CHIMBU
Goroka
EASTERN H'LDS
MOROBE
Lae
WEST NEW BRITAIN
Hoskins
EAST NEW BRITAIN
Sohano
BOUGAINVILLE
WESTERN
GULF
Kerema
Daru
NORTHERN
Popondetta
Port Moresby
CENTRAL
MILNE BAY
Samarai

PHYTOPHAGOUS INSECT PESTS IN PAPUA AND NEW GUINEA

INTRODUCTION.

An annotated list of Territory phytophagous insect pests is being prepared by Dr. J. J. H. Szent-Ivany, previously Senior Entomologist, Department of Agriculture, Stock and Fisheries, Konedobu. It is expected that this list will be published in 1970, with records extending up to June, 1966.

To overcome delays in publishing records obtained since June, 1966, annual insect pest surveys are to be published, commencing with this list for the year ended 30th June, 1967.

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. The abbreviation N.D. in the text refers to the Northern District of Papua.

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 Messers. I. F. B. Common and F. J. Gay, C.S.I.R.O., Canberra, Australia ; Dr. M. O. de Lisle, Paris, France ; Mr. R. A. I. Drew, Department of Primary Industries, Brisbane, Australia ; Drs. J. L. Gressitt, Y. Kondo, N. Wilson and Mr. G. A. Samuelson, Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A. ; Dr. Z. Kaszab, Hungarian Natural History Museum, Budapest, Hungary ; Dr. K E. Schedl, Forstliche Bundes-versuchsanstalt, Lienz, Austria ; and Dr. J. N. L. Stibick, Catholic University of America, Washington D.C., U.S.A.

COMMERCIAL TREE CROPS.

CACAO (*Theobroma cacao*).

Acanthotyla sp. (Coreidae).

Adults very numerous on cacao, mainly on pod stems, Popondetta/Sangara area, N.D., July, 1966-June, 1967. Its status as a pest species is not known.

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 latter half of 1966, and virtually ceased to be a problem from November onwards. Larvae present in limited numbers throughout the year but damage slight, Gazelle Peninsula, New Britain.

One moderate outbreak was reported from Gobari Plantation, Lae, Morobe District, in December.

Adoxophyes aestivana Walk. (Tortricidae).

Larvae caused minor damage to flush foliage, Serovi Plantation, Popondetta, N.D., August.

Adoxophyes fasciculana Walk. (Tortricidae).

The most commonly encountered tortricid found in the Popondetta/Sangara area, N.D. Larvae were found feeding on flush foliage throughout the year. An increase in both larval numbers and foliage damage occurred during the period August to October.

Amarygmus sp. nov. aff. *solomonis* Geb. (Tenebrionidae).

This large tenebrionid was often found scavenging in the jorquette region of cacao trees and also in empty *Pantorhytes* larval channels, N.D.

Amblypelta gallegonis bougainvillensis Brown (Coreidae)—Amblypelta.

Adults feeding on pods, Tanaboia Plantation, Bougainville, March.

Amblypelta theobromae Brown (Coreidae)—Amblypelta.

Adults and nymphs numerous on pods at Jerarota, N.D., October, 1966, and in the Markham Valley, January-February, 1967. Damage to young pods severe, resulting in a 50 to 70 per cent. reduction in production.

Adults and nymphs also present on pods in cacao blocks in the Kokoda Valley (Kokoda-Ilimo) and Popondetta/Sangara area, N.D., July, 1966-June, 1967. Isolated areas of severe damage to young pods reported from time to time.

Archips spilotoma Meyr. (Tortricidae).

Larvae cause minor damage to flush foliage, Sangara, N.D., August.

Candalides sp. ? *tringa* Gr.-Sm. (Lycaenidae).

Larvae collected from flush foliage, Girua, N.D., September. Of very minor importance.

Crossotarsus barbatus Chapuis (Platypodidae).

Adults found boring into unthrifty and/or dying trees which had been badly damaged by *Pantorhytes szentivanyi*. Small holes, ½ in. in diameter, were bored from the wood surface into the centre of the tree. There were no external signs of attack on the bark. Girua, N.D.

Crossotarsus biconcavus Schedl (Platypodidae).

Adults found boring into unthrifty and/or dying trees which had been badly damaged by *Pantorhytes szentivanyi*. Small holes, 1/10th in. in diameter, were bored from the wood surface into the centre of the tree. There were no external signs of attack on the bark. Girua, N.D.

Dasychira mendosa Hubn. (Lymantriidae).

Larvae present on flush foliage from November onwards. Larval numbers increased in November and remained at this higher level until March, Popondetta/Sangara area, N.D. Damage to foliage only slight, but urticating hairs caused discomfort to labourers working in infested cacao blocks.

Dasychira sp. (Lymantriidae).

Minor larval feeding on flush foliage and surface of ripening pods, Serovi area, N.D., August.

Diacrisia turbida Butl. (Arctiidae).

Adults collected from flush foliage, Serovi area, N.D., October.

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.

High larval populations were observed on Keravat, New Britain, during November and December but this outbreak was rapidly brought under control by the tachinid *Winthemia* sp. nr. *diversa* Mall. without resort to chemical control measures.

In December and January a high larval population was observed on Wairiki Plantation, Warongoi, New Britain, where frequent insecticide treatments were carried out. Although present, *W. ? diversa* did not appear capable of bringing the outbreak under check in this situation and high populations continued for the remainder of the year.

Eilema ekeikei B-Bkr. (Arctiidae).

Larvae found feeding on flush foliage, Sangara, N.D., August. Of little importance.

Elytrocheilus coeruleatus Pasc. (Curculionidae).

Adults feeding on foliage and young stems of cacao growing under primary bush shade, Arehe Plantation, Sangara, N.D., May-June, 1967. Damage slight.

Eublemma rubra Hamps. (Noctuidae).

Larvae feeding on flush leaves, Koke Bagu Plantation, C.D., July.

Eupholus sp. (Curculionidae).

Adults collected from cacao, Kokopo, New Britain, April.

Euproctis sp. nr. *variana* Walk. (Lymantriidae).

Larvae were very common on cacao in the Northern District, with noticeable population increases in October-November and again in April-May. Whilst being a flush feeder, it has also been observed feeding on pods previously damaged by other insects (e.g., *Tiracola plagiata, Pantorhytes szentivanyi*). Flush damage was never severe and it is doubted whether the species will become of economic importance.

Euproctis sp. (Lymantriidae).

Observed in May and June in high population densities at Rainau, Gela Gela, Wairiki and Vunapau plantations, Gazelle Peninsula, where larvae were causing damage to young pods and young flush. The occurrence of *Euproctis* sp. appears to be seasonal with an interaction between tachinid parasites and a polyhedrosis virus normally keeping the population in check.

Larvae were also collected from cacao flush, Serovi area, N.D., September to October. Of little importance.

Eurycania splendida F. (Ricaniidae).

Very light populations were observed on cacao at Keravat, New Britain, during the year, whilst moderate populations were recorded at Gela Gela plantation, Gazelle Peninsula.

Ferrisia virgata (Cock.) (Pseudococcidae).

High populations were observed on cacao seedlings growing in the insectary, Keravat, New Britain.

Glenea aluensis Gah. (Cerambycidae).

Larvae were observed boring in the trunks of cacao trees at Keravat, New Britain, during the year and at Talasea, New Britain, and Penekindu Plantation, New Ireland, in June.

? *Glenea* sp. (Cerambycidae).

Severe larval damage to cacao trees was reported from the Kieta area, Bougainville, March.

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

By far the most widespread and damaging cacao mirid in the Northern District, but 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 was both severe and widespread, especially during dry spells. Loss of production often approached 80 per cent. of the expected crop, especially on smallholders' blocks.

Damage to cacao pods was also reported from Koke Bagu Plantation, C.D.

Homona sp. (Tortricidae).

Larvae feeding on flush foliage, Gela Gela Plantation, New Britain, February, but damage negligible.

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.

Larvae were found in conjunction with larvae of *Ectropis sabulosa* at Keravat, New Britain, during November and December and at Wairiki, New Britain, in January.

Imma sp. (Glyphipterygidae).

Larvae found feeding on flush foliage, Popondetta area, N.D., August. Damage of no importance.

Nacaduba berenice dobbensis Roeber (Lycaenidae).

A few larvae of *N. berenice dobbensis* were observed in the Sangara/Popondetta area, N.D., feeding on flush foliage in July. Numbers increased during August and by September/October, they were the dominant flush defoliator. Populations decreased in late October and remained at a low level for the remainder of the year. Young leaves can be completely destroyed, but on older leaves, feeding is confined to the interveinal tissue on the lower surface.

Neotermes sp. (Kalotermitidae).

Cacao trees were damaged by this species at Nambung (Bainings) Plantation and Talasea, New Britain, in June.

Olethreutes sp. (Olethreutidae)—Cacao Pod Borer.

Larvae observed boring into the mesocarp of ripening pods on various plantations on the Gazelle Peninsula, New Britain, during the year, but little or no penetration of the endocarp was noted.

Opogona sp. (Lyonetiidae).

Pupae were collected from the surface of partly decomposed trunks of dead cacao trees, Sangara, N.D., September.

Orgyia postica (Walk.) (Lymantriidae).

Observed in May and June in moderate numbers on various plantations on the Gazelle Peninsula, New Britain. Larvae were feeding on young pods and flush.

Pansepta teleturga Meyr. (Xyloryctidae).

The incidence of this pest increased during the year on New Britain, with increased infestations being recorded from the Bainings plantations, the Warongoi area and Tavilo Plantation. No infestation was noticed on Keravat. The larvae feed on the cambium of stems and branches of cacao trees, often completely ringbarking them.

Pantorhytes albopunctulatus Heller (Curculionidae)—Pantorhytes.

Adults collected from cacao, Kokoda, N.D. Its status as a cacao pest is still not clear, but if a pest, then a very minor one at the moment.

Pantorhytes batesi batesi Faust (Curculionidae)—Pantorhytes.

Adults, larvae and eggs very numerous in cacao plantations along Markham Valley and lower Wau Valley, Morobe District, July, 1966-June, 1967. Damage to trees by larvae and adults, severe.

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

Continued to cause severe damage to cacao trees on the Gazelle Peninsula, particularly the Warongoi area, and at Talasea, New Britain.

Pantorhytes stanleyanus White (Curculionidae)—Pantorhytes.

Severe weevil damage to cacao trees reported from Sewa Bay, Normanby Island, Milne Bay District.

Pantorhytes szentivanyi Marsh. (Curculionidae)—Pantorhytes.

Adults, larvae and eggs were very numerous in most cacao plantations in the Popondetta/Sangara area, N.D., July, 1966-June, 1967. Damage to older cacao (2 to 5 years) particularly severe, resulting in the death of from 100 to 200 acres of cacao.

Pantorhytes verrucatus Bates (Curculionidae)—Pantorhytes.

Adults collected from cacao plantations at Talasea, New Britain. Associated with *P. plutus*, but not as numerous.

Pinzulenza kukisch Her. (Limacodidae).

A very common species in the Sangara-Popondetta area, N.D., throughout the year. The larvae feed on the lower surface of leaves, leaving the upper epidermis more or less intact. However, as the feeding scars dry, the upper epidermis dies and breaks, giving the damaged leaf a 'peppered' appearance.

Larval populations increased greatly over the period September/October and damage in some areas was severe, with trees losing 25 to 30 per cent. of their total leaf area.

Cacao at Viamiri, Gulf District, was severely defoliated by a small limacodid (probably *P. kukisch*) in July.

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

Became established in high populations from time to time on cacao growing in the insectary at Keravat, New Britain, and caused many of the growing points to die.

Platolenes sp. nov. aff. *papuanus* Kasz. (Tenebrionidae).

This large tenebrionid was often found scavenging in the jorquette region of cacao trees and also in empty *Pantorhytes* larval channels, Northern District (cf. *Amarygmus* sp.).

Pseudodoniella laensis (Mill.) (Miridae)—Red Capsid.

Very heavy infestation of adults and nymphs noted at Gabensis plantation, Lae, Morobe District, in August, 1966. Damage to pods was moderate.

Pseudodoniella typica (China & Carv.) (Miridae)—Capsid.

Very heavy infestations noted in native plantings in the Warongoi settlement area, New Britain. Damage and loss of crop severe.

Psychidae, gen. et sp. indet.

Larvae caused severe defoliation to a ten acre area of cacao on Navuvu Plantation, New Britain.

Rhinoscapha thomsoni Waterh. (Curculionidae).

Adults feeding on foliage, Serovi Plantation, N.D., October, 1966; common, but damage negligible.

Rhyparida duni Gress. (Eumolpidae).

Adults feeding on cacao flush foliage throughout the year, Keravat, New Britain. Damage slight.

Rhyparida spp. (Eumolpidae).

Adults noted feeding on young flush foliage from time to time during the year in the Popondetta/Sangara area, N.D., but damage slight.

Ricania sp. (Ricaniidae).

Adults collected from cacao, Kokopo, New Britain, April.

Salina sp. (Collembola).

Adults and nymphs always numerous on cacao foliage, Keravat, New Britain. Its status/non-status as a pest has not been proved.

Scopelodes dinawa B-Bkr. (Limacodidae).

Larvae observed feeding on foliage in moderate numbers, Vunapuna Plantation, New Britain, July.

Scopelodes sp. (Limacodidae).

Larvae observed feeding on foliage, Popondetta/Sangara area, N.D., October, but of no economic importance.

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

Larvae observed feeding on cacao flush, Popondetta, N.D., October. Of little importance.

Striglina asinina Warr. (Thyrididae).

Larvae observed feeding on flush foliage, Popondetta/Sangara area, N.D., September to November. Of minor importance only.

Striglina vulpina Warr. (Thyrididae).

Larvae fed on flush foliage, Girua, N.D., August. Of very minor importance only.

Striglina sp. (Thyrididae).

Larvae fed on flush foliage, Sangara, N.D., August. Of very minor importance only.

Thosea sinensis Walk. (Limacodidae).

Larvae fed on cacao foliage, Popondetta/Serovi area, N.D., August. Of very minor importance.

Tiracola plagiata (Walk.) (Noctuidae)—Cacao Army Worm.

Light larval populations persisted at many localities in the Popondetta/Sangara area, N.D., but except for areas of cacao still shaded by *Leucaena leucocephala*, very little damage resulted. In areas still shaded by *L. leucocephala*, moderate to severe damage was experienced in August-September, 1966, and from February through to June in 1967.

Increasing damage to cacao under *Leucaena* shade was reported from Madang and Wewak areas during July-September, 1966 and January-June, 1967.

Larvae were collected twice during the year at Keravat, New Britain, but were not observed on any other plantations.

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.

Trachycentra sp. nr. *chlorogramma* Meyr. (Tineidae).

Adults bred from dead branch, Sangara, N.D., July.

Xyleborus destruens Blandf. (Scolytidae).

Adults bred from dead cacao wood, Kar Kar Island, Madang District, December, 1966-January, 1967 ; from weakened cacao trees, Inus Plantation, Bougainville (associated with *X. perforans*), April.

Xyleborus perforans Woll. (Scolytidae).

Adults collected from weakened cacao trees, Inus Plantation, Bougainville, April.

Zeuzera coffeae Nietn. (Cossidae)—Coffee Borer.

Larvae observed tunnelling in cacao stems, Warisota Plantation, Oro Bay, N.D., August-September, 1966. Damage moderate.

Damage was also reported from Pinekindu Plantation, New Ireland, June, and from the Gazelle Peninsula, particularly the Warongoi area, during the year.

COCONUT (*Cocos nucifera*).

Amblypelta lutescens papuensis Brown (Coreidae).

Adults and nymphs present on palms causing premature nutfall, Goodenough Island, Milne Bay District, November-December, 1966, January-February, 1967 ; Popondetta, N.D., February-May, 1967.

Brontispa longissima Gestro (Hispidae)—Coconut Hispid.

Larvae and adults severely damaged young palms (1 to 3 years) Barisari, N.D., November-December, 1966, March-June, 1967. Caused some damage in coconut seedling nurseries throughout the year on New Britain. Damage to young palms was recorded in the Sepik District in July, 1966, and Gulf District in March, 1967.

Coccus hesperidum L. (Coccidae)—Soft Brown Scale.

Collected from palms at Stockholm Plantation, New Britain, May, 1967. All specimens submitted showed signs of parasitism by a small unidentified chalcid wasp.

Labienus ptox Kaup (Passalidae).

Adults collected from rotting coconut palms, Ihu, Gulf District, May.

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

An outbreak of *L. migratoria* (phase gregarious) caused widespread and severe damage to palms, Goodenough Island, Milne Bay District, November-December, 1966. Out of 150,000 coconuts on the island, 50,000 were defoliated to the extent of 60 per cent. or more, whilst many thousands of others were slightly damaged (10 to 20 per cent. defoliation).

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

Caused moderate damage to palms throughout the year on New Britain and New Ireland. One adult was submitted from Anir Island in March.

Promecotheca papuana Csiki (Hispidae)—Coconut Leaf-miner.

A serious outbreak of *Promecotheca* was reported from Toriu Plantation, New Britain, in February which persisted through to April. The Toma-Baliora area on the Gazelle Peninsula recovered considerably during the year from the 1965-1966 attack, but to date production from this area is still very low.

Prosopocoelus bison cinctus (Montr.) (Lucanidae)—Coconut Stag Beetle.

One male adult submitted from Kerema, Gulf District, April. No report of any damage to palms.

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

Damage continued to be severe throughout the year on the Gazelle Peninsula and in the Talasea area, New Britain.

Rhynchophorus spp. (Curculionidae)—Palm Weevil.

Approximately 150, five to six-year-old palms inspected at Maralumi Plantation, Erap, in September were found to be badly damaged by larvae of *Rhynchophorus* spp. Inadequate planting techniques, mechanical damage by grass knives and growth in relation to soil types appeared to be responsible for development of the infestation.

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

Very heavy infestation (80 per cent.) of 3 to 5-year-old palms, Situm-Gobari land settlement areas, Lae, Morobe District, January-April, 1967 ; one to three beetles present per infested palm. Hand removal of beetles during April, May and June reduced population to negligible proportions.

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

Severe damage continued throughout the year on the Gazelle Peninsula and in the Talasea area, New Britain.

Scapanes sp. (Dynastidae)—New Guinea Rhinoceros Beetle.

Light infestation in young (3 to 6 years) palms, Popondetta, N.D., July, 1966, to June, 1967.

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

Caused increased damage to palms on New Ireland, New Hanover and in West New Britain during the year. A particularly severe outbreak occurred at Volupai Plantation, Talasea, West New Britain, in February, 1967. Approximately 60 acres of palms were affected and the outbreak persisted into July, 1967, although numbers had been reduced by spraying.

Taenaris myops kirschi Stgr. (Amathusiidae).

Larvae fed on fronds, Kapogere, Central District.

Telicota sp. (Hesperidae).

Larvae fed on fronds, Keravat, New Britain.

Trichogomphus semilinki Rits. (Dynastidae).

Damage to palms reported from Anir Island, March.

Zophiuma lobulata Ghauri (Lophopidae)— Coconut Leafhopper.

Adults and nymphs numerous on palms in Finschhafen area, Morobe District, July, 1966, to June, 1967.

This species appears to be the cause of palms showing a diseased or unthrifty condition. Adults and nymphs have also been observed on healthy palms, but in light numbers.

The most characteristic symptoms are seen in the fronds of affected palms, and are most evident towards the latter stages of the condition. Peripheral necrosis of the fronds occurs with sub-peripheral chlorosis and the central portion of the frond remains an unaffected green. The chlorotic effect is most evident as a bronze-yellow sub-peripheral band.

Small necrotic areas approximately $\frac{3}{8}$ in. in diameter are evident in many of the leaflets. This symptom is not universal to all affected palms. Smaller puncture marks were also observed in some instances and these may have been caused by some sucking insect.

The symptoms are most evident in the lower fronds and as the condition develops, it appears to spread upwards to younger fronds. The lower fronds die prematurely and frequently normal abscission does not occur. A marked reduction in nut production is evident in the later stages of the condition.

The disorder certainly suggests one caused by a toxicogenic insect.

The *Z. lobulata* population appears to have waned during 1966/67, but there were a few areas of infestation discovered to the south-west of Finschhafen (May-June, 1966).

COFFEE (*Coffea arabica, Coffea canephora*).

Agromyza sp. (Agromyzidae).

Larvae collected from mined leaves, Aseki, Morobe District, January.

Amarygmus cupreus Guer.-Men. (Tenebrionidae).

This large black tenebrionid was resting on flowers, Sila, N.D., September.

Anisotelus haveriensis Wittm. (Cantharidae).

Adults collected from flowers, Sila, N.D., September.

Antestiopsis sp. (Pentatomidae).

This pentatomid was suspected as the probable cause of damage to berries, Western Highlands District, June.

Aulacophora sp. (Galerucidae).

Adults collected from foliage, Sila, N.D., September.

Bothrichara cyanea Borchm. (Lagriidae).

Adults resting on berries, Sila, N.D., September.

Cardiodactylus novae-guineae de Haan (Gryllidae)—Tree Cricket.

Following reports of severe insect damage to coffee gardens in the Salamaua area of the Morobe District, a visit was made to Logui, Komiatam and Bobdobi villages in March to investigate the problem. There are reported to be about 40,000 coffee trees in the area, of which perhaps 20 per cent, had been appreciably damaged.

The insect most consistently found in affected gardens was the tree cricket *Cardiodactylus novae-guineae*. This was the species alleged by the villagers to have caused most of the damage, and was observed several times feeding on coffee cherries and laterals. Some six species of tettigoniids were also collected but these appeared to be leaf feeders of minor importance.

Where the attack had been severe, a 6 ft. coffee tree may have had only six or fewer laterals remaining, the rest having been broken off at the point of chewing, 6 in. from the main trunk. Chewing damage was typically on the upper half of the lateral, extending for a distance of one half to over two inches.

There was a definite association of cricket damage with gardens which had been flooded during December when the Logui River rose to an unusually high level and remained so for some weeks. Reasons for this are uncertain, but *Cardiodactylus* is typically an insect of forest borders which are reasonably well lit. Most of the gardens which had been flooded were somewhat undershaded as a result of setback to the *Leucaena*, and also had supported a dense and fairly tall growth of grass. Both of these factors could have favoured build-up of the cricket. It is also possible that drying out of the soil following flooding may have provided abundant oviposition sites which were utilized.

Damage to foliage and berries was also reported from Papoga Village, N.D., in May.

Carphurus sayeri Champ. (Melyridae).

Adults resting on berries, Sila, N.D., September.

Chlorophorus praetextus Pasc. (Cerambycidae).

Adults resting on flowers, Sila, N.D., September.

Dromaeolus sp. (Eucnemidae).

Adults resting among berries, Sila, N.D., September.

Ectropis sabulosa Warr. (Geometridae).

Larvae fed on foliage, Papoga Village, N.D., May. Light infestation. (See also under *Tiracola plagiata* below).

Monocrepidius sp. (Elateridae).

Adults resting amongst berries, Sila, N.D., September.

Nocar sp. (Cistelidae).

Adults resting on stems, Sila, N.D., September.

Nyctemera baulus Boisd. (Arctiidae).

Adults resting on leaves, Sila, N.D., September.

Oides sp. (Galerucidae).

Adults resting on leaves, Sila, N.D., September.

Rhyparida sp. (Eumolpidae).

Adults resting on stems, Sila, N.D., September.

Tiracola plagiata Walk. (Noctuidae)—Cacao Army Worm.

The *Tiracola plagiata/Ectropis sabulosa* problem in the Morobe District intensified during 1966-1967. Formerly, populations only built up late in the dry season and declined after the onset of wet weather. Damage was then relatively minor.

In the dry season of 1966, damage was unusually severe and by October was causing concern on several plantations.

In October, 1966, moderate populations of *Tiracola* were to be found throughout the Wau Valley. Most larvae were in a late instar, and substantial leaf damage had been caused by these and previous generations. Approximately 50 per cent. of larvae appeared to be affected by a nuclear polyhedral virus.

In November a visit was made to a plantation at Mumeng. A heavy, multiple stage infestation of *Tiracola* was present, and *Ectropis* larvae were found in moderate numbers. Neither parasites nor predators were abundant, and no trace was seen of the virus which had been exerting some control at Wau.

The Wau Valley and Mumeng were re-visited early in June. At Mumeng the shade had been lopped on all heavily infested areas, and by February the caterpillars had disappeared and the coffee made rapid progress following shade thinning and fertilizing. No caterpillars were found in June, and the coffee looked set for a heavy flowering.

In the Wau plantations, the *Tiracola* generation was in its latter stages. Once again, over 50 per cent. of larvae were dead or moribund from virus infestation. Leaf damage was generally not severe, but heavy damage to buds, flowers and young cherries was evident.

Heavy damage was also caused by larvae feeding on foliage and ripening cherries, Wewak area, East Sepik District, July-September ; light/medium infestation, Mumeng area, Morobe District, September-October, 1966 ; light infestation, Saiho-Sairope area, N.D., April-May, 1967.

OIL PALM (*Elaeis guineensis*).

? gen. et sp. (Blattidae).

An unidentified large cockroach was alleged to have damaged seedlings at Epo plantation, Gulf District, October.

Papuana woodlarkiana (Montr.) (Dynastidae).

Adults caused appreciable damage to seedlings by boring into the boles, Murua, Gulf District, and Kavieng, New Ireland, February-May.

Papuana sp. (Dynastidae).

Adults damaged seedlings by boring into the boles, Keravat, New Britain, Hoskins, New Britain, May-June, and at Buin, Bougainville, May-June.

RUBBER (*Hevea brasiliensis*).

Coptotermes elisae (Desn.) (Rhinotermitidae).

Roots of living trees damaged and infested, Bisianumu, Central District, August.

Lagria palliata Macl. (Lagriidae).

Adults fed on leaves and caused slight damage, Ilolo Plantation, Central District, March.

Saissetia nigra (Nietn.) (Coccidae)—Nigra Scale.

Seedlings infested resulting in shoot dieback, Bisianumu and Kapogere, Central District, September.

Xylothrips religiosus Boisd. (Bostrychidae).

Dead trees infested, Kiunga, Western District, November.

TEA (*Camellia sinensis*).

Apirocalus cornutus Pasc. (Curculionidae).

Adults fed on foliage, Kainantu, Eastern Highlands District, July. Damage severe.

Homona coffearia (Nietn.) (Tortricidae)—Tea Tortrix.

Light larval infestation recorded Aiyura, Eastern Highlands District, July. Moderate numbers of larvae recorded from tea in Wahgi Valley, Western Highlands District, July.

Longitarsus ? sp. nov. (Alticidae).

Dense population of adults defoliated tea seedlings in a nursery at Pugamp, Western Highlands District, March.

Megachile sp. (Megachilidae)—Leaf Cutting Bee.

Slight defoliation caused to plants in nursery, Kudjip Plantation, Western Highlands District, July.

Oribius sp. ? *hostis* Marsh. (Curculionidae).

Adults fed on foliage, Nondugl and Wahgi Valley, Western Highlands District, July.

Papuana woodlarkiana (Montr.) (Dynastidae).

Adults and larvae damaged approximately one per cent. of young bushes in a smallholder scheme at Wurup, Western Highlands District, February. Adults fed on bark at or just below soil level, while larvae fed on root tissue. Damaged plants were severely set back, but most later recovered.

Schedorhinotermes sp. (Rhinotermitidae).

Infested roots of living bushes, Garaina, Morobe District, July.

FRUIT, NUT AND FOOD TREES.

BANANAS (*Musa spp.*).

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

Adults (phase gregarious) defoliated 2,500 to 3,000 banana plants, Goodenough Island, Milne Bay District, November-December.

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

Adults bred from infested bananas (*Musa* sp.), Popondetta, N.D., February-March.

CASHEW (*Anacardium occidentale*).

Selenothrips rubrocinctus Giard. (Thripidae)—Red-Banded Thrips.

Young trees defoliated, Bereina, Central District, June.

CITRUS (*Citrus* spp.).

Agrilus occipitalis Esch. (Buprestidae).

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

Amblypelta theobromae Brown (Coreidae)—Amblypelta.

Adults collected from muli trees, Sangara, July, feeding on ripening fruits.

Apirocalus sp. (Curculionidae).

Adults fed on foliage of lime trees, P.A.T.I., Popondetta, N.D., February-March, but damage slight.

Auxentius sp. ? integer Horv. (Pentatomidae).

Adults collected from lime trees, P.A.T.I. Popondetta, N.D., February.

Dihammus sp. ? *fasciatus* (Montr.) (Cerambycidae).

Adults collected from lime trees, P.A.T.I., Popondetta, N.D., February.

Eurygonia mitrata Dist. (Cicadellidae).

Adults collected from lime trees, P.A.T.I., Popondetta, N.D., February.

Monolepta sp ? *nigroapicata* Bry. (Chysomelidae).

Adults collected from foliage of lime trees, P.A.T.I., Popondetta, N.D., February.

Pterolophia subsellata Pasc. (Cerambycidae).

Adults collected from lime trees, P.A.T.I. Popondetta, N.D., February.

Pterolophia variabilis Pasc. (Cerambycidae).

Adults collected from lime trees, P.A.T.I. Popondetta, N.D., February

Rhinoscapha thomsoni Waterh. (Curculionidae).

Adults collected in numbers feeding on foliage of muli trees, Serovi area, N.D., June. Larvae and pupae were also found in the soil to a depth of 3 ft. in association with the root system. The roots often showed feeding scars, especially on their under-surface.

Tmesisternus trivittatus Guer.-Men. (Cerambycidae).

Adults collected from lime trees, P.A.T.I., Popondetta, February.

Unaspis citri (Comst.) (Diaspididae)—White Louse Scale.

Heavy populations recorded on citrus at Kapogere and Laloki, Central District, July, and Sangara, N.D., August. Splitting of bark occurred at Sangara.

MANGO (*Mangifera indica*).

Bombotelia jocosatrix (Guen.) (Noctuidae)—Large Mango Tip Borer.

Larvae feeding on flush leaves, Port Moresby, Central District, October.

Noorda albizonalis Hamps. (Pyralidae).

Larvae feeding in ripening fruits, Port Moresby, Central District, September.

SAGO PALM (*Metroxylon* spp.).

Promecotheca papuana Csiki (Hispidae).

First instar larvae observed mining in sago fronds, Toriu plantation, New Britain, April. However, they do not appear to be able to complete their life cycle in this species of palm.

FRUIT TREES, GENERAL.

Callantra sp. (Tephritidae).

Four adults collected from 'Dak-pot' male lure trap (baited with 1-(p-hydroxyphenyl)-butan-3-one and 1-(p-acetoxyphenyl)-butan-3-one), Konedobu, Central District, 29th August, 1st September, 18th and 21st December.

Dacus (*Zeugodacus*) sp ? *caudatus* Fabr. (Tephritidae).

Adults collected from 'Dak-pot' lure, P.A.T.I., Popondetta, N.D., July.

Neozeugodacus n. sp. (Tephritidae).

Four specimens were taken in a 'Dak-pot' lure at Konedobu, Central District, on the following dates : 23rd August, 16th, 18th and 21st December.

Strumeta barringtoniae (Tryon) (Tephritidae).

Adult collected from 'Dak-pot' lure, P.A.T.I., Popondetta, N.D., July.

Strumeta bryoniae (Tryon) (Tephritidae).

Adults collected from 'Dak-pot' lure, P.A.T.I., Popondetta, July-August, 1966. Common.

This species, together with two new *Strumeta* spp. which look very similar, represented 11.5 per cent. of the total catch at Konedobu. Central District. Catches were greatest during the period May-July, 1967. No information has been obtained on host plants in the area (Konedobu).

Strumeta frauenfeldi Schiner (Tephritidae).

This species represented 88.2 per cent. of the total 'Dak-pot' lure catch at Konedobu, Central District. The general pattern for the year was :—

5.8.1966-8.9.1966 small catches (maximum 20 flies during week 19th-25th August) ;

9.9.1966-3.11.1966 increasing catches (maximum 125 flies during week 7th-13th October) ;

4.11.1966-2.3.1967 peak catches (maximum 382 flies during week 30th December, 1966 to 5th January, 1967) ;

3.3.1967-23.3.1967 declining catches (maximum 173 flies during week 10th-16th March) ; and

24.3.1967-30.6.1967 small catches (maximum 73 flies during week 2nd-8th June).

A second trap was hung in the same tree a few feet from the first one on 26th April. Catches in this trap were usually less than those recorded for the old trap. A maximum catch of 44 flies was recorded during the week 2nd-8th June.

These catches show general correspondence with the abundance of ripe mangoes, the usual host of this species.

On several occasions at Konedobu, *S. frauenfeldi* has been bred from mango fruits previously damaged by the pyralid *Noorda albizonalis* Hamps.

Strumeta recurrens (Her.) (Tephritidae).

A single specimen was taken at Konedobu, Central District, in a 'Dak-pot' lure on 24th September.

SHADE TREES AND ORNAMENTALS.

Anomis flava F. (Noctuidae)—Cotton Looper.

Larvae caused damage to hibiscus (*Hibiscus rosa-sinensis*) foliage, Rabaul, New Britain, throughout most of the year.

Catopsilia pomona (Fabr.) (Pieridae)—Cassia Butterfly.

Larvae common on various species of *Cassia*, Popondetta, N.D., September-October. In some instances, damage to trees severe.

Cryphalus araucariae Schedl (Scolytidae).

Adults/larvae (?) ex needles and twigs of hoop pine (*Araucaria cunninghamii*) Bulolo, Morobe District.

Cryptophasa setiotricha Meyr. (Xyloryctidae).

Serious damage caused to bark of trunk and branches of raintrees (*Samanea saman*) in the Port Moresby area, Central District, by larvae during the period July-September.

Dasychira mendosa Hubn. (Lymantriidae).

Larvae feeding on hibiscus foliage, Keravat, New Britain.

Ischnaspis longirostris (Sign.) (Coccidae).

Heavy infestation recorded on *Ixora* sp., Bisianumu, Central District, September.

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

Adults (phase gregarious) defoliated all bamboo (*Bambusa* spp.) on Goodenough Island, Milne Bay District, November-December, 1966.

Lyphia sp. (Tenebrionidae).

Adults found in bored stems of bamboo, Brown River, Central District, June.

Maconellicoccus hirsutus (Green) (Pseudococcidae)—Hibiscus Mealybug.

This species continued to spread in the township area of Rabaul, New Britain, where ornamental hedges of hibiscus were heavily infested and suffered severe damage.

Mictis profana F. (Coreidae)—Crusader Bug.

Adults caused tip wilting of poinciana (*Delonix regia*) leaves, Port Moresby, Central District, May.

Pantorhytes decempustulatus (Gestro).

Adults fed on epidermis of *Schuurmansia henningsi*, Musgrave Range, Central District, July.

Pantorhytes opacus Faust.

Adults fed on epidermis of *Schuurmansia henningsi*, Musgrave Range, Central District, July.

FIELD CROPS.

SUGAR CANE (*Saccharum officinarum*).

Anomala anoguttata Burm. (Rutelidae).

Adults collected from cane, Popondetta, N.D., (New Territory economic record). Damage to foliage slight.

Araecerus sp. ? *levipennis* Jord. (Anthribidae).

Adults collected from sugar cane leaves, Popondetta, N.D. Its status as a sugar cane pest has not been proved.

Araeocorynus sp. nr. *cumingi* Jekel (Anthribidae).

Adults collected from sugar cane leaves, Munum, Markham Valley, Morobe District. Its status as a sugar cane pest has not been proved.

Atractomorpha crenaticeps Blanch. (Acrididae).

Adults were collected from cane at Popondetta, N.D. Foliar damage was of minor importance.

Aulacophora sp. (Galerucidae).

Adults common on cane at Popondetta, N.D., but is of little economic importance with only minor leaf damage occurring.

Austracris spp. (Acrididae)—Spur-Throated Locust.

Adults and nymphs were collected from *S. officinarum* in the Markham Valley, Morobe District, and at Popondetta, N.D. In the Markham Valley, foliage damage to young plantings and ratoon crops was severe at Munum, but light to moderate elsewhere. Only light damage has occurred to young cane at Popondetta.

Blattella sp. (Blattidae).

Adults commonly found sheltering in leaf rolls of cane at Munum and Kaiapit, Markham Valley, Morobe District, and at Popondetta, N.D. Would appear to be of no economic importance.

Carpophilus dimidiatus (F.) (Nitidulidae)—Fruit Beetle.

Adults bred from rotting cane collected at Kaiapit, Markham Valley, Morobe District, August.

Carpophilus ligatus Murr. (Nitidulidae).

Adults collected from central spindles of young cane, Munum, Markham Valley, Morobe District. Relationship to sugar cane not known.

Carpophilus mutilatus Ev. (Nitidulidae).

Adults collected from central spindles of young cane, Munum, Markham Valley, Morobe District. Relationship to sugar cane not known.

gen. et sp. indet. (Elachistidae).

Larvae mining in leaves, Bubia, Narakapor, Munum and Pyramid Hill, Markham Valley, Morobe District. Damage to young cane can be particularly severe.

Elassogaster sp. ? *lineata* de Meij. (Platystomatidae).

Adults collected from cane, Munum, Markham Valley, Morobe District. Platystomatid larvae had previously been dissected from dying and rotting cane shoots, but whether the larvae are truly phytophagous or saprophagous remains to be proved. They were not bred out and it is not known whether they are immature stages of *Elassogaster* sp ? *lineata*.

Elassogaster sepsoides Walk. (Platystomatidae).

Adults collected from cane, Munum, Markham Valley, Morobe District. Platystomatid larvae had previously been dissected from dying and rotting cane shoots, but whether the larvae are truly phytophagous or saprophagous remains to be proved. They were not bred out and it is not known whether they are immature stages of *E. sepsoides*.

? *Euconocephalus coniceps* (Redten.) (Tettigoniidae).

Adults collected from young cane at Kaiapit, Markham Valley, Morobe District, usually sheltering in the leaf roll. The status of this species as a sugar cane pest is not known.

Eumetopina sp. (Delphacidae).

Adults and nymphs were very numerous in the leaf rolls of cane at Bubia, Narakapor, Munum, and Kaiapit in the Markham Valley, Morobe District. It was also collected from *S. officinarum* at Popondetta, N.D.

Eurystylus apicifer Walk. (Miridae).

Adults collected from cane leaves at Narakapor, Morobe District. Its status as a sugar cane pest is not known.

Gesonula mundata sanguinolenta Kr. (Acrididae).

Adults collected from young cane at Popondetta, N.D., feeding on foliage, but damage Locust.

Heteropternis obscurella (Blanch.) (Acrididae).

Adults collected from young plantings at Munum, Markham Valley, Morobe District. Feeding on foliage, but damage slight.

Hypolixus ritsemae Pasc. (Curculionidae).

Adults collected in numbers on young cane at Munum and Kaiapit, Markham Valley, Morobe District, and from Popondetta, N.D. Long (20 to 25 mm.), narrow (1 to 2 mm. in width) areas had been chewed in the leaves, but damage was generally slight.

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

Adults (phase gregarious) completely stripped every plant of *Saccharum officinarum* growing in village gardens on Goodenough Island, Milne Bay District, during October and November.

gen. et sp. indet. (Lophopidae).

This species was collected from cane at Narakapor and Munum, Markham Valley, Morobe District, feeding on leaves in moderate numbers. It was usually found on the mid-veins.

Melanitis leda L. (Nymphalidae).

Larvae collected on foliage at Bubia, Markham Valley, Morobe District, and Popondetta and Sangara in the N.D. Damage slight.

Menida sp. (Pentatomidae).

Adults common, feeding on foliage, Kaiapit, Markham Valley, Morobe District.

Monolepta sp. ? *nigroapicata* Bry. (Galerucidae).

Adults collected from young cane, Popondetta, N.D.

Mulciber linnaei Thoms. (Cerambycidae).

Adults very common in sugar cane stands around Popondetta, N.D. Larvae of a relatively large species of Lamiinae, thought to be *M. linnaei*, have been commonly collected from sugar cane stems in the Popondetta area. They have not yet been bred through.

Oxya gavisa (Walk.) (Acrididae).

Adults collected from young cane at Popondetta, N.D.

Oxya vittigera (Blanch.) (Acrididae).

Adults collected from cane at Narakapor, Markham Valley, Morobe District. Feeding on foliage, but damage slight.

Pachybrachius nervosus Horv. (Lygaeidae).

Adults very numerous on cane at Kaiapit, Markham Valley, Morobe District, being found on young leaves and stems and often in the leaf rolls.

Phaenacantha spp. (Colobathristidae).

Adults numerous on cane at Munum and Kaiapit, Markham Valley, Morobe District, and at Popondetta, N.D. There are two species involved, both feeding on foliage with one species also occurring in leaf rolls.

Phaneroptera gracilis (Burm.) (Tettigoniidae).

Adults collected from young cane at Munum, Markham Valley, Morobe District. Damage to foliage negligible.

Plautia sp. (Pentatomidae).

Adults common on cane at Kaiapit, Markham Valley, Morobe District, feeding on foliage.

Pterolophia sp. (Cerambycidae).

Adult collected on cane, Popondetta, N.D. Its relationship to sugar cane is not known.

Rhabdoscelus obscurus (Boisd.) (Curculionidae) —Cane Weevil Borer.

Larvae and adults collected from maturing cane at Munum, Pyramid Hill and Kaiapit in Markham Valley, Morobe District. Damage to cane slight.

Rhyparida coriacea Jac. (Eumolpidae).

Adults were collected from cane, Popondetta, N.D. Damage to foliage was slight.

Riptortus sp. nr. *distinguendus* Blote (Coreidae).

Adults collected from cane at both Munum and Kaiapit, Markham Valley, Morobe District, where they were feeding on young stems and foliage. Of minor importance only.

Ropica sp. (Cerambycidae).

Adults collected on cane stems, Kaiapit, Markham Valley, Morobe District. Larvae of a species of Lamiinae were quite common in young and maturing cane at Pyramid Hill and Kaiapit during 1966, either girdling the stem at the nodes or boring in the stem between the nodes, with resultant death of the infested canes. Whilst the larvae were not bred out, the adults of this *Ropica* species were numerous enough in the stands of cane at both Kaiapit and Pyramid Hill to suggest that the larvae may have been this particular species.

Saccharicoccus sacchari (Cock.) (Pseudococcidae) —Sugar Cane Mealybug.

Light infestations noted at Pyramid Hill and Kaiapit, Markham Valley, Morobe District.

Scoliophthalmus sp. (Chloropidae).

Adults were bred from cane collected at Kaiapit, Markham Valley, Morobe District, August. The larvae were boring in stems.

Sesamia grisescens Walk. (Noctuidae).

Larvae caused heavy damage to cane in Markham Valley, Morobe District, but especially at Pyramid Hill and Kaiapit. Larvae were found in canes of all ages, including maturing canes.

Silba sp. (Lonchaeidae).

Adults bred from cane collected at Kaiapit, Markham Valley, Morobe District, August. The larvae were boring in stems, but were not plentiful.

Stenocatantops angustifrons (Walk) (Acrididae).

Adults collected from young cane, Kaiapit, Markham Valley, Morobe District. Feeding on foliage, but damage slight.

Valanga irregularis (Walk.) (Acrididae).

Adults and nymphs collected from young cane at Kaiapit, Markham Valley, Morobe District. Foliage damage moderate.

TOBACCO (*Nicotiana tabacum*).

Anomala sp. (Rutelidae).

Adults resting and/or feeding on foliage, P.A.T.I., Popondetta, N.D., August.

Heliothis armigera (Hubn.) (Noctuidae)—Budworm.

Larvae common, feeding on foliage, P.A.T.I., Popondetta, N.D., July-August. Damage moderate. As plants matured, larvae fed on flowers and stem (September).

Henosepilachna signatipennis Boisd. (Coccinellidae).

Adults feeding on foliage, P.A.T.I., Popondetta, N.D., August. Slight damage only.

Hypolixus ritsemae Pasc. (Curculionidae).

Adults resting and/or feeding on foliage, P.A.T.I., Popondetta, N.D., August.

Lygaeus hospes Fabr. (Lygaeidae).

Adults common, feeding on foliage, P.A.T.I., Popondetta, N.D., July-August.

Nysius sp. (Lygaeidae).

Adults feeding on foliage, P.A.T.I., Popondetta, N.D., July-August.

Paragraecia sp. (Tettigoniidae).

Adults feeding on foliage, P.A.T.I., Popondetta, N.D., August. Slight damage only.

Phaneroptera gracilis Burm. (Tettigoniidae).

Adults feeding on foliage, P.A.T.I., Popondetta, N.D., August. Slight damage only.

Sciophyrus diminutus Horv. (Coreidae).

Adults feeding on foliage, P.A.T.I., Popondetta, N.D., August. Damage not noticeable.

Scrobipalpa heliopa (Low.) (Gelechiidae)—Tobacco Stem Borer.

Adults bred from larvae boring in leaf petioles, P.A.T.I., Popondetta, N.D., September. The larvae bore along the centre of the petiole and the leaf subsequently dies. Slight damage only.

GRAIN CROPS.

MAIZE (*Zea mays*).

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

Adults (phase gregarious) completely defoliated all maize on Goodenough Island, Milne Bay District, November-December.

RICE (*Oryza sativa*).

Leptocorisa sp. (Coreidae).

Adults occurred in heavy population on rice growing in experimental plots, Bubia, Morobe District, January.

SORGHUM (*Sorghum vulgare*).

Plautia sp. (Pentatomidae).

Adults commonly found feeding in heads of grain sorghum, Wawin Plantation, Morobe District, June.

VEGETABLES.

AIBIKA (*Abelmoschus manihot*).

Sylepta derogata F. (Pyralidae).

Larvae very common, feeding on foliage. Capable, at times, of causing complete defoliation. Gazelle Peninsula, New Britain, March.

BEANS (*Phaseolus vulgaris*).

Aulacophora pallidifasciata Jac. (Galerucidae).

Adults collected from foliage, Sila, N.D., September.

Aulacophora papuana Jac. (Galerucidae).

Adults collected from foliage, Sila, N.D., September.

Caedius demeijerei Geb. (Tenebrionidae).

Adults common on ground under beans, Sila, N.D., September. Very common in the Northern District and responsible for considerable damage to young seedlings as they emerge from the soil.

Cassena sp. (Galerucidae).

Adults collected from foliage, Sila, N.D., September.

Henosepilachna signatipennis Boisd. (Coccinellidae).

Adults common, feeding on foliage, Sila, N.D., September.

Melanagromyza phaseoli (Tryon) (Agromyzidae)—Bean Fly.

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

Nezara viridula L. (Pentatomidae)—Green Vegetable Bug.

Adults fed on ripening pods, Sila, N.D., September.

Nysius sp. (Lygaeidae).

Adults very common on beans, Sila, N.D., September, causing yellow spotting of foliage.

Pachybrachius nervosus Horv. (Lygaeidae).

Adults very common on foliage, causing yellow spotting on leaves, Sila, N.D., September.

Phaneroptera brevis Serv. (Tettigoniidae).

Adults feeding on foliage, Sila, N.D., September.

Tetranychus marianae McGregor (Tetranychidae).

Heavy damage to beans, Popondetta, Sangara, September-November.

BRASSICA spp.

Plusia chalcites (Esper) (Noctuidae)—Green Looper.

Larvae feeding on cabbage, Sila, N.D., September.

Plutella maculipennis (Curt.) (Plutellidae)—Cabbage Moth.

Larvae feeding on *Brassica oleracea*, Ilimo Farm, Central District, and Olgaboli, Western Highlands District, October.

BROAD BEAN (*Vicia faba*).

Aulacophora similis Oliv. (Galerucidae).

Very heavy infestation of adults and larvae completely defoliated broad beans and then devoured leaf petioles and stems, Sila, N.D., August-September.

LETTUCE (*Lactuca sativa*)

Ananipa sp. (Gryllidae).

Adults collected from lettuce, Sila, N.D., September.

Cassida sp. (Cassididae).

Adults collected from lettuce, Sila, N.D., September.

Cicadella sp. (Cicadellidae).

Adults common, often associated with and thought to be responsible for severe brown spotting of leaves, Sila, N.D., September.

Coelophora inaequalis F. (Coccinellidae).

Adults common and appeared to be feeding on foliage leaving circular holes in leaves, Sila, N.D., September.

Euscyrtus hemelytrus De Haan (Gryllidae).

Adults collected from foliage, Sila, N.D., September.

Kolla sp. (Cicadellidae).

Adults very common, feeding on leaves causing black or brown spotting, Sila, N.D., September.

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

Larvae damaged lettuce in a Port Moresby market garden, June.

ONION (*Allium cepa*)

Agrotis ipsilon (Hufn.) (Noctuidae)—Black Cutworm.

Larvae caused severe defoliation to a block of onions, Navunaram, Gazelle Peninsula, New Britain, January-February.

PINEAPPLE (*Ananas comosus*).

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

Adults (phase gregarious) fed on leaves, Goodenough Island, Milne Bay District, November/December. Damage slight.

POTATO (*Solanum tuberosum*).

? gen. et sp. (Scarabeidae).

Larvae fed on potatoes, Sasembata, N.D., November.

RADISH (*Raphanus sativus*).

Caedius demeijerei Geb. (Tenebrionidae).

Adults common on ground under foliage, Sila, N.D., September.

? family (Dermaptera).

An unidentified small, dark brown species was found in moderate numbers feeding on decaying stems, Sila, N.D., September.

Gonocephalum ochthebioides Ful. (Tenebrionidae).

Adults fed on radish, Sila, N.D., September.

Onthophagus latenasutus Arrow (Scarabaeidae).

Adults very common, feeding on decaying radish stems, Sila, N.D., September.

SPINACH (*Beta vulgaris*).

Aulacophora papuana Jac. (Galerucidae).

Adults fed on foliage leaving circular holes, Sila, N.D., September.

Aulacophora similis Oliv. (Galerucidae).

Adults fed on foliage leaving circular holes, Sila, N.D., September.

Cassena sp. (Galerucidae).

Adults fed on leaves causing brown streaking, Sila, N.D., September.

Gen. nr. *Derispia* (Tenebrionidae).

Adults collected from spinach, Sila, N.D., September. No damage noticeable.

Euscyrtus hemelytrus (de Haan) (Gryllidae).

Adults collected from lettuce, Sila, N.D., September.

Henosepilachna signatipennis Boisd. (Coccinellidae).

Adults common, feeding on leaves producing small holes, Sila, N.D., September.

Lygaeus hospes Fabr. (Lygaeidae).

Adults common, fed on and caused yellow spotting of leaves, Sila, N.D., September.

Psylliodes sp. (Halticidae).

Adults very common, feeding on foliage and producing small, elongated feeding scars, Sila, N.D., September.

SWEET POTATO (*Ipomoea batatas*).

Bemisia tabaci (Genn.) (Aleyrodidae).

Recorded from sweet potato, Keravat, New Britain, November.

Cyclas formicarius F. (Curculionidae)—Sweet Potato Weevil.

Adults damaged tubers, Kamalili Mission, Eastern Highlands District, and Kapogere and Ilimo Farm, Central District, October.

? gen. et. sp. (Eriophyidae).

An unidentified eriophyid mite galled stems, Togoba, Western Highlands District, October.

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

Adults (phase gregarious) fed on foliage, Goodenough Island, Milne Bay District, November-December, damage slight.

TOMATO (*Lycopersicon esculentum*).

Nezara viridula L. (Pentatomidae)—Green Vegetable Bug.

Nymphs very common on tomato plants, Sila, N.D., September.

Spodoptera litura F. (Noctuidae)—Cluster Caterpillar.

Larvae very common, feeding both within and on young fruit, Sila, N.D., September.

YAM (*Dioscorea* spp.).

Lilioceris sp ? *bakewelli* Baly (Crioceridae).

Adults and larvae fed on foliage, Port Moresby, Central District, March.

Theratra nessus Dry. (Sphingidae).

Larvae defoliated vines, Keravat, New Britain.

Tagiades obscurus tindali Rbb. Hesperidae).

Larvae common throughout the year, feeding on foliage, Keravat, New Britain. Except for the odd occasion, damage was slight only.

SPICES.

CARDAMOM (*Elettaria cardamomum*).

Apirocalus sp. (Curculionidae).

Adults collected from foliage, Garaina, Morobe District, June.

Amarygmus sp. (Tenebrionidae).

Adults collected from foliage, Garaina, Morobe District, June.

Araecerus fasciculatus (Deg.) (Anthribidae).

Larvae (?) bored in stems, the adults emerging at the stem base, Sila, N.D., September.

Coptosoma sp. (Plataspidae).

Adults collected from foliage, Garaina, Morobe District, June.

Eupholus sp. (Curculionidae).

Adults collected from foliage, Garaina, Morobe District, June.

Lagria palliata Macl. (Lagriidae).

Adults collected from foliage, Garaina, Morobe District, June.

Leiochrodes sp. (Tenebrionidae).

Adults collected from foliage, Garaina, Morobe District, June.

Lema sp. nr. *cyanesthis* Boisd. (Crioceridae).

Adults chewing epidermis along top of leaf veins, giving the leaf a brown striped appearance, Sila, N.D., September.

Lema sp. (Crioceridae).

Adults collected from foliage, Garaina, Morobe District, June.

Oribius sp. nr. *leucopleurus* Fst. (Curculionidae).

Adults collected from foliage, Garaina, Morobe District, June.

Rhinoscapha sp. (Curculionidae).

Adults collected from foliage, Garaina, Morobe District, June.

Rhyparida sp. (Eumolpidae).

Adults collected from foliage, Garaina, Morobe District, June.

Riptortus sp. (Coreidae).

Adults collected from foliage, Garaina, Morobe District, June.

Stethotes sp. (Eumolpidae).

Adults collected from foliage, Garaina, Morobe District, June.

PEPPER (*Piper nigrum*).

Oribius cruciatus Fst. (Curculionidae).

Adults fed on leaves, Wanaru Plantation, Morobe District, December.

PASTURES.

Austracris spp. (Acrididae)—Spur-Throated Locust.

Adults and nymphs very numerous in native pastures, Goodenough Island, and at Raba Raba, Milne Bay District, November-December, 1966 ; January-March, 1967, and February-March, 1967, respectively. Specimens were also submitted from Afore, N.D., in March.

Clavigralla horrens Dohrn. (Coreidae).

Adults damaged seed pods of *Desmodium* sp. Bubia, Morobe District, July.

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

Adults and nymphs very numerous in native pastures, Goodenough Island, and at Raba Raba, Milne Bay District, November-December, 1966, January-March, 1967, and in February-March, respectively. Specimens were also submitted from Afore, N.D., in March.

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

Dense swarms of both adults and nymphs (phase gregarious) consumed quantities of native pastures (grasses) Goodenough Island, Milne Bay District, June-July, August-December, 1966 ; January-March and June-July, 1967.

The grass species (*Imperata* sp.) used for roofing material was selectively grazed by *L. migratoria* adults and had been almost completely eaten out on the north and north-eastern parts of the Island by mid-December.

Tetraneura nigriabdominalis (Sas.) (Aphididae).

Adults and nymphs feeding on roots of pangola grass (*Digitaria decumbens*), Keravat, New Britain, February.

Tetranychus marianae McGregor (Tetranychidae).

Heavy populations caused defoliation of *Dolichos lablab* and *Glycine javanica*, Popondetta September.

Valanga spp. (Acrididae).

Adults and nymphs were very numerous in native pastures, Goodenough Island, Milne Bay District, November-December 1966 ; January-March, 1967. Specimens were also submitted from Afore, N.D., in March.

WEEDS.

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

Larvae fed on puncture vine (*Tribulus cistoides*), Port Moresby area, Central District, July.

Pantorhytes szentivanyi Marsh. (Curculionidae) —Cacao Weevil Borer.

Adults and larvae collected from *Pipturus argenteus* plants, Popondetta-Sangara area, N.D. throughout the year.

Teleonemia scrupulosa Stal. (Tingidae)—Lantana Bug.

Adults and nymphs observed defoliating lantana (*Lantana camara*), Wewak, April. Damage to plants severe.

STORED PRODUCTS PESTS.

Ahasverus advena (Waltl.) (Cucujidae)— Foreign Grain Beetle.

Larvae and adults bred from peanut kernels, Atzera, Markham Valley, Morobe District, July-August. Common.

Cadra cautella (Walk.) (Pyralidae)—Tropical Warehouse Moth.

Larvae and adults very common in peanut store-houses and shelling buildings, Markham Valley, Morobe District, July-December. Larvae common in bagged peanut kernels, Atzera, Markham Valley, July-August.

Corcyra cephalonica (Staint.) (Pyralidae)—Rice Moth.

Larvae damaged stored rice and oatmeal, Madang, Madang District, November.

Oryzaephilus mercator (Fauv.)—Merchant Grain Beetle.

Adults bred from peanut kernels, Atzera, Markham Valley, Morobe District, July-August.

Tyrophagus putrescentiae (Schrank.) (Acarina : Acaridae)—Forage Mite.

Dense population infesting a small sample of dried pyrethrum flowers ex Laiagam, Western Highlands District, July.

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.

The ants were especially worrying at night when they were reported to enter the ears, noses, eyes, etc. of persons sleeping in the dwellings.

Heterobostrychus aequalis Waterh. (Bostrychidae).

Adults infested house timbers (*Syzygium* sp.), Madang, Madang District, August.

? family (Isopoda).

Swarms of unidentified Isopoda invaded a camp on the Vailala River, Gulf District, November.

Mastotermes darwiniensis Frogg. (Mastotermitidae)—Giant Termite.

Following a period of high activity during 1965-1966, infestations in both the Hospital and Milford Haven Road areas, Lae, continued at a high level during July and August, 1966.

However, following a general cleanup of the Milford Haven Road area in September and removal of an infested upright from a shed in October, *Mastotermes* was not detected at that site during the remainder of the year.

At the Hospital site, activity continued but at a low level. One troublesome infestation near houses at the southern end of the site was apparently eliminated, but repeated minor infestations occurred near the hospital buildings and orchard. It seems likely that all of these were initiated by small groups of survivors from previous treatments, emphasising the ability of *Mastotermes* to persist under low food supply conditions and to rapidly utilize any large quantity of susceptible timber subsequently encountered.

Very wet weather during the early part of 1966-1967 probably assisted the eradication campaign by increasing mortality in subterranean colonies and in encouraging activity near and above ground level, whereby infestations were more readily detected.

MEDICAL AND VETERINARY PESTS.

DOG.

Rhipicephalus sanguineus (Latr.) (Ixodidae)—Brown Dog Tick.

Occurred in large numbers in the Port Moresby area, Central District, during the 1966-1967 wet season.

MAN.

Cimex hemipterus F. (Cimicidae).

Infestations reported from houses in the Eastern Highlands, Central and Bougainville Districts in August, July and January respectively.

PIG.

Onthophagus consentaneus Har. (Copridae).

Adults recorded from pig droppings, Nomad River, Western District, August.

POULTRY.

Anoplolepis longipes (Jerd.) (Formicidae)—Crazy Ant.

Heavy populations invaded fowl houses at Gobari and Situm Land Setlement Schemes, Morobe District. Chickens were reported to have had their eyes removed whilst they roosted in fowl houses, and older fowls were continually irritated during the night by ants crawling over them. This irritation caused a general deterioration in condition and a complete cessation of egg laying.

Hermetia illucens L. (Stratiomyidae).

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

PARASITES AND PREDATORS.

Agrypnus sp. (Elateridae).

Adults collected from the central spindle of young sugar cane, Popondetta, N.D. Its relationship to sugar cane is not known, but its behaviour resembles that of *Compsolacon gracilis* (see below) so it may well be a predator of other insects occurring on sugar cane.

Apanteles sp. nr. *hyphantriae* Riley (Braconidae).

Adults bred from parasitized lymantriid larvae feeding on cacao, Girua Plantation, N.D., July.

Also bred (may be another species of *Apanteles*) from larvae of the lycaenid *Nacaduba berenice dobbensis* Roeber, a flush defoliator of cacao, Serovi-Sangara area, N.D., July to September.

Apanteles sp. (*glomeratus* group) (Braconidae).

Bred from parasitized *Nacaduba berenice dobbensis* Roeber larvae.

Asarcina aegrota Fabr. (Syrphidae).

Larvae were recorded as predators upon various species of Aphididae found on cacao flush, Haugata and Moale plantations, Popondetta, N.D., July.

Brachymeria euploeae Westw. (Braconidae).

Bred from *Pericyma cruegeri* (Butl.) pupae, Popondetta, N.D., March-April. It was also the dominant pupal parasite of *P. cruegeri* in the Port Moresby area, Central District, during April-May.

Brachymeria sp. (Braconidae).

Hyperparasite bred from the ichneumonid *Charops* sp. (see below) which was collected from Haugata plantation, Popondetta, N.D., August.

Carcelia sp. (Tachinidae).

Bred from *Tiracola plagiata* (Walk.) prepupae/pupae, Popondetta, N.D.

Carcelia (*Eocarcelia*) sp. (Tachinidae).

Bred from *Tiracola plagiata* (Walk.) prepupae/pupae, Popondetta, N.D.

Charops sp. (Ichneumonidae).

Bred from larvae or pupae of species of Psychidae collected Haugata Plantation, Popondetta, N.D., August.

Chelisoches morio (Fabr.) (Chelisocidae).

Adults very common at Kaiapit, Markham Valley, Morobe District and Popondetta, N.D., usually sheltering in leaf roll. It is suggested that it could be a predator of the sugar cane delphacid *Eumetopina* sp.

Closteroceros splendida Kowalski (Eulophidae). Oothecae of *Promecotheca papuana* Csiki collected from sago palms, Toriu River, New Britain in April, showed evidence of substantial emergence of *C. splendida.*

Coccinella arcuata F. (Coccinellidae).

Adults collected from sugar cane, Kaiapit, Markham Valley.

Compsolacon gracilis Cand. (Elateridae).

Adults of this species were commonly found in the central spindle of young cane at Bubia, Narakapor, Munum and Kaiapit, Markham Valley. Its relationship to sugar cane is not known, but it may be a predator on other insects (e.g., *Eumetopina* sp., *Blattella* sp.) which occur in the same situation.

Drino (*Prosturmia*) *subanajama* Tns. (Tachinidae).

Bred from *Tiracola plagiata* (Walk.) prepupae/pupae. Kokoda, N.D.

Echthromorpha insidiator Smith (Ichneumonidae).

Bred from *Pericyma cruegeri* Butl. pupae, Popondetta, N.D., March-April ; Port Moresby area, Central District, April-May. Common.

Euagorus sp. nr. *dolosus* Stal. (Reduviidae).

Adults collected from lettuce, Sila, N.D., September.

Euagorus sp. (Reduviidae).

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

Eurytomida sp. (Eurytomidae).

A free cocoon collected from cacao flush, Popondetta, N.D., August. The host species is not known.

Exorista fallax Mg. (Tachinidae).

Bred from *Tiracola plagiata* (Walk.) prepupae/pupae, Gobari Plantation, Lae, Morobe District ; Kokoda Valley and Sangara-Popondetta area, N.D. Common.

Bred from *Pericyma cruegeri* larvae/pupae, Port Moresby area, Central Distict, April-May.

Halyzia funerea Crotch. (Coccinellidae).

Adults feeding on eggs of an unidentified species of ricaniid laid on leaves of lime trees, P.A.T.I., Popondetta, N.D., February.

Helonotus exsugiens Stal. (Reduviidae).

Adults and nymphs commonly found feeding on 1st to 4th instar larvae of *Tiracola plagiata* (Walk.) and *Achaea janata* L., Sangara-Popondetta area, N.D.

Micraspis striata (F.) (Coccinellidae).

Adults collected from sugar cane, Kaiapit, Markham Valley, Morobe District.

? *Microceromasia sphenophori* Vill., (Tachinidae).

Pupae and dead adults were found in frass in a tunnel bored in sugar cane by, possibly, *Rhabdoscelus obscurus* Boisd., P.A.T.I., Popondetta, N.D., November.

Nerthra ampliatus Mont. (Gelastocoridae).

Adults collected from beneath radishes, Sila, N.D., September.

Noliphus sp. (Coreidae).

Adults collected from beans, Sila, N.D., September.

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

Preyed upon *Pericyma cruegeri* larvae which were migrating from defoliated poinciana trees, Port Moresby area, Central District, May.

Platynopus melacanthus Boisd. (Pentatomidae).

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

Propristocera sp. (Bethylidae).

Ectoparasite of *Pantorhytes szentivanyi* Marsh. Bred from *Pantorhytes* larva, Haugata Plantation Popondetta, N.D., September, 1966.

Prosapegus atrellus Dodd (Scelionidae).

Oothecae of *Segestidea* sp. ? *insulana* collected from the ground at the base of coconut palms and in the "skirt" at Volupai Plantation, Talasea, New Britain in June, were parasitized by this species. However, only a small percentage of oothecae were parasitized and it would appear that very litle control was exerted by this parasite.

Scolia nitida Sm. (Scoliidae).

Adults abundant and apparently responsible for some control of *Papuana* sp. larvae feeding on the trunks of tea bushes, Mount Hagen-Minj-Banz area, Western Highlands District, February. A *Scolia* cocoon was found beside the remains of a *Papuana* larva in the root zone of one of the damaged tea plants.

? *Spoggosia* sp. (Tachinidae).

Bred from *Tiracola plagiata* (Walk.) prepupae/pupae, Popondetta, N.D. Uncommon.

Tetrastichus sp. (Eulophidae).

Ex second instar *Tiracola plagiata* (Walk.) larvae feeding on cacao, Girua Plantation, N.D., July.

? gen. et sp. (Tipulidae).

Two tipulid larvae were found feeding on two curculionid larvae (? *Rhabdoscelus obscurus* Boisd.) within sugar cane stems, P.A.T.I., Popondetta, N.D., November.

Trichogramma spp. (Trichogrammatidae).

Ex eggs of *Achaea janata* L. Sangara-Popondetta area, N.D.

Xylocoris flavipes Reut. (Anthocoridae).

Nymphs and adults collected from insect infested (*Ahasverus advena* (Waltl.), *Carphophilus dimidiatus* (F.), *Cadra cautella* (Walk.) and *Oryzaephilus mercator* (Fauv.)) peanut kernels, Atzera, Markham Valley, Morobe District, July-August.

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

This was still the most important tachinid parasite of *Tiracola plagiata* (Walk.) larvae/pupae in the Sangara-Popondetta area, N.D., during the year.

BIOLOGICAL CONTROL PROJECTS.

A. INSECTS

Cacao armyworm—*Tiracola plagiata* (Walk.).

One shipment of approximately 40 *Winthemia* sp. ? *diversa* Malloch (Tachinidae) pupae was sent from Popondetta, N.D., to Wewak, East Sepik District, in June. The pupae had been bred from parasitized *T. plagiata* larvae collected from cacao.

Coconut Dynastids.

The *Platymeris laevicollis* Dist. distribution programme continued during the year but on a reduced scale. In all, 1,500 *Platymeris* were distributed, as follows :—

500 to Tavilo in July as adults

500 to Karu in October as adults and 5th instar nymphs and

400 to Bialla in April as adults.

Hibiscus mealybug—*Maconellicoccus hirsutus* (Green).

One shipment (50 adults) of the coccinellid predators *Pullus coccidivora* Agya and *P. pallidicollis* Muls. was received from the Indian Station, Commonwealth Institute of Biological Control, in November for use against *M. hirsutus*.

B. WEEDS.

Puncture vine—*Tribulus cistoides*.

Two shipments of the stem weevil, *Microlarinus lypriformis* (Wall.) were received from Hawaii, the first in December, 1966 and the second (500 adults) in April, 1967.

The December shipment of adults was used for feeding trials and for general observational/life history studies under caged conditions at Konedobu.

The second shipment was released directly into the field at three areas in the Port Moresby area, Hohola, Koki and Konedobu.

Two hundred weevils were released at both Hohola and Koki and 100 at Konedobu. Sites were checked daily during the following week and a few scattered individuals were found. In succeeding weeks larvae were found boring in stems of the plants at Koki and several plants began to show distinct signs of withering. These were examined and boring damage was obvious.

A teneral adult was found in June at the Koki site and it would appear that at this site at least there was emergence of a second generation; *Tribulus* in this area has since continued to show signs of regression.

QUARANTINE INTERCEPTIONS.

Caryedon gonagra F. (Bruchidae).

Seed of *Cassia bakeriania* received from Thailand was infested with larvae of *C. gonagra*, April.

Helix aspersa.

Young snails were found on cut flowers imported from Australia, May.

APPENDIX I—INDEX OF INSECTS MENTIONED.

Appendix I—Index of Insects Mentioned—*continued.*

Appendix I—Index of Insects Mentioned—*continued.*

APPENDIX II—INDEX OF PLANT HOSTS MENTIONED.

THE USE OF SELECTED LOCAL INGREDIENTS FOR PIG RATIONS IN THE TERRITORY OF PAPUA AND NEW GUINEA

J. A. SPRINGHALL.*

ABSTRACT.

A soybean/maize 14 *per cent. crude protein pig ration gave higher weight gains in pigs than a ration based on cooked sweet potato, with added soybean or meat meal, with a total crude protein content of* 16 *per cent. or* 8 *per cent., or a sweet potato ration without protein supplements, containing* 4 *per cent. crude protein.*

Sorghum based rations supplemented mainly with passionfruit seed and copra in varying proportions produced significantly higher weight gains than a sorghum/meat meal ration with the same crude protein level.

The substitution of peanut hay (2.5 *to* 20 *per cent.) for part of the sorghum ration did not produce significantly different weight gains when comparison was made with pigs fed the control soybean/sorghum ration.*

Substitution of 10 *to* 30 *per cent. sago for sorghum in pig rations containing peanut hay, fish meal or soybean meal did not affect weight gains. The substitution of meat meal for fish, however, produced significantly lower gains. Fifty per cent. sago was substituted with similar results.*

INTRODUCTION.

PIGS in developing countries are usually permitted to scavenge for food and are fed food scraps and peelings. Much of this material is high in water and carbohydrate, and low in protein. This is one of the reasons why the animals grow very slowly and rarely reach prime condition.

On the other hand, attempts are being made to rear relatively large numbers of pigs on intensive or semi-intensive systems. Such schemes using imported feeds cannot hope to compete, as far as cost is concerned, with those utilizing local materials. Attempts have been made to supplement imported pig feeds with some local materials.

The major feed ingredients used in the experiments reported here consisted of sago, sweet potato (kau kau), peanut hay, passionfruit seed and copra meal. These ingredients were supplemented with either soybean meal, meat meal or fish meal for protein.

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Sweet potato has been widely used as a pig feed in tropical areas (Calder 1960) for many years. No reference can be found in the literature on the use of passionfruit seed or peanut hay.

MATERIALS AND METHODS.

Five feeding experiments were conducted. Experiments 1, 3, 4 and 5 were conducted at the University of Queensland, and Experiment 2 in the Territory of Papua and New Guinea.

The pigs were housed in 36 individual pens measuring 4 ft. by 1 ft. 6 in. with sides 2 ft. 9 in. high. The floor was constructed of 2 x 1 in. wooden slats with $\frac{3}{4}$ in. space between them, and each pen had an individual galvanized iron feed trough (*Plate* I). The pens were raised 13 in. above the cement floor and the pigs were watered by low pressure drinking nipples supplied to each pen.

The pigs were fed once daily and offered an amount dependent on their weight. The amount was reduced if any feed was rejected. They were weighed at weekly intervals.

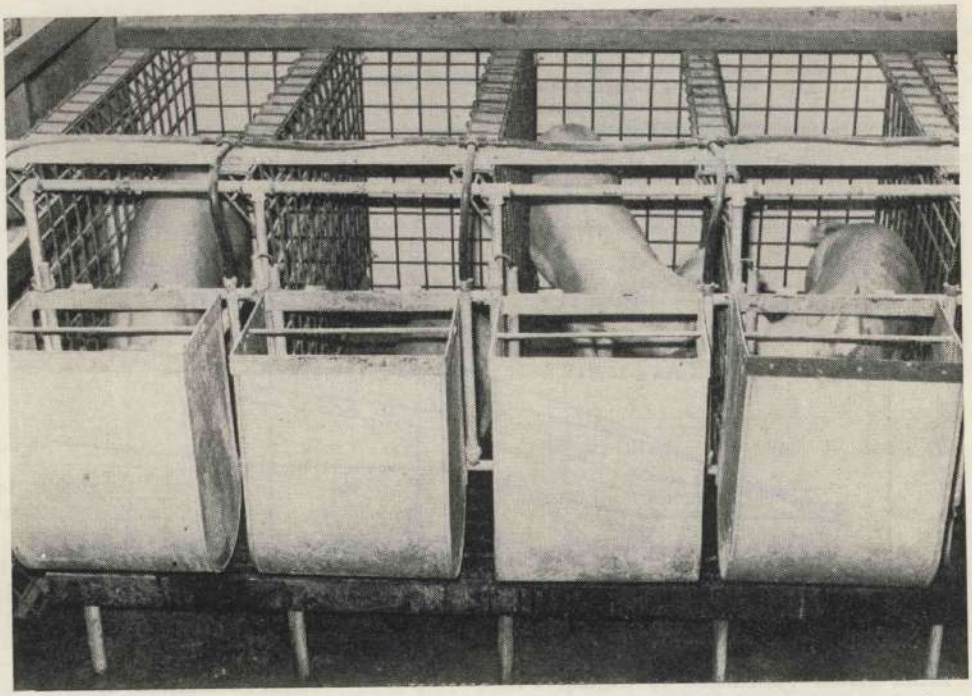


Plate I.—Pens used for all Experiments Conducted at the University of Queensland.

The pigs used in Experiment 1 were Large Whites purchased from a commercial piggery. Those used in Experiment 2, conducted at Goroka in the Territory of Papua and New Guinea, were Tamworth cross Berkshire, Berkshires and Large Blacks. The animals used in Experiment 3 were Large Whites and two Landrace crossbreds, obtained from a Brisbane saleyard. In Experiments 4 and 5 the pigs were all Large Whites obtained from a commercial piggery.

The pigs were drafted into groups of approximately equal weight.

The analyses of the feed ingredients are shown in *Table* 1.

Table 1.—Analysis of Ingredients.

Expressed on an Air Dry Basis.

Ingredient	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Ash (%)
Copra Meal	20	6	14	8
Passionfruit Seed	10.7	25.7	48.4	1.7
Peanut Hay	8.6	4.3	29.8	7.5
Sago	0.6	0.4	0.7	0.5
Sweet Potato	3.9	0.8	2.7	5.1

EXPERIMENT 1.

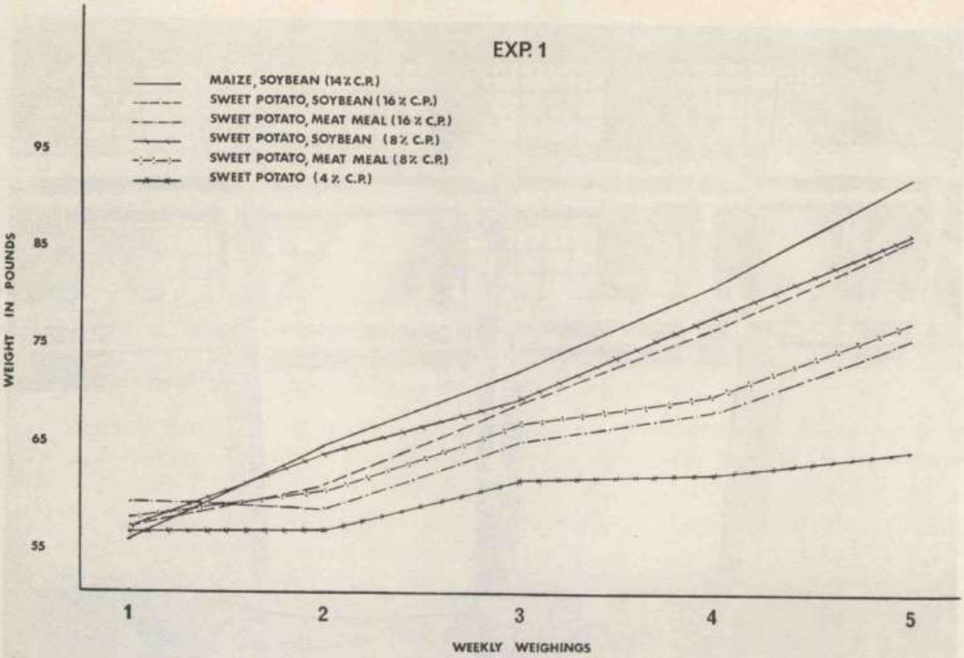
This experiment was designed to measure the effect of feeding wet cooked sweet potato, supplemented by a protein concentrate. The crude protein levels in this experiment were 16, 8 and 4 per cent. The concentrate used in the 16 and 8 per cent. rations was meat meal or soybean meal. Where the rations were isonitrogenous, they were not isocaloric.

The pigs were drafted into groups of six after weighing. They were fed the control ration (*Table* 2, Group 1) for a period of one week to allow them to become accustomed to their conditions. They were then fed the experimental rations.

The sweet potato used was steam cooked daily until soft for a period of half an hour, and fed wet. It was mixed by hand in the individual troughs with the dry concentrate portion of the ration. The experimental rations were fed for a period of four weeks.

Results and Discussion.

The summary of the mean weights at the conclusion of the feeding trial is given in *Table* 3. It will be seen that the control group on a



soybean/maize ration (calculated to contain 14 per cent. crude protein) weighed more than any other group, even though two groups were fed rations containing a higher crude protein level. The animals on the sweet potato ration did not consume their allotted amount of sweet potato owing to the high water content. It is suggested that this was the reason for the better performance of the pigs on the soybean/maize ration.

The 16 per cent. crude protein ration containing soybean, produced a higher weight gain than a comparable ration containing meat meal. This may have been due to the great variation and inconsistencies occurring during the manufacture of meat meal, or to the higher levels of calcium, causing a growth depression similar to that occurring in poultry (McDonald and Solvyns 1964). The pattern was repeated for the 8 per cent. protein rations.

As anticipated, the group receiving sweet potato without a protein supplement did not grow as well as any of the other groups. The crude protein level of the ration was 4 per cent., being that provided by sweet potato tubers alone. Where sweet potato is fed to pigs it is recommended that the crude protein level of the ration be adjusted accordingly.

EXPERIMENT 2.

Materials and Methods.

Sixty pigs were weighed and drafted into 12 groups so that all groups weighed approximately the same. They were housed in groups of five, not in individual pens. Each house had an outside concrete run attached.

The rations fed are shown in *Table* 4. The premix used was identical to that shown in *Table* 2 except for the addition of the antioxidant B.H.T. (butylated hydroxytoluene) at the rate of 4 oz. per ton, to those rations containing passionfruit seed. The passionfruit seed was ground in a mincer every two days and the B.H.T. added.

The *Leucaena* leaves were stripped from the petioles and sun-dried. The sweet potato tops were rolled into bunches, sliced, then sun-dried. The sorghum was hammermilled before being included in the ration.

This experiment was designed to ascertain the effect of varying levels of passionfruit seed and copra meal using a large number of local ingredients.

The amounts of soybean meal and sorghum were adjusted to keep the protein levels constant.

The pigs were fed once daily.

Table 2.—Rations based on Soybean Meal, Meat Meal and Sweet Potato.

Experiment 1.

All quantities expressed as percentages.

Ingredient	Group					
	1	2	3	4	5	6
Maize	84.4	....	....	....	....	....
Soybean	12.8	26.33	....	8.95	....	....
Meat meal	....	....	26.33	....	8.95	....
Sweet potato	....	70.87 (177)	70.87 (177)	88.25 (220)	88.25 (220)	97.2 (243)
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	0.3	0.3	0.3	0.3	0.3	0.3
Christmas Island phosphate	1.4	1.4	1.4	1.4	1.4	1.4
Vitamin and mineral premix	0.6	0.6	0.6	0.6	0.6	0.6
Total	100	100	100	100	100	100
Calculated crude protein percentage	14%	16%	16%	8%	8%	4%

Note 1.—Figures in brackets represent the equivalent quantity as wet weight.

Vitamin and Mineral Premix (Per pound of finished feed)

Vitamin A, 1500 I.U.; Vitamin D, 400 I.U.; Riboflavin, 2 mg ; Pantothenic Acid, 4 mg ; Niacin, 9 mg ; Vitamin B_{12}, 10 ug ; Ferrous Sulphate, 160 mg ; Copper Sulphate, 5 mg ; Manganese Sulphate, 108 mg ; Zinc Oxide, 45 mg ; Potassium Iodate, 0.25 mg.

Table 3.—Mean Weights of Pigs fed Soybean, Meat Meal and Sweet Potato for a Period of Four Weeks.

Experiment 1.

Group No.	No. of Pigs	Main Ration Ingredients	Crude Protein Percentage	Mean Starting Weight (lb)	Mean Finishing Weight (lb)	Mean Gain (lb)	Feed Conversion Ratios
1	6	Soybean/maize	14	55.4	92.6	37.2	3.0
2	5*	Soybean/sweet potato	16	56.3	86.0	29.7	3.2
3	6	Meat meal/sweet potato	16	59.4	75.5	16.1	6.0
4	6	Soybean/sweet potato	8	57.0	86.5	29.5	6.7
5	6	Meat meal/sweet potato	8	57.6	77.4	19.8	9.9
6	6	Sweet potato	4	56.1	64.5	8.4	41.0

* One pig was removed from the experiment owing to a rectal prolapse.

Note 1. With respect to weight gain, group 2=4, 3=5.
All other differences are significant $P < .01$

2. Feed conversion ratio significance, group $6 > (1=2=3=4=5)$, $P < .01$.

Results and Discussion.

The results are shown in *Table* 5. The ration containing meat meal produced significantly lower gains.

Variation of the passionfruit seed and copra meal had no significant effect on performance.

Table 4.—Rations based on Passionfruit Seed, Copra Meal, Soybean Meal, Meat Meal, Leucaena, Sweet Potato Tops and Sorghum.

Experiment 2.

All quantities expressed as percentages.

Ingredient	Group			
	7	8	9	10
Passionfruit seed	....	5	10	15
Copra meal	....	20	15	10
Soybean meal	....	5	6	7
Leucaena leaves	....	2	2	2
Sweet potato (kau kau) tops	....	5	5	5
Sorghum	88	61.4	60.4	59.4
Meat meal	10.4	....	....	....
Salt	0.5	0.5	0.5	0.5
Limestone	0.6	0.6	0.6	0.6
Vitamin and Mineral Mix	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated crude protein percentage	14%	14%	14%	14%

EXPERIMENT 3.

Materials and Methods.

The pigs were housed in individual pens as in Experiment 1. They were all fed a 14 per cent. protein soybean/sorghum ration for a period of four weeks. All pigs were treated with piperazine adipate at the rate of 24 grams per lb. of feed on being housed, and with thiabendazole (2 grams per pig) four weeks later. They were drafted into six groups of five so that each group's mean weight was approximately equal. Several pigs were not included in the first four week period, as they were suffering from enteritis, which later responded to treatment.

The aim of this experiment was to determine the optimum level of peanut hay.

The experimental rations are shown in *Table* 6. At the end of four weeks' feeding trial, the pigs were divided into two groups of approximately equivalent weight (14 in control and 19 on 20 per cent. peanut hay). The group previously receiving the control soybean/sorghum ration was kept on that ration during the second four week feeding period. Group 12 was also added to the control (Group 11) for that period. For the second four weeks the control ration was the same, and the second group was fed the ration containing 20 per cent. peanut hay (Group 16).

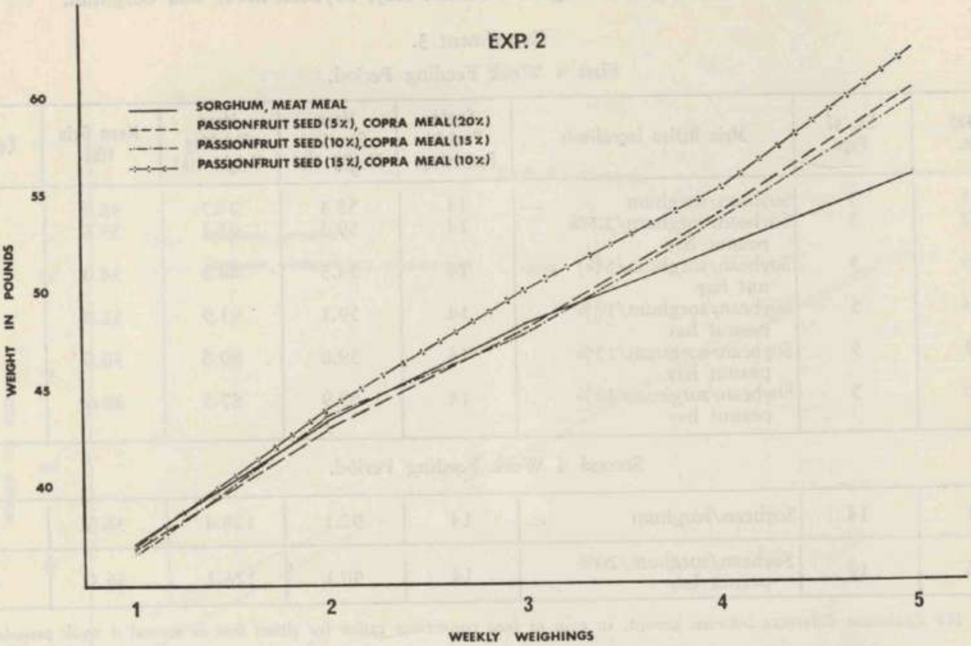
Table 5.—Mean Weights of Pigs fed Passionfruit Seed, Copra Meal, Soybean Meal, Leucaena, Sweet Potato Tops and Sorghum.

Experiment 2.

Group No.	No. of Pigs	Main Ration Ingredients	Crude Protein Percentage	Mean Starting Weight (lb)	Mean Finishing Weight (lb)	Mean Gain (lb)	Feed Conversion Ratio
7	14	Meat meal/sorghum	14	37.3	56.1	18.8	4.8
8	15	5% passionfruit seed/20% copra meal/sweet potato	14	37.1	60.5	23.4	5.4
9	15	10% passionfruit seed/15% copra meal/sweet potato	14	36.9	59.9	23.0	4.2
10	15	15% passionfruit seed/10% copra meal/sweet potato	14	37.1	62.5	25.4	3.9

Note 1. With respect to weight gain group $7 < (8 = 9 = 10)$, $P < .05$

group $7 < 10$, $P < .01$



Results and Discussion.

The results of the first and second four week feeding period are shown in *Table* 7.

There was no significant difference between groups at the end of the first four week feeding period nor at the conclusion of the final period. It is therefore considered that peanut hay is a useful ingredient for pig rations, and that it can be fed up to levels of 20 per cent. of the total ration. It could act as a substitute for lucerne in tropical areas.

Table 6.—**Composition of Rations based on Peanut Hay, Soybean Meal and Sorghum.**

Experiment 3.

All quantities expressed as percentages.

Ingredient	Group 11	12	13	14	15	16
Peanut hay	....	2.5	5.0	10.0	15.0	20.0
Sorghum	84.8	82.3	79.8	74.8	69.8	64.8
Soybean meal	12.8	12.8	12.8	12.8	12.8	12.8
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	0.3	0.3	0.3	0.3	0.3	0.3
Christmas Island phosphate	1.4	1.4	1.4	1.4	1.4	1.4
Vitamin and mineral premix	0.2	0.2	0.2	0.2	0.2	0.2
Total	100	100	100	100	100	100
Calculated crude protein percentage	14	14	14	14	14	14

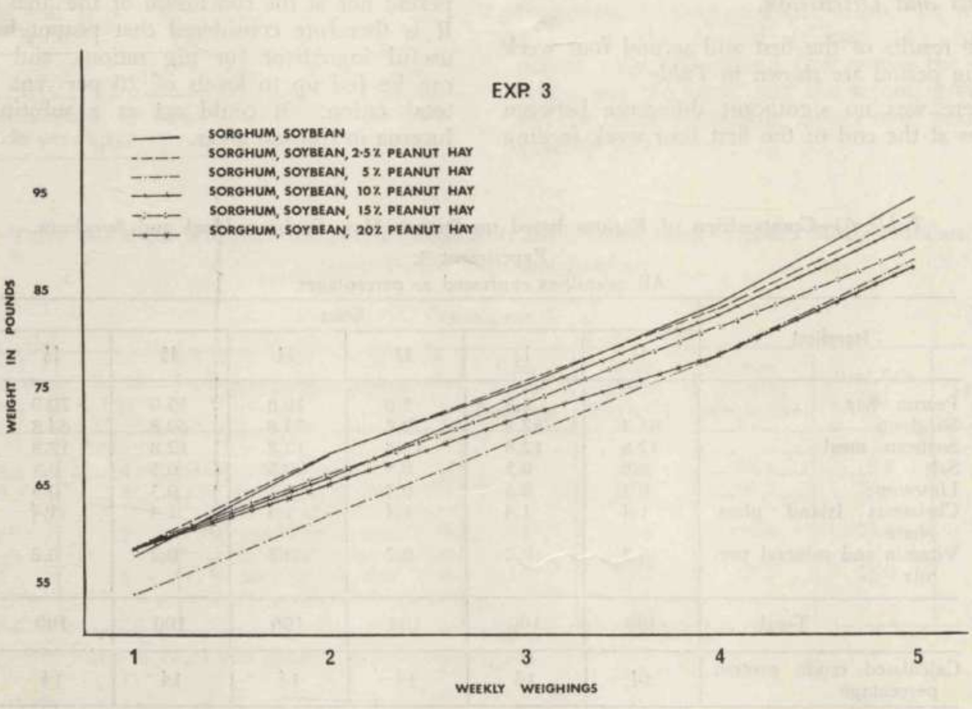
Table 7.—**Mean Weights of Pigs fed Peanut Hay, Soybean Meal and Sorghum.**

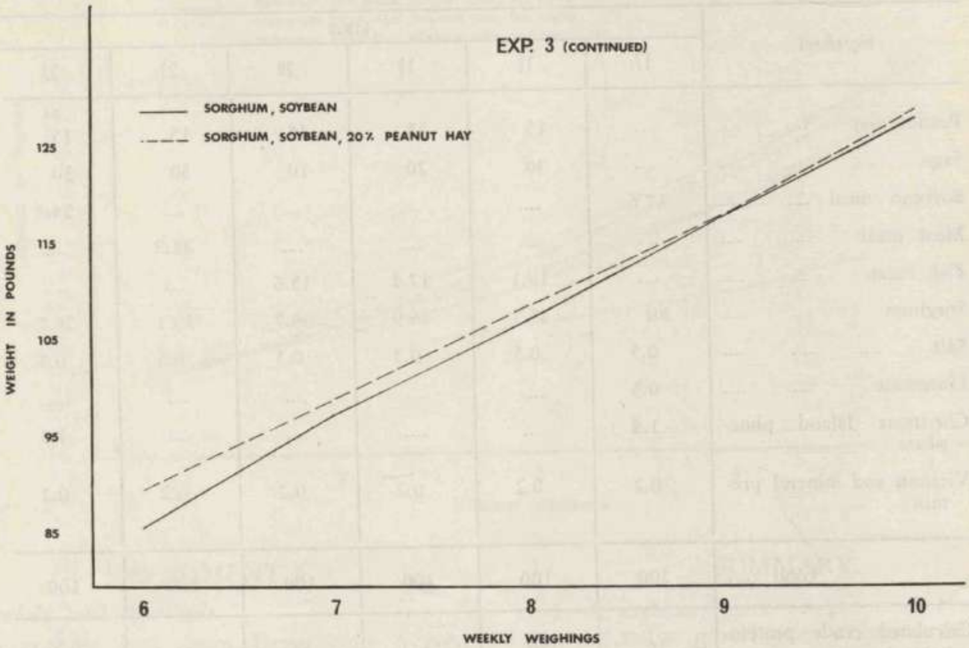
Experiment 3.

First 4 Week Feeding Period.

Group No.	No. of Pigs	Main Ration Ingredients	Crude Protein Percentage	Mean Starting Weight (lb)	Mean Finishing Weight (lb)	Mean Gain (lb)	Feed Conversion Ratio
11	5	Soybean/sorghum	14	58.3	94.7	36.4	3.0
12	5	Soybean/sorghum/2.5% peanut hay	14	59.3	93.1	33.8	3.3
13	5	Soybean/sorghum/5% peanut hay	14	54.3	88.3	34.0	3.2
14	5	Soybean/sorghum/10% peanut hay	14	59.1	91.9	32.8	3.4
15	5	Soybean/sorghum/15% peanut hay	14	59.0	89.6	30.6	4.0
16	5	Soybean/sorghum/20% peanut hay	14	58.9	87.5	28.6	4.4
Second 4 Week Feeding Period.							
11	14	Soybean/sorghum	14	92.1	128.4	36.3	3.3
16	19	Soybean/sorghum/20% peanut hay	14	90.1	126.2	36.1	4.1

Note 1. No significant difference between groups, in gain or feed conversion ratios for either first or second 4 week periods.





EXPERIMENT 4.

Materials and Methods.

The pigs were allowed one week to settle into their pens and to become familiar with the feed troughs and drinking nipples. During this period they were all fed a 16 per cent. crude protein ration of soybean meal and sorghum.

Any males were castrated, and thiabendazole was added to the feed (1 gram per pig). This anthelmintic treatment was followed with piperazine adipate four weeks later.

The experimental rations fed for four weeks are shown in *Table* 8. The control ration (Group 17) was based on soybean meal and sorghum. Three rations contained varying levels of sago, as a grain substitute, with fish meal as the protein source. Two other rations contained sago at the highest level (30 per cent.), with soybean and meat meal respectively as the protein source (*Table* 8). All rations were calculated to contain 16 per cent. protein.

Groups of six pigs were used with the exception of Group 21, which had five.

Results and Discussion.

All groups were significantly heavier than the group receiving meat meal (*Table* 9). There were no significant differences between the mean finishing weights of the other groups.

Variations in sago content from 10 to 30 per cent. did not affect performance. Rations containing fish or soybean meal produced almost identical results, but the ration containing meat meal was inferior as in previous experiments.

Table 8.—Rations based on Sago, Peanut Hay, Soybean Meal, Meat Meal, Fish Meal and Sorghum.

Experiment 4.

All quantities expressed as percentages.

Ingredient	Group					
	17	18	19	20	21	22
Peanut hay	....	15	15	15	15	15
Sago	....	30	20	10	30	30
Soybean meal	17.6	....	....	....	....	24.1
Meat meal	....	....	....	....	21.2	....
Fish meal	....	19.1	17.4	15.6	....	....
Sorghum	80	35.2	46.9	58.7	33.1	28.7
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	0.3	....	....	....	....	....
Christmas Island phosphate	1.4	....	....	....	....	1.5
Vitamin and mineral premix	0.2	0.2	0.2	0.2	0.2	0.2
Total	100	100	100	100	100	100
Calculated crude protein percentage	16	16	16	16	16	16

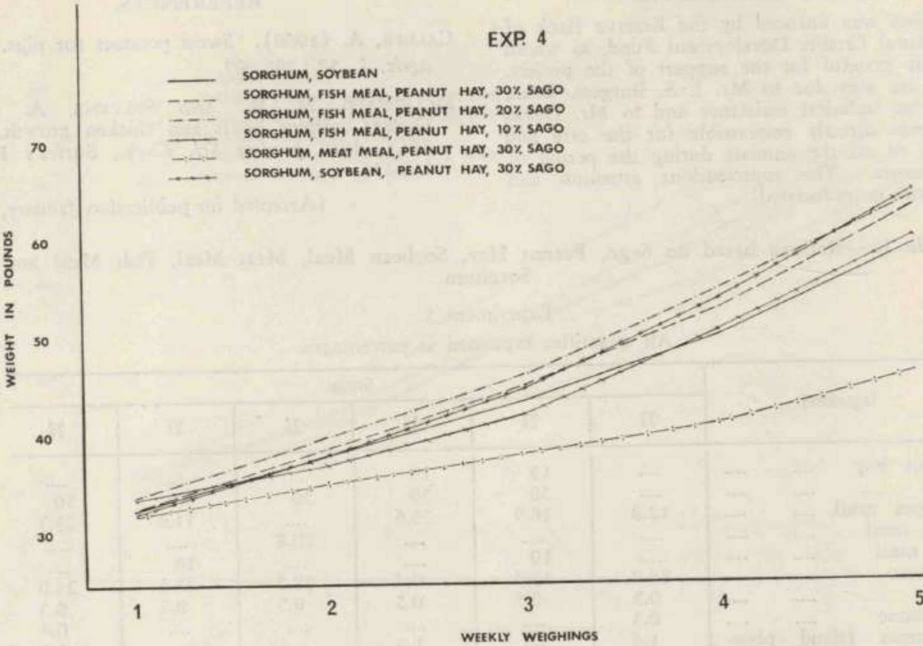
Table 9.—Mean Weights of Pigs fed Sago, Peanut Hay, Soybean Meal, Meat Meal and Sorghum.

Experiment 4.

Group No.	No. of Pigs	Main Ration Ingredients	Crude Protein Percentage	Mean Starting Weight (lb)	Mean Finishing Weight (lb)	Mean Gain (lb)	Feed Conversion Ratio
17	6	Soybean, sorghum	16	33.0	59.7	26.7	2.9
18	6	30% sago, peanut hay, fish meal, sorghum	16	33.1	63.6	30.5	2.5
19	6	20% sago, peanut hay, fish meal, sorghum	16	34.2	68.8	34.6	2.3
20	6	10% sago, peanut hay, fish meal, sorghum	16	33.0	60.3	27.3	2.8
21	5	30% sago, peanut hay, meat meal, sorghum	16	32.0	46.6	14.6	5.0
22	6	30% sago, peanut hay, soybean, sorghum	16	32.9	64.5	31.6	2.3

Note 1. Weight gain—group $21 < (17=18=19=20=22)$ $P < .01$

2. Feed Conversion—group $21 > (17=18=19=20=22)$ $P < .01$



EXPERIMENT 5.

Materials and Methods.

Thirty-three pigs from Experiment 4 were arranged into groups of approximately equal weight.

The control ration was based on soybean meal and sorghum. The experimental rations each contained 50 per cent. sago. Two rations contained 15 per cent. peanut hay, one of these contained fish meal. The remaining three rations contained meat meal, fishmeal and soybean meal or soybean meal *per se* as the principal protein source (*Table* 10).

Results and Discussion.

The group fed the control ration (soybean/sorghum) was not significantly different in finishing weight from those groups receiving 50 per cent. sago and fish meal and soybean meal without peanut hay (*Table* 11). The addition of 15 per cent. peanut hay in this experiment did depress weight gains when fed with 50 per cent. sago, which is to some extent at variance with the results of Experiment 4. The group receiving 50 per cent. sago with meat meal was similarly depressed.

SUMMARY.

1. A soybean/maize 14 per cent. crude protein pig ration gave higher weight gains in pigs than a ration based on cooked sweet potato, with added soybean or meat meal, with a total crude protein content of 16 per cent. or 8 per cent., or a sweet potato ration without protein supplements, containing 4 per cent. crude protein.

2. Sorghum based rations supplemented mainly with passionfruit seed and copra in varying proportions produced significantly higher weight gains than a sorghum/meat meal ration with the same crude protein level.

3. The substitution of peanut hay (2.5 to 20 per cent.) for part of the sorghum ration did not produce significantly different weight gains when comparison was made with pigs fed the control soybean/sorghum ration.

4. Substitution of 10 to 30 per cent. sago for sorghum in pig rations containing peanut hay, fish meal or soybean meal did not affect weight gains. The substitution of meat meal for fish meal, however, produced significantly lower gains. Fifty per cent. sago was substituted with similar results.

ACKNOWLEDGEMENTS.

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***Table* 10.—Rations based on Sago, Peanut Hay, Soybean Meal, Meat Meal, Fish Meal and Sorghum.**

Experiment 5.

All quantities expressed as percentages.

Ingredient	Group					
	23	24	25	26	27	28
Peanut hay	....	15	15	....	....	....
Sago	....	50	50	50	50	50
Soybean meal	12.8	10.9	23.6	....	11.0	23.7
Meat meal	....	....	....	20.8	....	....
Fish meal	....	10	....	....	10	....
Sorghum	84.8	13.4	9.4	28.5	28.3	24.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	0.3	....	....	....	....	0.4
Christmas Island phosphate	1.4	....	1.3	....	....	1.2
Vitamin and mineral premix	0.2	0.2	0.2	0.2	0.2	0.2
Total	100	100	100	100	100	100
Calculated crude protein percentage	14	14	14	14	14	14

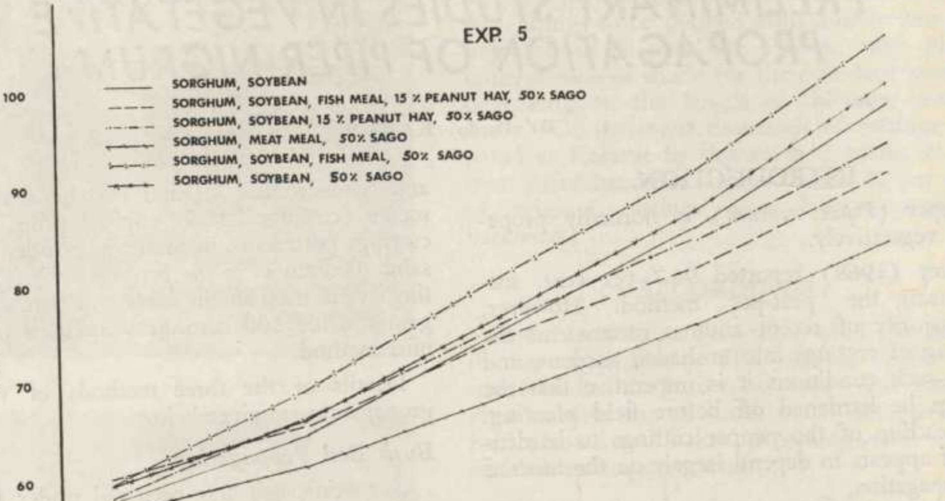
***Table* 11.—Mean Weights of Pigs fed on Sago, Peanut Hay, Soybean Meal, Meat Meal and Sorghum.**

Experiment 5.

Group No.	No. of Pigs	Main Ration Ingredients	Crude Protein Percentage	Mean Starting Weight (lb)	Mean Finishing Weight (lb)	Mean Gain (lb)	Feed Conversion Ratio
23	5	Soybean/sorghum	14	58.3	97.9	39.6	2.9
24	6	Sago, 15% peanut hay, soybean, fish meal, sorghum	14	60.9	90.9	30.0	3.6
25	6	Sago, 15% peanut hay, soybean, sorghum	14	59.0	93.7	34.7	3.2
26	4	Sago, meat meal, sorghum	14	57.0	83.7	26.7	4.0
27	6	Sago, soybean, fish meal, sorghum	14	60.5	105.0	44.5	2.7
28	6	Sago, soybean, sorghum	14	60.1	99.7	39.6	2.9

Note 1. Weight gain, group $(27=28=23) > (24=26)$, $P < .05$
$(27 > 25)$, $P < .05$

2. Feed conversion differences greater than 0.6 are significant at 5% level
3. Feed conversion differences greater than 0.8 are significant at 1% level



EXP. 5
SORGHUM, SOYBEAN
SORGHUM, SOYBEAN, FISH MEAL, 15 % PEANUT HAY, 50% SAGO
SORGHUM, SOYBEAN, 15 % PEANUT HAY, 50% SAGO
SORGHUM, MEAT MEAL, 50% SAGO
SORGHUM, SOYBEAN, FISH MEAL, 50% SAGO
SORGHUM, SOYBEAN, 50% SAGO
WEIGHT IN POUNDS
100
90
80
70
60
1
2
3
4
5
WEEKLY WEIGHINGS

PRELIMINARY STUDIES IN VEGETATIVE PROPAGATION OF PIPER NIGRUM

BY B. G. KAMP.*

INTRODUCTION.

Pepper (*Piper nigrum*) is normally propagated vegetatively.

Sickey (1968) reported 95.7 per cent. success using the 'peat-pot' method. However, the majority of recent authors recommend the planting of cuttings into unshaded gardens, and under such conditions it is imperative that the cuttings be hardened off before field planting. The reaction of the pepper cuttings to hardening off appears to depend largely on the method of propagation.

To investigate propagation methods suitable for smallholder use, a comparison was made between a bush bed method and a bamboo pot method in relation to losses involved in striking, hardening and field establishment, and field establishment following propagation in the mist propagator. Mist propagation is the method used at the Lowlands Agricultural Experiment Station at Keravat, New Britain.

MATERIALS AND METHODS.

Prior experiments with various methods of vegetative propagation had indicated that the best results were obtained by using 6 to 12 month old primary vine material with six nodes, in a rooting medium of black 'bush' top soil. The medium was selected after comparative tests on the following criteria :—

Three parts topsoil/one part gravel ;

Three parts sawdust/one part gravel ;

Sawdust ; and

Vermiculite.

It was decided to compare two root-inducing hormones, Seradix No. 1 and Seradix No. 2, as these hormones have been used very successfully with other crops. Thus comparisons were made between three methods of propagation (bush bed and bamboo pot and mist propagator), three hormone treatments (nil, Seradix No. 1 and Seradix No. 2), and two hardening treatments (cuttings left in original propagator and cuttings potted out in plastic bags filled with the same medium as in the propagators). Sixty cuttings were used in the bush and bamboo propagators while 100 cuttings were used under the mist method.

Details of the three methods of vegetative propagation are given below.

Bush Bed Propagation.

A rooting bed was prepared under *Leucaena* shade by arranging four logs about six in. in diameter into a rectangle and placing two others lengthwise on the bottom frame to form 'pillows', on which to rest the tops of the cuttings. The rooting medium was placed in this frame to a depth of about seven in. The three lowest leaves were removed from each of the six-node pieces of primary vine material, and the three top leaves were reduced to half their size. The lower half of each cutting (three nodes) was laid in a shallow furrow and pegged down with a piece of wire and covered with rooting medium. The cuttings were spaced about one in. apart. The top of each cutting was placed on the pillow (*Figure* 1). The whole bed was then thoroughly watered and covered with a piece of clear plastic which was nailed down to minimize evaporation. Care was taken to ensure that at least one of the halved leaves touched the plastic to allow absorption of the moisture which condensed on the underside of the sheet. Cuttings were not watered subsequently. The light intensity under the plastic sheet was estimated at between 30 to 40 per cent. of full sunlight.

Bamboo Pot Propagation.

Bamboo pots with a diameter of four in. and a length of ten in. were prepared by drilling a hole through the bottom septum and filling the pots with potting medium. Cuttings of *Piper nigrum* were prepared as described above, and planted one per pot. After inserting the cuttings, the pots were thoroughly watered and

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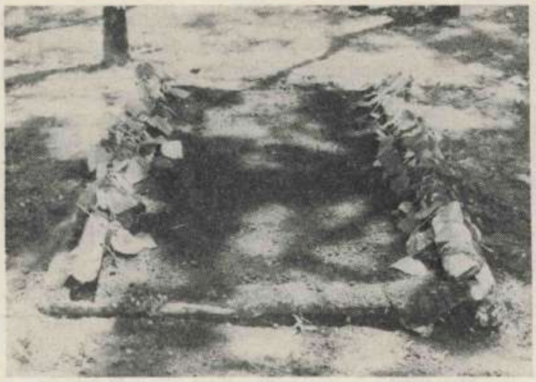
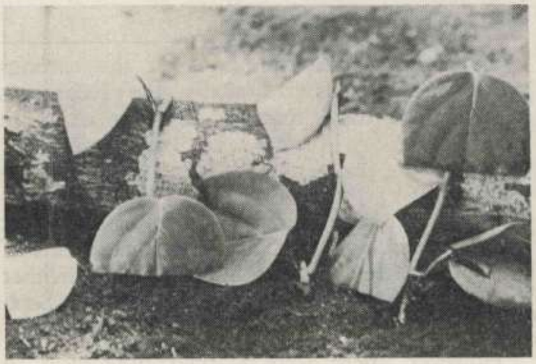




each was covered with a plastic bag (11 in. x 22 in.), the open end of which was fastened around the mouth of the bamboo pot to prevent evaporation. Care was taken to ensure that one of the halved leaves touched the plastic bag to allow absorption of condensed water. A wire frame was made up (*Figure* 2) to prevent the bag from collapsing, and to act as a support to which to tie the vine. The pots were placed under *Leucaena* shade estimated at between 30 and 40 per cent. of full sunlight. Vines in the propagator were not watered again.

Mist Propagator.

Single node cuttings were taken from primary vines three to nine months old. The one leaf remaining on each node was reduced to two-thirds of its original length. The cuttings were then inserted in a well-rotted sawdust medium. Misting was carried out continuously between 7 a.m. and 5 p.m. for three weeks, after which root development was sufficient to allow the cuttings to be planted individuallly into potting soil in plastic bags. These were placed under *Leucaena* shade for three to four months, depending on the length of the new primary shoot. Of the many thousands of cuttings prepared at Keravat by this method, about 95 per cent. strike has been obtained while 85 per cent. of original cuttings have been successfully hardened.

RECORDINGS.

Initial recordings were taken after one month in the propagator. The cuttings were then transferred to the hardening section and recorded after another month after which cuttings were field planted and a final recording made at the end of a subsequent month.

The following data were recorded :—

Percentage survival ;

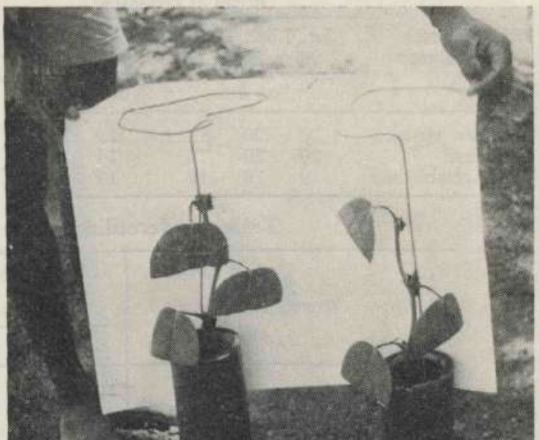
Number of new shoots per cutting ;

Average length of new shoots ;

Number of new leaves ; and

Average length of new leaves.

Percentage of cuttings with complete leaf-drop of original leaves.



All cuttings were left under shade for 14 days and then removed to an unshaded area for another 14 days during the hardening period. During the latter period, all cuttings were watered on two occasions as weather conditions were extremely dry.

At the same time 100 single node cuttings from the mist propagator (which had undergone a four month hardening period under *Leucaena* shade) were field planted.

RESULTS.

The number of cuttings that were struck, hardened and successfully established in the field (after one month) are shown in *Table* 1.

Table 1.—**Total number of cuttings struck, hardened and field established.**

Method of Propagation	Bush Bed 60 cuttings	Bamboo Pot 60 cuttings	Mist Prop. 100 cuttings
Total strike	59	59	95
Hardened	58	34	85
Field established	58	32	80

Relevant figures for various hormone treatments are shown in *Table* 2 (Seradix No. 1 and Seradix No. 2 were compared only in the bush bed propagator).

Table 2.—**Number of cuttings struck, hardened and field established.**

Hormone Treatments	Method of Propagation				
	Ser. 1 20	Ser. 2 20	Nil 20	Ser. 2 30	Nil 30
	Bush Bed			Bamboo Pot	
Number struck	20	20	19	29	30
Hardened	19	20	19	14	20
Field established	19	20	19	12	20

Differences were obvious between the cuttings struck in the bambo pot and those struck in the bush bed propagator, in terms of successful field establishment

There was no real difference in cuttings hardened in plastic bags and those left in their original medium although the former method is more convenient. Figures for survival are given in *Table* 3.

Table 3.—**Survival one month after field planting.**

Method of Propagation	Hardening Treatment	
	Plastic Bags 30 cuttings	Original medium 30 cuttings
Bush Bed	29	29
Bamboo Pot	19	17

To illustrate the conditions of the cuttings under the various treatments the recordings made at the third reading are summarized in *Table* 4.

DISCUSSION.

Both the bush bed and the bamboo pot methods were very successful from the point of view of *striking* of cuttings. With neither method was there any advantage in using Seradix No. 1 or Seradix No. 2.

However, there were marked differences in losses during hardening between the bush bed and bamboo pot methods of propagation. In spite of dry conditions during the last fortnight of hardening, 58 of all cuttings from the bush bed were successfully hardened while only 34 from the bamboo pots survived to the end of the hardening period. Losses with the bamboo pot method can be related to premature leafdrop, as 68 per cent. of cuttings had

Table 4.—**Recordings taken one month after field planting.**

Recordings	TREATMENTS Method of Propagation				
	Bush Bed		Bamboo Pot		Mist Prop.
	Hormone	Untreated	Hormone	Untreated	Untreated
Percentage survival	96.7	96.7	40.0	66.7	80.0
Number of new shoots per plant	1.30	1.30	2.08	2.05	1.00
Average length of shoots (in.)	7.00	7.30	5.25	5.70	7.50
Number of new leaves per plant	8.90	6.70	7.16	9.45	5.00
Average length of new leaves (in.)	1.9	1.7	2.3	1.9	1.5
Percentage of cuttings with complete leafdrop	17.2	6.9	83.3	60.0	60.0

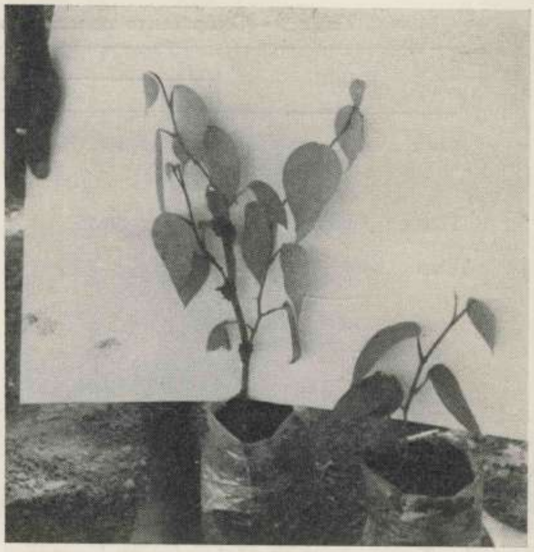
dropped all three original leaves at three months after striking, while only 12 per cent. of the cuttings in the bush bed had lost all original leaves over the same period. Following total leafdrop the main stem dehydrated, causing collapse of newly developed leaves.

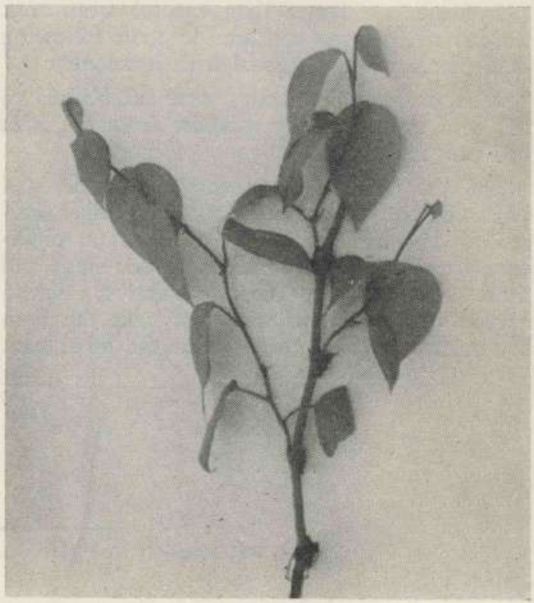
Virtually all cuttings which had survived hardening were successfully field established. A few deaths occurred with the hormone treated cuttings. It appears that for the bamboo pot method, the use of Seradix No. 2 may have been detrimental.

With a single node cutting as used in the mist propagator the first pruning is made traditionally when the primary shoot has developed ten nodes. Seven of these are removed leaving three to develop one new primary shoot each. This normally occurs about five months after striking. The author favours the use of six-node cuttings, as with bush bed and bamboo propagation methods, as it obviates the first pruning. The cuttings immediately have the potential to form the three primary shoots required. In practice, however, three primary shoots are not formed sometimes. All three buds will begin to grow but usually one or two primaries dominate. However, the other buds will develop immediately if the developing primary shoot or shoots are pruned. In the course of the trial 1.3 primary shoots were developed naturally per plant on those cuttings from the bush bed propagator, 2.0 per plant on those from the bamboo pots, and as expected one per plant from the single node mist propagator cuttings. Cuttings with three primary shoots were established from six-node material three months after striking. For single node cuttings the period is six months. The use of six-node cuttings, where suitable propagating material is freely available, would save three months.

The author considers that planting three nodes of a six-node cutting upright below the soil surface minimizes the chance of a cutting drying out and also provides a greater root 'feeding' area.

Table 5 sets out the approximate material cost per 100 rooted cuttings involved in the three methods of propagation.





Plates IV and V.—Six-node Cuttings.

SUMMARY.

The striking, hardening and field establishment of cuttings of *Piper nigrum* were compared using three methods of propagation. These were in bush beds and bamboo pots as well as

Table 5—Comparative material costs of propagating 100 pepper cuttings.

Material	Method		
	Bush Bed	Bamboo Pot	Mist Propagator
Clear plastic sheet	6 ft. x 6 ft. = $0.40	....	Available only from the Agricultural Station
Plastic planting bags	$0.55	$0.55	
Plastic bags 11 x 22	....	$1.90	The price is $0.05 per cutting
Fencing wire for frame at $7.91 per cwt.	....	$0.70	
TOTAL	$0.95	$3.15	$5.00

under a mist propagator. The first proved best because cuttings rooted by that method suffered fewer losses during the subsequent hardening period. Treatment with root-inducing hormones (Seradix No. 1 or Seradix No. 2) gave striking percentages no better than control treatments. Further slight losses appeared to occur following field planting when treated with hormones.

Mist propagated cuttings were established in the field as successfully as those from the bush bed propagator.

On the basis of perecentage survival and physiological condition of cuttings after successful field establishment there was no difference between those potted in plastic bags and those remaining in the propagators during hardening. On a material cost basis the bush bed method is far cheaper than the other two.

It is recommended that *Piper nigrum* cuttings be propagated by the bush bed method, that no hormone treatment be applied and that cuttings be transplanted into plastic planting bags following striking (for convenience). A hardening-off period of about one month appears to be adequate.

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