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ABSTRACTS

EVALUATION OF LEGUMINOUS COVER CROPS AT KERAVAT, NEW BRITAIN

R. Michael Bourke. *Papua New Guinea agric. J.* 26 (1) : 1-9 (1975)

An evaluation of 23 legume species and one non-legume as cover crops was carried out in a wet tropical lowland environment. Initially fortnightly and then monthly observations were made on crop performance for up to three years. Results of observations on 13 parameters are presented.

Pueraria phaseoloides was the best creeping species. *Calopogonium mucunoides* was also satisfactory. *Vigna unguiculata* (cowpea), *Stizolobium deeringianum* (velvet bean) and *Lablab purpureus* (lablab) were the best of the short-term creeping types. The best erect type was *Stylosanthes guyanensis* (Schofield stylo). *Flemingia congesta, Tephrosia candida, Crotalaria goreensis* and *Cajanus cajan* (pigeon pea) were the best of the shrubby types.

PHYTOPHTHORA PALMIVORA POD ROT OF CACAO IN PAPUA NEW GUINEA; INVESTIGATIONS 1962-1971

P. G. Hicks. *Papua New Guinea agric. J.* 26 (1) : 10-16 (1975)

New field infections of *P. palmivora* on pods were always present at Keravat in New Britain and no regular high or low incidence seasons occurred during 1962 to 1971. Incidence was over 20 per cent in 1955-56 but less than 3 per cent in 1962-65 and between 10 per cent and 20 per cent in 1969-71. Average annual rainfall for these three periods were 246, 277 and 289 mm respectively. No adequate records of rainfall type (e.g., drizzle, squall) are available for the first two periods.

On three occasions in 1963-65 long distance (beyond 20 metres) dispersal, as previously reported from Nigeria, was evident, contrasting with the usual short distance (less than 4 m) spread. Control may therefore be directed more economically at individual trees.

Some obviously susceptible clones have been recorded in the field but it is not clear whether the remainder are escapes or resistant ones.

EFFECTIVENESS OF LINDANE, DDT AND MONOCROTOPHOS FOR THE CONTROL OF THE CORN BORER *OSTRINIA FURNICALIS* GUENEE (LEPIDOPTERA:PYRALIDAE) IN MAIZE ON NEW BRITAIN

D. F. O'Sullivan and R. Michael Bourke. *Papua New Guinea agric.* J. 26 (1) : 17-19 (1975)

Within Papua New Guinea the corn borer *Ostrinia furnicalis* Guen. is a pest of maize in the Gazelle Peninsula of New Britain and on New Ireland. DDT (e.c.), lindane (granules and e.c.) and monocrotophos (w-s.c.) were tested against *O. furnicalis* in maize at the Lowlands Agricultural Experiment Station, Keravat, New Britain. Both monocrotophos as a water soluble concentrate, and lindane granules when applied at 6, 8, 10 and 12 weeks post planting at the rate of 1 kg a.i. per hectare per application significantly reduced the incidence of borer in both stem and cobs. However significant yield differences were not obtained.

[*continued overleaf*]

TUNA OFFAL MEAL FOR GROWING PIGS

G. L. Malynicz and H. Nad. *Papua New Guinea agric. J.* 26 (1) : 20-22 (1975)

Tuna offal meal was produced in experimental quantities by a tuna processing factory at Kavieng. In the first trial it was compared with two imported fishmeals and found to be inferior. In a second experiment three levels of tuna meal were compared with or without a vitamin-trace element supplement. The supplement produced highly significant beneficial effects on performance. The level of fishmeal also had some effect, but this was much smaller than that due to the supplement.

THE MARINE TOAD, *BUFO MARINUS*, IN PAPUA NEW GUINEA

J. R. Pippet. *Papua New Guinea agric. J.* 26 (1) : 23-30 (1975)

In an attempt to assess the economic effect of *Bufo marinus*, two different types of agricultural areas were selected for survey. Routine collections were made at a cocoa plantation near Popondetta in the Northern District of Papua New Guinea, and at the Plant Quarantine Station, Laloki, in the Central District of Papua New Guinea. The stomach contents of all individuals were identified at least to family level and more precisely if possible. An assessment was then made of the economic status, i.e., beneficial or harmful, of each grouping. The results indicate that in certain situations the presence of *Bufo marinus* can be beneficial.

EVALUATION OF LEGUMINOUS COVER CROPS AT KERAVAT, NEW BRITAIN

R. MICHAEL BOURKE*

ABSTRACT

An evaluation of 23 *legume species and one non-legume as cover crops was carried out in a wet tropical lowland environment. Initially fortnightly and then monthly observations were made on crop performance for up to three years. Results of observations on* 13 *parameters are presented.*

Pueraria phaseoloides *was the best creeping species.* Calopogonium mucunoides *was also satisfactory.* Vigna unguiculata (*cowpea*), Stizolobium deeringianum (*velvet bean*) *and* Lablab purpureus (*lablab*) *were the best of the short-term creeping types. The best erect type was* Stylosanthes guyanensis (*Schofield stylo*). Flemingia congesta, Tephrosia candida, Crotalaria goreensis *and* Cajanus cajan (*pigeon pea*) *were the best of the shrubby types.*

INTRODUCTION

The purpose of cover cropping is to provide a protective living cover on the soil and also to improve its chemical or physical status. The value of leguminous cover crops is widely known from temperate climates. Bourke (1974) and Kimber (1974) have expressed doubts about their usefulness in maintenance of soil fertility in arable farming systems in Papua New Guinea, although Bourke (1974) points out that leguminous crops have a role as grain crops, as cover and shade crops in plantations, in pastures and perhaps as a rotation crop with paddy rice.

There are currently numerous species and varieties of legumes potentially available for use as cover crops, and this study was commenced in 1970 to evaluate some of them in a wet lowland environment. It was commenced before I had begun to doubt the usefulness of legumes in arable farming systems.

Three recommendations for cover crops in the lowlands have been published previously. DASF (1954) recommended *Pueraria*, *Centrosema*, *Calopogonium* and *Vigna marina* as creeping legumes suitable as cover crops and green manure, and cowpea, mungo bean, *Crotalaria* spp., pigeon pea and *Tephrosia* as suitable erect species. In an evaluation of seven species and varieties as cover crops in the Markham Valley, DASF (1972, pp. 135-6) concluded that *Dolichos lablab* was the most suitable cover crop, with the Aurora variety of cowpea as second choice. In an observation trial with 11 entries in West New Britain, Mendham (1971) found *Pueraria phaseoloides* to be the most suitable legume cover crop for oil palms.

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MATERIALS AND METHODS

The evaluation was conducted in two nearby areas on the Lowlands Agricultural Experiment Station at Keravat on New Britain. The climate is wet lowland tropical with an average annual rainfall of 2760 mm fairly evenly distributed throughout the year, although one or two dry months can be expected each year. The months May to October are on the average drier with more hours of sunshine per month. The soil in the trial area is derived from pumiceous tuff and is a sandy loam overlying sand. The evaluation areas were cleared of vegetation, mainly *Sorghum propinquum*, prior to preparation of plots.

Seed of 11 species used in the evaluation was sent to Mrs J. Hale on New Hanover for an evaluation there. Mrs Hale kindly provided notes on the performance of these and other species on New Hanover. They were grown there on a very sandy soil.

Twenty-three legume species were included, as well as two varieties of two of the species. One non-legume, *Acioa barteri*, was also evaluated. Each species or variety was planted in a single plot six metres square. Seed was broadcast and covered with a few centimetres of soil. Most were planted in November-December, 1970. Performance of some species was checked in later plantings. Planting rate varied with seed size and also availability. High planting rates were used to allow for poor germination and to enable the legumes to compete with early weed growth. The species and varieties evaluated and planting rates are given in *Table* 1.

Grain producing species that normally would be grown on stakes to maximize grain yield were grown without support as the evaluation was primarily concerned with their performance as covers. It was originally intended not to weed plots, but irregular weeding was required in all plots to prevent the legumes from being overgrown by weeds, mainly *Sorghum propinquum* and *Mimosa invisa*. Despite this, some plantings were overgrown.

Initially fortnightly and then monthly observations were made on each plot until the death of the crop. Observations are continuing on a few perennial species three and a half years after planting. Crop vigour, ground cover, height of most plants, weed competition, amount of leaf fall, flowering behaviour, seed production and pest and disease problems were noted at each observation.

Growth vigour, ground cover, competition with weeds and leaf fall were classified as either very poor, poor, fair, good or very good. Maximum crop height is the maximum height attained by most plants in the plot. Period to full ground cover, apparent maximum growth, commencement of flowering, commencement of crop decline and death of crop were estimated from observations on ground cover, vigour and flowering behaviour. Full ground cover was taken to have occurred when all of the plot was covered by the species being evaluated.

RESULTS

Results of the observations are presented in *Tables* 1 and 2 together with common name, whether edible grain is produced, and the planting rate used. Species are grouped according to their growth habit as either creeping, erect or shrub types.

DISCUSSION

The ideal cover crop would have the following characteristics: It would be a fast grower, rapidly producing a good ground cover. It would be aggressive and able to compete with weed growth. Leaf production and litter fall would be high. It would seed freely producing an edible grain and it would be a perennial. It would not require inoculation with Rhizobium for effective nodulation and, finally, the crop would be resistant to pests and diseases. No one species is likely to fulfil all of these conditions, but some may fulfil most.

In general the faster growing species evaluated were short-lived, and the long-lived species were the slower growers. The creeping and erect species were generally faster growers than the shrubby types. Only amongst shrubby types was complete weed control found. The erect bushy species did not spread much and hence they did not provide such good competition with weeds. The shrubs all set seed freely. They were also less susceptible to disease, possibly because of their more open nature.

Each species is discussed individually below.

CREEPING TYPES

Calopogonium mucunoides. Calopo grew well, formed a dense sward and produced a good quantity of leaf litter. It seeded freely only in dry periods. It is somewhat similar to puero but it is faster growing in the establishment phase and it is not as persistent as puero.

Centrosema pubescens. Centro performed very poorly. It was very slow to become established and never really competed with invading weeds. Mendham (1971) in his evaluation in West New Britain also found that it grew poorly and was not vigorous. On New Hanover, Hale found it competed poorly.

Desmodium intortum. Green leaf desmodium was slow to become well established and did not flower. Hale reported the same on New Hanover. Hill (1970) states that it is generally not suited to the lowlands.

Glycine wightii. The two glycine cultivars differed in the time taken to cover the ground, and flowering behaviour. Cooper covered the ground faster than Tinaroo but it suffered from severe weed competition (mainly from *Mimosa invisa*) and a completely weed-free cover was never established. Cooper glycine flowered but no seed was observed. Tinaroo was slower to establish a ground cover and it did not flower. Mendham (1971) also found that Tinaroo spread slowly and did not set seed. Both cultivars were very susceptible to grey leaf rot (*Rhizoctonia solani*) and at times large gaps appeared in the stands. For this reason they are probably not suitable for wet lowland conditions. Cooper glycine seems the better of the two evaluated as it is a faster grower and sets flowers.

Plate I.—A vigorous stand of puero (*Pueraria phaseoloides*)

Photo by author

Lablab purpureus. Lablab covered the ground quickly and produced a dense stand. It was not particularly persistent and was susceptible to grey leaf rot. It does not flower in the lowlands except under water stress conditions (Hill, 1967). It could be considered as a suitable short term cover crop. It is not as long-lived as puero, but lives longer than cowpea or velvet bean. In a cover crop evaluation in the Markham Valley (DASF, 1972, p. 135) lablab was the only species to maintain a complete soil cover throughout the duration of the trial. Its dry matter production was also greater than the other species.

Macroptilium purpureum. Siratro grew quickly and established a good cover. However it was overgrown by the creeper *Ipomoea bederifolia* after a few months, so its potential is uncertain. Mendham (1971) found that it grew well initially but later became sparse and badly infested with weeds. This would suggest that the Keravat experience was not unusual and that this species is not suited to this environment.

Psophocarpus tetragonolobus. Wing bean grown as a cover crop did not produce a good ground cover or much top growth. It is not suitable as a cover crop.

Pueraria phaseoloides. Puero was slow to become established, but once established it grew fast to produce a very good ground cover. It is a perennial. It is capable of climbing other species and is aggressive. It did not seed in this evaluation but it is known from other plantings at Keravat that it only seeds under very dry conditions. The crop is attacked by grey leaf rot, but is not particularly susceptible. In this evaluation it was the best of the creeping species.

Stizolobium deeringianum. Velvet bean grew rapidly and produced a good stand. It was a good competitor with weeds and climbed over taller species. Hale found it to be a slow starter

Table 1.—Observations on characteristics and behaviour of species

Species	Common name	Edible grain produced	Planting rate kg/ha	Growth vigour	Ground cover	Competition with weeds	Leaf fall
Creeping Types							
Calopogonium mucunoides	calopo	no	30	good	very good	good	good
Centrosema pubescens	centro	no	30	poor	fair	poor	fair
Desmodium intortum	green leaf desmodium	no	5	fair	good	fair	good
Glycine wightii (syn. G. javanica) cv. cooper	cooper glycine	no	30	good	good	fair	good
Glycine wightii cv. tinaroo	tinaroo glycine	no	15	good	good	good	good
Lablab purpureus (syn. Dolichos lablab) cv. Rongai	lablab	no	60	good	very good	good	very good
Macroptilium purpureum (syn. Phaseolus atropurpureus)	siratro	no	23	very good	good	very poor (1)	good
Psophocarpus tetragonolobus	wing bean	yes	60	(2)	fair	poor	poor
Pueraria phaseoloides	puero	no	30	good	very good	good	very good
Stizolobium deeringianum (syn. Mucuna pruriens)	velvet bean	yes	120	very good	very good	good	fair
Vigna unguiculata (syn. V. sinensis)	cowpea	yes	30	very good	good	good	good
Vigna unguiculata sesquipedalis (syn. V. sesquipedalis)	yardlong bean	yes	15	very good	fair	poor	poor
Erect Types							
Glycine max	soya bean	yes	30	very good	good	fair	poor
Macroptilium bractearum (syn. Phaseolus lathyroides)	phasey bean	no	30	very good	good	good	fair
Stylosanthes guyanensis (syn. S. gracilis)	Schofield stylo	no	30	good	very good	fair	fair
Vigna radiata (syn. Phaseolus radiatus)	green gram	yes	15	very good	good	fair	poor
Vigna unguiculata (syn. V. sinensis)	poona pea	yes	30	very good	fair	fair	poor
Shrub Types							
Acioa barteri	—	no	(3)	very poor	good	poor	poor
Cajanus cajan	pigeon pea	yes	60	very good	good	good	fair
Crotalaria anagyroides	—	no	30	good	good	good	fair
Crotalaria goreensis	—	no	30	very good	very good	good	good
Flemingia congesta	flemingia	no	50	initially poor then good	very good	very good	good
Leucaena leucocephala (syn. L. glauca) cv. Niugini	leucaena	no	15	good	fair	good	poor
Sesbania punctata	—	no	30	good	very poor	very poor	very poor
Tephrosia candida	—	no	30	poor	very good	very good	fair
Tephrosia noctiflora	—	no	30	poor	good	fair	fair

(1) Plot overgrown by the creeper *Ipomoea bederifolia*.

(2) Cowpea grew in plot and evaluation incomplete.

(3) Seedlings 3½ months old planted at 18 300 per hectare.

***Table* 2.—Observations on characteristics and behaviour of species**

Species	Maximum crop height	Seed Production		Period from planting to:					Pest and disease problems
		Frequency	Quantity	Full ground cover	Apparent max. growth	Flowering	Commencement of crop decline	Death of crop	
Creeping Types									
Calopogonium mucunoides	30 cm	occasional	fair	7 weeks	2½ months	6 months	12 months	20 months	
Centrosema pubescens	10 cm	(6)	none	6 months (4)	6 months	7 months	10 months	20 months	Infected by *Rhizoctonia solani*
Desmodium intortum	50 cm	(5)	none	3½ months	5 months	(5)	14 months	24 months	Infected by *R. solani*
Glycine wightii cv cooper	40 cm	(6)	none	2 months	4 months	8 months	7 months	13 months	Very susceptible to *R. solani*
Glycine wightii cv tinaroo	40 cm	(5)	none	3 months	4 months	(5)	—	13 months	Very susceptible to *R. solani*
Lablab purpureus	60 cm	(5)	none	7 weeks	3 months	(5)	12-14 mths	17 months	Susceptible to *R. solani*
Macroptilium purpureum	30 cm	(6)	none	5 weeks	3 months	9 weeks	4 months	5 months (1)	
P. tetragonolobus	30 cm	(2)	fair	9 weeks	(2)	5 months	5 months	11 months	Susceptible to *R. solani*
Pueraria phaseoloides	60 cm	(5)	none	10 weeks	3 months	(5)	22 months	(7)	Infected by *R. solani*
S. deeringianum	1 m	continuous	fair	4 weeks	2 months	3½ months	7 months	12 months	Infected by *R. solani*
Vigna unguiculata	60 cm	continuous	good	7 weeks	2 months	2 months	8 months	15 months	Infected by *R. solani*
Vigna unguiculata sesquipedalis	50 cm	continuous	fair	5 weeks	7 weeks	2 months	5 months	10 months	Beans attacked by a bug. Susceptible to *R. solani*
Erect Types									
Glycine max	60 cm	one seed crop	good	4 weeks	6 weeks	2 months	3 months	5 months	
Macroptilium bractearum	1.2 m	continuous	good	5 weeks	2 months	2 months	7 months	11 months	Infected by *R. solani*
Stylosanthes guyanensis	60 cm	(6)	none	10 weeks	3½ months	4½ months	—	24 months	
Vigna radiata	60 cm	continuous	fair	5 weeks	2 months	7 weeks	2½ months	6 months	
Vigna unguiculata cv poona pea	60 cm	one seed crop	fair	5 weeks	7 weeks	6 weeks	2½ months	3½ months	
Shrub Types									
Acioa barteri	2 m	occasional	fair	12 months	(8)	20 months	(8)	(8)	
Cajanus cajan	4 m	continuous	good	7 weeks	6 months	6 months	12 months	20 months	Grain severely attacked by insects
Crotalaria anagyroides	4.2 m	continuous	good	3 months	8 months	4 months	11 months	23 months	
Crotalaria goreensis	1.5 m	continuous	good	3 months	5 months	3 months	7 months	12 months	
Flemingia congesta	4 m (9)	continuous	v. good	4 months	12 mths (10)	5½ months	(11)	(11)	
Leucaena leucocephala	6 m (9)	continuous	v. good	9 weeks	3 months	3 months	(11)	(11)	
Sesbania punctata	3.5 m	continuous	fair	not achieved	4 months	4 months	6 months	7 months	
Tephrosia candida	4 m	continuous	good	4 months	24 months	9 months	(11)	(11)	
Tephrosia noctiflora	3.5 m	continuous	good	5 months	14 months	3 months	16 months	23 months	

(4) Plots slashed at 1 month. Severe weed competition.
(5) Crop did not flower.
(6) Crop flowered but did not set seed.
(7) Crop still present 2½ years after planting.
(8) Crop still growing 3½ years after planting.
(9) Height at 3½ years after planting. Maximum height not yet attained.
(10) By 12 months most of growth had occurred.
(11) Crop still vigorous 3½ years after planting.

on New Hanover, but this is not the usual experience on the Gazelle Peninsula. It was not as long-lived as cowpea, nor did it seed as well. The seed is edible.

Vigna unguiculata. Cowpea quickly produced a ground cover and the resulting sward was dense and a good competitor with weeds. It was short-lived and was attacked by grey leaf rot. It seeds well and its pod is edible. Hale considered cowpea to be the best legume in her evaluation.

Vigna unguiculata sesquipedalis. Yardlong bean grew quickly and was short-lived. Ground cover, competition with weeds and leaf production were not good and the crop cannot be considered as a cover crop.

ERECT TYPES

Glycine max. Soya bean grew quickly, produced a good ground cover and set a heavy seed crop. However it was short-lived and produced little leaf matter. For these reasons it is not suitable as a cover crop.

Macroptilium bractearum. Phasey bean produced a good ground cover quickly, and provided an adequate although not a dense cover. It was short-lived. Overall it was satisfactory as a cover crop but not as good as some of the creeping short term covers.

Stylosanthes guyanensis. Schofield stylo produced an impressive dense cover although it was unable to compete with invading *Sorghum propinquum*. Flowering was recorded at one observation but no seed was observed. At Dami, Mendham (1971) found that stylo grew well but did not spread well from the planting strips. It maintained a high proportion of planted legume. It did not flower. Hale also recorded no flowering on New Hanover.

The crop is not as long-lived as puero nor does it compete with weeds as well because of its upright habit. However it could be considered as an alternative to puero.

Vigna radiata. Green gram grew rapidly and produced a reasonable cover. The crop started to die back after only two and a half months.

Vigna unguiculata. The Poona pea variety of cowpea grew rapidly and produced a seed crop. Ground cover was only fair and the crop was short-lived.

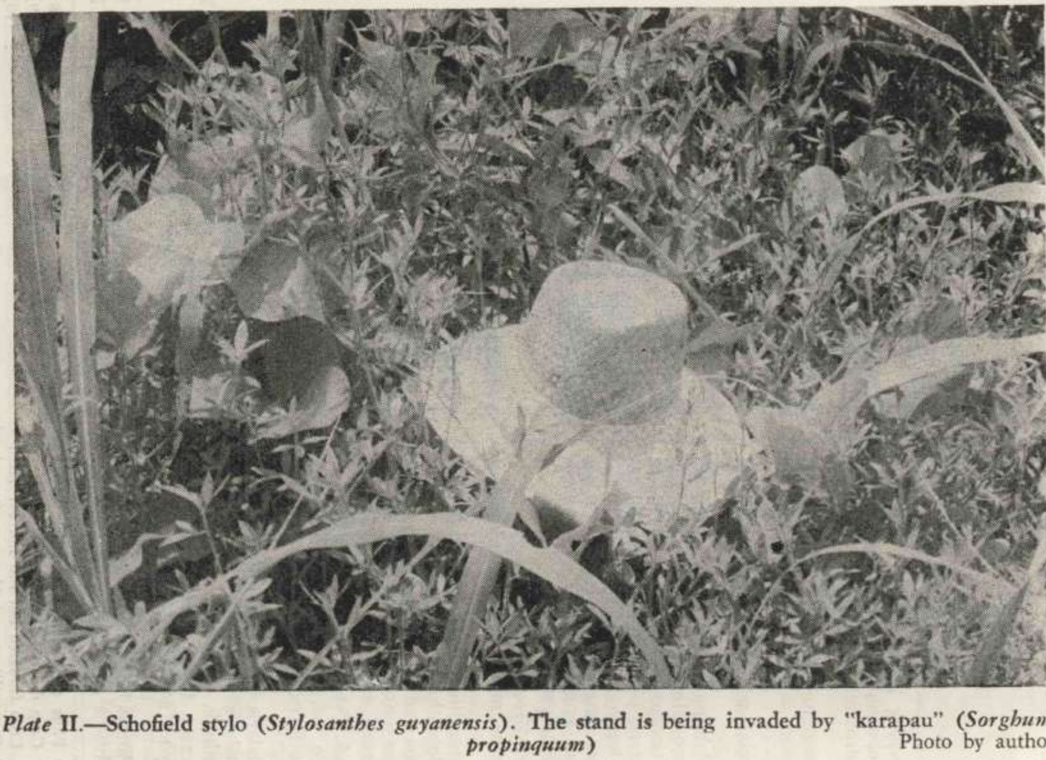

Plate II.—Schofield stylo (*Stylosanthes guyanensis*). The stand is being invaded by "karapau" (*Sorghum propinquum*) Photo by author

SHRUB TYPES.

Acioa barteri. This Rocaceous tree is planted as a fallow crop in Southern Nigeria and is almost the only satisfactory fallow cover which can be established on the leached impoverished acid soils in that region (Newton, 1960).

Growth rate was extremely slow in this evaluation and the crop provided very little competition with vigorous weed growth. It is not worth further consideration for this environment.

Cajanus cajan. Pigeon pea provided a ground cover quickly, particularly for a shrubby legume. It also produces an edible seed, although this is rarely eaten in Papua New Guinea. It is difficult to obtain a seed crop because of insect attack. Henderson (1954) states that pigeon pea is extremely susceptible to insect attack and to pinks disease (*Corticium salmonicolor*). Leaf production was not especially good and the crop was short-lived for a shrub type.

Crotalaria anagyroides. This shrub grew well, although it did not produce a lot of leaf litter nor was it very long-lived. Henderson (1954) states that it is susceptible to pinks disease. Other shrubs performed better than *C. anagyroides.*

Crotalaria goreensis. This short shrub produced a dense ground cover reasonably quickly. It was short-lived.

Flemingia congesta. Flemingia grew very slowly initially, but after four months growth rate was satisfactory. It produced an excellent cover and remained almost weed-free with a good quantity of leaf litter being produced. The crop is still vigorous three and a half years after planting. Other plantings at Keravat have persisted for at least ten years and probably longer. Flemingia suckers and seedlings come up under the crop. It would be difficult to eradicate the crop at the end of the cover cropping phase.

Leucaena leucocephala. Leucaena grew rapidly and produced a good ground cover initially. Leaf production was poor. When the crop is planted densely, the leucaena stems tend to bend after a few years. This allows more light penetration and weed growth occurs under the crop.

Sesbania punctata. This quick-growing, short-lived shrub did not even cover the ground, so it afforded very poor competition with weeds. Top growth production was very poor and it is not worth considering as a cover crop.

Tephrosia candida. This shrub was slow to produce a ground cover, but once it did so it formed a very good weed-free cover. Leaf production was fair. It is long-lived. Henderson (1954) states that it persists for up to three years. In this evaluation it is still growing vigorously three and a half years since planting. On New Hanover, Hale also recorded four months to establish a good ground cover and nine months to flowering.

Ground cover and leaf fall were not as good as flemingia, but it would be easier to remove because it does not sucker.

Tephrosia noctiflora. This was very slow to produce a ground cover, although it was hindered by poor germination. Once established ground cover was satisfactory. Competition with weeds was only fair. The crop started to decline after sixteen months. It is not as good a cover crop as *T. candida.*

FOOD CROPS

A number of the species in the evaluation produce an edible grain. Because of the grain's high protein content and storage ability, grain legumes are most useful and hence it would be valuable if a cover crop also produced an edible grain. Species that produce edible grain in this evaluation were *Cajanus cajan* (pigeon pea), *Glycine max* (soya bean), *Psophocarpus tetragonolobus* (wing bean), *Stizolobium deeringianum* (velvet bean), *Vigna radiata* (green gram), *Vigna unguiculata* (cowpea), and *V. unguiculata sesquipedalis* (yardlong bean).

Of this group the creeping cowpea and velvet bean are the best covers for reasons discussed earlier. The seed of cowpea can be eaten green or dry. Velvet bean did not produce much grain and its use as a food crop is much less widespread than cowpea. Of the others, only pigeon pea was satisfactory as a cover crop and its seed production was poor because of insect attack.

OTHER SPECIES

Two other cover crops were not included in the evaluation because they were known from other plantings to be unsuitable. These were *Mimosa invisa* and *Phaseolus calcaratus.* Notes on these two covers are given below.

Mimosa invisa produces an excellent cover and a good bulk of green material fairly rapidly. However it is difficult to deal with and its aggressive nature, prolific seeding ability and thorny nature make it a weed in garden areas. It is very susceptible to root knot nematodes (*Meloidogyne* spp.) and stands are often killed by nematodes, although they quickly regenerate.

Phaseolus calcaratus. Rice bean was used as a cover crop in the Keravat rotation trial for some years. However it was sometimes killed by nematode attack before it reached maturity (Newton and Jamieson, 1968) and for this reason was replaced by cowpea which at Keravat has been found more resistant to the root knot nematodes.

Plate III.—*Flemingia congesta.* Flemingia produced a dense weed-free cover

Photo by author

Some of the limitations of the evaluation should be pointed out. There was, for most species, no replication in time or space. However, comparison of results with those from West New Britain, New Hanover, other plantings at Keravat and the literature (Whyte *et al.*, (1953) and *Queensland Country Life* (1967)) has provided a check on the results. In most cases the observations were in agreement with those from the other sources.

With the exception of two species only one variety of each was examined. Other varieties may have performed differently. Flowering of several of the legumes is affected by day length, temperature or moisture stress, so flowering behaviour at Keravat may not be the same at different altitudes or at latitudes further south.

Competition from weeds was fairly severe. This however is probably a realistic situation, for the legume crop would be following a food crop in a rotation and at this stage weeds would be becoming a problem.

CONCLUSIONS

Amongst the creeping types puero was the best species as it fulfils most of the requirements listed earlier for a cover crop. Calopo could also be considered if a faster growing species with a shorter life was required. Of the short-lived creeping type species, cowpea, velvet bean and lablab performed well. Each species has some advantages and disadvantages compared with the others. For example velvet bean covers the ground faster than cowpea, but is not as long-lived nor does it seed as well. Lablab persists better than the other two but is more susceptible to grey leaf rot and it seeds in the lowlands only in periods of water stress.

Schofield stylo was the only erect type to perform well and this species could be considered as an alternative to puero.

Both flemingia and *Tephrosia candida* would be excellent long term shrub type cover crops, provided they could be removed effectively when required. Flemingia provided better cover and leaf fall than *T. candida*, but the latter would be easier to remove. *Crotalaria goreensis* would be the best species where a quick-growing short-lived shrub was required. Pigeon pea would also be suitable as a fast-growing, relatively short-lived shrub.

ACKNOWLEDGEMENTS

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PHYTOPHTHORA PALMIVORA POD ROT OF CACAO IN PAPUA NEW GUINEA INVESTIGATIONS 1962—1971

P. G. Hicks*

ABSTRACT

New field infections of P. palmivora *on pods were always present at Keravat in New Britain and no regular high or low incidence seasons occurred during* 1962 *to* 1971. *Incidence was over* 20 *per cent in* 1955-56 *but less than* 3 *per cent in* 1962-65 *and between* 10 *per cent and* 20 *per cent in* 1969-71. *Average annual rainfall for these three periods were* 246, 277 *and* 289 *mm respectively. No adequate records of rainfall type (e.g., drizzle, squall) are available for the first two periods.*

On three occasions in 1963-65 *long distance (beyond* 20 *metres) dispersal, as previously reported from Nigeria, was evident, contrasting with the usual short distance (less than* 4 *m) spread. Control may therefore be directed more economically at individual trees.*

Some obviously susceptible clones have been recorded in the field but it is not clear whether the remainder are escapes or resistant ones.

PREVIOUS STUDIES

The pre-1962 level of incidence (sometimes 25 per cent, Thrower (1960) and van Velsen, unpublished) of *Phytophthora palmivora* pod rot (*Ppr*) on cocoa at Keravat warranted field trials on control of the disease. A trial based on spraying and frequent harvesting found effective overseas (Smith, 1955, Thorold, 1959) was conducted from July, 1962 to September 1965 and was reported by Hicks (1967). Although 3-weekly spraying with Bordeaux mixture resulted in statistically significant control, the practical significance of the results is limited by the low incidence of *Ppr* (4.9 per cent 3-weekly maximum in unsprayed pods over 12 cm long) in this block at that time. The frequent (i.e., weekly compared with the normal three weekly) harvest treatment was ineffective.

LACK OF SEASONAL INCIDENCE

At Agodi and Owena in Nigeria the disease tends to follow a similar course from year to year, less than 3 per cent of the year's *Ppr* being recorded in the January-June period and over 60 per cent in September-November (Thorold, 1955). In Ghana it is also quite seasonal (Lockwood, 1971). With such definite seasons spraying and sanitation can be effective even if applied for only four months of the year.

Monthly incidence from records taken at Keravat mainly for statistical purposes are shown in *Table* 1 for the cuttings of the very susceptible clone K26 during 1962-65 and in *Table* 2 for a mixture of open-pollinated progeny during 1967-71.

It will be noted from the data shown in *Tables* 1 and 2, that no month had consistently less than half the monthly average *Ppr* number for the respective year and each of the six months from November to April scored double the average at least once. Maximum numbers occurred at various times from October to April inclusive. The most consistent pattern is evident for the years 1967 and 1969-71 when June-September periods averaged 12 per cent (range 6 to 20) of their years' *Ppr* total and February to April 43 per cent (30-47).

No regular *Ppr* season is therefore apparent. For the same degree of control it therefore appears that direct spraying or sanitation would be necessary for most of the year at Keravat

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Table 1.—Monthly records of *Ppr* in pods and total number of pods over 12 cm long in K26 cacao cuttings (spacing-pruning trial, Block 708, Keravat)

	1962		1963		1964		1965	
	Ppr	Total	Ppr	Total	Ppr	Total	Ppr	Total
January			4	82*	139	571	152	423
February			f	f	58	149	31	246*
March			f	f	184	278	351	702
April			f	f	101	287	247	671
May			f	f	NA	NA		
June			f	f	NA	NA		
July			32	NA	82	362		
August			195	876	90	224		
September			381	2319	103	466		
October	96	723	336	2005	220	638		
November	78	1524	685	1847	209	734		
December	50	1628	1271	3441	164	547		
"Average"†			260		140			

* 1-3/1/63 and 1-18/2/65 only respectively

† Only where relevant to the text, taking totals of the five f's as 216 and the two NA's as 330, maximum probable sums.

f = Few

NA = Not Available

Table 2.—Monthly counts of *Ppr* in pods and total pods over 12 cm long in a 7/9 acre observation trial on seedling trees planted in 1948 in Block 405, Keravat

Month	1967		1968		1969		1970		1971	
	Ppr	Total	Ppr	Total	Ppr	Total	Ppr	Total	Ppr	Total
January	13	574	147	777	140	964	199	1347	53	636
February	34	415	130	895	165	1216	183	680	67	545
March	74	532			206	705	170	557	121	784
April	53	799			245	1328	62	407	141	692
May	22	838			117	1494	42	526	122	627
June	7	776			11	931	58	433	70	790
July	7	634			6	270	34	280	49	392
August	10	344			35	219	15	319	13	133
September	23	191			31	243	53	447	23	513
October	19	325			44	500	116	498	48	690
November	38	639			114	972	57	363	20	422*
December	44	480			293	534	43	646	28	386*
Average	29	547			117	781	86	542	63	551

* 0.6 of the area sprayed weekly with copper oxide from November 1971.

on blocks with high incidence, certainly for longer than the four months or less in Nigeria or Ghana.

LONG TERM INCIDENCE CHANGES

Estimates of the general incidence levels of *Ppr* in pods over 12 cm long at Keravat over much of the 1955-1971 interval are shown together with total rainfall in *Table* 3.

The results show that even taking full account of variation between estimates, it remains clear that incidence was much lower in the 1962-65 period than in 1955-56 and 1969-71. In 1962-65 only the K26 clone (*Table* 1) and a few others (between 0 and 3 according to various estimates) of 60 under observation had incidence of *Ppr* above 3 per cent.

Although Thrower (1960) and Hicks (unpublished details of the 1962-65 trial) at Keravat found strong positive correlations between *Ppr* incidence and total rainfall taking unit intervals of 30 days or less, the data from *Table* 3 show that some years of high incidence had about the same or lower rainfall than years of much lower incidence. It appears that some factor other than total rainfall is significant over these long periods. Temperature, atmospheric humidity and bright sunshine records have also been examined but none have indicated why incidence in 1962-65 was so low.

The author wonders whether there were more periods of extended drizzle (which are inadequately recorded on available pluviometers) in 1967-71 than in 1962-65. In future visual observations on these periods will be recorded with emphasis on determining the effect of duration rather than intensity of rain on the incidence of the disease.

DISPERSION

Thorold (1955) found gradients of both short (less than 4 m) and long (over 180 m) distance dispersion and asserted that these resulted respectively from rain splash and airborne (less frequent) dispersal of sporangia.

Materials

There were large, apparently uninfected, areas of young heavily bearing cacao at Keravat in 1962 (*Figure* 1).

The seed of the cocoa in Blocks 108, 309 and 2010 had been selected mainly on yielding ability of the parent (mother) trees, and planted in small plots at random with respect to resistance to *Ppr*. The cacao in Blocks 3010 and 708 had been planted as cuttings selected on the yielding ability of the parent trees, and sections of these blocks consisted largely of one clone of one grade of susceptibility, although over the whole block there were clones with a fairly continuous range of susceptibilities.

The spacing-pruning trial (two areas marked S in *Figure* 3) consisted of 20 small plots of trees of the KA5-104 clone, each surrounded and separated by single guard lines of trees of the very susceptible clone K26 which can be considered evenly distributed throughout this area. The remainder of Block 708 (Clone test series I-V) consisted of rectangular sections, each planted predominantly with a single clone (184 trees) with single six tree plots of nine other clones evenly spaced within it.

Table 3.—**Rainfall and estimated *Phytophthora* pod rot incidence on cacao at Keravat**

Period	Average Annual Rainfall (mm)	Estimated Average Incidence* (pods over 12 mm long)
1955-56	2460	Above 20%†
1959-61	3050	Between 5% and 25%‡
1962-65	2770	Below 3%
1967	3150	Between 3% and 10%
1969-71	2890	Between 10% and 20%

* After considering how the recorded level of incidence may vary according to observers, assessment methods, clones, shade, sanitation, spread and other factors, the author is 99 per cent confident that an estimate of average incidence for each period specified in column 1 would have been between the limits shown in column 3.

† Derived from Thrower (1960).

‡ Derived from van Velsen's figures (Hicks 1967).

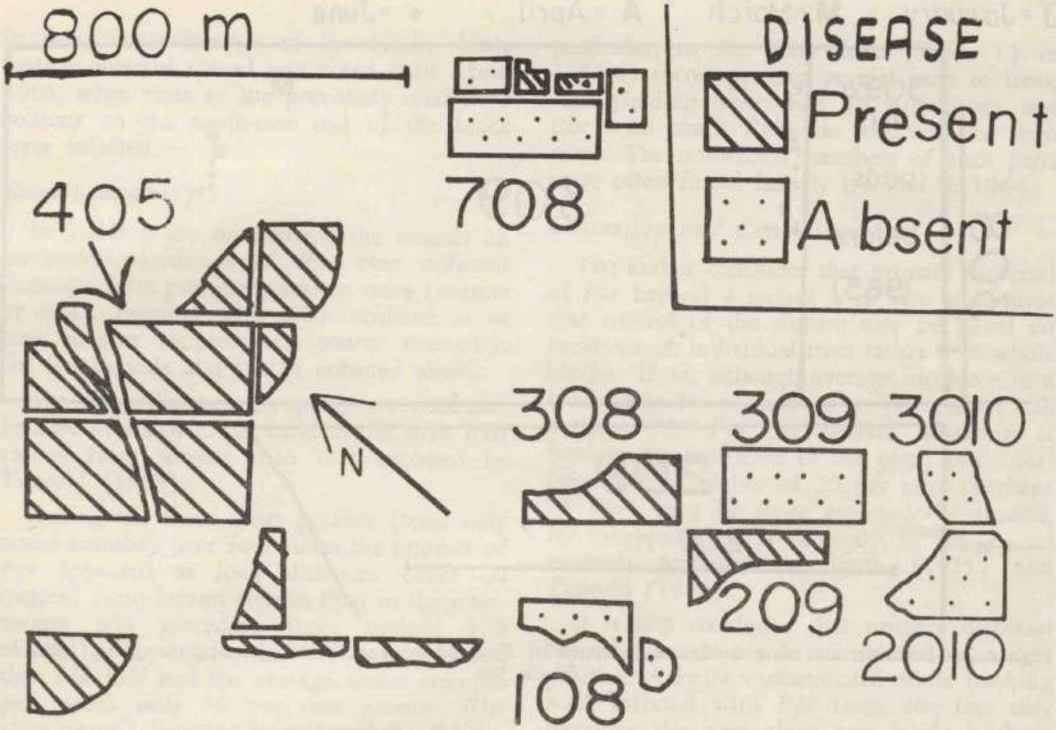

Figure 1.—Distribution of *Phytophthora* pod rot in bearing cacao at Keravat in 1962. Block 405, in the middle of a group of infected blocks, is arrowed

Observations

In order to observe the unassisted (i.e., from natural foci) spread of *Ppr*, all the trees in these areas were checked at least monthly and the presence of the disease recorded.

Some pods were maturing on the trees all the time, with ratios within clones usually less than 8:1 between the high and low month yields. Ratios as high as 3441:149 (23:1) as shown in *Table* 1, were rather unusual.

In the period October, 1962 to June, 1965 no *Ppr* was found in Block 3010. In Block 2010 three widely separate trees, each with one to three cases, were found in April, 1964, and two others in the succeeding 14 months.

In Block 108, three adjacent trees became infected between January and July, 1963. Newly infected trees were found at distances of 13, 14, 16, 16, 26 and 39 metres respectively from them in August, September and October of 1963. Observations were discontinued after a group of three trees at the end of the block over 100 metres from those previously affected, was found infected in April, 1964.

In Block 309 no *Ppr* was noted prior to January, 1965. The records from then on are shown in *Figure* 2. There was a marked increase in the number of infected trees in April, May and June, 1965 with many of the June infected trees within 20 metres of ones infected earlier.

The spread of *Ppr* through Block 708 is illustrated in *Figure* 3. Although it is apparent that the clones differed in susceptibility to *Ppr*, the sequence of epidemics in Block 708 is still fairly clear.

For the first three months from November, 1962 to January, 1963 *Ppr* in Block 708 was confined to small areas of the spacing-pruning trial only. All infected pods were harvested weekly and left on the ground. After January, 1963 counting was discontinued while incidence was very low, until July, 1963 when 32 cases were seen, all within the previously affected area. Thenceforth, only approximately 50 per cent of the infected pods in the block were removed at 3-weekly intervals. By 3rd October, 1963 cases were noted on trees scattered over the remainder of the spacing-pruning trial and

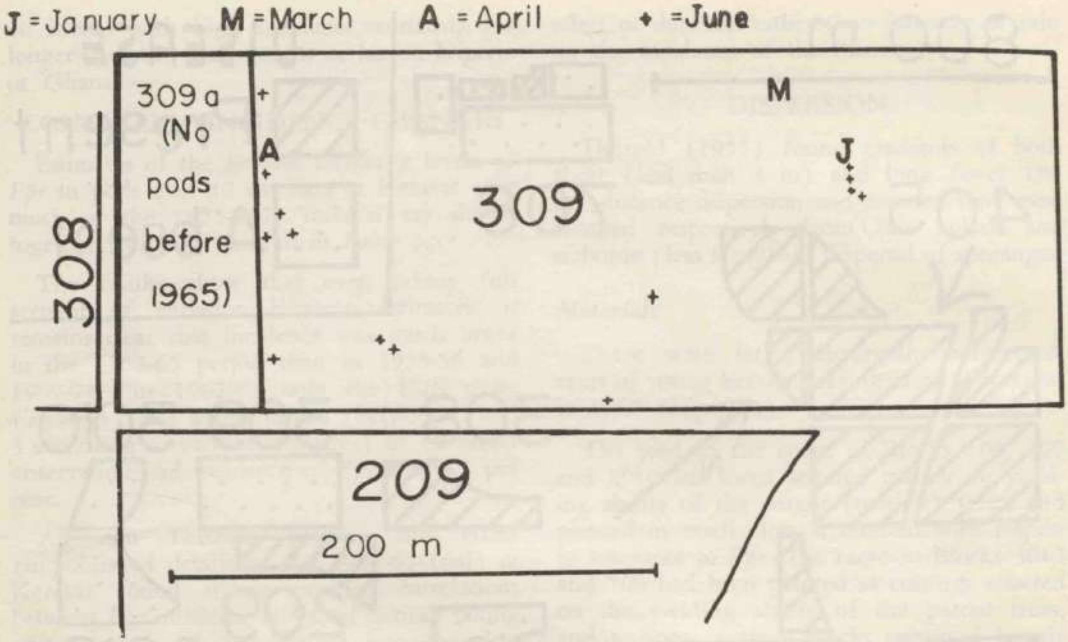

Figure 2.—Location and date of first occurrence of *Phytophthora* pod rot, January to June, 1965 in Block 309

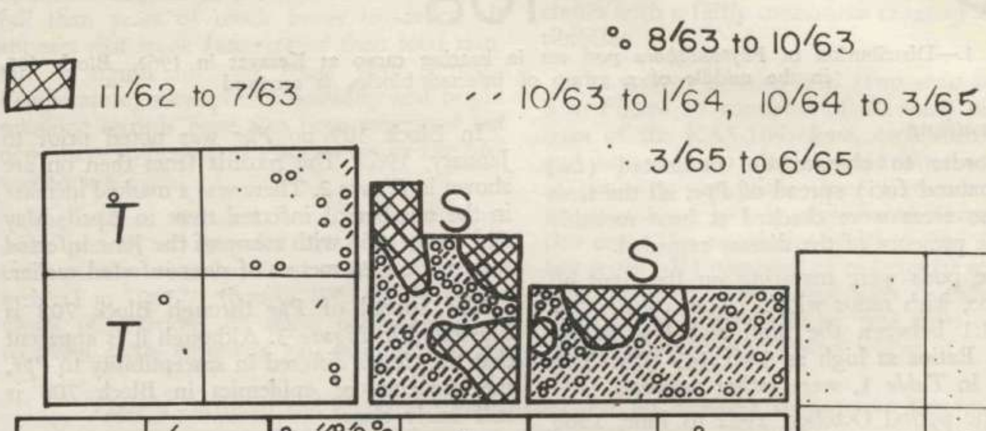

Figure 3.—Dates and location where *Phytophthora* pod rot was first seen in Block 708. Except for the spacing-pruning trial, S, symbols represent individual trees (T = few pods produced) in some other sections of the block. Little further outward spread was noted until April, 1965, when trees in the previously unaffected sections on the south-east end of the block were infected.

Results summary

In *Table* 4 are summarised the records on successive occurrence of *Ppr* over different distances from previously known cases (sources or foci), together with K26 incidence at or near sources (approximate source strength), for the periods and blocks outlined above.

The large distance groupings are necessary because of much lower incidence at over four metres from sources than that reported by Thorold (1955).

During the three short periods (total only seven months) over four times the number of *Ppr* appeared at long distances (over 20 metres) from known sources than in the intervening and preceding three periods (26 months). The total source strength was less than one half and the average source strength per month only 50 per cent greater. The spraying and frequent harvesting trial (Hicks, 1967) records (unpublished) showed that conditions during the stated short periods would have favoured no more than an average of double the normal monthly incidence. Average numbers of large pods on the trees were also about the same for the two sets of periods.

Observations at Keravat generally show the relative absence of long distance dispersal with many cases of escape for over a year. In particular, in the K26 clone (*Table* 1) in 1962-63 there appeared several pairs of trees, each yielding more than 50 large pods, one tree with much *Ppr*, the adjacent one with none. The uninfected members of such pairs were often found heavily infected in 1964.

Discussion and Conclusions

The author concludes that primary dispersal of *Ppr* beyond 4 metres is so rare at Keravat that control of the disease may be based on incidence on individual trees rather than whole blocks. If so, although average incidence in a block may be as low as 3 per cent (with perhaps 700 *Ppr* per hectare occurring at random through most of the year) individual trees with incidence of 20 per cent (perhaps 25 *Ppr*) may be more economically treated, for the whole year if necessary, by the general methods proposed by Smith (1955) and Thorold (1959).

It is also concluded that primary dispersal beyond 4 metres can be accentuated by careless practice. A knife contaminated while hooking pods infected with *Ppr* from one tree may inoculate the next clean tree while hooking pods rotted from other causes.

Although Thorold (1953) published figures showing nonrandom distribution of *Ppr* neither his nor any other publication seen has emphasised individual trees as targets of control.

RESISTANCE

Thrower (1960) published results of field trials and laboratory tests in 1955-57 showing that pods from some cacao trees were more

Table 4.—**Number of new *Ppr* cases recorded at intervals from cases recorded within six months previously (sources) October, 1962 to June, 1965. Numbers expected from source strengths (calculated from bottom line) are in parentheses, e.g., (80 + 49) × 1800/(1800 + 4300) = 38**

Interval	Short Periods 8-10/63, 4/64, 4-6/65 (7 Months Total)	Remaining Periods (26 Months Total)	Significance (Chi squared contingency)
Over 20 m	55 (20)	13 (48)	Less than 0.001
4 m to 20 m	80 (38)	49 (91)	Less than 0.001
Less than 4 m (from Table 1 and unpublished records)	Less than 1800	More than 4300	—

resistant to *Ppr* than those from others. In particular, he classed K23-102 as very susceptible (between 40 and 100 per cent incidence in the field) and K5 as resistant (5-10 per cent).

Laboratory tests (unpublished) between 1962 and 1965 show some correlation with Thrower's results.

Because of low incidence the surveys on blocks of cuttings in 1962-67 revealed no significant resistance. A block of cuttings from the "very susceptible" K23-102 had been planted in 1958 in Block 708, separated by a 6-metre wide roadway from the clone K26 in the spacing-pruning trial (*Table* 1). It bore over 10,000 pods, none found infected, in the 1962-65 period, while trees of two other clones planted within the block were infected. The surviving mother tree in Block 405 yielded 832 pods, only one with *Ppr*, in the period January, 1967 to April, 1968 and January, 1969 to September, 1970. In 1971 when 11.4 per cent average infection was recorded in the Block 405 trial the K23-102 mother tree and cuttings from it continued to have less than 0.5 per cent *Ppr* while cuttings from the "resistant" K5 had over 10 per cent infection.

Surveys were resumed on blocks of cuttings in 1969. From December, 1969 to March, 1970 two or more plots each bearing over 100 pods were checked for each of eleven clones. The incidence ranges between plots for the clones were 5-54, 1-3, 4-10, 22-30, 0-1, 1-3, 1-4, 4-86, 11-46, 0-4 and 0-56 per cent. They were checked thereafter when the author expected an incidence maximum. The 4-10 and 1-4 clones changed the most to 31 and 44 respectively in April 1971. Variation between adjacent trees within plots was much higher showing further that even readings from blocks of cuttings for one year appear insufficient for assessing general resistance/susceptibility levels. Further readings are therefore necessary to classify any clone with consistently less than 20 per cent field infection as "resistant" but those with over 20 per cent field infection in some years may be classed as "susceptible".

The undisturbed pods on some cuttings have been sprayed with zoospore suspensions. Of those tested only the clone K82 has had low incidence both naturally and following such artificial inoculation.

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EFFECTIVENESS OF LINDANE, DDT AND MONOCROTOPHOS FOR THE CONTROL OF THE CORN BORER *OSTRINIA FURNICALIS* GUENEE (LEPIDOPTERA: PYRALIDAE) IN MAIZE ON NEW BRITAIN

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ABSTRACT

Within Papua New Guinea the corn borer Ostrinia furnicalis *Guen. is a pest of maize in the Gazelle Peninsula of New Britain and on New Ireland. DDT (e.c.), lindane (granules and e.c.) and monocrotophos (w-s.c.) were tested against* O. furnicalis *in maize at the Lowlands Agricultural Experiment Station, Keravat, New Britain. Both monocrotophos as a water soluble concentrate, and lindane granules when applied at* 6, 8, 10 *and* 12 *weeks post planting at the rate of* 1 *kg a.i. per hectare per application significantly reduced the incidence of borer in both stem and cobs. However significant yield differences were not obtained.*

INTRODUCTION

The corn borer *Ostrinia furnicalis* Guen. (synonyms of which include *Pyrausta nubilalis* (Hubner var. *salentialis* Snellen) and *P. damoalis* (Walker) (Mutuura and Munroe (1970)) is an important pest of maize in the oriental region (Jepson, 1954). Within Papua New Guinea, *O. furnicalis* has been recorded from East New Britain, New Ireland, and the Morobe and Northern Districts on the New Guinea mainland from maize, sugarcane and rice.

O. furnicalis damage to maize is often severe in native food gardens on the Gazelle Peninsula of New Britain and also on New Ireland. In 1970, maize introduction plots and yield trials at the Lowlands Agricultural Experiment Station suffered severe but sporadic damage. The first crop of a high lysine hybrid maize variety introduced from Michigan, U.S.A. (NG.6683), suffered heavy damage at the end of its growing period between March and May 1970. The second crop of this variety was sprayed weekly with DDT at the rate of 1.4 kg per hectare. Damage was minimal and confined to infestations in the tassel late in the growing period of the crop.

In a third variety trial, despite weekly applications of DDT at the same rate, stem and cob damage was severe. At harvest, 95 per cent of plants of both NG.6683 and a local variety were infested. Twelve per cent of cobs of these two varieties were damaged and considered unsaleable. In the same variety trial, 80 to 90 per cent of plants of the Queensland introduction QK 37 (NG.6658) were also infested.

In two subsequent variety trials, despite applications of lindane granules, 44 and 81 per cent of plants were infested respectively. The granules were applied at the rate of 1 kg per hectare at 9 and 11 weeks after planting in trial four and at 6 and 8 weeks after planting in trial five.

The biology and chemical control of *O. furnicalis* in Malaysia has been critically reviewed by Yunus and Thian Hua (1969). These authors concluded that the borer "has a life cycle of about four weeks, with an incubation period of three days, a larval period of about 18 days and a pupal period of six days. The larval stage has five instars. Adults live for an average of about six days. There are at least 11, probably 12, generations in one year and the generations overlap in the

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field. The larva spends about nine days in the leaf whorl before boring into the plant. It is then in its 3rd or 4th instar".

The same authors carried out a series of three field trials and one laboratory screening trial. In the first field trial six insecticides, namely BHC, dieldrin, carbaryl, endosulfan, endrin and trichlorphon were evaluated as foliar sprays against the corn borer. BHC and dieldrin were the most effective materials used. In the second trial, four different formulations (dust, granules, emulsion and wettable powder) of BHC and dieldrin were tested. With a total of four applications granules, emulsion and wettable powder were demonstrated to be equally effective. Dust was not as effective as the other three formulations. In another trial, the number of applications, the interval between applications and the time of first application were determined. In this trial 6 per cent BHC granules at the rate of 15 lb per acre were used. It was found that four applications at fortnightly intervals commencing from one month after sowing was most effective for borer control.

In the laboratory trial to evaluate newer chemicals, five insecticides namely phosphamidon, dicrotophos, fenitrothion, Phenthoate (R) and dichlorvos were compared with BHC. Results of this trial indicated that BHC was still the superior insecticide. Dicrotophos was the second most effective chemical.

Consequently a trial comparing DDT (e.c.), lindane (as both an e.c. and a granular formulation) and monocrotophos, a material closely related to dicrotophos, was carried out at Keravat during the period March to July 1971.

MATERIALS AND METHOD

The insecticides, the formulations and application rates tested are shown in *Table* 1.

The treatments were compared in a randomized block with four replications per treatment. Plot size was 9 by 9 metres (0.00836 hectare). Two guard rows separated each plot from its neighbours.

F2 seed of the hybrid NG.6658 was planted in rows 0.9 metres apart and at 30 cm spacing within rows. Three seeds were planted at each position. The crop was planted six weeks after an infested maize crop had been harvested from the same area. Although pregermination tests were carried out, final germination was erratic and some transplanting was required to provide a more even plant distribution within the plots. At five weeks, the seedlings were thinned out to one plant per position and a basal dressing of NPK-Mg (12:12:17:2) compound fertilizer at a rate equivalent to 434 kg/ha was applied to all plots.

The emulsifiable and water-soluble concentrate formulations were applied by knapsack sprayer at an equivalent rate of 750 1/ha at the first application and then at an equivalent rate of 1000 1/ha for the remaining applications.

The granule formulation was applied by hand from a small plastic dispenser. The insecticides were applied at 6, 8, 10 and 12 weeks after field planting. Periodic sampling of levels of infestations were made in each plot by randomly selecting 10 per cent of the total plants in each plot.

All plots were harvested on 7th July, 110 days after planting. Measurement of the level of infestation, the weight of cobs and the amount of cob damage were made from all plants in each harvested block.

RESULTS AND DISCUSSION

The level of infestation of *O. furnicalis* in the various treatments during the growing period of the crop is shown in *Table* 2.

It can be seen that the lowest populations of *O. furnicalis* were maintained in plots treated

Table 1.—Insecticide treatments

Material	Formulation	Application rate (kg active ingredient per hectare)	Cost of treatment per application per hectare
DDT	25% w/v e.c.	1.5	$ 3.76
Lindane	16% w/v e.c.	1.0	$ 9.62
Lindane	6% w/w granule	1.0	$ 7.01
Monocrotophos	60% w/v w-s.c.	1.0	$13.93

Table 2.—Levels of corn borer infestation in each treatment

Weeks from planting	Per cent of plants infested in plots treated with				
	Monocrotophos	Lindane granule	Lindane spray	DDT	Nil
10	8	10	17	43	19
11	14	18	32	36	23
12	8	18	22	40	35
13	9	33	33	33	58
14	10	35	38	35	41
15	7	33	28	32	42

Table 3.—*O. furnicalis* infestation in maize plants at harvest

Treatment	Per cent plants infested				
	Nil infestation*	Tassel only	Single stem	Multiple stem	Total infested* stems—single and multiple
Control	41.3 a b	29.9	13.0	15.8	28.8 a b
DDT	36.0 a	33.1	14.2	16.7	30.9 a
Lindane (e.c.)	45.8 b	26.2	14.0	14.0	28.0 b
Lindane (g)	52.2 c	28.7	12.1	7.0	19.1 c
Monocrotophos	65.6 d	23.2	7.7	3.5	11.2 d

* Treatments followed by the same letter or letters do not differ significantly at $p = 0.01$ (Result analysed by Student-Newman-Keul Test)

Table 4.—Effect of treatments on insect damage to cobs and on yield

Treatment	Per cent Insect Damaged Cobs*	Yield (kg/ha)
Monocrotophos	4.8 a	2407
Lindane (g)	6.3 a	1917
Lindane (e.c.)	10.9 b	2381
DDT	16.4 c	2032
Control	15.4 c	2303

* Treatments followed by the same letter do not differ significantly at $p = 0.01$ (Results analysed by the Student-Newman-Keul Test).

with monocrotophos. There was little difference between the levels of infestation in the other treatments.

At harvest each individual plant was examined for *O. furnicalis* damage and classified into one of the following classes; free, single infestation in stem, multiple infestation in stem and tassel only infestation. Results are shown in *Table* 3.

As was to be expected from the data obtained during the growing season (see *Table* 2), the monocrotophos treatment resulted in the lowest level of infestation. Lindane granules were the next best treatment followed by lindane emulsifiable concentrate. Levels of infestation in DDT treated plots were not significantly different from those in the control plots.

All cobs were collected from the harvested plants and examined for insect damage. The cobs were then weighed and yield figures obtained. Results are shown in *Table* 4.

Both monocrotophos and lindane granules significantly reduced the incidence of *O. furnicalis* damage to cobs. There was no difference between the DDT and control treatments.

Surprisingly, there were no significant differences between yields from the various treatments. Agronomically, the average yield of 2208 kg/ha was considered poor for the area.

One other point of interest was that the monocrotophos treatment also provided excellent control of the corn aphid *Rhopalosiphum maidis* (Fitch) which was prevalent in all plots during the initial period of rapid vegetative growth of the crop. Relatively high populations of *R. maidis* were maintained in all other treatments.

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TUNA OFFAL MEAL FOR GROWING PIGS

G. L. MALYNICZ AND H. NAD*

ABSTRACT

Tuna offal meal was produced in experimental quantities by a tuna processing factory at Kavieng. In the first trial it was compared with two imported fishmeals and found to be inferior. In a second experiment three levels of tuna meal were compared with or without a vitamin-trace element supplement. The supplement produced highly significant beneficial effects on performance. The level of fishmeal also had some effect, but this was much smaller than that due to the supplement.

INTRODUCTION

The properties of fishmeal as a stockfood have been described by Woodman (1933) who commented on the high content of protein, its high digestibility, the high quality of the protein in terms of amino acids and the high vitamin and mineral content. Woodman also drew attention to the problem of meat taint caused by oil content higher than 5 per cent.

At present there is no locally produced protein source for feeding pigs and poultry in Papua New Guinea. Meatmeal, fishmeal and proprietary supplements are all imported. The present report describes two preliminary experiments designed to evaluate a locally produced batch of tuna (*Katsuwonus pelamis*) offal meal.

MATERIALS AND METHODS

The meal was prepared in the following way: tuna offals, including heads, fins, tails, scales and spines, but excluding vis era, were boiled in a shallow vat for 2 hours. After cooling, the offal was placed in a forced hot air drier for 2 hours. It was then dried for 8 hours before finally being placed in the hot air drier for 5 hours. The dried offal was then hammermilled. The resultant meal contained 10 per cent moisture and 16.5 per cent fat.

Experiment One

This was designed to compare the performance of pigs fed a ration using tuna offal meal with rations containing two imported fishmeals. The imported fishmeals were designated new and old. The chemical composition of the three fishmeals was determined and is shown in *Table* 1. The composition of the three rations used is shown in *Table* 2. The rations were composed only of fishmeal and sorghum; no additional vitamin or mineral supplements were used.

Twenty four weaner pigs comprising four litters of six were allocated at random to the three treatments, in a randomised block design, so that there were two pigs from each litter on each treatment;

The pigs were housed in concrete floored individual feeding pens which measured 150 x 90 cm. Water and feed were available *ad*

***Table* 1.—The chemical composition of three fishmeals* used in Experiment One**

		Tuna Meal	New Fishmeal	Old Fishmeal
Dry Matter	%	90.3	87.8	84.3
Crude Protein	%	47.4	60.5	72.0
Ash	%	23.1	14.7	19.3

* The above analysis was conducted by W. J. Turner, Department of Agriculture, Stock and Fisheries, Lae, Papua New Guinea.

***Table* 2.—Composition of rations used in Experiment One**

		Tuna Meal	New Fishmeal	Old Fishmeal
Fishmeal	%	23.7	17.6	14.3
Ground Sorghum	%	76.3	82.4	85.7
Moisture	%	11.5	11.1	12.0
Crude Protein	%	17.7	18.9	16.9

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libitum. Food consumption was measured daily and pigs weighed weekly during the experiment which lasted 87 days. Food conversion ratio, weight gain and food consumption were subjected to analysis of variance.

Experiment Two

This was designed to study the effect of protein level and supplementation with vitamins and minerals in rations formulated from tuna offal meal and sorghum. Three combinations of tuna meal were fed each with or without the addition of a vitamin mineral supplement. The rations used are shown in *Table* 3. Four litters of six weaner pigs were allocated on the basis of litter origin to one of the six treatments in a randomised block design. The pigs were housed and fed in groups in half-covered pens having an area of 18 m^2. Food and water were available *ad libitum.*

Food consumption of each group was measured as was individual liveweight gain. Weight gain data were analysed by covariance with initial weight as the co-variate.

Table 3.—Composition of rations used in Experiment Two

Rations		1	1A	2	2A	3	3A
Tuna Meal	%	16.5	16.5	20	20	25	25
Ground Sorghum	%	83.5	83.5	80	80	75	75
Vitamin/Mineral Supplement (g/Kg)[1]		—	2.2	—	2.2	—	2.2

1 Chemical Resources Pty/Limited, Artarmon, N.S.W. Contains per kilo of premix, Vit. A, 3,300,000 IU, Vit. D, 660,000 IU Vit. B2, 1.37 g. Vit. E., 3,300 IU, Cu. 22 g. I 0.22 g., Fe 88 g., Mn., 44 g., Zn 110 g.

RESULTS AND DISCUSSION

Experiment One

The results of the experiment are shown in *Table* 4. The performance of pigs receiving tuna offal meal was inferior to that of pigs receiving the imported meals. Weight gain and food consumption were significantly inferior.

Table 2 shows that the samples of the rations which were analysed were not exactly iso-nitrogenous. It is unlikely that the relatively small observed differences in crude protein content could have caused the inferior performance of pigs on the tuna meal treatment.

Table 4.—The growth performance of pigs fed three fishmeals

	Tuna Meal	New Fishmeal	Old Fishmeal
Initial Weight (kg)	14.25	15.00	14.65
Daily Weight gain (g)[1]	458	590	577
Voluntary feed consumption (kg)[2]	1.56	1.92	1.92
Feed conversion ratio[3]	3.39	3.25	3.33

1Tuna meal significantly lower than old and new ($p < 0.01$).

2Tuna meal significantly lower than old and new ($p < 0.05$).

3No significant difference.

Table 5.—The effect of level of tuna offal meal and vitamin mineral supplementation on growing pigs

	Level of fishmeal (%)				
	16.5	20	25	Non Supplemented	Supplemented
Average daily weight gain (g)[1]	655	603	673	550	737
Average daily food consumption (g)	1820	1555	1675	1573	1793
Food conversion ratio	2.78	2.58	2.49	2.86	2.43

1There were significant differences in means due to level of fishmeal ($p > 0.05$) and supplementation ($p > 0.001$).

Experiment Two

The results of this experiment are shown in *Table* 5. There were significant differences in mean daily weight gain due to level of tuna offal meal. Food consumption and weight gain were least at the 20 per cent level of fishmeal. Food conversion ratio improved as the level of fishmeal increased.

The increase in daily gain resulting from the addition of the vitamin-mineral supplement was large and highly significant. Supplemented pigs grew 34 per cent more quickly. The effect of supplementation declined as levels of fishmeal rose, due possibly to the natural levels of micro-nutrients in the meal. It appears, therefore, that tuna offal meal, while a reasonable source of protein and probably calcium and phosphorus, is deficient in vitamins or trace elements. Any rations made using this ingredient would require adequate supplementation.

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THE MARINE TOAD, *BUFO MARINUS*, IN PAPUA NEW GUINEA

J. R. Pippet*

ABSTRACT

In an attempt to assess the economic effect of Bufo marinus, *two different types of agricultural areas were selected for survey. Routine collections were made at a cocoa plantation near Popondetta in the Northern District of Papua New Guinea, and at the Plant Quarantine Station, Laloki, in the Central District of Papua New Guinea. The stomach contents of all individuals were identified at least to family level and more precisely if possible. An assessment was then made of the economic status, i.e., beneficial or harmful, of each grouping. The results indicate that in certain situations the presence of* Bufo marinus *can be beneficial.*

INTRODUCTION

The marine toad, *Bufo marinus* is a native of the lowlands of central and northern South America.

This toad is a savanna species with a propensity for eating insects and other arthropods, and has been introduced into many tropical countries as a biological control measure against pests which attack commercial crops.

Bufo marinus was first introduced into Papua New Guinea in February, 1937 at the Department of Agriculture, Stock and Fisheries' experimental station at Keravat, near Rabaul, New Britain, in an effort to control the Sweet Potato Moth, *Hippotion celerio*, a serious pest at the time. A considerable degree of success was achieved in Keravat as it was reported that there was a 100 per cent control of the moth (Lear, 1970).

There does not appear to be any record of its introduction into Papua New Guinea although it is believed that prior to World War II, the Department of Public Health brought the toads to Port Moresby for use in pregnancy tests. In this role the toad was not successful, and was either released or escaped.

The purpose of the present study was to examine areas in which *Bufo marinus* was already established, and where the food taken was more likely to be of economic importance in order to further study the usefulness, if any, of the toad in Papua New Guinea.

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It will be appreciated that there are considerable difficulties in "pigeon-holing" the majority of organisms in terms of economic importance. What may be termed a pest in one area, could well be of no significance in another.

Distribution and Reproduction

The following brief summary has been taken from Zug *et al.* (1974). *Bufo marinus* has spread throughout the lowlands and islands of Papua New Guinea below the 300 metre contour, with the exceptions of the Sogeri Plateau 600 metres altitude, and Wau Valley (786 metres). It was also introduced to Goroka (1525 metres), but did not survive there.

Bufo marinus has not been found in the Gulf District or, with the exception of Daru Island, in the Western District. *Figure* 1, taken from Zug *et al.* is a distribution map of the toad in Papua New Guinea.

As the minimal critical temperature for *Bufo marinus* is 15° C (Stuart, 1951) it is unlikely that the toads will move into the highlands above the 1475 metre contour, where the air temperature frequently falls below 15° C. This would bear out their disappearance from Goroka.

Since *Bufo marinus* appears to have been remarkably successful in colonising areas into which it has been introduced, especially urban areas, and since *Bufo marinus* does not have any known predators in Papua New Guinea, it would seem that temperature could be the most

***Figure* 1.—Distribution of *Bufo marinus* in Papua New Guinea. The continuous line on the mainland and larger islands shows the approximate 300 m contour. *Bufo* present ● *Bufo* absent °**

important factor in restricting it to elevations where the air temperature does not frequently fall below 15 degrees.

Bufo marinus will breed in almost any body of water, either fresh or brackish. Although preferring standing water it will breed in rivers. As some of the toads are able to breed throughout the year they are able to take advantage of any heavy rains, which trigger their breeding cycle.

About 10,000 jet-black eggs imbedded in a gelatine-like substance are laid in long ropes of up to 23 metres in length. These ropes are curled around vegetation at the water's edge. The eggs hatch within two to three days and the tadpoles take about thirty days to complete their metamorphosis (Oliver, 1949). The newly developed toad is about 6 mm long. The toadlets usually stay in the vicinity of their pond for about four days feeding on ants and small flies, they then disperse into the surrounding vegetation.

The female may have two breeding cycles during the year.

METHODS

Over a two-year period collections were made in seven different localities. In 1971-72 collections were made bi-monthly at the Waigani Sewage Farm 14 kilometres north-west of Port Moresby and along a 10 kilometre stretch of the Brown River Road bordered by forest and 24-34 kilometres north-west of Port Moresby. As neither of these areas is of any agricultural importance, we concentrated during 1973 on two diverse areas which are agriculturally more significant.

1) The DASF quarantine station on the alluvial plains of the Laloki River, 15 kilometres north-west of Port Moresby, in an area used for growing vegetables.
2) A cocoa plantation at Serovi, near Popondetta, in the Northern District.

Collections were made at monthly intervals on the last quarter of the lunar phase between 2000-2100 hours. Fifty *Bufo marinus* were taken monthly at Popondetta; the numbers taken at Laloki varied between 17-50 depending on the number it was possible to pick up in the time available.

Toads collected at Popondetta were injected with formalin and flown to Port Moresby for examination, whilst those collected at Laloki were deep frozen on the night they were captured.

All toads were weighed, measured (snout-vent length) and sexed. The fat body was also recorded, and the ovaries of the females were weighed and classed according to their degree of maturity. Stomach contents were weighed and classified, at least to family level and if possible to species. They were then classified as either harmful, neutral or beneficial according to their economic importance. The classification was based on the experience of the DASF entomologists for the more important pests of Papua New Guinea, whilst Imms (1964) and CSIRO (1970) were used for determining minor pests.

In order to gauge the variety of insects in the area an ultra-violet light trap was run at the Laloki collecting station, weather permitting. The trap was started after the collection of *Bufo marinus* had been made and ran until the following morning, approximately 11 hours running time.

Tables 1 and 2 show the numbers and type of prey taken by *Bufo marinus* at Laloki and Popondetta respectively. In each case the four largest groups are Coleoptera (296 individuals at Laloki/824 individuals at Popondetta), Lepidoptera (302/453), Hemiptera (143/375), Orthoptera (132/87) and Myriapoda (6/176). The reason for Laloki having a greater proportion of Orthoptera as opposed to other orders, is probably due both to the extensive use of cover crop prior to ploughing and planting and the type of crop grown, i.e., market garden produce, which appear to be particularly favoured by grasshoppers, at least in the Port Moresby area.

Light trapping at Waigani Sewage Farm gave an average biomass of 6 grams, often consisting mainly of moths which had been attracted to the light, and were seldom found in the stomachs of toads collected prior to the setting of the light trap.

At Laloki only spasmodic light trapping was carried out, and the results are inconclusive. However, the biomass of the catch was more than double that of the Waigani Sewage Farm, being 13.6 grams. Here again a considerable number of Lepidoptera was taken, although the analysis of the stomachs show relatively few imagos in comparison with the numbers attracted to the light trap.

Prey taken from the stomachs of captured *Bufo marinus* was so far as practical divided into three categories: beneficial, neutral and harmful. *Tables* 3 and 4 list the number of individuals and their suggested economic category.

In the Laloki area (*Table* 3) the harmful species exceeded the combined total of the beneficial and neutral in both numbers and biomass, whilst in the Popondetta area (*Table* 4) the number of beneficial and neutral species exceeds that of the harmful species, although the biomass of the latter is very much greater than that of the beneficial and neutral species combined.

DISCUSSION

Bufo marinus is omnivorous and will grab at anything which moves and is small enough to swallow. It was originally thought that the toads were only attracted to moving objects, regardless of whether they were edible or not (Oliver in Alexander, 1964). Alexander (1964) also refers to the toads' taste for dog food. Our studies have confirmed this for Papua New Guinea as it is a very common sight in the urban areas of Papua New Guinea to see toads around a dog's dish eating the left-overs of canned pet food and rice.

At the Waigani Swamp Pond where the population of *Bufo marinus* appears to have reached saturation point, we found that the majority of the population was both undersized and emaciated, nor was it uncommon to find up to 20 per cent of the night's catch with either stomachs crammed full of grass and leaves, or empty.

It would seem that the toads whose stomachs were full of grass had purposely eaten the vegetation, since there were no insects amongst the grass.

The catch from the light trap bears out the paucity of insects available to the toads over 7-8 months of the year.

In none of the other areas from which collections were made did we find toads with their stomachs full of grass and nothing else. It is naturally quite common to find pieces of vegetation in the stomach contents of *Bufo marinus*, such pieces have been ingested when the toad snapped at its prey.

Table 1.—Stomach contents of *Bufo marinus* taken at Laloki between January and December, 1973. Number of individuals 351. Mean stomach contents 1.5 g

ANNELIDA
OLIGOCHAETA
1 earthworm
MOLLUSCA
GASTROPODA
1 snail
ARTHROPODA
CRUSTACEA
ISOPODA
2 slaters
MYRIAPODA
CHILOPODA
3 centipedes
DIPLOPODA
6 millipedes
SCORPIONES
1 scorpion
ARACHNIDA
ARANEAE
12 spiders
ACARINA
1 mite
INSECTA
BLATTODEA
BLATTIDAE
4 cockroaches
ISOPTERA
26 termites
ORTHOPTERA
GRYLLIDAE
64 crickets *Acheta commoda*
ACRIDIDAE
64 short-horn grasshoppers
TETTIGONIIDAE
4 long-horn grasshoppers
HEMIPTERA
2 FLATIDAE
5 CICADIDAE Cicadas
16 MIRIDAE
5 REDUVIIDAE Assassin bugs
1 ENICOCEPHALIDAE *Oncylocotis*
26 COREIDAE
1 PLATASPIDAE
45 CYDNIDAE
50 PENTATOMIDAE Shield bugs

COLEOPTERA
30 CARABIDAE including
5 Cicindelinae Tiger beetles
1 *Pheropsophus verticalis*
2 HYDROPHILIDAE
8 STAPHYLINIDAE
82 SCARABAEIDAE including
3 Cetoniinae
9 Melolonthinae Chafers
30 *Aphodius*
29 Hybosorinae
33 ELATERIDAE, Click beetles including
17 *Lacon*
2 *Heterodes*
2 *Colacon*
4 BOSTRYCHIDAE
5 LANGURIIDAE
18 COCCINELLIDAE Ladybirds
13 TENEBRIONIDAE
4 LAGRIIDAE
2 ANTHICIDAE
16 CERAMBYCIDAE Longhorn beetles
54 CHRYSOMELIDAE including
3 Cassidinae Tortoise beetles
1 BRENTHIDAE
6 APIONIDAE *Cylas formicarius*
18 CURCULIONIDAE Weevils including
2 *Oribius*
2 *Leptopius squalidus*
DIPTERA
2 (1 larva, 1 adult)
LEPIDOPTERA
12 moths
290 Larvae, including
82 SPHINGIDAE including
59 *Herse convolvulus*
198 NOCTUIDAE including
152 *Spodoptera*
60 *Plusia*
17 GEOMETRIDAE *Ectropis*
HYMENOPTERA
395 including
2 VESPIDAE
4 SPHECIDAE
1 ICHNEUMONIDAE
385 FORMICIDAE mainly *Pheidole*
CHORDATA
SQUAMATA
SCINCIDAE
1 skink

Table 2.—Stomach contents of *Bufo marinus* taken at Serovi Plantation, Popondetta, Northern District, from March to November, 1973. Number of individuals 405. Mean stomach contents 2.3 g

ANNELIDA
OLIGOCHAETA
3 earthworms

MOLLUSCA
GASTROPODA
17 snails, 2 spp

ARTHROPODA
CRUSTACEA
ISOPODA
2 slaters

MYRIAPODA
CHILOPODA
2 centipedes

DIPLOPODA
172 millipedes, 3 spp

ARACHNIDA
ARANEAE
28 spiders

ACARINA
2 ticks

PHALANGIDA
1 harvestmen

INSECTA
BLATTODEA
BLATTIDAE
16 cockroaches

ISOPTERA
94 termites

DERMAPTERA
20 earwigs, including
9 Forficulidae
8 Labiidae

ORTHOPTERA
GRYLLIDAE
48 crickets *Acheta commoda*

ACRIDIDAE
2 short-horn grasshoppers

TETTIGONIIDAE
31 long-horn grasshoppers

GRYLLOTALPIDAE
1 mole cricket

PYRGOMORPHIDAE
5 specimens

COLEOPTERA
67 CARABIDAE
1 DYTISCIDAE
4 HYDROPHILIDAE
27 STAPHYLINIDAE Rove beetles
3 LUCANIDAE Stag beetles
2 PASSALIDAE

220 SCARABAEIDAE including
94 Hybosorinae
4 *Aphodius*
54 Coprinae
5 Dynastinae *Papuana*
57 Melolonithinae Chafers
1 Rutelinae

1 BYRRHIDAE Pill beetle
1 HETEROCERIDAE
1 RHIPICERIDAE

123 ELATERIDAE Click beetles including
4 *Aeolus*
9 *Colacon*
4 *Corodius*
14 *Compsolacon*
83 *Lacon*
3 *Lanelater*

18 EUCNEMIDAE
1 LYCIDAE
2 ANOBIIDAE
10 BOSTRYCHIDAE
42 NITIDULIDAE
2 EROTYLIDAE
5 COCCINELLIDAE
19 LANGURIIDAE
40 TENEBRIONIDAE
2 LAGRIIDAE
57 CERAMBYCIDAE Longhorn beetles
14 CHRYSOMELIDAE Leaf beetles
2 ANTHRIBIDAE
10 BRENTHIDAE
6 APIONIDAE *Cylas formicarius* (Sweet Potato Weevil)

146 CURCULIONIDAE, Weevils, including
48 *Pantorbytes szent-ivanyi*
25 Cryptorrhynchinae sp
2 Cossoninae sp
1 *Oribius* sp
13 *Leptius* sp including
10 *Leptopius squalidus*

Table 2 *continued next page*

Table 2.—continued

HEMIPTERA	LEPIDOPTERA
3 FLATIDAE	105 moths
1 CERCOPIDAE	348 caterpillars, including
31 CICADIDAE emerging nymphs	242 GEOMETRIDAE
1 MEMBRACIDAE	167 *Ectropis*
70 MIRIDAE	75 *Hyposidra*
8 REDUVIIDAE Assassin bugs including	8 NOCTUIDAE *Plusia*
1 Emesinae	10 AGARISTIDAE
1 PYRRHOCORIDAE	23 LYMANTRIIDAE
248 DINIDORIDAE *Megymenum papuense*	HYMENOPTERA
10 PLATASPIDAE	982 including
12 PENTATOMIDAE Shield bugs	1 VESPIDAE
DIPTERA	1 APOIDEA
76 Larvae, including	1 ICHNEUMONIDAE
1 STRATIOMYIDAE	954 FORMICIDAE various spp
3 TIPULIDAE Crane flies	CHORDATA
	SQUAMATA
	SCINCIDAE
	2 skinks

Amongst the more unusual objects found in the stomachs of these toads were: cigarette butts, a small cork, feathers, two small *Bufo marinus* (SVL 32 and 33 mm), skinks, and quite large pieces of gravel.

Bufo marinus is only able to prey upon animals within its reach at and near ground level. This therefore is one of the limiting factors in its use as a biological control. As the incidence of pest species in commercial plantations or market gardens is likely to be higher than either neutral or beneficial species, the toad may be regarded as beneficial in these situations.

Minor outbreaks of caterpillar pests at Laloki were kept in check by toad predation. *Bufo marinus* also made considerable inroads on the Pentatomid *Megymenum papuense* a minor pest of curcurbits, at Serovi Plantation.

Bufo marinus cannot increase indefinitely in the niche it has found in Papua New Guinea, as the population is limited by the availability of habitat and the concomitant competition for food. It is essentially an urban and open habitat species with poor representation in rain forest areas. When the savanna population increases beyond the food carrying capacity many individuals suffer extreme emaciation and die.

In Papua New Guinea, habitat and density appear to play an important part in the ultimate size reached by the adult. *Table* 5 shows the average size of all toads caught in the seven areas from which they were collected as well as the size and weight of the largest individuals.

Toads taken from the Waigani Sewage Farm, where the population has reached a high density, include individuals with atrophy of the liver, whilst others had cysts on the walls of their stomach and intestines. In 1965 a similar situation was observed at Keravat (DASF, 1965).

In practically all areas of the Pacific into which the toad has been introduced, as maximum population density is approached the size of the individuals decreases (Alcala, 1957).

In the two areas covered by this survey, *Bufo marinus* appears to be beneficial. The results of the investigation carried out by Zug *et al.* in non-economic areas show the toad to be neutral in so far as prey consumed is concerned.

It must not be forgotten that in toad-infested areas the introduction of other methods of biological control, such as parasitic wasps, may be jeopardised by the non-selective feeding habits of *Bufo marinus* which can devour both pest and predator with equal avidity.

Table 3.—Economic importance of prey consumed by 350 *Bufo marinus* at Laloki, Central District, Papua New Guinea January to December, 1973

	Number of individuals		
	Beneficial	Neutral	Harmful
ANNELIDA	1		
MOLLUSCA			1
ARTHROPODA			
CRUSTACEA		2	
ISOPODA			
MYRIAPODA	3		6
SCORPIONES	1		
ARACHNIDA	12		1
INSECTA			
BLATTODEA		4	
ISOPTERA			26
ORTHOPTERA			132
HEMIPTERA	6	47	82
COLEOPTERA	59	64	183
LEPIDOPTERA		12	290
HYMENOPTERA	7	385	
VERTEBRATA			
SQUAMATA			
SCINCIDAE	1		
	90	514	721

Table 4.—Economic importance of prey consumed by 450 *Bufo marinus* at Serovi Plantation, Popondetta, Northern District, Papua New Guinea March to November, 1973

	Number of individuals		
	Beneficial	Neutral	Harmful
ANNELIDA	3		
MOLLUSCA			17
ARTHROPODA			
CRUSTACEA	2		
ISOPODA			
MYRIAPODA	2		
DIPLOPODA			172
ARACHNIDA		29	2
INSECTA			
BLATTODEA		16	
ISOPTERA			94
DERMAPTERA	20		
ORTHOPTERA			87
HEMIPTERA	9	48	355
COLEOPTERA	190	228	402
DIPTERA	3	76	
LEPIDOPTERA		105	348
HYMENOPTERA	3	954 (ants)	
VERTEBRATA			
SQUAMATA			
SCINCIDAE	2		
	261	1429	1477

It is recommended that further introductions of *Bufo marinus* into new areas be discouraged until further research has been conducted on its interaction with the endemic fauna of Papua New Guinea, such as snakes, *Dasyurus* and frogs.

F. Parker (pers. comm.) states that over the past few years there has been a marked reduction in the number of Papuan Black Snakes *Pseudechis papuanus* in the Port Moresby area. This is possibly due to the snake catching toads in mistake for the various local frogs which are their normal diet. There have been reports of the carnivorous marsupial *Dasyurus* sp. having died through attacking toads (J. Waithman pers. comm.), also Breeden (in Lear, 1970) states that since the introduction of *Bufo marinus* into Northern Queensland the number of Quoll *Dasyurus* sp. has declined.

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Table 5.—Measurements of *Bufo marinus* from seven localities in Papua New Guinea

Locality	Total Number	Snout Vent Length mm Mean ± sd	Largest Individual		
			S.V. Length mm	Weight g	Sex
Waigani Sewage Farm, 14 km NW Port Moresby	915	83 ± 11	112	145	M
Brown River Road, 24-34 km N Port Moresby	33	102 ± 8	152	445	F
Laloki Plant Q'tine Station, 15 km N Port Moresby	351	87 ± 20	125 125	243 198	F M
Serovi Plantation, Popondetta, Northern District	405	91 ± 14	126	271	F
Talasea, West New Britain	30	92 ± 13	137	326	F
Daru, Western District	90	77 ± 8	98	117	F
Varirata National Park, 21 km N Port Moresby	17	88 ± 11	105	100	M

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