The
Papua and New Guinea
Agricultural Journal

Vol. 17 DECEMBER, 1965 No. 4

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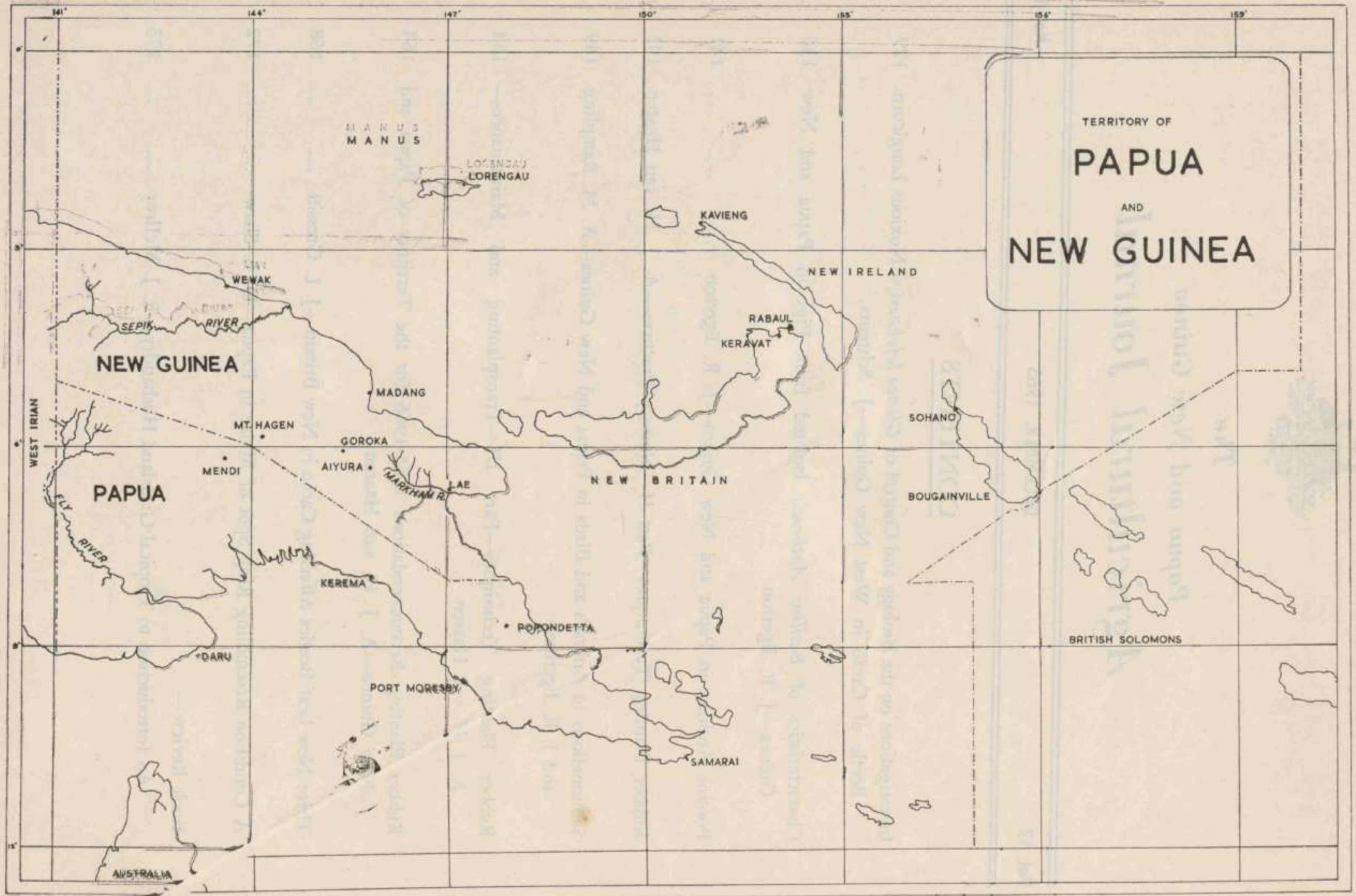

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BOUGAINVILLE
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BRITISH SOLOMONS
DARU
PORT MORESBY
SAMARAI
AUSTRALIA

Investigations on the Biology and Control of Glenea lefebueri, *a Noxious Longicorn Beetle of Cacao in West New Guinea.*

J. SCHREURS. *

ABSTRACT.

In the years 1961 *and* 1962 *the biology and methods of control of the noxious longicorn cacao borer,* Glenea lefebueri *Guer., were studied in the Vogelkop of West New Guinea. The larva first tunnels superficially in the bark of the stem and thicker branches of* Theobroma cacao, *and penetrates deeper into the bark as it matures, making galleries in the cambial layer. In this stage equal parts of wood and bark tissue are consumed. Finally, the larva makes a tunnel into the wood to pupate. The development from recently hatched egg to the adult stage takes approximately three months. Die-back of branches or death of the whole tree can be the result since branches and the stem are more or less ring-barked by the larvae.*

The Glenea *pest can be controlled by cutting out the larvae at intervals of three to four weeks. A more satisfactory control is obtained by spraying with Dieldrin in a concentration of* 1 *per cent. of an emulsifiable concentrate, containing* 18 *per cent. active ingredient, which product has also a long-lasting preventive action.*

An ichneumon was found, Xanthocryptus vesiculosus (*Brulle,* 1846), *which is most likely a parasite of the* Glenea *borer.*

INTRODUCTION.

In 1961 and 1962 the stem and branch borer *Glenea lefebueri* Guer.[1] (Cerambycidae, Col.) was a very destructive pest in cacao plantations in the Vogelkop of West New Guinea (Manokwari and Ransiki). This longicorn beetle was not found elsewhere in West New Guinea, but does occur in the Territory of Papua and New Guinea, where cacao is also damaged by the species *Glenea aluensis* Gah. (Szent-Ivany, 1961.) A third species, *Glenea novemguttata* Cast., is found in Indonesia. (Kalshoven, 1951.)

Larvae of other longicorn beetles also attacked cacao trees in the Vogelkop, but actual damage was restricted to only a few trees. In some areas other cacao borers are more harmful, such as *Pansepta teleturga* Meyr. (Xyloricticlae, Lep.) at Seroei and *Alcides australis* Boisd. (Curculionidae, Col.) at Ransiki. (Schreurs and Simon Thomas, 1961.)

DAMAGE.

In cacao plantings not properly maintained, large numbers of larvae were found in stem and branches. Once, 27 infections were counted in a stem of 70 cm. height and 23 cm. girth. The heaviest concentration of the borer is generally in the lower part of the stem, and relatively few larvae attack the branches. To determine the

Plate I.—*Glenea lefebueri* Guer.

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[1] Identified by Dr. J. L. Gressitt, Bernice P. Bishop Museum, Honolulu, Hawaii.

area of greatest infestation, the stems of 30 trees were divided into ten equal parts, and the mean number of stem infections was calculated for each level. Measuring from the base to the top, the percentage of the total infections in each stem section was as follows :

15 per cent., 17 per cent., 14 per cent., 9 per cent., 8 per cent., 6 per cent., 8 per cent., 8 per cent., 9 per cent., and 6 per cent.

The trees become susceptible in the third year after planting. The borer atacks only living trees, although a few pupae or adults may be found in recently killed trees. Most likely, there are clonal differences in susceptibility to this pest. In a four to five year old cacao planting at Ransiki 23 per cent. of the trees of a clone were affected in 1962, being the vegetative progeny of a seedling, selected from the descendants of a cross between two Java clones, while only four to eight per cent. of the trees of the other clones were damaged (ICS 89, ICS 95, Manokwari 4 and the vegetative progeny of another seedling of the mentioned cross between two Java clones).

In neglected plantings almost every tree may be affected, resulting in the death of the branches or of the whole tree. In properly maintained plantings, however, the *Glenea* borer is normally no major problem as this pest can be kept well under control.

DEVELOPMENT OF THE LARVA INTO ADULT.

A. *Infection Technique.*

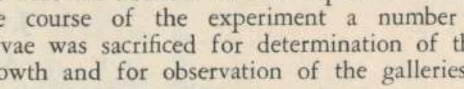
Healthy cacao stems were infected with young larvae and their development observed at regular intervals for the purpose of studying their life cycle and feeding habits. Eggs of the *Glenea* beetle were never found ; therefore the investigations were begun with young larvae. These were excised from affected trees and transferred to the bark of healthy trees.

The following technique gave the best results. A half to one cm. wide and two cm. long flap of bark was lifted up with a knife, and a hole was drilled tangentially through the bark with a gimlet. The sap secreted from the freshly-made wound was drained off with a piece of absorbent cotton. Finally the larva was placed in the hole, the flap lowered and tightened with string. This method was successful in 40 per cent. of the infections carried out. A total of 26 successful infections were obtained. The infected parts of the stem were covered with copper screen at the time the adults would be expected. During the course of the experiment a number of larvae was sacrificed for determination of their growth and for observation of the galleries.

B. *Observations.*

The tunnelling habits and development of the larva are discussed on the basis of *Figures* 1 to 8.

A young natural infection is presented in *Figures* 1 and 2. The bark of this cacao stem was 3.3 mm. thick. A newly hatched larva



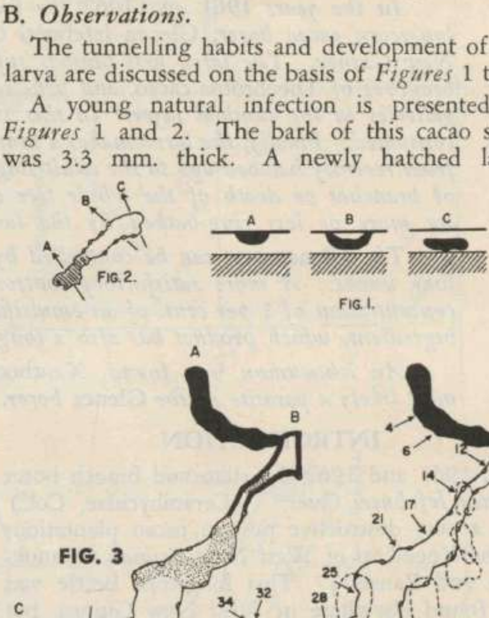


Figure 1.—Cross sections through spots A, B and C of the tunnel in *Figure* 2. The shadowed parts represent wood tissue. 2 x enlarged.

Figure 2.—Tunnel of young larva in the bark. Natural size.

Figure 3.—Tunnel in cambial layer. The cross section through the end of the tunnel is made at the spot where a " ventilating burrow " was gnawed. Natural size.

Figure 4.—Same gallery as presented in *Figure* 3. Special attention is paid to the secreted gum lumps and the progress of the larva in days after infection. Natural size.

feeds in the exterior bark, protected only by a very thin dead bark layer of 0.20 to 0.25 mm. thick (see shadowed part of tunnel in *Figure* 2 and the cross section through A in *Figure* 1). Soon afterwards, possibly within a week after hatching, the larva penetrates deeper into the bark and feeds for some time in the middle layers (see Section B). Small holes are gnawed to the exterior at distances of a few millimetres ; *Figure* 1 B shows a section through two of those holes. These burrows serve for secretion of various material and probably for ventilation as well. The larva had almost reached the cambial layer at spot C and was at that moment 7 mm. long. The larvae start tunnelling in the cambium when they have grown to 7-10 mm.

A bore tunnel in the cambial layer is presented in *Figure* 3. The stem of this tree was infected with a larva of 6 mm. at point A. The girth of the stem was 17 cm. and the thickness of the bark 4.3 mm. The larva tunnelled first for eight to ten days exclusively in the bark (blackened part of tunnel) and then entered the cambium at point B. The tunnel was opened when the larva had reached point C, 34 days after infection. It had grown to 21 mm. In the cambial layer the larva eats equal parts of bark and wood tissue as is shown in the cross section through the gallery. Also in this stage small burrows are gnawed to the exterior ; they are usually at the borders of the tunnel, only occasionally in the middle. When this tunnel was opened, the shadowed parts were compactly filled with fibrous chips. Bark renewal starts quite soon after the damage is done, about two and one-half weeks later. The area of these cambial activities is represented in *Figure* 3 by thicker border lines from point B to the point reached 17 days after infection.

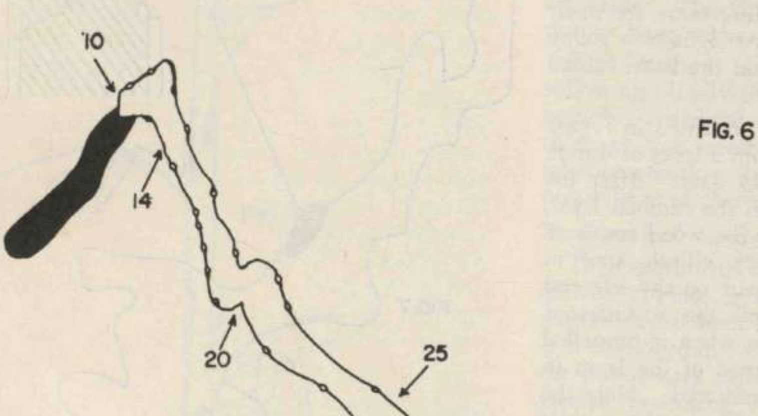


Figure 5.—Completed tunnel in bark and cambium. Natural size.

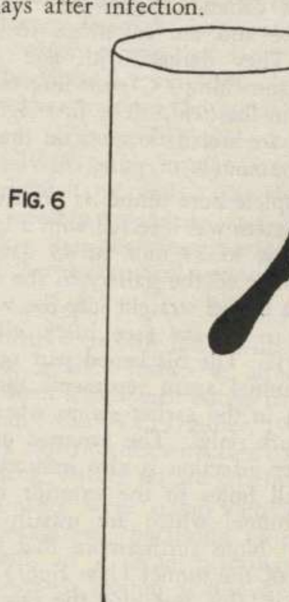


Figure 6.—Arrangement of tunnel of Figure 5 around the stem. Natural size.

The same bore tunnel is presented in *Figure* 4. In this presentation, the advance of the larva is marked in days after infection. The larval progress could be observed without opening the tunnel as the freshly made burrows to the exterior indicate the spot where the larva is tunnelling. Through these holes particles of wood and bark tissue are secreted in a foamy gum lump, in which substance probably excrements are included. The gum lumps produced between 12 and 34 days after infection are drawn in *Figure* 4 as they appear in the fresh state. In general, the lumps stay in this shape only for a few days. At the time the larva was cut out (34 days after infection), the gum lump made 28 days after infection may still have been there in this shape, while the older ones were washed off by rain or dried out. However, sometimes small strands of pure gum are secreted through older holes. The most common lumps have a clear, foamy appearance and are colourless to light reddish brown. They darken with age. Due to the secreted gum lumps *Glenea* infections are easily detected in the field. The first signs of a young infection are wet dark spots on the bark, caused by small amounts of gum.

A complete bore tunnel is presented in *Figure* 5. This stem was infected with a larva of 4 mm. which grew to 23 mm. in 43 days. After the larva completed the gallery in the cambial layer, it made a tunnel straight into the wood for some distance to pupate (see black elliptic spot in *Figure* 5). The blackened part on the left end of the tunnel again represents the activities of the larva in the earlier stages when it tunnelled in the bark only. The progress of the larva in days after infection is also indicated. Note the two small holes to the exterior in the middle of the tunnel which are usually made at the borders. Note furthermore that most holes at the end of the tunnel (low right) are made the lower side, this was also the case in *Figure* 3. The tunnel of *Figure* 5 made a full spiral around the stem which had a circumference of 14½ cm. (see *Figure* 6). Usually the trees are affected by several larvae in the same bark area at the same time ; thus it is possible for trees to be ringed in this way, and the branch or the whole tree can be killed.

An old natural infection is presented in *Figure* 7 on a stem of 10 cm. girth. The longitudinal section through the stem in *Figure* 8 shows the shape of the tunnel in the wood and of the pupal chamber. The shadowed parts of this chamber were compactly filled with chips of wood. The pupal chamber is made 1-2 cm. deep into the wood and always slants upwards in the stem. The opening of this tunnel is plugged with fibrous chips.

After the larva has made the pupal chamber, it takes about a month before it pupates. The pupal state lasts approximately one week. The adult remains a few days inside the pupal chamber before flying out.

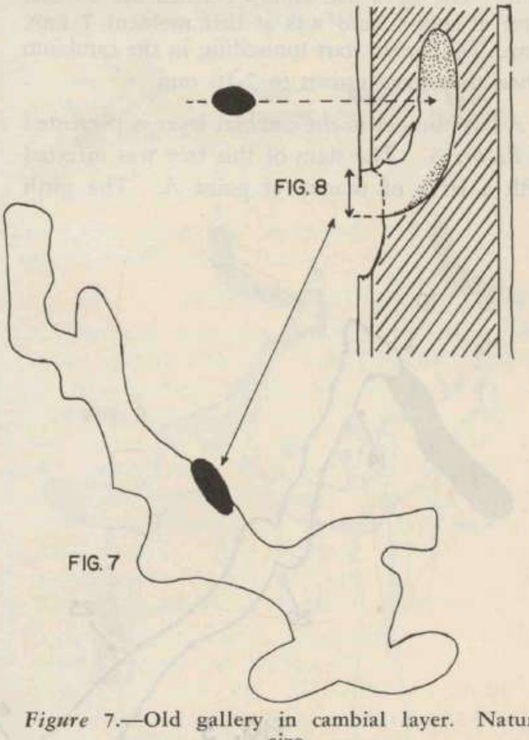


Figure 7.—Old gallery in cambial layer. Natural size.

Figure 8.—Section through the pupal chamber in the wood of a stem belonging to the gallery presented in Figure 7. Natural size.

Summarizing, it can be said that at the end of 1½ months a larva of 3-4 mm. length finishes tunnelling and reaches a length of 22-24 mm. Larger larvae were seen occasionally and the maximum length is possibly 30 mm. The total development from the hatching of the egg to the emergence of the adult takes about three months ; this assumes that a recently hatched larva is 3-4 mm. long in one week's time, and allows

$1\frac{1}{2}$ months for further tunnelling activities, one month for the rest state of the larva and one week for the pupal state.

The adults were quite regularly seen in cacao plantings, resting on a leaf or on the bark, but seldom in large numbers. Only in one case 30-40 beetles were collected in a couple of hours. This was in a young planting of one year old, adjacent to an old neglected cacao planting, which was severely affected. It is likely that the beetles were feeding on the young green shoots, since in breeding cages the same type of damage to the shoots could be reproduced (see *Figure 9*).


FIG. 9

Figure 9.—Young *Cacao* shoot damaged by the *Glenea* adult. Natural size.

The larvae and pupae of this *Glenea* borer are bright yellow. They can be easily distinguished from the larvae of other longicorn borers by their colour as the others are usually greyish white and never bright yellow. The pupae and adults of the *Glenea* borer are 12-14 mm. long. The males are somewhat more slender than the females. The elytra are steel blue and marked with a broad, darker-coloured cross band. The thorax and the head are yellow. The thorax is marked with a black to steel blue round spot.

CONTROL.

The *Glenea* pest can be controlled by excising the larvae or by application of insecticides. A parasite of the borer was found which means the borer is biologically controlled to a certain extent. Alternate hosts of the borer were not found. The different possibilities for control are discussed in the following.

A. *Mechanical Control.*

The pest can be kept under control if all the cacao trees are inspected every three to four weeks and the larvae are excised. When the inspections are made at longer intervals, larger larvae have to be excised, which means that larger wounds are made. The larvae are very difficult to reach if they have withdrawn into the pupal chamber.

This method of control has, however, the following disadvantages : (1) infections of branches are difficult to reach ; (2) the tree is more or less severely wounded ; and (3) it is laborious work. It is for these reasons that the possibilities of chemical control were investigated.

B. *Chemical Control.*

The experiments were only made with Dieldrin as this product is well known as an excellent insecticide for stem and branch borers in general. It is employed in cacao (Van Dinther, 1960) and the preliminary experiments with this compound yielded promising results on the *Glenea* borer.

Two experiments were done with Dieldrin emulsifiable concentrate, containing 18 per cent. active ingredient, in a cacao planting of the Agricultural Research Station at Ransiki. Tested were concentrations of 1 per cent., 2 per cent. and 3 per cent. of the commercial product. The spray liquid was applied with a knapsack sprayer.

The first experiment was done in a four to five year old cacao planting, grown from cuttings. The majority of the trees was pruned back to 30-40 cm above the ground level. Only the stumps of these plants could be affected as the new shoots had not reached the susceptible stage. A smaller number of trees was left unpruned at that time and had susceptible branches. The planting consisted of five clones, each one represented by approximately the same number of trees, namely—ICS 89, ICS 95, Manokwari 4 and the vegetative progeny of two seedlings, selected from the descendants of a cross between two Java clones.

There were four treatments, the three concentrations mentioned above and one control. All susceptible parts were thoroughly sprayed. A pre-treatment count of the number of infections showed that 13 per cent. of the stumps and 27 per cent. of the unpruned trees were affected by one or more *Glenea* larvae (trees with the characteristic gum lumps). One week after the application of Dieldrin all infections were opened to determine the mortality of the larvae.

The three concentrations yielded about the same, indicating that a concentration of 1 per cent. (0.18 per cent. active ingredient in the spray liquid) gives almost the best possible control ; 93 per cent. of the larvae in the stumps were killed and at least 93 per cent. in the unpruned trees. In all the five clones a high mortality of larvae was obtained. All stages of the larvae were killed effectively with possibly the greatest effect on the youngest stages.

This experiment also showed that the residual action of Dieldrin lasted at least one month as is shown in *Table* 1.

Table 1.—**Number of New Infections after treatment with Dieldren after :**

	10 days.	15 days.	23 days.	28 days.
on 327 treated stumps	0	0	0	1
on 80 untreated stumps	2	4	10	14

The second experiment was carried out in a five and one-half to six years old planting of Keravat bulk seedlings on 2nd May, 1962. Only the affected spots of the tree were sprayed in this experiment. A long spray boom was connected to the knapsack sprayer to facilitate spraying of infections in the higher branches. A quarter of a square foot was treated per affected spot. This is quite feasible with a knapsack sprayer provided the pressure is kept low. Per infection 30-40 ml. spray liquid was used. One week after the treatment the mortality of the larvae was determined. The experiment was repeated twice on other trees in the same planting, namely on 9th May and 29th June, 1962. The results are presented in *Table* 2.

Table 2.

	Number treated infections in experiment of : May 2.	May 9.	June 29.	Per cent. mortality of larvae in experiment of : May 2.	May 9.	June 29.	Average mortality, per cent.
1 per cent. Dieldrin em. conc.	26	14	23	89	100	91	93
2 per cent. Dieldrin em. conc.	36	18	24	92	97	96	95
3 per cent. Dieldrin em. conc.	53	20	22	97	97	95	96

Also in this experiment there were no important differences in effectiveness between the three concentrations. The mortality was in all cases high, particularly in cases of very young larvae ; of 67 young larvae only one survived.

Small scale experiments were also conducted with dibutylphthalate, which was added to the Dieldrin for the purpose of improving the penetration of the Dieldrin into the bark. These investigations were stopped as it soon turned out that satisfactory results could be obtained with Dieldrin only. Probably the spray liquid runs through the small " ventilating burrows " into the galleries. It is not likely that the effectiveness of Dieldrin is based on actual penetration through the bark, as older larvae in the bark can also be killed effectively within a short time.

Apart from the insecticidal properties of Dieldrin its phytotoxic aspects have been investigated. Concentrations of 1 per cent., 2 per cent., 4 per cent. and 8 per cent. of a Dieldrin emulsifiable concentrate, containing 15 per cent. active ingredient, had no noticeable effect on the bark. These cacao trees had been sprayed four times in six months. However, undiluted emulsifiable concentrate damaged the bark severely ; one spraying alone resulted in the death of the bark.

All flowers and flower buds can be lost when sprayed with 4 per cent. of the Dieldrin emulsifiable concentrate. No notable damage was seen when concentrations up to 2 per cent. were employed. One month after spraying 4 per cent. of the emulsifiable concentrate new normal flowers were produced again.

As Dieldrin also may have an adverse effect on the beneficial insects, which play a part in the pollination of the cacao, it is recommended that only the affected spots of the tree be sprayed with a concentration of one per cent. (0.15 to 0.18 per cent. active ingredient in the spray liquid). Spraying of all susceptible parts of the tree is possibly justified in cases of severe attack. Perhaps the spray concentration can still be lowered more than 1 per cent., but it is not very likely but it is not very likely that the same high percentage mortality is obtained.

It may be concluded, since every tree of a plantation can be affected by this pest, there should be a greater emphasis on regular inspection and the use of Dieldrin in localities where the *Glenea* borer is a major pest.

BIOLOGICAL CONTROL.

Pupae of an ichneumon were found several times inside the pupal chamber of the *Glenea* borer. When 31 cacao stems were analysed for the presence of *Glenea* borers, seven pupae of the ichneumon were found on a total of 217 *Glenea* larvae and 33 *Glenea* pupae and adults. Some adults of the ichneumon emerged from the collected pupae in breeding cages and were identified by J. G. Betrem. The species concerned is *Xanthocryptus vesiculosus* (Brulle, 1846), fam. Ichneumonidae, subfam. Gelinae (= Cryptinae), tribus Echthrina. The following information may be quoted from the letter of Dr. Betrem : "Synonyms are : *Mesostenus pictus* Sm., 1859 ; *M. multipictus* Sm., 1863 ; *Stenarella nigritarsis* Szepl., 1916 and *Xanthocryptus monstratus* Cheesman, 1936. The species is known from the whole of the Island of New Guinea. The genus *Xanthocryptus* Cameron, 1911, is known from New Guinea, Solomons Islands, Australia and New Zealand. The Echthrina have a very wide distribution. They are parasites of wood boring Coleoptera and of other wood borers (Lepidoptera, etc.)."

A living pupa of this ichneumon was found once inside the pupal chamber of the *Glenea* borer together with a dead, shrivelled *Glenea* adult. The adult was caught only once.

In my opinion it can be assumed that *Xanthocryptus vesiculosus* is a parasite of the *Glenea* borer, however, this parasite seems to be of little practical importance as it was rarely found.

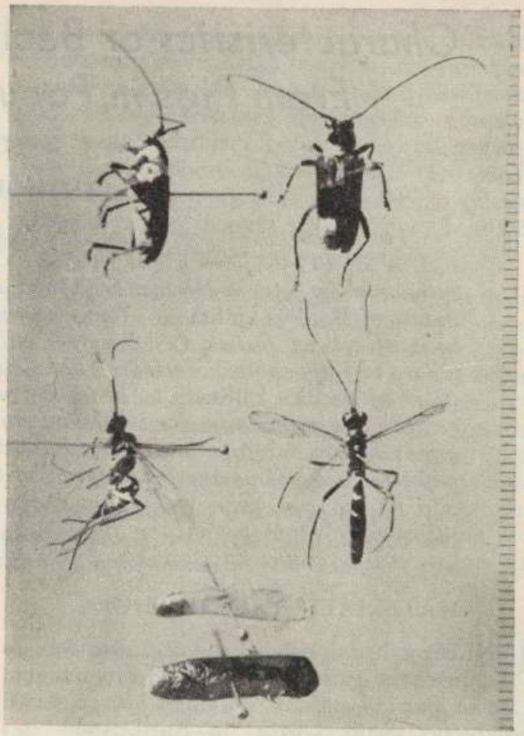


Plate II.—Top : *Glenea lefebueri* Guer. Bottom : *Xanthocryptus vesiculosus.*

ACKNOWLEDGEMENTS.

The author wishes to thank Mr. J. Ph. van Driest for his assistance in the investigations carried out at Manokwari, and Mr. E. B. Vreugdenburg for the execution of the experiments at Ransiki. (Received June, 1965.)

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Characteristics of Bacillus Anthracis *Isolated* From Pigs in Papua and New Guinea.

J. R. EGERTON. *

INTRODUCTION.

The organism of porcine anthrax in the Territory has previously been examined by 1 *AMVSU* (1946), *and Carne* (1958). *The former isolated the bacillus from cases of anthrax in the Eastern Highlands District and discussed its close resemblance to classical strains of* Bacillus anthracis. *Carne examined subcultures of this organism and on the basis of several factors* (a) *lowered pathogenicity for laboratory animals and* (b) *the failure to form spores, concluded that the New Guinea organism may be an atypical strain of* Bacillus anthracis. *Subsequent work by the same worker established the pathogenicity of the organism for laboratory animals and pigs. Anderson* (1960) *described briefly anthrax of pigs in Highlands Districts of the Territory. Egerton* (1965), *has given more detail on the field aspects of the disease.*

In this paper it is proposed to present results of laboratory investigations into the characteristics of the New Guinea strain of Bacillus anthracis, *and of investigations into the possibility of immunizing against the disease.*

MATERIALS AND METHODS.

UNLESS otherwise stated the organism used in the investigations was derived from a field case of porcine anthrax at Ningil village, Lumi Subdistrict, Sepik District in April, 1962.

Bacteriology.

Media. The medium used for propagation has been tryptose agar (Difco) and stock cultures have been maintained on slopes of the same medium. Stains used for morphological descriptions have been Gram stain, giemsa and crystal violet.

Biochemical Reactions. Media used in the determination of biochemical characteristics were those described by Knight and Proom (1950), and Smith, Gordon and Clark (1946).

Preparation of Spore Suspensions. Heart blood from guinea pigs which died following inoculation with the organism were spread on agar plates and incubated aerobically for 48 hours.

Colonies were scraped off into distilled water suspended evenly by shaking with glass beads and heated at 80 degrees C. for five minutes in a water bath. Following this, spores were washed and centrifuged three times with distilled water. Spore counts were made by the method of Miles and Misra. Suspensions were stored at 4 degrees C.

LD50 *Estimations.* Groups of five mice and five guinea pigs were inoculated intra-peritoneally with measured doses of anthrax spores.

Survival of the Organism. Estimations of the survival time of spores and vegetative organisms in various environments were made.

Soil. 10 g. soil samples (5 per cent.-6 per cent. water content) from the enzootic area, were inoculated with 1,000,000 spores in 1 cc. water. Qualitative estimations of survival were made at monthly intervals and at twelve months, counts of surviving spores were made. Sterilized and non-sterilized duplicates of soil samples were used, and the samples maintained at room temperature (18-28 degrees C.).

Carcases. The carcases of five mice which died following anthrax inoculations were kept at 4 degrees C. and examined at intervals for the persistence of the organism. The thoracic and abdominal cavity of one mouse was opened and kept at 30 degrees C. for two days before placing in the refrigerator.

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Immunity Studies.

Goats. Two adult goats were vaccinated with 0.5 cc. McGarvie Smith anthrax vaccine. Fourteen days later the goats were challenged, one intravenously the other subcutaneously with 20,000 spores of a virulent suspension. Two controls were inoculated with the same dose by the same routes.

Pigs. (*a*) *Establishment of Immunity.* Four native Berkshire cross pigs were vaccinated subcutaneously with 0.5 cc. McGarvie Smith anthrax vaccine. Three weeks later these animals and four unvaccinated controls were challenged intravenously with virulent anthrax spores.

(*b*) *Duration of Immunity.* Twenty-one pigs, Berkshire cross, were vaccinated at about three months of age with 0.5 cc. McGarvie Smith vaccine subcutaneously behind the ear. At intervals of three months, groups of these pigs were challenged with intravenous doses of spores shown to be lethal for an unvaccinated control at the time of challenge. Other pigs from the station herd at Goroka vaccinated six months previously to the experimental group were also challenged at quarterly intervals.

Experimental per Os Infection of Pigs.

Fifteen Berkshire pigs 4-6 months old were divided into three groups of four and one of three animals. In each group the pharynx of two animals was lacerated under light nembutal anaesthesia. Doses of *Bacillus anthracis* ranging from 10^5 spores to 10^8 spores were introduced into the buccal cavity of all pigs under light anaesthesia.

RESULTS.

Bacteriology.

Morphology and Staining Reactions. In smears from lesions in pigs *Bacillus anthracis* is a large rod usually with square ends which occurs singly and is surrounded by a loose capsule. When stained by the Gram method, the bacillus has an irregular foamy appearance. The capsule is best demonstrated with giemsa stain. When this is used the loose envelope-like nature of the organism is apparent. After exposure to the atmosphere recently isolated strains readily form spores, usually within 24 hours. The spores show as stain resistant sub-terminal structures which do not alter the shape of the bacillus.

Cultural Features. B. anthracis grows readily on nutrient agar. At 24 hours the colonies have a ground glass appearance and typically the margins of the colonies are irregular consisting of entwined chains of the organism growing from the periphery of the colony. On blood agar plates haemolysis does not occur. In gelatin, incubated at 20 degrees C. an inverted fir-tree type of growth occurs.

When *B. anthracis* is grown on 10 per cent. serum agar plates in an atmosphere of about 10 per cent. CO_2, mucoid colonies form. The mucoid nature of the colonies is apparent when they are touched with a loop, and is derived from the exaggerated capsule formation in organisms grown under these conditions. The ability to form spores under otherwise suitable conditions is lost after five or six subcultures away from an infected animal. Sporulation can be reinduced by passage of the organism in massive doses through a susceptible animal.

Biochemical Reactions. Acetoin is produced from Voges-Prosgauer reagent in which phosphate is replaced by sodium chloride. Tests for the digestion of starch, casein, gelatin and egg yolk are all positive. Nitrates are reduced and the Gibson Abdel Malek test is negative. Glucose, but not arabinose or xylose is fermented when included in an inorganic base medium.

Pathogenicity. (*a*) *Mice. Table* 1 below gives details of the inoculation of groups of five mice with varying doses of spores.

Table 1.

Inoculation Dose Spores	Deaths Day 2	Day 3	Day 4	Total
20,000	5/5	....	....	5/5
10,000	4/5	....	....	4/5
1.000	2/5	1/5	1/5	4/5
100	1/5	2/5	....	3/5
10	....	1/5	....	1/5

Using Thompson's moving average method of estimation of LD50 doses, the following results were obtained :—

2 days—1,340 spores.

3 days—112 spores.

4 days—76.4 spores.

(*b*) *Guinea Pigs.* A similar estimation using guinea pigs, indicated that the LD50 for this species was of the order of 4,250 spores at five days post inoculation with the culture used. Individual doses of as low as 200 spores have however been shown to be lethal for guinea pigs.

(*c*) *Goats.* 20,000 spores inoculated intravenously and subcutaneously into two goats resulted in their death at four and five days respectively. Full autopsies were not carried out. It was shown that a terminal bacteraemia was present in each case.

(*d*) *Man.* Five days after the limited post mortem examination carried out on the goats above, the author developed a lesion on the dorsal aspect of the right index finger. The lesion arose as a small red bleb containing reddish serous fluid. Over the succeeding three days the lesion increased in size and a peripheral erythema occurred. Smears at this stage demonstrated the presence of fragmenting, irregularly staining Gram positive bacilli. An overnight culture resulted in the growth of typical anthrax colonies. By this time a lymphangitis involving the medial aspect of the forearm and the axillary lymph node had developed. Treatment with tetracycline was rapidly effective.

(*e*) *Pigs.* Pigs have proved difficult to infect other than by the intravenous route. It has been shown that 10^8 spores of a culture of which 1,000 spores are lethal for guinea pigs will regularly kill pigs when introduced intravenously. Death in these cases occurs in four days. Of nine susceptible pigs inoculated with doses of this order all have died.

Subcutaneous inoculation of pigs with quite large doses has variable and inconsistent results. Of five pigs inoculated subcutaneously with about 10^9 organisms of a Goroka isolate, two animals died and three recovered.

Attempts at experimental per os infection have been unsuccessful. Spore doses ranging from 10^5 to 10^8 were given to fifteen pigs, eight of which had a deliberately lacerated pharynx. No clinical signs of illness developed. Examination of the pharynx of pigs which had been lacerated showed apparent healing 48 hours after treatment.

Immunity.

Goats. 0.5 cc. McGarvie Smith spore vaccine was shown to protect two goats against challenge with a dose of spores which killed unvaccinated controls. The latter died four and five days after challenge, respectively.

Pigs.

(*a*) *Establishment of Immunity.*

It was demonstrated that three weeks after subcutaneous inoculation with spore vaccine a solid immunity was established. Two young adult pigs inoculated with 0.5 ml. vaccine resisted challenge by intravenous inoculation of 6 x 10^6 virulent spores. Two unvaccinated controls of similar age and body weight died within 72 hours after treatment with the same challenge. Two weaners immunized with 0.25 ml. vaccine similarly resisted challenge while controls died. The challenge dose in this case was 1.5 x 10^6 spores.

The vaccinated animals showed no signs of illness in the period under observation (six weeks) after challenge. Signs of illness appeared in controls within 24 hours of challenge.

(*b*) *Duration of Immunity.*

Pigs vaccinated in January, 1963, were shown to have maintained immunity up to September, 1964. Pigs which resisted challenge were removed from the experimental group. A sow aged about three years which was vaccinated in July, 1962, did not resist a challenge dose administered in June, 1964. *Bacillus anthracis* was re-isolated from the oedematous lungs and pleural fluid of this animal which died seven days post challenge.

Survival of the Organism.

Soil. Spores inoculated into soil samples at the rate of 100,000 per gram survived for at least twelve months. There was evidence of a decline in spore numbers especially in more acid soils. There appeared to be no difference in the survival rate in autoclaved and non-autoclaved soil samples. Details are presented in *Table* 2 below.

Table 2.—Spore counts/gram of soil samples inoculated 12 months previously with 100,000 spores per gram.

Soil Sample	pH	Autoclaved	Not Autoclaved
7191	4.9	8,000	4,000
7221	5.2	2,400	4,000
7330	5.8	22,000	8,000
7291	6.0	5,000	6,000
K1	7.8	400,000	1,200,000

The first four samples were from enzootic areas in the Highlands. Sample K1 was from the Veterinary Station at Kila Kila near Port Moresby. In the latter there is evidence of multiplication of the spores.

Carcases. (*a*) *Unopened*. It was not possible to culture *B. anthracis* from unopened carcases of experimental mice kept for longer than three days at refrigerator temperature.

Attempts at culture from the heart blood, liver and spleen were consistently unsuccessful.

(*b*) *Opened Carcases*. *B. anthracis* was cultured at regular intervals for up to three months following death from carcases in which sporulation had been induced by exposure to the atmosphere.

DISCUSSION.

Bacillus anthracis isolated from pigs in Papua and New Guinea behaved similarly in the laboratory to strains isolated in other countries. When freshly isolated it was morphologically the same and it sporulated readily. Its biochemical reactions were identical with those described by other workers.

In mice and guinea pigs small doses of spores were lethal. It was shown to be pathogenic for a fairly wide range of other hosts including man. The difficulty in setting up experimental infections in pigs other than by using heavy intravenous inoculations has confirmed the experience of other authorities. Pigs are recognized as having considerable resistance to anthrax (Sterne, 1959, Ferguson and Bohl, 1959). In other countries anthrax in pigs is usually associated with the ingestion of large numbers of organisms or viable spores, in contaminated feedstuffs.

In Papua and New Guinea, feeding of artificial rations to enclosed pigs is not commonly practised in the enzootic area. Infective doses for swine in the field must come from either the soil when pigs are grazing or through the consumption of pigs which have died of the disease. The infective dose for pigs *per os* would appear to be so high that it is difficult to believe that contaminated soil would be able to set up the infection. For this reason the ingestion of carcases is considered to be the usual source of infection. It is possible that in particular areas organisms may multiply in the environment but this would be contrary to accepted views on the life history of *B. anthracis*. Minett and Dhanda (1941) showed that, while in moist sterilized soils multiplication and subsequent sporulation occurred, *B. anthracis* did not multiply when in competition with soil and/or water organisms. These authors concluded that *B. anthracis* was an obligatory parasite.

A further complication to the understanding of the epizootiology of anthrax in pigs is that the only type of the disease seen here has been the pharyngeal type in which there is usually a localization of the organism in the throat area. The carcase of such a pig would not provide such a great source of infection as a herbivore which died of anthrax. It is possible that the septicaemic form of anthrax does occur in the Territory and is not recognized because of the absence of the characteristic symptoms seen in the pharyngeal form.

Under field conditions it might be postulated that the resistance of the native pig, on a subsistence diet and heavily parasitized, may be considerably lower than in experimental animals. Certainly when a favourable set of circumstances exists epizootics of anthrax result in the loss of many animals.

It has been shown that commercially available spore vaccines are quite effective in protecting against anthrax in pigs in this Territory. Immunity persists for at least eighteen months. Within the enzootic areas it should be possible, by widespread vaccination, to reduce the losses caused by anthrax. Vaccination campaigns should be instituted during the dry season in order to establish immunity before the onset of the wet season with its greater frequency of the disease.

Sterne (1959) has suggested that total eradication is possible if sufficiently intensive vaccination is carried out even in areas where husbandry is primitive. In Papua and New Guinea the biggest difficulty would be to get the co-operation of native owners. Experience with limited vaccination campaigns in the past has been disappointing. Activity at the present stage of development should be directed towards demonstrating at the field level that vaccination is effective. The realization of this by native owners which may be concurrent with some development of husbandry methods will allow a more intensive application of compulsory vaccination campaigns in the future.

There has been a tendency in the Territory to undertake localized vaccination to prevent the spread of an outbreak. Success has been claimed for vaccination of this type but has not been proven. Nicol (1933) stated that in South Africa this method of immunization proved disappointing. In the Territory environment it is considered that every effort should be made to avoid vaccinating pigs possibly in incubation. The loss of pigs following vaccination will bring the vaccine into disrepute and increase the difficulty of future full scale vaccinations.

SUMMARY.

Bacillus anthracis isolated from cases of porcine anthrax in Papua and New Guinea had the morphological and biochemical characteristics of classical strains of the organism. Its pathogenicity was of the same order and its host range similar.

There are some unanswered questions regarding the transmission of the disease. Commercially available vaccines are effective in the establishment of immunity. Use of these vaccines in the Territory has been discussed briefly.

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Porcine Anthrax in Papua and New Guinea.

J. R. EGERTON.*

INTRODUCTION.

In 1946, an Army Veterinary Survey Unit described a disease of pigs in the Highlands of New Guinea which closely resembled anthrax (unpublished report). Carne (1958), who examined cultures of the organism derived from cases investigated by the Survey Unit, considered it to be a strain of Bacillus anthracis *of lower than normal virulence.*

Anthrax is a disease of a wide range of mammals. It is generally accepted that herbivorous animals are more usually affected (Sterne 1959). Anthrax in pigs is not, however, an uncommon disease and has been recorded in most parts of the world. In advanced communities anthrax in pigs usually results from the feeding of infected foodstuffs to confined animals (Brennan 1953). Experience has shown that anthrax in the Territory of Papua and New Guinea assumes epizootic proportions in large areas of the country. In a country where the pig is still the most common domestic animal the resulting loss is considerable.

In this introductory paper it is proposed to present available evidence on field aspects of porcine anthrax. Laboratory experiences with the causative organism will be described in a later publication.

DISTRIBUTION.

THE Territory of Papua and New Guinea is divided into 15 Administrative districts (see frontispiece map) : Of these the Southern Highlands District of Papua and the Eastern and Western Highlands Districts of New Guinea are considered to be anthrax enzootic areas.

In addition to these areas, the presence of anthrax has been confirmed in the Lumi Subdistrict of the Sepik District. Unconfirmed reports suggest the disease may exist in a small area of coastal country in the Madang District, about the mouth of the Ramu River.

The climate in Highlands Districts is more temperate than tropical. Climate data for the administrative centre of the three Highlands districts are given in *Table* 1. The valleys in which these centres are situated range in altitude from 5,000-5,500 feet above sea level. Subsidiary valleys may range in altitude up to 8,000 feet above sea level. Rainfull varies from 80-120 inches per annum and there is a concentration of rainfall in the months November to April, during the north-west monsoon season. Scattered rain falls throughout the drier south-east trades season.

The enzootic area in the Sepik District—the Lumi Subdistrict—is situated on the inland slopes of a coastal range, the Torrecelli Mountains, and ranges in altitude from 700 to 2,800 feet. Temperatures are accordingly higher, as is the rainfall at about 160 inches per annum. The country is less mountainous and generally more heavily timbered than the Highlands region.

Table 1.

	Mean Max. °F	Mean Min. °F	Relative Humidity %		Annual Rainfall ins.
			9 a.m.	3 p.m.	
Goroka	77.9	57.6	83	56	76.59
Mendi	74.2	54.6	75	74	111.58
Mount Hagen	76.8	54.5	82	64	102.57

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OCCURRENCE AND SEASONAL INCIDENCE.

In enzootic areas two types of outbreaks occur, the most striking being an epizootic form which causes the death of a large number of pigs. Epizootics occur in restricted areas such as a river valley system and recur at 3-5 year intervals. The second type of outbreak involves individual cases of anthrax which occur throughout the enzootic area at sporadic intervals.

It is probable that, within a given geographical area, a herd immunity develops following an epizootic which lasts for approximately the life of a pig, that is 3-5 years. Individual cases occur in those animals which were not involved in the previous epizootic or in which immunity has waned. The development of a new population with neither active nor passive protection against anthrax provides the basis for a further epizootic.

There is some evidence to suggest that the majority of outbreaks of anthrax occur during the wet season. *Table* 2 records the seasonal occurrence of outbreaks which have been investigated by officers of this Department.

Table 2.

Outbreak.	District.	Year.	Months.
Asaro River Valley	Eastern Highlands	1954	November-December.
Kama Valley	Eastern Highlands	1959	March.
Nebilyer Valley	Western Highlands	1961-1962	December-February.
Ningil	Sepik District	1962	January-April.
Henganofi	Eastern Highlands	1962	September.
		1963	June-August.
Kerowagi	Eastern Highlands	1960	April, May, June.
		1963	November-December.

MORBIDITY AND MORTALITY RATES.

The percentage of pigs affected in an outbreak is difficult to assess. Native owners only recognize the disease by the characteristic swelling of the neck region which occurs in the advanced cases. Since the development of this sign is usually followed by death, natives claim that all pigs affected die. It is likely, however, that infection producing no characteristic sign may occur in other animals and that the majority of these recover.

Mortality rates in pigs exposed to risk vary from 10-25 per cent. Two outbreaks which were investigated and confirmed bacteriologically as anthrax are summarized in *Table* 3.

Table 3.

Outbreak.	Pig Population.	Deaths.
Nebilyer, Western Highlands District	Estimated 4,000	400
Ningil Village, Sepik District	255	51

Pig populations in villages are difficult to count accurately as individuals may share ownership of several pigs and many of the village pigs spend most of the time foraging in surrounding bushland. The figures quoted in *Table* 3 are derived from questioning people in outbreak areas but do not necessarily account for the local feral pig population.

CLINICAL SIGNS AND POST MORTEM LESIONS.

Field cases of anthrax in Papua and New Guinea have all shown unilateral or bilateral swelling of the throat region which is accompanied by dyspnoea and sometimes dysphonia. Vomiting may occur. The temperature ranges from normal to 108 degrees F., respiratory and heart rates are elevated whilst depression and anorexia mark the terminal stages.

The swelling at the throat develops rapidly and death usually occurs 2-4 days after it first becomes obvious. In a small percentage of cases regression of the swelling occurs over about fourteen days and the animal recovers. No cases of intestinal infection have been diagnosed. At necropsy, lesions are confined to the affected throat area. Incision into this area shows the presence of a blood tinged gelatinous oedema and free fluid escapes from the incision. The organism can usually be cultured only from this area of oedema and sometimes from the regional lymph glands. Splenomegaly does not occur and a terminal bacteraemia is not usually present.

TRANSMISSION.

The nature of the lesion seen in field cases suggests that infection occurs by ingestion and possibly that infection is aided by the presence of lacerations in the mouth and throat regions.

DISCUSSION.

Bacillus anthracis strains isolated from pigs by officers of the Army Veterinary Survey Unit (unpublished) report were considered by Carne (1958) to be of lowered virulence. This view has been supported by Anderson (1960) who described porcine anthrax in the Territory of Papua and New Guinea as atypical. In fact anthrax in swine in the Territory is quite typical of that described in other countries. Losses resulting from the disease number many hundreds each year and anthrax is probably the most important bacterial disease of animals in the Territory. The organism when freshly isolated in the laboratory has all the characteristics described in standard texts.

The failure to diagnose field cases in other susceptible species in the enzootic area has lent support to the view that anthrax in the Territory of Papua and New Guinea is atypical. The native people live in very close association with their pigs and in the past the Highlands native usually ate pigs which died of anthrax. Throughout the area, however, the infective nature of the disease is recognized and the affected head region is discarded. Since a bacteraemia is not common in porcine anthrax the risk of acquiring anthrax from eating a pig is considerably less than from a herbivore.

Skin infection has been diagnosed bacteriologically in man once only in the Territory. The case occurred in a laboratory worker (Egerton unpublished). In 1962-1963, four cases of cutaneous anthrax were reported in native people in New Guinea (Commonwealth of Australia, 1964). None of these cases was confirmed bacteriologically (Abbott, 1964). Considering the high human population in the enzootic areas (ca. 700,000 people) and the degree of close association, the recorded cases of human anthrax are extremely low. Man is said to be quite resistant to anthrax however and symptoms, even when severe, tend to subside rapidly (Sterne, 1959).

The number of cattle grazing throughout the enzootic area of the Highlands is relatively small —5,000 to 6,000 head—and no deaths are known to have occurred from anthrax. The density of the pig population in the same region is much greater, and is estimated to be between quarter and half a million pigs. It is likely that as the bovine population grows and the grazing pressure increases, cases of anthrax will occur in these animals.

It has been demonstrated that sporulation is of importance in the persistence of anthrax in an enzootic area. Competition with organisms of decay or even soil saprophytes results in the destruction of the vegetative form of *Bacillus anthracis*. Minett (1950) showed experimentally that sporulation occurred slowly at 21 degrees C. and increased in tempo as the environmental temperature approached 37 degrees. The relative humidity of the environment also had some influence on sporulation. In conditions of relative humidity lower than 60 per cent. it was observed that desiccation might supervene before spores formed. Minett concluded from his investigations, however, that under practical conditions temperature is the most important factor controlling sporulation.

Minett (1951) on the basis of monthly climatological data divided India into areas according to their favourability for the development and persistence of anthrax. When the Territory of Papua and New Guinea is considered according to Minett's climatological data it is found that the Highlands region is only slightly favourable for sporulation and thus the maintenance of infection in the area. The mean daily temperature throughout the Highland valleys is in the vicinity of 70 degrees F. and relative humidity 65-70 per cent. Throughout the coastal plains the higher temperatures (80-90 degrees F.) and relative humidity between 50 and 60 per cent. would be more favourable for persistence if the disease was established as in the Sepik District. There is a possibility that if spread occurred the disease could become established in river valleys such as the Ramu and

Markham where cattle grazing is assuming some significance. While vaccination outside the present known enzootic areas would probably not be justified it would be desirable to vaccinate all cattle in the Highlands region and Lumi Subdistrict annually. Vaccination in both cattle and pigs should be carried out annually and timed to precede the wetter periods of the year, as evidence indicates that outbreaks are more prevalent at this time. The absence of proven cases of bovine anthrax until now does not necessarily prove that they have not occurred or will not occur in the future. The introduction of susceptible bovines as a potential source of infective material will do nothing to alleviate the present problem.

SUMMARY.

Porcine anthrax has been recognized in Papua and New Guinea since 1946. It is enzootic throughout the Eastern, Western and Southern Highlands Districts and in the Lumi area of the Sepik District. Throughout the enzootic areas sporadic losses occur throughout the year. From time to time epizootics occur in restricted areas resulting in an annual loss of many pigs. All cases of the disease seen have been characterized by unilateral or bilateral swelling of the pharyngeal region.

Field cases of anthrax have not been reported in other domestic animals. Cases in man are also apparently rare. The possibility of the establishment and persistence of anthrax in other parts of the Territory has been discussed.

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Rubber Planting Techniques—Part II—Nursery Practices.

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In a previous article, Papua and New Guinea agric. J. 17 (1), *the author discussed the handling of ruber seed. This series is now continued with nursery practices.*

NURSERY BEDS.

NURSERY beds must naturally be situated on good soil, in proximity to a water source, as regular watering of the young plants will be required. Flat land, in a central position to the area which is to be planted, is preferred.

A soil with a high water table must obviously be avoided. The plants on such soil may grow quite well in the early stages but when the taproot reaches the waterlogged level growth comes practically to a standstill and the plant will eventually die.

Nursery beds may vary in width from 4-8 feet with a spacing of 2-4 feet between beds. Length of the beds depends on the shape of the area and the number of plants required ; in other words the beds could be of any desired length. However, for practical reasons a rectangular lay-out of beds would be preferable to an elongated one. At the Bisianumu Rubber Centre a standard nursery bed is eight feet wide with four feet between beds and 40-60 feet in length. It was found that this shape of nursery bed was more practicable for digging and shading work and was of a convenient size for the propagation of seedling-stock as well as for seedling stumps.

In establishing the nurseries it is a normal practice in this Territory to dig the beds to a depth of at least two feet, preferably three feet. The usual method is to dig out the soil placing the top soil on one side and the subsoil on the other side. Upon reaching the depth required, the soil is returned into the hole, subsoil first. Another method is to dig out the soil to a depth of 1-1½ feet and then fork a further depth of one foot. This method can only be used on the lighter soils and where there are no stumps and big roots to be removed. The deep digging of rubber nursery beds is done to ensure a loose soil for straight root development which will assist vigorous, healthy growth of the young plants and which facilitates pulling of the stumps for transplanting. A good nursery bed is built up to some 4-6 inches above ground level in order to drain surplus water ; the sides may be supported by bamboo or other suitable material. The top of the bed is worked into a fine tilth and levelled off with a rake. Overhead shade is erected at a convenient height. Palm leaves, kunai grass or any other suitable bush plant may be used as overhead shading material. Shade should be light and is only temporary. It must be of sufficient density to protect the young emerging plants from direct sunlight during the first month of growth. The erection of overhead shade completes the nursery bed.

In areas where bandicoots, pigs or other bush animals are troublesome it is advisable to surround the nurseries with a fence. Rats can also do considerable damage to seed and young seedlings.

PLANTING GERMINATED SEED.

The seeds are considered to have germinated as soon as the micropyle bursts and the tiny white rootlet, or radicle, appears. Germination beds should be inspected daily for germinated seeds which are immediately transplanted to the nursery beds. Transplanting is most successful if done before the young root is one inch in length, preferably before the young stem develops, as explained in Part I of this series under the heading *Germinated Seed*. Before placing the germinated seeds in the soil the bed is lightly watered for ease of working. Planting is done slightly deeper than at the germination beds ; the seeds must be just covered with soil. After planting, the nursery bed is thoroughly watered. Spacing of the germinated seed at the nursery bed depends on the length of time required before transplanting into the field. The longer the plants are to be kept in the nursery, the wider the spacing has to be. For the propagation of pencil stumps of about ⅜ in. to ¾ in. in diameter, for which normally a growing period of 6-9 months is required, a spacing of 9 in. x 6 in. is recommended. Normal seedling stumps of about $\frac{3}{4}$ in.-$1\frac{1}{4}$ in. in diameter, requiring some 10-12 months of growth, a spacing of 12 in. x 9 in. will be needed.

When propagating seedling stock for future bud-grafting a most convenient spacing are double rows of one foot apart with two feet between the double rows and the plants spaced nine inches in the row. Clonal seedlings at Bisianumu are propagated at a spacing of 9 in. x 6 in. on an eight feet wide bed ; the first row at 6 in.-8 in. from the edge giving a total of ten rows. Spacing between rows is nine inches. These seedlings are kept in the nursery beds for approximately 8-9 months.

The above are recommended spacings for the planting of the germinated seed. This initial spacing of the seedlings becomes naturally wider after the thinning out of weak and diseased plants, as will be discussed in the following.

NURSERY MAINTENANCE.

There is no need to stress the importance of both weeding and watering during the early growing period. The growth of weeds is considerable in the first months after planting ; weeds compete with the rubber seedlings for water and plant food. Efficient weeding during the first 3-4 months is essential for healthy and rapid development of the seedlings. As the seedlings grow, the shade of their leaves helps to prevent heavy weed growth and the need for weeding will become less frequent. Inefficient weeding reduces growth of the rubber seedlings, lengthening the nursery period and thus increasing expenditure. The newly planted seed may require daily watering in its initial two weeks in the nursery. Frequency of watering depends on weather conditions. The topsoil should be kept in a moist condition and must not be allowed to dry out. Watering is gradually reduced as the plants develop. Mulching will greatly help in moisture preservation as well as reducing weed growth and improving soil structure. Mulching is best carried out after completion of the first growth cycle, when the first pair of leaves have matured and the second growth cycle commences. This occurs normally in about 6-8 weeks after planting of the germinated seed.

Kunai grass (*Imperata cylindrica*) is most widely used for mulching in the Sogeri District, but other cut grasses and vegetable matter may also be used to advantage. Mulching could well coincide with the first reduction in overhead shade, which should be removed gradually in the period of 6-10 weeks from planting in the nursery.

Heavy shading over a long period results in weak, spindly seedling growth. Shade should always be reduced gradually, as removal of all shade at once will result in severe sunburn of the leaves. Weather conditions will more or less dictate the shade removal programme. In areas where cloudy and rainy conditions prevail, the removal of shade can be done earlier than in the sunnier and drier districts. In this connection it may be mentioned here, that at the Bisianumu Rubber Centre where cloudy and rainy conditions usually prevail during nursery establishment in April-May, overhead shade is not used at all on nursery beds for local seedlings *, and mulching is commenced within a month from planting. The normal practice, however, is to provide a light shade, up to approximately three months from planting in the nursery. The fact that no overhead shade is used at Bisianumu is mentioned merely to illustrate the point that there are no rigid rules on nursery shade management. The planter should judge local conditions and adapt his nursery shade establishment to the prevailing climatic conditions. Generally speaking, planters in this Territory establish a too heavy overhead shade on their rubber nurseries and leave this shade longer than is desirable.

Other nursery maintenance work includes the early removal of double stems. In cases where a double stem develops, the strongest of the two is maintained and the other one cut away with a sharp pruning knife or secateurs. Side shoots are regularly removed.

Weak plants and seedlings with deformed leaves are removed and discarded. Only strong, healthy plants, which will develop into vigorous rubber trees, are kept. Thinning out of the weak and undesirable plants is best done in two operations, at three and six months old respectively. This will reduce the number of seedlings by some 20-30 per cent.

* Seedlings derived from locally collected seed, clonal as well as common seed ; seedlings derived from imported seed are propagated under temporary shade at Bisianumu.

MANURING.

Although manuring of rubber nursery beds is not a common practice in this Territory, it may be advisable to give some directions on the subject. Manuring depends entirely on the natural fertility of the soil, and the need for it should be judged by the growth of the plants. Territory rubber soils are generally of better natural fertility than are most of the soils for rubber cultivation in the Malayan Peninsula, where heavy manuring is the normal practice.

If compost or dung is available the initial manuring of a nursery could be done at the rate of 3-4 tons per acre. On Malayan inland soils it is a common practice to apply rock phosphate and magnesium lime at the rate of 5 cwt. and 2 cwt. per acre. This is worked into the soil to a depth of some 6-9 inches.

At the Bisianumu Rubber Centre nursery beds are not manured when established on virgin land. However, when the same land has to be used for a second time a dressing of a compound fertilizer, containing N.P.K. with the accent on the nitrogen component (N.P.K. 21 : 14 : 14), is usually given at the rate of approximately 3 ozs. of fertilizer per square yard of nursery bed. This is lightly worked into the top soil before the planting of the germinated seeds. Subsequent nursery manuring at the rate of 1 oz. per yard of plant row could be done at three-monthly intervals but only when the growth of the plants indicate that fertilizing is desirable.

PESTS AND DISEASES.

Pests and diseases of rubber nurseries in this Territory are fortunately limited to a few which need regular control measurements.

The most common nursery pest in the Sogeri District is the Papuan tip-wilt bug, *Amblypelta lutescens papuensis,* Brown. This insect sucks the soft tissues of the terminal growth and may cause severe wilting and dieback of the stem. The result is the growth of numerous unwanted side branches, making it difficult to develop the desired straight and single stem. Cassava is one of the favourite host plants of *Amblypelta* and should not be allowed to grow in the vicinity of rubber nurseries.

Insecticidal spraying is to be carried out as soon as this pest is noticed and regular spraying rounds at three-weekly intervals will effectively control this bug. A widely used insecticide in the control of *Amblypelta* at rubber nurseries is Dieldrin concentrate 15 per cent. It is usually applied by means of a knapsack spray as a 0.3 per cent. solution, i.e., one part of Dieldrin to 50 parts of water.

D.D.T. emulsion 25 per cent. may also be used as a 0.25 per cent. solution, i.e., one part of D.D.T. to 100 parts of water.

Another troublesome insect in nurseries as well as in the field are the *Idiopsis* weevils, *Idiopsis grisea* and *Idiopsis caerulea*, these are leaf eating weevils which have been recorded on a great number of host plants including sweet potato, cacao and coffee. They can be a serious pest in young rubber. Damage consists of numerous small holes, " shotholes ", in the leaves and they have also been known to completely defoliate a field of young rubber in the Sogeri District.

Control by D.D.T. emulsion as mentioned above for *Amblypelta.*

Army worm (*Tiracola plagiata*), when appearing in plague proportions is a serious threat to rubber of all ages. This pest has been recorded several times in the Sogeri District since 1958 ; the last time in April-May, 1964. It has also been reported in other rubber growing districts of Papua. These caterpillars completely defoliate the trees and practically all other growth in their path. They are a particularly serious pest in young budgrafted trees as they eat away the emerging shoot from the budpatch, resulting in a complete loss of the budgraft. They can destroy a rubber seedling or budgraft nursery in a matter of a few hours. D.D.T. spraying with a knapsack spray at 0.25 per cent. solution is the recommended control.

The above pests are the more important ones during the nursery stage. Further details of rubber pests are described by Smee : " Insect Pests of *Hevea Brasiliensis* in the Territory of Papua and New Guinea : their Habits and Control ", *Papua and New Guinea agric. J.* 17 : 1.

With regard to diseases in the nursery, only the *Gloeosporium* fungus is of importance at this stage. Pink disease, caused by the fungus *Corticium salmonicolor*, is seldom found in the nurseries.

The *Gloeosporium* fungus causes the young leaves to shrivel and fall, and often results in deformations of the older leaves. In severe cases it will cause dieback of stem and branches. The disease retards the growth of the plants, but usually does not result in death. The fungus is effectively controlled by copper spraying ; Copper Oxychloride, 3-4 lbs. in 100 gallons of water, or approximately 1 oz. for every two gallons of water, applied by means of knapsack spray at 2-3 weekly intervals. The use of a sticker to the fungicide is advisable, particularly during the wet season when the disease is more prevalent. Leaves should be sprayed on upper and lower surface to be effective.

PROPAGATION OF BUDDED MATERIAL.

When it is intended to propagate seedling-stock for subsequent budgrafting at the nurseries, the initial spacing of the germinated seed is usually wider than for the propagation of seedling stumps as described above under " Planting Germinated Seed ". Otherwise, establishment, maintenance, etc., is the same as for seedling stumps.

Budgrafting of common seedling-stock is done either at 4-7 months of age (the so-called green budding method), or at 8-14 months of age for the conventional shield budding method, as described in the *Papua and New Guinea agric. J.* 10 : 3. The budgrafted trees are transplanted from the nursery to the field either as budded stumps within 1-6 months after budding, or as stumped buddings at 9-15 months after budgrafting.

A budded stump is a budgrafted seedling tree in which the grafted bud is still dormant. The tree is stumped shortly before transplanting and the bud is then allowed to develop into a tree.

A stumped budding is a grafted tree which has been stumped before transplanting, i.e., the seedling stock has been grafted with the selected bud and this bud has over a period of approximately one year at the nursery grown into the desired grafted tree.

Propagation of budded stumps is the more common nursery practice when budded material is required. Stumped buddings are more costly in propagation and transplanting and are not generally recommended.

Transplanting and the care of all types of planting material will be discussed in Part III of this series.

(Received March, 1965.)

Salmonellosis in Animals and Birds in Papua and New Guinea.

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INTRODUCTION.

The domestic animal population of the Territory of Papua and New Guinea is relatively disease free. The so-called exotic virus diseases do not occur.

Bacterial diseases of livestock, brucellosis and tuberculosis, are subject to eradication campaigns. Salmonellosis of animals, which is of considerable significance in most livestock-producing countries in a wide range of animals, appears at present to occur sporadically in this Territory.

This paper describes clinical outbreaks of salmonellosis in cattle, pigs, poultry, a horse, a cat and guinea pigs, confirmed by the Veterinary Laboratory, Kila Kila, Port Moresby, in the period July, 1962 *to August,* 1964. *It also presents results of a limited survey into the incidence of carriers of* Salmonella *serotypes in pigs and cattle in the Territory.*

MATERIALS AND METHODS.

MATERIALS used in the diagnosis of clinical cases of salmonellosis have been faeces, intestinal content and organs of animals taken at post mortem examinations. Survey material consisted of faeces and paired faeces and mesenteric lymph node samples from abattoir pigs.

The laboratory practice has been to culture faecal lymph node samples overnight in an enrichment broth (tetrathionate and selenite) and to subculture at 24 hours on to desoxycholate citrate agar and MacConkey agar. Suspect colonies have been plated onto nutrient agar and submitted to standard biochemical tests. Those isolated which have had the biochemical reactions of the *Salmonella* group have been subjected to slide agglutination tests, using serum supplied for the purpose from Commonwealth Serum Laboratories, in Australia. Definitive typing has been carried out by either the above laboratory, the Institute of Medical and Veterinary Science, Adelaide or Department of Health, Brisbane.

DESCRIPTION OF CLINICAL SYNDROMES.

Horse.

Salmonella paratyphi C was isolated from one of four horses in the Rabaul area all of which had chronic diarrhoea. Treatment with antibiotics was of little if any value in four of the five cases. The horses belonged to two stables and there was contact between them by virtue of a mare being brought to service from one to the other.

The organism was isolated from a foal of about four weeks old. It had had diarrhoea from a few days of age and treatment with sulphaguanidine for two weeks apparently effected a cure.

The affected horses were shown to have significantly higher antibody levels to both O and H antigens of *Salmonella paratyphi* C than other unaffected horses, which were at risk. A native labourer whose duties included feeding of the affected horses was found to be an asymptomatic carrier of *S. paratyphi* C.

RESULTS.

Table 1.—Isolations from July, 1962 to August, 1964, from clinical cases of Salmonellosis.

Group.	Serotype.	Host.	No. of outbreaks.	Place in which outbreak occurred.
B	*S. saint-paul*	Cat and cattle	2	Port Moresby and Munum Plantation, via Lae.
C	*S. paratyphi* C	Horse	1	Rabaul.
	S. bareilly	Pig	1	Port Moresby.
	S. cholerae-suis	Pig	1	Port Moresby.
	S. virchow	Chicken	1	Port Moresby.
	S. thompson	Cattle	1	Rigo, via Port Moresby.
D	*S. pullorum*	Chicken	3	Kokoda, Lae and Port Moresby.
E	*S. anatum*	Pig and Cattle	2	Port Moresby and Munum, via Lae.
	S. london	Pig	1	Erap, via Lae.
	S. weltevreden	Guinea Pig	1	Port Moresby.

Poultry.

Two classical outbreaks of pullorum disease have been diagnosed in the Territory of Papua and New Guinea in the period under review. They were characterized by high mortality rates in the first week of life. Lesions at post mortem examinations were congested livers, pericarditis, caseous nodules in the lungs and unabsorbed yolk sacs. *Salmonella pullorum* was isolated from all these sites. In one outbreak in chickens imported by the Administration for distribution to native owners, all chickens in the batch were destroyed.

The third outbreak of pullorum disease occurred at an Administration owned brooding establishment. The disease history was unusual in that deaths did not occur until six weeks of age and initial mortality was not high. The whole brooding establishment was subjected to agglutination tests and over a 4-6 week period after the initial diagnosis, 15 per cent. positive reactors were found in the 1,200 birds on the property.

Some difficulty was experienced in isolating *S. pullorum* from these positive reactors. It was eventually isolated however from the liver and gall bladder of birds submitted to the laboratory.

Salmonella virchow. Deaths from toxaemia occurred in another batch of 100 (week-old) chickens imported as day-olds to the Animal Quarantine Station, Kila Kila, Port Moresby. Eight deaths occurred within two days and it was decided to destroy the whole batch. Lesions were typical of acute toxaemia and *S. virchow* was isolated from visceral organs and heart blood.

Guinea Pigs.

The outbreak of salmonellosis in guinea pigs due to *S. weltevreden* has been described previously by Egerton and Rampling (1963). It was characterized by intermittent losses in the laboratory's colony. The features of the disease were abscess formation in the liver, spleen and mesenteric lymph nodes and peritonitis.

Pigs.

Salmonella london. This organism was isolated at Erap via Lae, from a sow which died of toxaemia shortly after farrowing.

S. cholerae-suis. Diphasic strain. This outbreak occurred at the Animal Quarantine Station, Kila Kila. The piggery at the time housed four adult locally bred pigs, one boar and three sows —one sow with a litter of six (four-week-old) piglets, and 55 imported pigs which had been introduced from New Zealand about one month previously and were in contact with the local stock by virtue of having common attendants.

All stock was fed a ration made up of coconut meal, wheatmeal, cracked corn and meat meal with a vitamin supplement. Hygiene and management was considered to be sound.

The first loss occurred in a locally-bred boar which died with acute toxaemia after twenty-four hours' sickness. Post-mortem examination revealed haemorrhages in the heart and lungs and small areas of congestion in the small intestine and mesenteric lymph nodes. A pure culture of a diphasic strain of *S. cholerae-suis* was obtained from the bile, lung and pericardial fluid.

On the following day a locally bred sow died. The principal lesions were massive areas of congestion and necrosis in the stomach and small intestine. *S. cholerae-suis* was isolated from the organs and the heart blood. These deaths were followed by the deaths of two or four piglets with similar lesions. No clinical illness was observed in any of the imported pigs.

The first tests, which were carried out on the day after the first death, revealed no carriers amongst the pigs but four different *Salmonella* serotypes were isolated from the food mix and the remainder of the meat meal which had been added to that mix. A repeat test five days later revealed that 21 pigs were excreting group E serotypes and one pig a group C serotype.

Subsequent typing confirmed that *S. Anatum* was present in the meat meal and was being excreted by the pigs. The presence of *S. cholerae-suis* in the meat meal was confirmed and also three other serotypes (see *Table* 2). It is likely that many more serotypes were present in the meat meal but not confirmed.

Cattle.

S. thompson. This organism was isolated from faecal samples of a group of sixteen cattle, which had been transported 42 miles by truck from one property to another in the Rigo (near Port Moresby) area. About a week after arrival four deaths occurred following scouring and several beasts had a milder enteritis. Unfortunately, post mortem examinations were not carried out.

Table 2.—**Bacteriological Findings.**

Group.	Serotype.	Source.
C	*S. cholerae-suis*	.... Dead pigs and meat meal.
E	*S. anatum*	.... Pigs (no symptoms) and meat meal.
C	*S. bareilly*	.... Pigs (no symptoms).
C	*S. infantis*	.... Meat meal.
E	*S. vejle*	.... Meat meal.

S. anatum and *S. saint-paul.* An outbreak of salmonellosis occurred in a herd of 242 young heifers at Munum Plantation, via Lae. These cattle had been imported recently from North Queensland and the final batch of 103, along with one stallion, had arrived four weeks before the start of the outbreak. Five cattle had bloody diarrhoea and four deaths occurred. Three dead heifers were examined, the post mortem picture being that of acute septicaemia. *Salmonella saint-paul* was isolated from the peritoneal fluid.

Salmonella anatum was also isolated from the faecal specimen of an eighteen months old heifer which was scouring and in poor condition. This animal was treated unsuccessfully with sulphadimidine and died after a few days.

Thirty-nine faecal specimens were tested from other beasts in the herd and eleven of these were found to be positive for *S. anatum.* This organism was also found in the faeces of the stallion which was in contact with the herd.

The stallion was being fed on a locally compounded ration containing some imported meat meal. This same ration was being fed to ducks which were dying in large numbers on another property. Samples of the ration and faecal specimens from the ducks were tested but it was not possible to prove any cross infection.

Cat.

S. saint-paul. This organism was isolated from a cat which was treated at the Veterinary Clinic, Port Moresby. The cat was submitted with an elevated temperature and suffering from severe diarrhoea. The organism was found to be sensitive in vitro to streptomycin and the animal was treated with Streptomagma. The cat was not brought back for re-examination.

SURVEY.

Results of our survey investigations into the incidence of carriers amongst cattle and pigs are given in *Table* 3.

Table 3.

Salmonella Survey.	Samples.		Isolations.
Swine (New Britain abattoir)	Faeces	309	1
	Mesenteric lymph nodes	109	1
Swine (New Guinea Highlands)	Faeces	320	1
Cattle (all main centres of Papua and New Guinea)	Faeces	150	1
		888	4

Two of the organisms isolated from the 738 pig specimens were of group D (not further identified) of the Kaufmann-White classification and the other was *Salmonella anatum*. The cattle sampled came from the main centres of Papua and New Guinea and were all aged twelve months or less. One group E serotype was isolated from the bovine faeces but not identified.

DISCUSSION.

Poultry.

S. pullorum. Day-old chicks were imported only from Australian hatcheries which have a satisfactorily low incidence of positive pullorum reactors in their flocks. For two of the pullorum outbreaks described, the authorities in Australia were able to show that the incidence of pullorum reactors had risen above the acceptable level. In the outbreak at Lae which occurred in older birds it could not be shown that the hatchery was at fault. The disease syndrome suggested that the infection may have been acquired locally.

S. virchow. It is probable that this infection was picked up on the property, as there had been an outbreak of porcine salmonellosis some time before and on testing it was found that some pigs were still excreting a variety of *Salmonella* spp. serotypes. Cross infection would have been easy because at the time the same attendants fed both the pigs and the chickens.

Pigs.

S. cholerae-suis. S. cholerae-suis does not as a rule, produce an acute fatal illness in adult pigs and it is interesting to note that, although all the herd was exposed to infection, only the locally-bred stock succumbed. These animals were in good condition and on a balanced ration. The only apparent reason for their susceptibility is that their isolated environment had not enabled them to acquire any active immunity by previous exposure to infections.

Our results seem to incriminate the meat meal as a source of infection and as a variety of serotypes were isolated from it, it is most likely that contamination occurred during manufacture. Tests on the imported pigs revealed no carriers at the time of the first death but, after a few days of exposure to contaminated feed, several pigs were excreting *Salmonella*.

The production of sterile meat and bone meal presents difficulties as the environment of the plant invariably contains a variety of contaminants originating from the raw bones and offal (Gray *et al*, 1960). Even under strict conditions of production it is easy for a bag or batch of meat meal to become contaminated. *Salmonella* spp. have been shown to multiply and survive for several years in meat meal and consequently this feed is a source of danger in a pig breeding enterprise such as this. This is especially so in the Territory of Papua and New Guinea where, if our preliminary results are confirmed, little, if any, immunity to *Salmonella* exists in pigs.

Cattle.

S. thompson. This appears to be a classic example of mature cattle, which are not under normal conditions susceptible to acute salmonellosis, becoming clinically affected after being subjected to the rigours of transportation.

S. anatum and *S. saint-paul*. The outbreak at Munum occurred in young cattle within the age group which is generally considered to be susceptible to salmonellosis, i.e., under two years old. It is unfortunate that it was not possible to trace the source of infection.

GENERAL DISCUSSION.

The results of our limited survey on cattle and pigs agree with indications obtained in clinical outbreaks that the incidence of *Salmonella* infections in animals and domestic fowl in the Territory of Papua and New Guinea is very low. In addition Public Health Department's records of clinical outbreaks in the human population over the past two years confirm our opinion that the incidence of salmonellosis (excluding typhoid and paratyphoid) in man and animals is lower here than in Australia.

At the Kila Kila Veterinary Laboratory only ten different strains of *Salmonella* spp. were isolated from clinical outbreaks. Of these it was evident that in some cases the infection had been introduced, as in the outbreak of porcine salmonellosis at Kila when meat meal was incriminated and in two of the outbreaks of pullorum disease.

It is interesting to note that *S. cholerae-suis*, which was found by Simmons *et al*, 1963, to be the cause of 162 out of 239 outbreaks of porcine salmonellosis in Queensland, was isolated only once by us, in spite of the large pig population of the Territory. This organism has been recorded only once in a human patient during the past years. *Salmonella typhimurium* has been recorded by the authors (Simmons *et al*. 1963) as the strain most frequently found in Queensland animals and birds but it does not appear to have reached the Territory as yet.

SUMMARY.

A record of the *Salmonella* diagnosed in animals and domestic fowl from July, 1962, to August, 1964, has been made. Only ten different strains have been isolated and it appears that salmonellosis is not as yet of economic significance in livestock enterprises in the Territory.

ACKNOWLEDGEMENTS.

The authors are grateful for the assistance of the Veterinary Officers of the Department of Agriculture in carrying out post-mortem examinations and submitting specimens and information to us.

We also wish to thank Dr. J. Gulasekharam, Commonwealth Serum Laboratories, Melbourne, Dr. K. F. Anderson, Institute of Medical and Veterinary Science, Adelaide and Dr. J. Tonge, Department of Health, Brisbane, for the serological typing of cultures.

(Received January, 1965.)

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Rubber Planting Techniques—Part III—Transplanting and Maintenance.

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INTRODUCTION.

In Part I and II of this series *Rubber Planting Techniques* the handling of rubber seed and nursery practices respectively have been discussed. The final part deals briefly with land preparation, and more extensively with transplanting operations and field maintenance until the tapping stage is reached. Mulching, Manuring and Cover Crops, which are part of rubber plantation establishment are also discussed.

FIELD PREPARATIONS.

Before transplanting operations can commence the area to be planted must be prepared. After clearing of the land, planting lines and planting points are to be marked out, plant holes are to be dug and cover crops have to be planted.

In clearing the land the aim should be to clear no more than is necessary for accessibility and ease of working conditions. Burning should be limited to a minimum. Complete clearing and heavy burning destroys the humus constituent of the soil erosion. In felling operations, the trees should be dropped along the contours to assist in erosion control and they may also be used to advantage in terracing work.

TERRACING.

On hilly terrain terracing is strongly recommended. In terracing operations a contour line is pegged out with the aid of a dumpy level, an "A" frame or by another suitable method. Terraces follow contour lines. Digging of the terrace is commenced by starting at about four feet upwards from the previously pegged-out contour line. Soil thus removed is shoveled down this slope to about four feet on the opposite side of the contour line. The result will be a terrace of approximately 6-8 feet width.

Terraces must be sloped inwards into the hill so that water running down the hill is caught on the terraces. The object thereof is prevention of soil erosion. A slope giving a difference of 9-12 inches between outer and inner perimeter is usually sufficient. To check the flow of rain water along the terraces it is normal practice to construct stops at regular intervals. A stop is an uncut part in the contour line of some 2-3 feet in width. For instance, with a spacing of ten feet between trees on the terrace a stop could be constructed at 30 feet intervals, in between every third and fourth planting point. Planting points are measured at about two and a half feet outward from the inside perimeter of the terrace. This allows for sufficient room to walk along the outside of the terrace in future tapping operations.

Individual terraces, i.e., a platform of some 4-6 feet in diameter around the tree, are sufficient on the more gentle slopes, but in general the "continuous" type of terrace is recommended.

SPACING.

The spacing of the trees depends on the type of terrain to be planted. On hilly land the distance between planting rows is usually wider than on flat land. An "avenue" of spacing, i.e., a wide distance between rows and a relatively close spacing between trees in the rows, will simplify future tapping operations and latex collection. It will also reduce terracing and weeding costs.

Spacing depends on whether a high yield per acre or a high yield per tapper is required. With high labour costs and relatively low rubber prices it would be more economical to concentrate on yield *per tapper*. In that case the stand per acre should be less than when yield per acre is aimed at. Another point to remember is that seedling trees have a greater variation in yield than budgrafted trees and that they therefore require more rigorous culling. This is the reason why the initial stand per acre is usually more for seedling trees than for budgrafted trees. To achieve the optimum number of trees per acre when they reach maturity, the initial stand should be 20-30 per cent. more than the desired final stand. Stand per acre is of course directly related to spacing. A popular spacing on flat land in Malaya is 15 x 14 feet for seedling stumps, giving 207 trees per acre and 17 x 16 feet for budded stumps, with 160 trees per acre. On hilly terrain the more popular spacings are 24 x 10 feet (182 trees/acre) and 27 x 9 feet (197 trees/acre). Some years ago a spacing of 30 x 8 feet (182 trees/acre) was not unusual but lately a wider spacing of trees in the row is recommended.

Whatever spacing is decided upon it should be remembered that the "avenue" type spacing is more economical in establishment, maintenance and latex collection costs.

For these reasons, a spacing of 24 x 10 feet, with an initial stand of 182 trees per acre could generally be recommended for rubber plantings in this Territory .

HOLING.

Planting holes are usually made about one month prior to planting operations. For normal size planting material, i.e., stumps of approximately one year of age a hole of two feet in diameter and tapering to one foot at a depth of two feet is quite satisfactory. For smaller planting material, like pencil stumps, a hole of 12 x 12 x 15 inches will be adequate. Leaving the hole open for some weeks will allow weathering of the soil. The holes are filled in to half of their depth a few days before planting. Any water in the holes is removed prior to filling. Subsoil is placed in the hole before the top-soil.

DRAINAGE.

Drainage of wet areas is another preparation required before planting. Surplus rainwater must be able to drain off effectively. A water-table at a minimum depth of three feet is normally essential to healthy growth of the trees. Although the rubber tree likes an abundant water supply it will not grow in a water-logged soil.

COVER CROPS.

The disastrous effects rain and sun can have on exposed soils under tropical conditions is well known.

In practically all plantation crops, the soil is protected against the adverse effects of weather and erosion by the planting of ground covers or cover crops. In rubber cultivation it is preferable to have these ground covers established before the rubber is planted. Ground covers may either consist of natural vegetation or may be planted crops. The latter type of cover is usually a leguminous creeper or shrub. The advantage of a leguminous type of cover crop over non-leguminous natural covers is that the legumes mobilise, through bacterial action in their root nodules, considerable amounts of nitrogen which become available to the rubber tree. Disadvantages of leguminous covers are the relatively high costs of establishment and maintenance as compared to natural covers. Legumes are often difficult to establish.

Natural, as well as leguminous covers improve soil structure by their decaying vegetable material and thus enrich the soil with organic plant food. On the other hand, both types of covers may become competitive to the rubber trees in nutrients and water intake.

The question of which is best—leguminous or natural cover is a matter of opinion which should be based on the economics of the two systems and which vary with location. Generally speaking, in Malaya the establishment of leguminous ground covers is common plantation practice. Cover crops in Malaya are meticulously weeded and fertilized as well.

In the Territory of Papua and New Guinea the natural covers are much more common and only a few plantations have seriously attempted to establish leguminous cover crops. The reason for this lack of interest in legumes among Territory rubber planters is probably due to insufficient labour being available for regular weeding rounds as well as the relatively high costs of establishment and maintenance of legumes.

There seems to be no doubt that legumes generally have an advantage over natural covers, provided the maintenance work, in particular weeding, is strictly under control. Neglect in legume maintenance could result in complete failure of the cover crop and will certainly make legumes compare most unfavourably with natural covers—as well as proving un-economic.

The Department of Agriculture, Stock and Fisheries, at their Bisianumu Rubber Centre, has adopted natural covers as a general policy in their clonal yield trials. Promising legumes, such as *Calopogonium caeruleum* and *Flemingia congesta* have been established in observation plots. In both systems at Bisianumu the rubber planting lines are strip-weeded and mulched. Finally some notes on the establishment of ground covers :

Leguminous Covers.

Among the better known leguminous creepers in rubber cultivation are : *Pueraria phaseoloides, Calopogonium mucunoides* and *Centrosema pubescens*. Leguminous shrubs are not as widely used as the creepers ; among the better known shrubs are—*Crotalaria anagyroides* and *Tephrosia candida,* while *Flemingia congesta* has become more popular in recent years. The creepers are usually sown in drills about five feet apart and not closer than six feet from the rubber lines. Calopogonium, Centrosema and Pueraria are mostly planted as a mixture (5 : 4 : 1 by weight) at the rate of 4-5 lb. per acre. Centrosema grows rather slowly but is more persistent. Pueraria and Calopogonium both grow fast but *Calopogonium mucunoides* dies back during drought and is found difficult to re-establish, while Pueraria is more susceptible to insect pests. One of the newer species of leguminous creepers is *Calopogonium caeruleum.* It has proved to be the most vigorous legume introduced at Bisianumu. When properly established it suppresses all grass and weed growth. *Calopogonium caeruleum* does not die back during drought and appears to be shade tolerant. It may prove, however, to be rather competitive to rubber. *Calopogonium caeruleum* does not produce seed under Territory conditions (as is also the case in Malaya). Malaya imports the seed from the Philippine Islands. At Bisianumu *Calopogorium caeruleum* is propagated from cuttings with 80-90 per cent. successful establishment under favourable conditions.

Of the leguminous shrubs, both *Crotalaria anagyroides* and *Tephrosia candida* proved susceptible to pink disease at the Bisianumu Rubber Centre. Both had to be eradicated as they were a source of infection to the rubber trees. *Flemingia congesta* appears to be promising. Flemingia seedlings are raised in nurseries, sown in rows four inches apart. The young seedlings are transplanted to the field when 2-3 inches high at a spacing of 4 x 4 feet and not closer than eight feet from the rubber lines. Flemingia is a slow starter, is shade tolerant and produces great quantities of leaf mulch when regularly slashed, at 2-3 feet from the ground. It tolerates slashing well. Seed production, if required, is abundant within 6-10 months from slashing or planting.

Like most of the legume cover crop seeds Flemingia seed has a very hard seed coat and is therefore extremely slow in germination if not specially treated. Untreated seed showed approximately 60 per cent. germination after nine weeks, against 80 per cent. germination in ten days with treated seed. Seed treatment is quite simple and most effective. It consists of placing the seed in a dish or a bucket and pouring hot water over the seed while stirring. The seeds are left in the water for 6-8 hours, floating seeds and debris are scooped off and discarded. Seeds are sun dried for 5-10 minutes and are then ready for planting. Successful establishment of leguminous cover crops depends for a great deal on favourable weather conditions after sowing or planting in the field. Another important factor is to keep the plants free of weeds. Under Territory conditions weeding of cover crops may prove rather costly and in such instances it appears to be more practical to have a natural cover established.

Natural Covers.

In newly cleared areas natural grasses and shrubs quickly establish themselves. By removing the harmful weeds and those with undesirable characteristics a natural cover of harmless grasses, weeds and shrubs is obtained in short time and at minimum cost. Maintenance of natural covers consists of periodic removal of undesired growth. In the areas under natural cover at the Bisianumu Rubber Centre unwanted growth is removed during the regular rubber-row weeding rounds. All growth between the rows is slashed to a few inches above ground level once or twice a year during the period of immaturity of the rubber trees.

When the trees reach maturity, most grasses and shrubs die out and only the shade-tolerant species remain. This applies also to leguminous cover crops.

PLANTING MATERIAL.

The various types of planting material discussed in this article are :

(*a*) Seedling stumps ;
(*b*) Budgrafted stumps ; and
(*c*) Germinated seed.

Besides the above-mentioned, there is another type of planting material which is becoming increasingly popular in Malaya, namely young seedlings and budded stumps propagated in polythene bags.

Although a few Territory plantations, including the Bisianumu Rubber Centre, are experimenting with this type of planting material there is at present insufficient information available to enable recommendation to be made on general usage. Planters interested in polythene bag planting techniques are referred to No. 63 of the *Planters' Bulletin* of the R.R.I.M.

For the Territory of Papua and New Guinea, we are at present mainly interested in the planting material as mentioned above under (*a*) ; (*b*) ; and (*c*).

(*a*) *Seedling Stumps.*

This is the more commonly used planting material in the Territory, probably on account of the ease of propagation and handling during transplanting operations. A stump of 10-12 months of age, with a diameter of approximately one inch at ground level, seems to be the adopted standard size of seedling stump in this Territory. This kind of stump is hardy and can stand packing and transport over several days quite well. If temporary storage is required they may successfully be kept in damp packing materials, such as hessian, or alternatively they could be kept in a shady spot while their roots are covered with loose, damp soil.

The smaller type of seeding, the so-called pencil stumps of $\frac{3}{8}$ in. to $\frac{3}{4}$ in. in diameter, and usually 6-9 months of age, are not popular in the Territory. Although propagation and transport costs will be less than for the standard type seedling they are not as hardy as the latter. Adverse weather conditions after transplanting will affect them more severely.

Stumps of a bigger size than the above mentioned standard type also make good planting material, but will be more costly in propagation and transplanting. Seedlings stumps within the meaning of this article are high yielding clonal seedlings, but the above naturally applies to common seedlings as well. The latter are, however, not used as planting material anymore except as seedling-stock for future budgrafting.

(*b*) *Budgrafted Stumps.*

With budgrafted planting material we must differentiate between budded stumps and stumped buddings as is explained in Part II of this series. The recommended type of budgrafted planting material for this territory is the budded stump. Budgrafting of the seedling-stock is usually done in the nursery when the seedling is approximately one year old, but budding at the age of 8-9 months is not at all unusual under good growing conditions. At one month from the date of budgrafting the tree is ready for transplanting into the field. The grafted tree is stumped at about 3-4 feet height and becomes a budded stump. They are transplanted with the grafted bud in a dormant condition.

Stumped buddings are not generally recommended for the Territory. They require considerable nursery space, canot be pulled but have to be dug out, are bulky in transport, need bigger planting holes and most careful attention in transplanting. Timing the planting is even more important than with budded stumps as losses can be more severe than in budded stumps when unfavourable weather prevails after planting. However, the advantage of stumped buddings is the reduction in time between planting and maturity. It is claimed that up to two years can be saved on the immaturity period in the field with stumped budding plantings as compared to seedling stumps.

(*c*) *Germinated Seed.*

This type of planting material is seldom used in field plantings. Clonal seed is normally propagated in the nursery and transplanted to the field as a seedling stump. Planting of germinated clonal seed directly from germination bed into the field is not advisable for obvious reasons. The only practical use of germinated seed plantings in the field is for the growing of seedling-stock. The normal size planting hole, as described earlier, is made and filled-in completely a few days before planting the seed. Germinated common seeds are then planted three to four seeds per point and some 6-8 inches apart. Approximately 12-15 months afterwards the more vigorous trees are budgrafted. The advantage is that no transplanting has to be done resulting in an unchecked growth of the budshoot after stumping. The disadvantage is that the field has to be prepared and maintained for at least one year before budgrafting takes place.

On the other hand, budgrafting in the field reduces the time between budgrafting and tapping by some six months at least compared with budded stump plantings.

The planting of seed at stake, i.e., planting of ungerminated seed directly into the field, is not encouraged. Losses due to unfavourable weather, animal damage, etc. make this practice an entirely uneconomic proposition for the Territory.

PLANTING SEASON.

Transplanting is preferably done at the commencement of the rainy season, so that the young trees are properly established before the dry season sets in. If planting is left until late in the wet season and a dry period follows upon completion of planting operations it may cause a serious set-back to the young trees and could result in severe losses. It is most important for a successful establishment in the field and for continuous healthy growth of the transplanted material that planting operations are well timed for a period of reasonable certainity that there will not be a prolonged dry spell.

TRANSPLANTING.

Planting material in the nursery is prepared for the transplanting operation as follows :

The seedlings are cut back with a sharp knife or secateurs to a few inches below the limit of the brown bark. Cutting back into green bark is not advisable as this green bark may deplete the water supply of the stump through excess transpiration and could result in complete die-back of the stump. The height of stumping depends on the size of the trees, but 18 inches of brown bark is generally considered the minimum. Well developed trees of one year old usually have three feet or more of brown bark.

After stumping, the trees are left in the nursery for 5-7 days. At the end of this period, most of the buds at the top of the stump are beginning to swell ; this is the time to transplant. If the weather is not quite suitable, the stumps may be kept in the nursery for another week or two. In case circumstances prevent planting for several weeks after stumping, the green shoots at the top of the stumps are merely removed and the stumps may either be transplanted immediately or left at the nursery until other buds begin to swell.

Removal of the stumps from the nursery is done by pulling straight upwards ; not by turning and twisting as is frequently done by inexperienced planting gangs when stumps prove difficult to pull. Twisting and turning the stumps results in serious damage to the taproot. Stumps which cannot be pulled up are dug out. Digging on one side is sufficient to pull the stump out. In case the soil in the nurseries is rather dry and hard it is good practice to water the beds thoroughly prior to lifting the stumps. This facilitates pulling and will give less breakage of lateral roots. Taproot and lateral roots are cut back. The length of taproot left after pruning depends on the size of the stumps. In well-grown 12 months old seedlings it is usually 18-24 inches, but if in doubt it is safe to prune at a point where the taproot is about the thickness of a thumb. In pencil stumps at least 12 inches of taproot is left. Laterals are pruned to some 6-9 inches depending on size. Roots of the stumps awaiting planting must be protected from drying out and should never be exposed to direct sunlight. It is advisable not to pull more stumps than can be handled in the next two hours. It is better to come back to the nursery several times a day than to pull up a day's planting all at once. In case pulled-up stumps have to be left overnight it is best to place them with the roots in water. It needs no emphasis that only strong and healthy trees are transplanted ; weak plants in the nursery will not become vigorous trees in the field and they are not worth transplanting.

Preparations for transplanting budded stumps and stumped buddings are the same as described above for seedlings.

Transplanting is best carried out on overcast days. Hot sunny days should be avoided. Every care in transplanting the stumps must be taken and the operation should always be supervised by experienced staff. Planting must never become a " rush job ". The future life and health of the plantation depends for a good deal on the planting operation, which is carried out as follows :

A crobar or pointed stick is used to make a cavity in the partly filled hole to suit the stump. The stump is placed in the cavity and the soil around the end of the taproot is firmed. This is the most important part of the planting operation. It is essential to the survival and growth of the stump that there be no air gap at the end of the taproot, it must be in firm contact with the soil. This is done by firming the soil towards the end of the root with a stick. The soil is then further firmed at the base of the hole ; filling and firming continues to about three-quarters of the depth of the hole. In the second part of the planting operation the lateral roots are laid out in a natural position and the hole filled in. When the laterals are covered the soil is firmed again ; this is best done with the feet but without tamping down. A properly transplanted stump is planted at the same depth as it was in the nursery. It may be slightly deeper, but should never be higher than its original nursery level.

Budded stumps are often planted deeper than their nursery level, to about one inch from the budpatch. This is done to have the so called " elephant's foot " which develops at the point of union between stock and graft as low as possible on the trunk in order to tap more of the high yielding bark. Budded stumps are planted with the bud facing either North or South to avoid as much as possible direct sunlight on the budpatch. Immediately after planting the budded stump is cut back to about 2-3 inches above the bud patch. This is best done with a pruning saw and at an angle of 45 degrees upwards from the bud patch. The soil around the stump is then firmed once more. Sealing the cut surface by " Areoseal " or similar preparations is not necessary. If desired, sealing may be done quite effectively by spreading the latex, which appears after sawing, over the cut surface of the stump with the finger. To prevent excess transpiration through the bark a wax emulsion known as " Ceremul M " is sometimes used when circumstances force planting under less favourable weather conditions. This wax emulsion is diluted in water (1 : 1) and applied to the above-ground part of the stumps either by immersion before planting or by brush application after planting. Although the beneficial effect of this treatment could not be proven, there were indications that it helped to reduce transpiration and probably prevented serious losses during a dry spell immediately after planting.

The final part of the planting operation is :

MULCHING.

A layer of grasses, up to four inches in thickness and some 1-2 feet width, is spread around the newly planted tree. This will complete the planting. Care should be taken not to place the mulch in direct contact with the base of the tree as this could cause collar rot and may result in death of the budpatch in the case of budded stumps. The mulch will prevent drying out of the surface soil surrounding the lateral roots. Kunai grass (*Imperata cylindrica*) is most suitable for this purpose.

If enough mulching matter is available it is a good practice to mulch the entire length of the planting lines ; so called strip mulching. This however is only practicable in the avenue type of plantings with a relatively short distance between the trees in the line. In other cases the mulch can be gradually extended as the trees grow bigger.

A good mulch, besides preserving soil moisture will reduce weeding costs, helps to control soil erosion and improves soil structure. Decaying mulch makes organic matter available to the rubber roots, thus stimulating tree growth. Mulching in tropical agriculture generally, and of rubber in particular, is considered a throughly recommendable practice. Rubber roots thrive under a mulch. Improve soil structure and the numerous lateral feeding rootlets appearing within a matter of months are convincing evidence of the beneficial effects of mulching in rubber cultivation.

MANURING.

The manuring of the planting hole prior to, or at the same time as, planting the stump is not common in this Territory. As stated in Part II of this series Territory rubber soils are generally of better natural fertility than most of the Malayan soils where fertilizing is common practice throughout the life of the rubber tree. It has also been said that the need for fertilizing depends entirely on the natural fertility of the soil. In view of the above it is believed that rubber in this Territory, when properly planted, at the right time and supplied with a good mulch, will grow unchecked and does not need any fertilizer in the first year after planting. If the trees are showing lack of growth and general vigour it may be advisable to supply additional plant food in the form of fertilizers or animal manure. However, it should be understood that the reason for the lack in vigour is not always attributable to nutrient deficiencies of the soil. The water relationship of the soil, for instance, is a factor of great influence on the growth of the rubber. Changes in the water content of the soil have an influence on the root system and consequently on growth and appearance of the trees. Competition for water from weed growth and cover crops could result in a general backwardness of the rubber trees and must not be confused with nutrient deficiencies of the soil. Soil and leaf analysis, a service carried out by the Department of Agriculture, Stock and Fisheries will be helpful in determining whether fertilizing is required. Unless the lack of a known element is indicated it will be best to fertilize with a compound fertilizer containing the main elements nitrogen, phosphorous and potassium (N. P. and K.), during the early years of growth of the rubber. When the trees become older the phosphorous and potassium requirements decrease and nitrogen fertilizer, such as sulphate of ammonia or urea, may have to replace the compound fertilizer.

When applying fertilizers in mulched plantings the mulch is removed first, fertilizer applied and lightly worked into the soil, after which the mulch is replaced. It is better to give small quantities of fertilizer at regular intervals of say four months than to apply the recommended yearly amount all in the one application. General fertilizer recommendations are presently based on overseas experience. The following application rates may serve for general guidance during the period of immaturity.

The use of a compound fertilizer with a N.P.K. ratio of 21 : 14 : 14 is assumed.

- 1st year : 4 oz. per tree, divided over two applications at respectively 6 and 12 months after planting.
- 2nd year : 6 oz. per tree over three applications at 16, 20 and 24 months.
- 3rd year : 9 oz. per tree over three applications at 28, 32 and 36 months.
- 4th year : 12 oz. per tree over three applications at 40, 44 and 48 months.
- 5th year : 16 oz. per tree over three applications at 52, 56 and 60 months.

It must be emphasised that these rates are for general guidance only and are not a standard recommendation on the fertilizing of rubber trees in the Territory. Before starting on a full scale fertilization programme it is suggested to find out which fertilizers and application rates are the most effective for the plantation. This is best done by soil analysis and a small scale fertilizer trial.

FIELD MAINTENANCE.

Field maintenance work includes :

(*a*) Weeding ; (*b*) Replanting ; (*c*) Pruning ; (*d*) Thinning ; and (*e*) Disease and Pest Control.

(*a*) *Weeding.*

A strip of about three feet on each side of the rubber lines is kept free from grasses, creepers and shrubs which compete for soil moisture and nutrients. Strip-weeding is practised in the avenue type of planting system, including terraces. In other planting systems, circle weeding, whereby a circle around the tree is kept free of weeds, will be more economical. Kunai grass, which is most detrimental to the growth of the young rubber tree, is forked out completely or is controlled by weedicide spray. Weeding rounds are naturally more frequent in the early years of establishment, and become less frequent as the trees grow bigger and crown development is shading out many grass species.

As discussed earlier, mulching will reduce weeding costs. Natural covers between the lines are periodically slashed ; leguminous covers have to be regularly weeded.

(*b*) *Replanting.*

The replanting of trees which die after transplanting to the field is carried out as early as possible. If planted well and at the right time, losses will be very few (0.5-2 per cent. is normal) and it is often considered not worthwhile to replant these few misses. Where losses occur in a group of two or more together it is advisable to replant. Replanting is done with material of the same age and type as the original plantings, a supply of which is normally kept in reserve in the nurseries. Replanting must be carried out within two years. Thereafter it is impracticable and uneconomical to replace misses as these late replants cannot successfuly compete with the earlier established trees and are unlikely to develop into useful trees.

(*c*) *Pruning.*

The first pruning is usually done within three months from the planting date and is aimed at selection of the strongest and healthiest of the emerging shoots to form the main stem. Unwanted shoots are removed with secateurs or pruning knife. Sometimes it is difficult to select a suitable leader and two or more shoots are kept until a definite, straight growing leader can be selected. Pruning of side shoots to a height of 7-8 feet is done to obtain a tapping panel without interference from side branches. A word of caution on the pruning of young trees seems advisable because pruning is often over-done in the early growing years. It must be understood that every tree will endeavour to produce the maximum amount of foliage necessary for manufacture of essential plant food. Pruning deprives the tree partly of its ability to produce food from the leaves (by photosyntheses), and must result in slower growth. Severe pruning will seriously retard growth. It also results in the production of numerous branches as a natural reaction of tree regeneration, thereby depleting food reserves even more.

Pruning in the first two years should be restricted to a minimum, necessary for correct and continuous growth. A limited number of side branches could be allowed to grow until the tree is vigorous enough to regenerate new growth before branch pruning to a height of eight feet is done. Pruning must never be left to untrained labourers but should be done by experienced workers who are familiar with rubber propagation and who understand the principles of pruning.

Pruning wounds not bigger than an inch or two are left untreated. Bigger wounds may be treated with "tree seal" or other wound dressings. In cases of wind damage, the break is sawn to form a smooth surface and the wound is treated.

Budded stumps require more pruning attention than seedling stumps. Shoots which emerge from the seedling stock of budded stumps are cut away in monthly inspection rounds. Some clones produce numerous side branches at a low level; these should be nipped off by hand in the early stages to stimulate the upward growth of the main stem. The snag of wood from the seedling-stock above the bud-patch is sawn off within a year from planting. The cut is made at an angle of 45 degrees with the top of the cut coming out at the top of the junction between bud-shoot and stock. To leave this stock snag decay and fall off is not recommended as this often leads to infection by wood-rotting fungi and may encourage termite attack. Some clones, as well as individual seedling trees, have a tendency to an uninterrupted upright growth resulting in a tall slender stem without branches. RRIM 600 is a typical example of such growth. Pollarding is sometimes practised in such cases whereby the tree is stumped at a height of approximately eight feet. Pollarding, however, is not recommended as it causes a considerable set-back in growth resulting in a longer period of immaturity. To induce branching of these tall growing types it would be better to pinch out the growing point at a height of 10-12 feet after which attention must be given to select two or three strong and well spaced branches to form the frame work of the canopy. This is particularly important; failure to do so will result in a weak branching system susceptible to wind damage.

A final pruning is given on some plantations around the time when the trees are reaching the tapping stage. The more or less horizontally-growing branches, up to a height of 12-15 feet, are sawn off. It is said that this final pruning will help the tapping panel to dry out more quickly. It is considered that this pruning system has its merits in the really wet districts but that it is of little value in the drier areas. In most instances these lower side branches die off naturally as the crown develops.

(*d*) *Thinning.*

The aim of thinning out is to obtain an optimum stand of tappable trees per acre. Removal of poorly growing trees gives the remaining ones a better chance to develop. Better growing conditions for the remaining trees results in improved yield per tree and consequently a higher yield per tapper with lower taping costs. After the weak, and badly damaged trees are taken out, any further culling must be based on girth of the trees. Thinning commences in the third year; it should be uniform over the whole area and trees to be removed must therefore be selected by size as well as by position.

With an initial stand of 180-200 trees per acre it is normal practice to thin out to about 160 trees by the time the trees are brought into tapping. Any further thinning must be based on yield. Reducing the stand to 140-120 trees per acre by removal of the low yielders during the first 3-4 tapping years seems justified only when it leads to cheaper production costs. It would be impossible to state the optimum number of trees per acre as this depends on many factors, such as growth rate, planting material, labour situation and a number of other factors, in direct relation to effective plantation management.

(*e*) *Pest and Disease Control.*

Although this Territory is rather free of the serious diseases which occur in other rubber growing countries, a few of the more common ones to the Territory will be discussed. Besides the pests and diseases mentioned in Part II of this series, all of which may occur in the field as well as in the nurseries, the following are more prevalent in field plantings.

Pink Disease caused by the fungus *Corticium Salmonicolor* is often a serious problem in the wetter districts of the Territory. The fungus attacks the branches, penetrates into the wood and the branch dies off. When several branches are affected the whole crown may be lost. The disease is easily recognized by the pink coloured fungal incrustation on the surface of infected branches. The disease seldom occurs in very young rubber ; trees from three to seven years of age appear to be most vulnerable. At Bisianumu, clones RRIM 501 and RRIM 614 have proved particulary susceptible. Spores of the fungus are carried by wind and spread the disease. Control should be aimed at preventing the spread of the disease by removing and destroying infected branches in the early stage.

Gloeosporium Dieback.

The Gloeosporium leaf disease is common in young seedlings in the nurseries. In the field it is usually of less importance except in cases of a particularly susceptible clone, such as RRIM 526, where it may cause dieback of the terminal growth as a result of fungal infection of the stem. In severe cases, the whole tree may die back. Affected shoots are cut off below the infection and burnt.

Root Diseases.

Decaying roots of jungle trees infected by fungal parasites are the cause of rubber root diseases. Loss of mature trees through root diseases appears to be less common in the Territory than in other rubber producing countries. Whether the loss of trees is not recognised as possibly due to root disease is not known, but there are practically no cases of rubber root disease reported in the Territory. At Bisianumu there were a few cases of suspected red root disease in the loss of some 5-7 year old trees, but this could not be proven.

The three major diseases of rubber trees in Malaya are : White Root Disease (*Fomes lignosus*), Red Root Disease (*Ganoderma pseudoferreum*) and Brown Root Disease (*Fomes noxius*). The last one is less common in Malaya.

These root diseases spread among rubber trees when the expanding root system comes into contact with diseased material. The fungus grows along the infected root to the tree collar and the tree will eventually die when tap-root and main laterals are infected.

Unfortunately, root diseases cannot be recognised until the above ground parts of the tree show the symptoms of disease. Regular and careful inspection of the foliage is necessary for early detection of root diseases. When leaves are discoloured, drooping and falling off, the tree is suspect. The top of the taproot is then inspected and lateral roots are exposed and examined. Where infected material is found the root system is opened further until the source of infection is found. Infected material is removed and burned. Where a root-diseased tree is found, it is advisable to inspect the collar and lateral roots of nearby trees as well.

Lightning Strike.

Although injury caused by lightning is not a disease, it is often mistaken for one. The symptoms are : Splitting of the trunk, torn-off bark, discolouration of bark tissue, latex may exude and green leaves may fall off with stalk attached.

Sometimes the symptoms are less clear and may resemble a die-back disease or a bark cancer. Lightning strikes usually affect rubber trees in groups and occur more often than is generally thought. At Bisianumu in 1960 a group of 25 trees in a 4 year old planting were affected by lightning—two trees were a complete loss and 20 trees needed to be stumped. As recently as November, 1964, lightning killed three trees and affected nearby trees in a five year old clonal yield trial.

Treatment consists of removal of dead and dying trees and the cutting back of damage trees to healthy tissues.

Pests.

In addition to the earlier mentioned nursery pests *Amblypelta* and *Idiopsis,* the only other more serious treat to rubber in the field is the attack by termites or white ants. Although no serious infestation has been reported so far, a close watch should be kept as termites of the species *Coptotermes elisae* (Desneux) have been found to attack healthy taproots of rubber trees in the Territory. Invasion of white ants is however more likely when roots are diseased. The recommended treatment is a dieldrin solution, one part of dieldrin 15 per cent. concentrate in 600 parts of water, poured around the base of the tree. One to four pints of this solution is used depending on the size of the tree.

Disease inspection and control rounds are carried out at 2-3 months intervals.

Finaly it must be emphasised that proper field maintenance is of the greatest importance and influences the future health and growth of the plantation. Without constant care even the best planting material will be disappointing. Proper maintenance reduces the period of unproductivity. Under favourable conditions the rubber tree may be expected to reach tappable size in its fifth year after planting into the field. Negligence in maintenance could extend this period of un-productivity to eight years and more. The degree of supervision and maintenance is the key to successful plantation management.

CONCLUSION.

In this series *Rubber Planting Techniques* the handling of seed, nursery practices, transplanting and maintenance of rubber cultivation have been discussed with particular reference to the Territory of Papua and New Guinea.

These articles do not pretend to be a complete manual on rubber propagation, but are intended as a guide to Agricultural Field Officers and prospective rubber planters on small-holdings as well as on plantations.

The articles are based upon practical experience and knowledge gained at the Bisianumu Rubber Centre of the Department of Agriculture, Stock and Fisheries, as well as from visits to rubber plantations in the Territory and overseas.

Further details on all aspects of rubber cultivation in this Territory may be obtained from The Director, Department of Agriculture, Stock and Fisheries, Konedobu, Territory of Papua and New Guinea.

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(Received March, 1965.)

Rubber Planting Recommendations 1965-1966 for the Territory of Papua and New Guinea.

Compiled by ANTON J. H. VAN HAAREN.

The following rubber planting recommendations for Papua and New Guinea are based on overseas experience with this planting material as well as on observations from the experiments conducted by the Department of Agriculture, Stock and Fisheries, at the Rubber Research Centre, Bisianumu.

THE Department of Agriculture, Stock and Fisheries maintains extensive rubber budwood nurseries in which a total of 87 clones are represented. Forty of the more promising clones have been established in field experiments over 56 acres of clonal yield trials at the Bisianumu Rubber Centre. These clones are tested under local conditions for yield and such secondary characteristics as susceptibility to diseases, wind damage, vigour, etc.

Whether to plant clonal seedlings or budded material is a matter of opinion. It must be realized however that budgrafts of the modern clones are undoubtedly superior in yield to clonal seedlings. On the other hand, the variability of clonal seedlings renders them less likely to suffer severely from specific diseases. Establishment costs for clonal seedlings are lower than for budgrafts.

Departmental recommendations are for an establishment of 50 per cent. clonal seedlings and 50 per cent. budgrafted trees.

In the choice of a clone, local conditions must be taken into consideration. No clone, or seedling family for that matter, is the best planting material under all circumstances or for all purposes. Planting recommendations must inevitably be generalizations. Characteristics such as vigour, bark thickness and bark renewal, disease resistance, wind damage, etc., must be taken into consideration when making a choice for a given locality.

With regard to the above, the following planting material is recommended for Papua and New Guinea in 1965-1966.

Class I—*For large scale planting*—

Clones : PR 107, PB 5/51, RRIM 600, RRIM 623.

Clonal Seedlings : Prang Besar Gough Garden 1 seed and PBIG garden Fand G.

Class II—*For moderate scale planting*—

RRIM 513, 605, 607, 628 and 701.

LCB 1320, GT 1, Chem. 26 and Chem. 30.

PB 213 and PB 217.

DESCRIPTION OF RECOMMENDED CLONES.

PR 107.

Overseas—

Average vigour during immaturity—straight stem with heavy, but well-balanced crown—one of the clones least likely to be affected by wind damage—virgin bark and renewed bark thickness is above average, yields are disappointing in the early years but improve considerably later because of high girth increment on tapping—yielding around 1,200 lb. per acre per annum. Yield in fifth year at RRIM large scale clonal trials 1,598 lb. per acre per annum.

Local—

Growth average—no wind damage, slightly susceptible to *Gloeosporium* in early years but shows good recovery—this appears to be one of the hardiest clones available with few, if any, physical defects—it seems the ideal choice for the small holder in this Territory because of its toughness, thick bark and high girth increment after tapping.

Budding success : above average.

Price : 7s. 6d. per yard of budwood.

PB 5/51.

Overseas—

Average vigour—good branching habit—appears to be resistant to wind damage—smooth bark of average thickness with good renewal—

should not be planted too closely, Prang Besar Estate recommends a stand of 150 trees per acre with at least ten feet between trees in the planting line—this clone is becoming increasingly popular and was the most planted clone on European-owned estates in Malaya during 1962. Yields of over 1,700 lb. per acre have been reported in commercial plantings and over 2,000 lb. (2,059 lb.) in the large-scale RRIM trials in its fifth year of tapping.

Local—

Average to good vigour—no wind damage—heavy seeder—this clone suffered badly from a die-back disease in young budgrafts in the third clonal yield trial—appears resistant to pink disease.

Budding success: below average.

Price : 80s. per yard of budwood.

RRIM 600.

Overseas—

Not a vigourous clone, but with a very good girth increment of tapped trees—straight and tall stem, with narrow, fan-shaped crown—average susceptibility to wind damage—bark renewal is good but the renewed panel sometimes bulges. Yield : The highest yielder in the RRIM 600 series trials with a mean yield of 1,989 lb. per acre in fifth year of tapping and over 3,000 lb. (3,098 lb.) in eighth year of tapping.

Local—

Average vigour—late branching—very tall stem bending of the stem in young trees has been experienced—no wind damage—no pink disease—susceptible to *Gloeosporium* in early years.

Budding success : well above average.

Price : 15s. per yard of budwood.

RRIM 623.

Overseas—

Outstanding vigour—branches upright and heavy, the junction of the main branches is weak and some branch-split has been experienced—virgin and renewed bark are below average in thickness—girth increment on tapping is above average. RRIM 623 was the most popular clone among Asian-owned estates in Malaya during 1962.

Yield : Together with RRIM 600 and 628 this clone belongs to the highest yielders in the RRIM 600 series trials—mean yield in fifth year of tapping at RRIM experimental station was 1,768 lb. per acre and in the sixth year 2,435 lb. per acre.

Local—

The most vigorous clone in the second clonal yield trial—susceptible to branch break and a few cases of trunk snap—low susceptibility to *Gloeosporium* and pink disease.

Budding success : below average.

Price : 15s. per yard of budwood.

RRIM 513.

Overseas—

Average vigour—low girth increment on tapping—virgin bark below average thickness—bark renewal of average thickness—little wind damage reported, trees may lean on poorly drained soils.

Yield : Slow starter, but increased yields on second panel average yield level in postwar RRIM experiments third year 1,400 lb. per acre, fourth year 1,600 lb., fifth year 1,800 lb.

Local—

Poor vigour—this is the slowest growing clone in the first clonal yield trial with approximately 20 per cent. under the average girth for the trial—no wind damage and no fungi diseases experienced.

Budding success : average.

Price : 15s. per yard of budwood.

RRIM 605.

Overseas—

Average vigour—low branching—balanced crown—no serious wind damage reported—girth increment of tapped trees satisfactory—bark thickness and bark renewal are good.

Yield : At RRIM trials in fifth year of tapping mean yield of 1,429 lb. per acre.

Local—

Average growth—no wind damage and no particular susceptibility to fungi diseases experienced.

Budding success : average.

Price : 15s. per yard of budwood.

RRIM 607.

Overseas—

Average vigour—low branching with dense crowns—due to heavy self-pruning in later years the crown becomes high and small, with rather wide main branches—one of the most wind resistant clones in the RRIM 600 series—bark is of average thickness, particularly good bark renewal—low incidence of brown bast.

Yield : At RRIM trials in fifth year 1,437 lb. per acre.

Local—

Average to good growth, no wind damage—no diseases reported.

Budding success : average.

Price : 15s. per yard of budwood.

RRIM 628.

Overseas—

Below average in vigour—upright branching with good canopy—low incidence of wind damage—bark above average thickness—bark renewal satisfactory—poor girth increment of tapped trees—tapping intensity of less than 100 per cent. is probably desirable (brown bast).

Yield : With RRIM 600 and 623 this clone belongs to the highest yielders in the RRIM 600 series trials—mean yield in RRIM trials fifth year of tapping, 1,892 lb. per acre.

Local—

Average to poor growth in budwood nurseries, no diseases or wind break experienced so far.

Budding success : average to good.

Price : 15s. per yard of budwood.

RRIM 701.

Overseas—

Exceptionally vigorous—straight stem—wide, rather low branching habit—heavy, well-balanced crown—no wind damage experienced—bark above average in thickness—susceptible to *Gloeosporium* disease.

Yield : high yielding—no yield figures published yet.

Local—

Recently established in clonal yield trials—excellent growth in budwood nurseries.

Budding success : below average.

Price : 15s. per yard of budwood.

LCB 1320.

Overseas—

Very vigorous—tall stem with tendency to lean—late, irregular, long branches—narrow fan-shaped crown—susceptible to wind damage—above average susceptibility to pink disease—virgin bark above average in thickness—renewed bark below average in thickness—girth increment after tapping below average to average.

Yield : In fifth year of tapping at RRIM trials 1,187 lb. per acre pre-war trials in Java—fifth year tapping 1,630 lb. per acre.

Local—

Above average vigour—little wind damage—not susceptible to *Gloeosporium*—above average susceptibility to pink disease.

Budding success : above average.

Price : 15s. per yard of budwood.

GT 1.

Overseas—

Average vigour—straight stem—compact crown of dark, glossy leaves—branching late, upright—resistant to wind damage—smooth bark of average thickness—poor bark renewal in Indonesia.

Yield : Yield at RRIM trials in third year 1,128 lb. per acre in Java in pre-war trials yield in fifth year of tapping 1,520 lb. per acre.

Local—

Recently established in clonal yield trials—growth in budwood nurseries very good—not susceptible to *Gloeosporium* disease.

Budding success : above average.

Price : 15s. per yard of budwood.

Chem. 26.

Overseas—

Vigorous grower—tall upright stem—wide crown with heavy canopy—light branches—susceptible to wind damage—average bark thickness—average renewal and average girth increment after tapping—resistant to pink disease and *Gloeosporium*.

Yield : Around 1,300 lb. per acre in fifth year of tapping.

Local—

Above average in vigour—no wind damage—a few incidences of pink disease experienced.

Budding success : average.

Price : 8s. 6d. per yard of budwood.

Chem. 30.

Overseas—

Vigorous—stem has tendency to lean—heavy canopy with dark, glossy leaves—reasonably resistant to wind damage—resistant to pink disease and *Gloeosporium*—smooth bark of above average thickness—bark renewal average.

Yield : Has outyielded Chem. 26 after a number of years although it was a slow starter in trials at the Chemara Central Research Station. In RRIM trials yields average 90-100 per cent. of RRIM 501 in second and third year (RRIM 501—second and third year mean yield of 1,018 lb. and 1,320 lb. per acre).

Local—

Recently established in clonal yield trials—appears to be well above average in vigour—no diseases or wind damage experienced in older trials.

Budding success : well above average.

Price : 8s. 6d. per yard of budwood.

PB 213.

Overseas—

Average vigour—straight stem—dense foliage—wind resistant—susceptible to *Oidium* disease—good bark renewal.

Yield : No RRIM information available—according to Prang Besar yield in 1961 (fifth year of tapping) was 236 per cent. of PB 86 yields.

Local—

Recently introduced clone—showing average vigour—no disease susceptibility so far.

Budding success : below average.

Price : 80s. per yard of budwood.

PB 217.

Overseas—

Good vigour—straight stem—moderately light branches—well-balanced crown—wind resistant—good bark renewal—susceptible to *Gloeosporium*.

Yield : No RRIM information available—according to Prang Besar yield in 1961 (fifth year of tapping) was 280 per cent. of PB 86 yields.

Local—

Recently introduced—good vigour in budwood nurseries—some *Gloeosporium* incidence, but not serious.

Budding Success: below average.

Price : 80s. per yard of budwood.

Note—

Average yields which can be expected from modern clones tapped at the RRIM trials under normal estate conditions on S/2, d/2 tapping—ref. Annual Report—Rubber Research Institute of Malaya, 1963, p. 34.

Year	1st	2nd	3rd	4th	5th
lb. per acre	600	1,000	1,300	1,400	1,500

Average yields which can be expected from Gough Garden 1 clonal seedlings tapped under normal estate conditions on S/2, d/3 (Prang Besar Circular and Price list—January, 1964—p. 6).

Year	1st	2nd	3rd
lb. per acre	550	920	1,100

Budwood—is available from the Bisianumu Rubber Centre.

Prices—quotes are ex-Bisianumu nurseries.

In the case of proprietary clones a condition of sale of budwood is the completion of a standard sales agreement prohibiting the further distribution or resale of the budwood or material multiplied therefrom.

Further information may be obtained from : The Director, Department of Agriculture, Stock and Fisheries, Konedobu, Papua.

(Received March, 1965.)

Three New Leaf-Beetles Affecting Cacao in New Britain. (Coleoptera : Chrysomelidae)

J. LINSLEY GRESSITT.

Bishop Museum, Honolulu.

Three new species of eumolpine chrysomelid beetles are described from cacao *in New Britain. The adult beetles feed primarily upon the new leaves.*

Two lots of leaf-beetles found feeding upon the young leaves of cacao on the Gazelle Peninsula of New Britain were studied. The most abundant species in these shipments were Deretrichia szentivani *Selman and three new species described in this article. Some additional species were represented by smaller series or unique specimens. These latter included at least one or two species of* Rhyparida *which must await more extensive material before they can be described.*

SUBFAMILY EUMOLPINAE.

Rhyparida cacaona Gressitt, n. sp.

Colouration.

Pale testaceous to pitchy black ; head dark chest-nut brown, paler on each side of occiput ; palpi pale testaceous ; antenna testaceous, duller on segments 6 to 11 ; prothorax pitchy black, slightly reddish pitchy along anterior margin ; scutellum pale ochraceous, pitchy at side ; elytron dark pitchy brown, pale ochraceous on most of basal ¼, somewhat testaceous near apical margin ; ventral surfaces pitchy brown, largely testaceous on abdomen ; legs translucent yellowish testaceous, pitchy brown at apices of femora and bases of tibiae, dorsum glabrous and shiny, a few hairs on labrum ; antenna with but few sub-adpressed pale hairs and suberect hairs at apices of segments ; ventral surfaces glabrous on thorax and with sparse hairs on abdomen ; legs sparsely clothed with pale hairs, particularly on femora.

Structure.

Head nearly as broad as apex of prothorax ; occiput raised, convex, with scattered distinct punctures ; frontoclypeus not separated from occiput, slightly broader than long, flattish and distinctly punctured, deeply arcuate-emarginate, ¾ as wide as deep, 6 x as deep as gena.

Antenna not quite ¾ as long as body, moderately slender ; segment 1 swollen in middle, 2.5 x as long as broad ; 2 similar in shape, 2/3 as long ; 3-5 very slender, similar, each fully as long as 1 ; 6-10 stouter, thickened preapically, progressively slightly shorter ; 11 about as long as 5.

Prothorax 1.7 x as broad as long, wider anteriorly than posteriorly ; side obtuse, widest somewhat behind middle ; disc subevenly convex, finely and subregularly punctured.

Scutellum subpentagonal, smooth, obtuse apically.

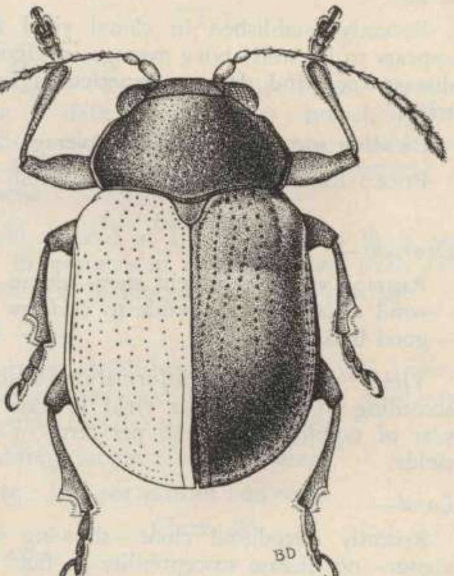

Figure 1.—*Rhyparida cacaona* n. sp., dorsal view of adult.

Elytron 2.5 x as long as broad, widest anterior to middle, narrowed to apex ; disc swollen near base followed by a weak depression, surface with 11 rows of punctures just behind humerus and at middle ; punctures mostly 1/3 to $\frac{1}{2}$ as long as interspaces longitudinally, 1/5 to $\frac{1}{4}$ as wide as interspaces transversely.

Ventral surfaces nearly impunctate on thorax, sparsely punctured on abdomen.

Legs slightly stout ; hind femur swollen ; hind tibia quite broad just before preapical emargination ; hind tarsus with segment 1 much longer than 2 or 3, as long as last. Length 3.2 mm ; breadth 1.85.

Holotype ♀ (BISHOP 3730), Keravat, 10 metres alt., Gazelle Peninsula, New Britain, on young cacao leaves, 9th Sept., 1964, D. August collector ; 2 paratypes (DASF, BISHOP), 1 same data, 1st Aug., 1964, I. Kalto collector.

Differs from *R. terminata* Jacoby in having prothorax longer and more convex anteriorly, and in having different colour patterns with pronotum and elytral apex not pale. Differs from *R. humeronotata* Jacoby in being slightly larger, in having prothorax shorter, humeral spot more distinct and more quadrate, head less closely punctured and frontoclypeus not separated from vertex by a groove.

Rhyparida duni Gressitt, n. sp.

Colouration.

Dull yellowish testaceous, mandible pitchy ; eye black ; metasternum somewhat ochraceous. Dorsum glabrous ; antennae with a few fine adpressed hairs and suberect hairs, mostly at ends of segments ; abdomen with sparse suberect hairs ; legs sparsely clothed with oblique hairs.

Structure.

Head slightly narrower than anterior end of prothorax ; occiput subevenly convex, wider than frontoclypeus, feebly grooved beside eye ; vertex horizontal ; frontoclypeus flat, slightly wider than deep, narrowest just below middle, with apical margin produced on each side, deeply emarginate in middle ; eye reniform, 2 x as deep as wide, 6 x as deep as gena.

Antenna slender, 3/5 as long as body ; segment 1 elliptical, nearly 3 x as long as broad ; 2 thickened preapically, 3/5 as long as 1 ; 3 slender, slightly thickened apically, as long as

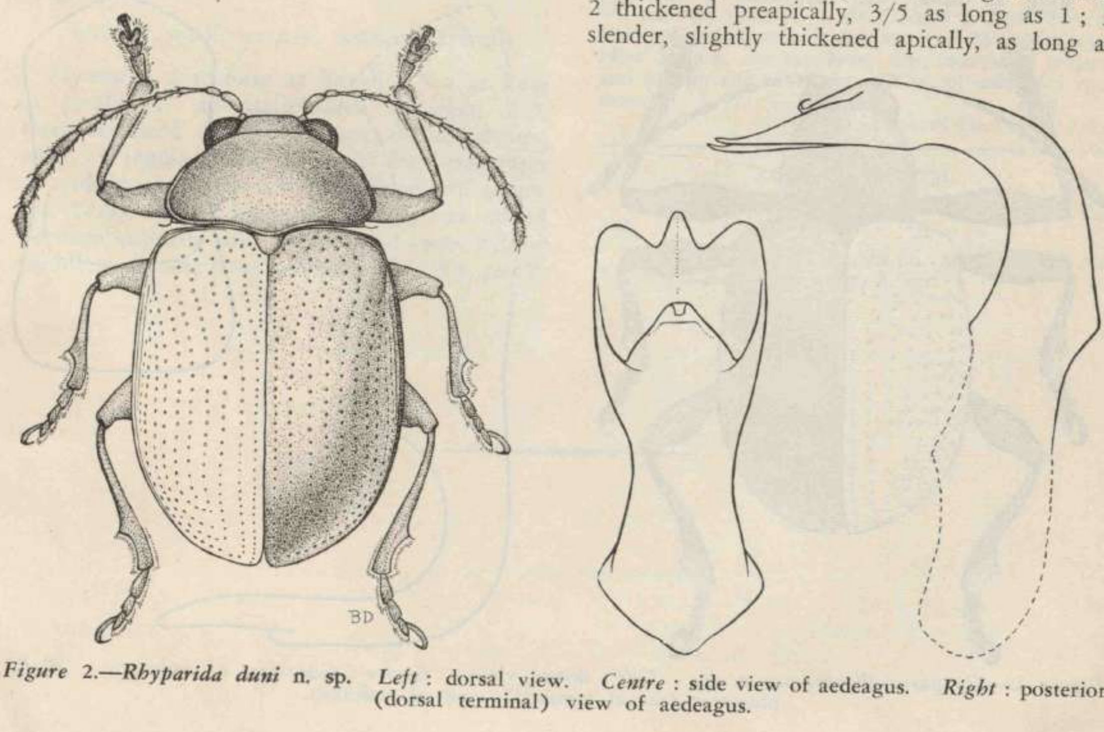

Figure 2.—*Rhyparida duni* n. sp. *Left* : dorsal view. *Centre* : side view of aedeagus. *Right* : posterior (dorsal terminal) view of aedeagus.

1 ; 4 slender, slightly longer than 3 ; 5 similar to 4 ; 6 slightly stouter ; 6-10 subequal ; 11 barely longer than 10.

Prothorax nearly 2 x as broad as long, considerably narrower at apex than at base ; side strongly convex, rounded-obtuse well behind middle ; basal margin produced and somewhat truncate in central portion ; disc strongly and subevenly convex, sparsely and minutely punctulate.

Scutellum smooth, broadly rounded apically.

Elytron nearly 3 x as long as broad, widest in central portion, narrowed apically ; disc subevenly convex, very weakly depressed behind a weak basal swelling ; surface with fairly regullar puncture-rows, 9 just behind humerus, 11 just behind middle ; punctures mostly 1/3 to ½ as large as interspaces longitudinally and ¼ to 1/5 as wide transversely.

Ventral surfaces in large part smooth and impunctate.

Legs shiny ; femora moderately stout ; hind tibia straight ; slender, broadest preapically, with posterior emargination ; hind tarsus slender, ¾ as long as tibia, with segment 1 distinctly longer than 1 or 2, shorter than last. Length 4.15 mm ; breadth 2.4.

Paratypes : Length 3.7-4.2 mm : breadth 1.8-2.2 Holotype ♂ (BISHOP 3731) Keravat, 10 m, Gazelle Peninsula, New Britain, Aug., 1964, I. Kalto ; 5 paratopotypes (BISHOP, DASF, ANIC, BMNH), 11th Jan., 1964, G. S. Dun ; June, 1964, Sept. 9, 1964, I. Kalto and D. August.

Differs from *R. nigrostriata* Bryant in having pronotum less distinctly microgranulose and in being smaller and subuniformly coloured. Differs from *tenuis* Lac. in being less slender and more uniformly coloured, with frontoclypeus having smaller punctures. Named in honour of Mr. Gordon S. Dun, Principal Entomologist, Territory of Papua and New Guinea.

Cleaporus theobromae Gressit, n. sp.

Colouration.

Shiny black with a slight bronzy purplish tinge ; more greenish on front of head and sides of prothorax and elytron, more purplish on legs, metasternum and first abdominal segment. Body glabrous above, with rather sparse short oblique hairs.

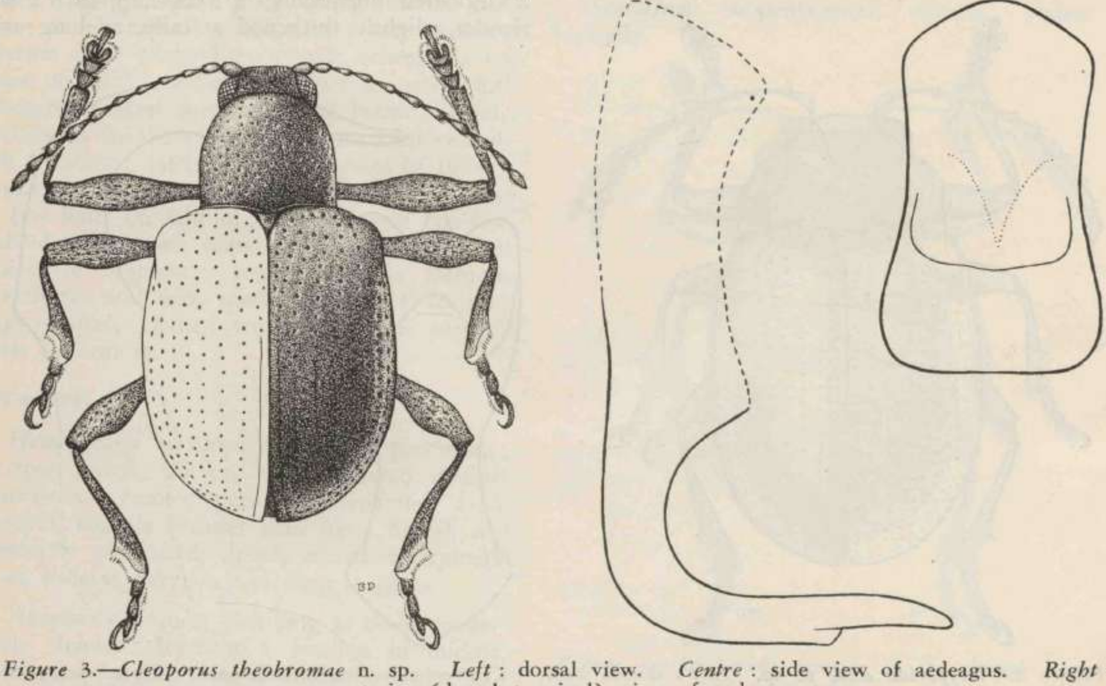

Figure 3.—*Cleoporus theobromae* n. sp. *Left* : dorsal view. *Centre* : side view of aedeagus. *Right* : posterior (dorsal terminal) view of aedeagus.

Structure.

Head about as wide as anterior end of prothorax, vertical and smooth in front, with same plane extending from anterior margin of frontoclypeus to well above eyes (this area finely and sparsely punctured and obtusely set off above), deeply grooved above eyes ; postocciput densely and longitudinally punctuate-striate ; eye rounded-oval, about 5 x as deep as gena ; frontoclypeus deeply emarginate apically.

Antenna $\frac{3}{4}$ as long as body, fairly slender ; segment 1 arched, 2.5 x as long as broad ; 2 similar in shape, $\frac{3}{4}$ as long ; 3 shorter, much more slender, 4 similar to 3 ; 5 slightly longer and more slender ; 6 similar to 5 ; 7 longer than 2, thickened preapically ; 8 as long as 7, slightly stouter ; 8-10 sub-equal ; 11 longer, elliptical, with a preapical constriction and ring of hairs.

Prothorax not quite as long as broad, arched anteriorly, with anterior margin concave above lateral line (and above seta and pleuron) ; sides weakly convex, subparallel-sided ; disc convex, somewhat deeply and sub-strongly punctured, about 15 punctures in an approximate longitudinal row.

Scutellum small, narrow, rounded apically.

Elytron 3 x as long as broad, 2.5 x as long as prothorax, subparallel-sided in basal 2/5, then narrowed to subacute apex ; disc convex, with 11 regular rows of fairly deep punctures at middle : an extra row near scutellum, a new row added behind humerus, another row added between ultimate and penultimate rows behind middle and some rows lost behind middle, resulting in 11 rows on most parts ; most of punctures slightly smaller than interspaces longitudinally and transversely, but some larger longitudinally.

Ventral surfaces with metasternum short and coarsely punctured, and abdomen in large part vaguely punctured.

Legs slender, hind femur pedunculate, slightly swollen in middle, with a fine short tooth on underside of swelling ; hind tibia weakly arched, ridged, thickened apically ; hind tarsus slender, segment 1 longer than 2 or 3, stouter than last, 3 deeply forked and subparallel-sided. Length 2.2 mm ; breadth 1.05.

Holotype ♂ (BISHOP 3732), Lowlands Agricultural Experiment Station, Keravat, 10 m, Gazelle Peninsula, New Britain, on cacao, Aug., 1964, G. S. Dun ; 2 paratopotypes (BISHOP, DASF), August, 1964.

Differs from *C. ribbei* Jacoby in being much smaller, narrower and less rugose. Differs from *metallicus* Bryant in having a deeper groove above eye, in being smaller and narrower, less metallic, with elytron more regularly punctured.

ACKNOWLEDGEMENTS.

I am very grateful to Mr. Gordon S. Dun, Principal Entomologist, Lowlands Experimental Station, Keravat, New Britain, for supplying this interesting material, and to him and his assistants for collecting the specimens.

(Received December, 1964.)

CORRIGENDUM.

Volume 16 (2-3) September-December, 1963. Page 112.

" Genus *Kurumeld* Gressitt, n. gen." should read, " Genus *Kurumela* Gressitt, n. gen."

* Reprint of the article published in the *Commonwealth Phytopathological News*, Part 1, page 4, January, 1965, from which the illustration was omitted because of short age of space.

A Condition Resembling Ring Spot of Maize in Papua.

DOROTHY E. SHAW,

Principal Plant Pathologist, D.A.S.F., Port Moresby.

A CONDITION not previously recorded in Papua or New Guinea has been found present on maize leaves collected during February-March, 1964, by a Papuan field assistant, Mr. R. Ora, from a native garden in Papua located in an area of scattered and somewhat isolated hamlets in secondary bush at an altitude of 3,500 feet near Efogi on the south-west flank of the Owen Stanley Ranges. It consists of "marbled" interveinal spots, not very evident unless held to the light, but then distinctly translucent ; the smallest spots about 2 mm. in length, but the majority much larger, some even running nearly the whole length of the leaf and forming long translucent strips of tissue, possibly representing the end-to-end confluence of individual spots and strips. Laterally the spots and strips appear to be limited by the veins, and are seldom over 4 mm. wide (*Plate* 1). Necrotic tissue occurs in the older spots, in a few cases repeating the marbled appearance, but in others forming elongated oval areas of necrotic tissue, again mainly bounded by the veins.

The condition appears similar to that from Nigeria described and illustrated by Cammack (*Commonw. phytopath. News* 3 (4) : 61-62, 1957) and Simons (Ibid 9 (2) : 29-30, 1963). The marbled, translucent lesions in the Papuan material are unaccompanied by the fine chlorotic spotting noted by Cammack but considered by Simons to be damage caused by maize leaf aphid. No fungi or bacteria were isolated from the present material and no fungi were detected in the tissues. The condition does not appear to resemble other virus diseases described on maize.

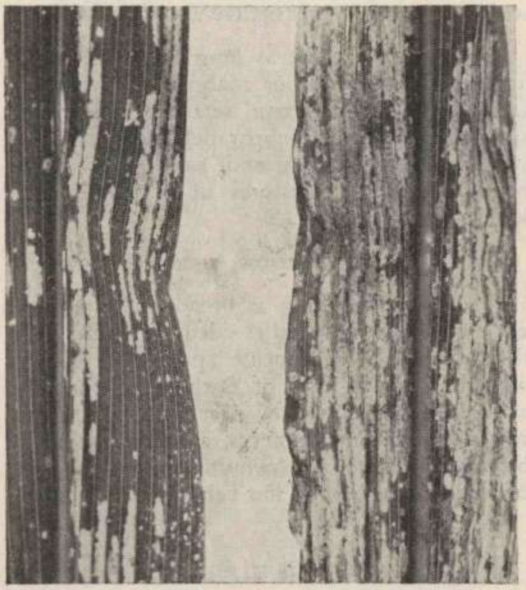

Plate I.—Translucent, "marbled", interveinal spots on maize leaves, as seen by transmitted light.

[Photo D.I.E.S.]

Book Review.

An Introduction to Tropical Grassland Husbandry.

R. J. McIlroy,
Oxford University Press, 1964.
111 pp. 26s. 6d.

This publication is one of the first in which the basic agronomic principles of grassland farming and grass/animal relationships under tropical conditions are reviewed.

Tropical Grassland Husbandry as a science is of recent derivation. However many of the basic principles of plant and animal production vary little with environment and consequently inferences are often drawn from temperate research. The author does, however, draw excessively from temperate experiments where comparable though perhaps not as statistically obvious evidence could be obtained from tropical research. However it is a truism that much of the .... " present experimental data concerning agronomic research into the grass/animal complex in the Tropics has offered little facility for critical experimentation .... " and consequently the author may have deemed it preferable to exclude some available tropical references.

The extensive bibliography containing many further reading suggestions should prove adequate for all student purposes. For the general reader the book provides useful empirical summaries generally not included in a publication of this magnitude, e.g., " Why grasses are suitable as herbage plants ".

The book is divided into 15 chapters. Commencing with a general introduction on grasslands the sequence is through ecology, anatomy, seed production to general husbandry. A brief but informative anatomical description of grass parts is provided without the aid of diagrams. " Some Tropical Grassland Associations " (Chap. 5) and " Some Grass and Legume Species of Tropical Regions " (Chap. 4) are extensive without being voluminous and sources of more extensive information are quoted in both chapters. The technical value of the short chapter " Seeds Mixtures " (Chap. 8) would have been enhanced had a more comprehensive list, compiled from a more extensive range of literature, been substituted as many of the now utilized mixtures are not included. Fertilization, which must necessarily play an ever-increasing role in the maximum utilization of the environment, particularly in the humid tropics, for pasture production, receives little mention under the heading " Management and Manuring " (Chap. 10) where only short references to Calcium, Nitrogen, Phosphorous and Potassium occur.

Chapter 12 " Grassland Improvement " provides a necessarily summarized review of experimental work being undertaken by scientific organizations throughout the Tropics. " The Nutritive Value of Tropical Pasture Grasses and Legumes " (Chap. 13) is probably adequate regionally speaking, i.e., Central Africa but offers little " nutritive value " information on species at present being planted extensively in other tropical countries. The two appendices by G. Jackson apply essentially to Tropical Africa.

Understandably most of the data quoted which is not of temperate origin is African based which necessarily precludes the use of the book in its entirety as a set of lecture notes (from which it was derived) in other tropical teaching institutions where environment and husbandry practices differ. As an introduction to the topic the book fulfils, with the abovementioned reserves, its purpose in that it provides information concerning economic, ecological, agronomic, nutritional and productional data on tropical grasslands.

(D. R. Petty.)