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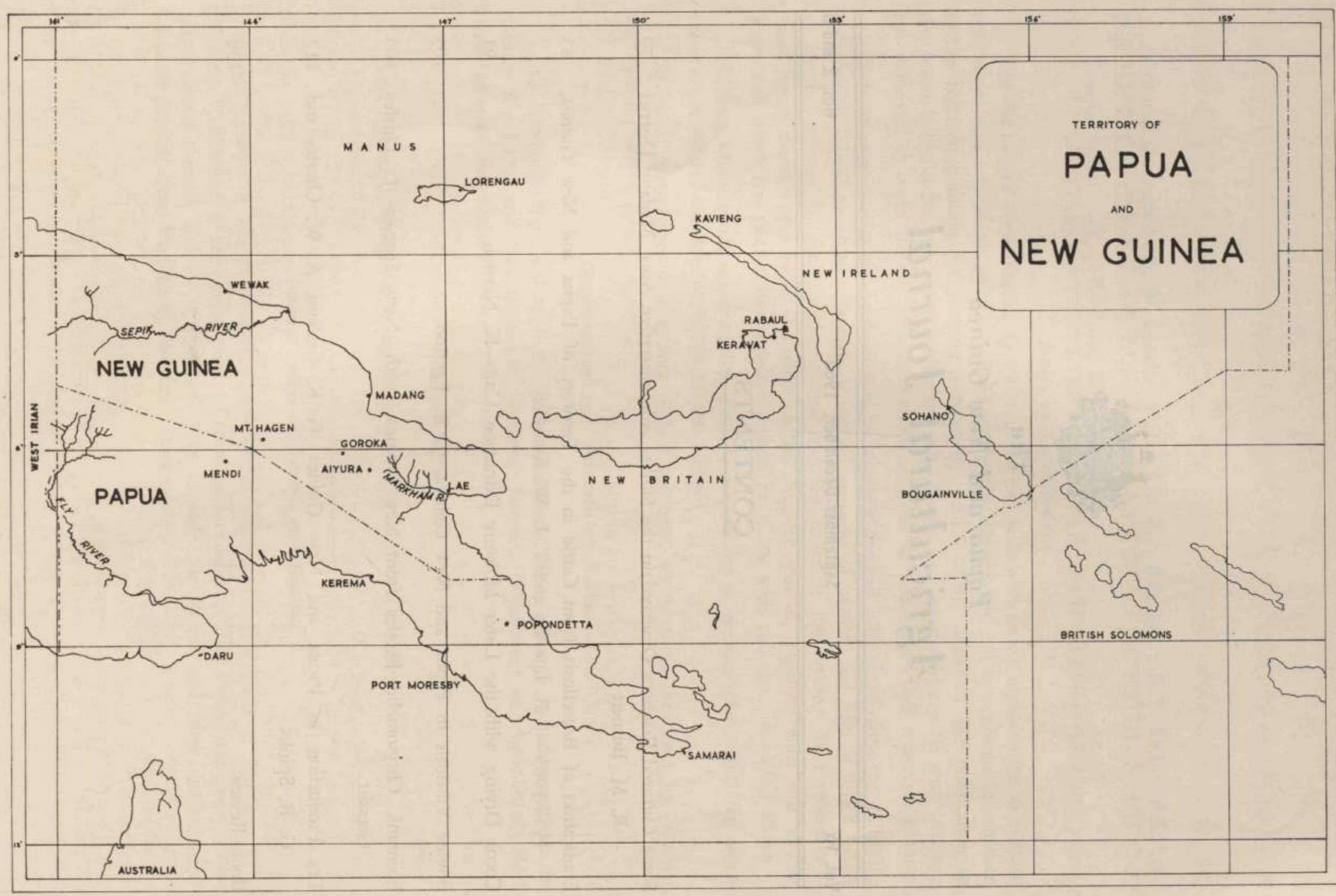
*The*

*Papua and New Guinea*

# *Agricultural Journal*

**Vol. 16** **September-December, 1963** **Nos. 2 and 3**

## CONTENTS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PAPUA
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141°
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MANUS
LORENGAU
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NEW IRELAND
RABAUL
KERAVAT
WEWAK
SEPIK
RIVER
NEW GUINEA
MADANG
WEST IRIAN
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# Some Cultural Practices Observed in the Simbai Administrative Area, Madang District.

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*Introduction.*

During the initial agricultural patrol to assess the economic potential of this area, made from Aiome during August-September, 1962, a number of unusual cultural practices was observed.

The Simbai area comprises the valleys of the Asai and Simbai Rivers, which flow east to the Ramu, and the Kaironk River, which joins the Jimi River of the Western Highlands, subsequently to enter the Sepik. These valleys are separated by the main ranges and spurs of both the rugged Bismarck and Schrader systems.

Some seven years after the earliest penetration of the area, a patrol post was established at Simbai in early 1959, and law and order has been brought to the area since that time. However, no work has been undertaken in the fields of education, health or economic development except for recent small-scale moves by the missions with regard to education and health.

Recent census figures revealed a population of some 12,500, broken into four dialect groups, the bulk of which resides between the altitudes of 2,000 feet and 5,500 feet. The inaccessability of the area to any means of transport, together with the scarcity of arable land, would appear to preclude any agricultural development on present lines, i.e., with plantation crops.

*Subsistence Agriculture.*

The subsistence gardening techniques follow closely the "Highlands" pattern, especially in the range and diversity of plant species utilized for food production. The major variation noted is in land utilization. The Highland pattern is a semi-perennial cropping of one area; the practice adopted within this area follows the coastal pattern, i.e., an annual cropping with a three to eight years fallow period.

The male members of the clan or group clear, fence and burn the land, after which it is divided into plots which are planted and maintained by individual female members of the same clan. Despite this individual work, all foodstuffs are cooked and eaten communally.

Owing to lack of arable land, cultivation of extremely steep slopes becomes necessary in order to prevent exhaustion of the better soils. Several practices employed to achieve this can be clearly observed. (Plate II). A solidly constructed retaining wall of casuarina and bush timbers is built across the length of the lower side of the gardens. This also serves to exclude pigs. Then rough terraces of casuarina limbs are constructed across the slope at approximately ten-foot intervals to prevent, to some degree, extensive erosion.

In grassland areas such as the Asai, little timber is available for fence building, hence the practice of ditch construction. Depths range from three to six feet, widths from three to four feet, with ditches running both across and down the slope, thus becoming erosion foci. This is a major cause of soil erosion.

Mixed gardens are planted throughout the year but a more or less seasonal planting of the staple sweet potato occurs in November-December. A number of different varieties was observed. There is no definite cultural technique or practice adopted with this staple, such as hilling or mounding, the runners being planted into a small hole made by a digging stick of fire-hardened casuarina.

When the sweet potato, *Ipomoea batatas*, has been harvested for the final time at 12 months of age, (previous harvests made at five and eight and a half months), pigs are allowed to graze the garden. No damage is caused to the sugar-cane, *Saccharum officinarum,* or bananas,

*Plate* I.—The Asai valley, looking east towards the Ramu.

*Musa* spp., which were originally interplanted with the sweet potato, but considerable soil movement is caused by the foraging habit of the pig, followed inevitably by gully and sheet erosion.

Taro, *Colocasia esculenta*, is the secondary staple and is planted both in dry land and irrigated gardens.

Some groups have so-called "off season" gardens which are planted during hunting expeditions to other valleys, but are no more than rough clearings in the forest which receive little further attention. Among the groups are the upper Asai people, with gardens in the Aunja Valley, and the Maring people of the lower Simbai with gardens on the north wall of the Jimi Valley.

The use of *Casuarina equisetifolia* as a cover-fallow crop, as practised in other Highland areas, was noted only in the Kaironk and upper Asai Valleys. The young seedlings are transplanted from stream sandbars to the gardens immediately after the food crops have been planted. Thus, at the end of 12 months, a partial cover is present and this appears to be the only feasible agronomic method to combat infestation of kunai grass, *Imperata arundinacea*. This is then replaced by *Paspalum conjugatum*, *Digitaria violascens* and other soft grasses. Depending on land pressures, the area may remain under casuarina cover for from three to eight years. When the land is required for gardens again, the casuarinas are ringbarked, the branches lopped for fence and retaining wall construction, while the trunks remain until required for firewood or for building materials.

Each clan or group has at least two or more producing gardens at any one time, together with a newly planted one and one reverting to bush. Garden areas range from some two to three square chains to over an acre in extent. Reversion of gardens to montane forest is unusual, except

*Plate* II.—Steep hillside subsistence garden Kaironk valley.

in the case of the previously discussed "off-season" types; rather, most areas revert to grasslands, or, as in the lower Asai and Tagui Valleys, reversion to a dense forest of *Alsophila* spp., occurs. Retrogression to grassland is aided by the practice of burning off for hunting purposes.

The use of *Casuarina equisetifolia* for a garden cover is to be recommended as this will not only prevent the spreading of grasslands, but will eliminate the use of ditches by providing building materials.

### *Irrigated Taro Gardens.*

These are ancillary to normal gardens, providing food during the slight shortage occurring during the time of planting sweet potato gardens in November-December. These were found only among the Karam people of the Asai Valley. Areas varied from a half to four or five square chains. Some were located on slightly sloping land close to the larger streams while others clung to greater than 40 degree slopes, thus involving more work terracing. Clearing commences in May. The area is burnt off and strongly fenced with casuarina. Then large quantities of casuarina are split and terracing commenced. The billets are lined across the slope at approximately two to three-foot intervals and strongly pegged in place by small pieces of casuarina.

The soil may be loosened and then firmed in place on the topside of the terraces, thus preventing excess water losses. Lengths of timber placed on top of the terraces and lying down the slope delineate individual plots in some cases; in others, the garden is planted progressively by the owner so that there may be a gradual age difference of some weeks within the garden, depending on labour availability and weather conditions. The terrace along the upper boundary of the garden is large to allow a good flow of water. This can be noted in *Plate* III.

*Plate* III.—Irrigated Taro garden—distant view.

Depending on the nature of the soil, the topography and the distance to the stream, the inlet line may be constructed by one of two methods. Where there are few boulders in the soil and the ground is fairly level from the stream to the point of inlet to the garden, a ditch may be dug some 12 to 18 inches wide and the same depth. This is contoured surprisingly well, little scouring being apparent. Some inlet ditches were anything from 10 to 25 yards in length. Where soils are stony and terrain uneven, fluming of bark is obtained and supported by light timber frames. These flumes are never of any great length. Often the top terrace serves as the inlet also. This occurs where the stream flows through the garden, thus allowing the water to be diverted directly into this terrace with a small piece of bark. Where internal high points occur, short lengths of bark bring water from a higher terrace, thus allowing for as near to maximum utilization of existing land as possible.

The water then filters from one terrace to the other, and, provided the correct flow is maintained after saturation of the soils, very little erosion can or does occur. Planting is done in June or July. Occasionally the soil is irrigated prior to planting but this is by no means common. However, it has much to commend it in that any breaks can be repaired and the soil is loose and allows for easier planting, apart from the fact that the taro would strike much more rapidly. A hardened digging stick of casuarina or a shovel is then used to make the planting holes at approximately 12-inch intervals. The taro butts are then planted and the soil firmed around the bases. The only species of taro planted in the garden is *Colocasia esculenta,* but Aibika (*Hibiscus abelmoschus*) and *Xanthosoma* spp. taro are often planted along the garden borders. Tapioca (*Manihot esculenta*) was noted in some gardens, but only on the borders.

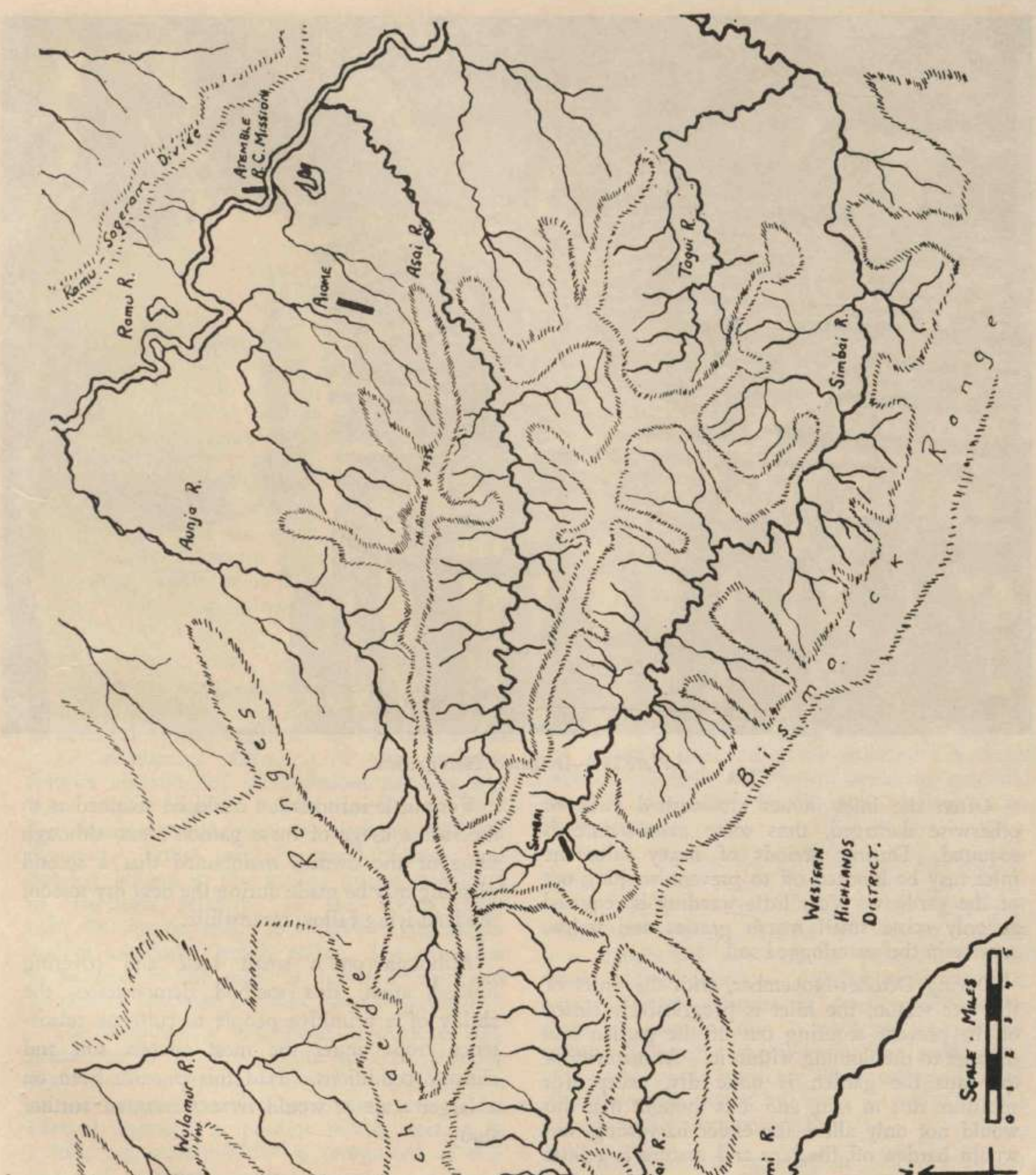
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*Plate* IV.—Irrigated Taro garden.

Often the inlet flumes are washed away or otherwise damaged, thus some maintenance is required. During periods of heavy rain, the inlet may be blocked off to prevent washing out of the gardens. Very little weeding is required as only some small marsh grasses and sedges survive in the waterlogged soil.

During October-November, with the onset of the wet season, the inlet is progressively closed off to prevent scouring out of the garden and damage to the fluming within it. At maturity of the taro the garden is quite dry, except for moisture due to rain, and it is thought that this would not only allow for easier harvesting, but would harden off the taro and mature it a little earlier.

Very little information could be obtained as to the future usage of these garden areas, although some of the owners maintained that a second planting may be made during the next dry season, the land lying fallow meanwhile.

Although on a small scale and covering limited areas, this method demonstrates the ability of a primitive people to cultivate subsistence crops under the most adverse soil and climatic conditions. Had this practice been on a larger scale it would have warranted further study.

(Received January, 1963.)

# *Eradication of Brucellosis from Cattle in the Territory of Papua and New Guinea—1956-1963.*

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*Introduction.*

It has been the policy of the Administration to establish a cattle industry in the Territory of Papua and New Guinea, free, as far as possible, from serious infectious and parasitic diseases (Anderson 1962). Of the bacterial diseases of cattle, brucellosis (*Brucella abortus* infection, contagious bovine abortion, Bang's disease) is one of the most important because of the economic loss in cattle herds (Technical Committee Report, 1960) and also because the causative organism causes a serious disease in man (Undulant fever).

Brucellosis in cattle causes abortion of the foetus usually at about six months pregnancy. The premature expulsion of the foetus follows localization of the organism in the uterus and foetal membranes. Infection of other animals follows ingestion of contaminated pastures and water. Apart from the loss of the calf, infertility and lowered production in aborting cows is common. Bulls may become infected and develop lesions in the genital organs, resulting in decreased fertility. In the non-pregnant cow, *Br. abortus* tends to localize in the udder and/or associated lymph nodes. The organism is secreted in the milk of infected cows and brucellosis becomes a public health problem.

The diagnosis of brucellosis in cattle is confirmed either by the culture of the causative organism from morbid material, milk or semen, or the application of a serological test to the affected animal. A positive serum reaction to a tube agglutination test is recognized as evidence of infection.

Control schemes for brucellosis have been based on several methods. That most commonly used is the use of a vaccine to control its clinical effects (i.e., abortion and infertility). The vaccine used most widely has been Strain 19—an attenuated strain of *Br. abortus*. Strain 19 vaccination markedly reduces the economic loss due to brucellosis, but it does not eradicate the disease. In areas where the incidence of brucellosis is high, Strain 19 vaccination of calves has been used to reduce the incidence of the disease to a point at which a test and slaughter compaign becomes economically feasible. Any breakdown in a vaccination programme will result in an increase in the incidence of the disease.

Eradication of brucellosis can only be achieved by identification of infected animals and their removal from the herd. In some countries management standards have permitted the running of two herds on one property—an infected one and a non-infected. A clean herd is gradually built up by replacing animals, as they are culled, by livestock shown to be non-infected.

Where the conditions of management do not allow the " two herd " system to operate, eradication must be carried out by a " test and slaughter " policy. Under this policy animals are slaughtered as soon as practicable after their identification as positive reactors. To ensure the co-operation of stock owners, some form of compensation is paid by the governmental authority administering the eradication. (In areas where incidence of brucellosis is high the economic shock of such a policy would otherwise be insupportable).

When it became apparent in 1956 that bovine brucellosis was present in the Territory of Papua and New Guinea, it was decided to undertake a test and slaughter eradication scheme. The scheme was initiated in areas where staff of the Animal Industry Division were available to collect samples for test and to control the application of the scheme. Since its initiation, the scheme has been extended to the majority of cattle herds in the Territory. This paper records progress in the eradication of brucellosis from the cattle herds in the Territory of Papua and New Guinea.

### *Laboratory Materials and Methods.*

The tube serum agglutination test has been used throughout the campaign. Antigen has been obtained from one supplier in Australia(†). Two techniques have been used according to the type of antigen supplied.

In the first year of the scheme (1956-57) the antigen used was prepared in accordance with the Minnesota technique and was diluted before use 1 in 100 with carbol saline solution. After 1957, *Brucella abortus* antigen, prepared according to methods recommended by the FAO/WHO expert committee on brucellosis, was used.

#### *The test using Minnesota technique.*

Serum samples for the test were diluted 1 in 10 with physiological saline. 0.2cc, 0.1cc and 0.03 cc of this diluted serum was placed in one of the three tubes in the test. To each tube was then added 1cc of the diluted antigen suspension. The tubes in racks were shaken and incubated at 37 degrees centigrade for 48 hours.

#### *Interpretation.*

Tubes were read at bench temperature after incubation. Agglutination reactions in tubes were classified as complete (+), incomplete (I) and negative (—).

Tubes with complete sedimentation in either the first two or all three tubes were classified as positive.

The following tests were classified suspicious :—

| Tube 1 | Tube 2 | Tube 3 |
|---|---|---|
| + | — | — |
| I | — | — |
| I | I | — |

Negative reactions showed no sedimentation in any tube.

(†) Commonwealth Serum Laboratories, Parkville N2, Victoria.

#### *The Test using the Joint FAO/WHO expert committee on Brucellosis technique.*

The test used employed a final volume of 1cc. Four tubes (3in. x ⅜in. diameter) were used for each serum sample. O.8cc. carbol saline was placed in tube 1. Tubes 2, 3 and 4 received 0.5cc. carbol saline. To Tube 1 was added 0.2cc. undiluted serum. After mixing, 0.5cc. from Tube 1 was transferred to Tube 2, and the process repeated through to Tube 4 after which 0.5cc. was discarded. To each tube was added 0.5cc. standard suspension antigen. Shaken tubes were maintained at 37 degrees centigrade for 20 to 24 hours in an incubator. Final dilutions in this test were 1/10, 1/20, 1/40 and 1/80.

#### *Interpretation of the FAO/WHO test.*

Tubes in each test were classified as follows :—

| | |
|---|---|
| ++ ++ | 100 per cent. clearing—agglutination + sedimentation. |
| +++ | 75 per cent. clearing. |
| ++ | 50 per cent. clearing. |
| + | 25 per cent. clearing. |

Sera showing a ++ (50 per cent.) reading in the third tube (1/40) or higher titre were classed as positive reactors.

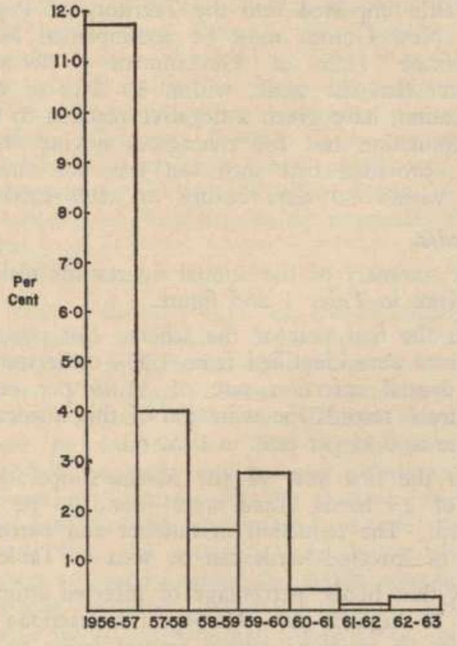
Suspicious reacations were those with a ++ (50 per cent.) reaction in the second tube (1/20) but less than 50 per cent. clearing in the third tube. Negative reactions included all those with less than ++ reading in the second tube (1/20).

#### *Procedure with suspicious reactors.*

Titres of suspicious reactors were recorded and at subsequent sampling rises or falls in titre noted. A rise in titre to a ++ (50 per cent.) reading in the third tube (1/40) or higher resulted in a classification of the animal as positive. Three consecutive samples at monthly intervals from suspicious reactors in which no change in titre could be shown, or in which the titre fell, resulted in a classification of the animal as negative.

#### *Procedure with Strain 19 reactions.*

Reactions in animals which could be proven to have had Strain 19 vaccination and whose serum did not cause 50 per cent. agglutination at a dilution of greater than 1/40 were classified as negative.




Percentage incidence of positive reactors in cattle tested.

*Procedure with haemolysed serum samples.*

In the first two years of the campaign, haemolysed serum samples were not tested. Later these samples were tested and noted on the racks as haemolysed. Positive reactions arising from these samples were reported as suspicious and further samples requested. Negative reactions were passed as negative.

*Field Methods.*

All entire cattle over six months of age were considered eligible for testing.

Blood was collected from the jugular vein using a 13 or 14 gauge 3in. hypodermic needle into 6in. x ½in. diameter test tubes. Tubes were numbered in series from 1 to 100 and the ear tag numbers corresponding to each tube recorded. These tubes were carried in the field and transported in wooden boxes containing 100 tubes.

Blood samples were kept at room temperature for at least four hours and then refrigerated at least overnight prior to being airfreighted to the Central Veterinary Laboratory at Kila Kila, Port Moresby. If prolonged delays in shipment were expected, the serum was poured off into sterile bottles and refrigerated until transhipment to Kila Kila could be arranged.

The Laboratory was notified by radio of the departure of the specimens and generally received them within six hours of removal from refrigerator at point of despatch.

*Field Organization.*

Until 1962-63, all herds were tested at 12 monthly intervals. If a reactor was found in a herd, monthly testing was introduced until three clean tests at monthly intervals, another three months later, and a fifth six months later, were obtained. The disease was then considered eradicated from the herd and annual testing begun.

In 1962-63, to reduce the burden of repeated testing of clean herds and thus allow extension of testing to previously untested herds, a different field organization was developed. For the purpose of the Brucellosis Eradication Programme, cattle herds in the Territory were grouped into "areas". These areas consisted of a herd or groups of herds, separated by natural boundaries from surrounding herds.

Areas were classified according to their brucellosis status as :—

A. Brucellosis Free Areas.

B. Brucellosis Eradication Areas.

C. Brucellosis Unknown Areas.

A. Brucellosis Free Areas : To qualify as a Free area all herds in the area must have given two consecutive complete clean tests at twelve monthly intervals. The test carried out on imported cattle prior to importation, was accepted as one of these twelve monthly tests. In Brucellosis Free Areas, testing will be carried out at three yearly intervals.

B. Brucellosis Eradication Areas : Individual herds were classified as :—

(*a*) *Brucellosis clean herds* are those which have been completely tested but never produced a positive reactor, or herds from which the disease has been eradicated. Clean herds are to be tested at annual intervals.

(*b*) *Modified clean herds* are defined as beef herds of over 1,000 head in which at least 50 per cent. of the adult cattle (except steers) when tested annually are negative to the test.

(*c*) *Brucellosis infected herds* were those in which brucellosis has been diagnosed but not eradicated. Herds in an eradication area which did not qualify as clean or modified clean herds were classified as infected until testing showed they qualified as clean or modified clean herds. Testing in herds in which brucellosis has been diagnosed was carried out at one monthly intervals until three clean tests were obtained. If after a further six months a clean test was obtained, the disease was considered eradicated from the herd.

C. Brucellosis Unknown Areas are those in which testing has not been introduced.

### *Testing prior to Movement.*

Negative brucellosis tests are required before movement of breeding cattle from a property in the Territory is permitted, except for cattle from brucellosis free areas. Movement from brucellosis infected herds has been prohibited since 1962-1963.

### *Compensation.*

Compensation for cattle slaughtered during the brucellosis eradication campaign has been either replacement with a similar animal from an Administration owned herd or, at the Administrator's discretion, in cash.

### *Legislative Powers.*

The legislative powers for the brucellosis eradication campaign are embodied in the Animal Disease and Control Ordinance of 1952-1957 of the Territory of Papua and New Guinea.

### *Quarantine Regulations.*

Cattle imported into the Territory of Papua and New Guinea must be accompanied by a certificate from a Government Veterinary Officer that the stock, within 30 days of embarkation, have given a negative reaction to the agglutination test for contagious bovine abortion, provided that such test was not carried out within 30 days before or after calving.

### *Results.*

A summary of the annual figures for testing is given in *Table* 1 and figure.

In the first year of the scheme 230 positive reactors were identified from 1,938 cattle tested, an overall infection rate of 11.86 per cent. Figure 1 records the reduction of this incidence figure to 0.25 per cent. in 1962-63.

In the first year of the scheme's operation, 10 of 23 herds tested were found to be infected. The reduction in number and percentage of infected herds can be seen in Table I.

Within herds, percentage of infected animals was as high as 20. Non-specific reactions or Strain 19 reactions caused several herds to be classed as infected although only one reactor was identified in them.

The increase in incidence in 1959-60 was due to concentration on eradication in two large beef herds, in both of which positive reactors were not destroyed immediately after identification and in which unnecessary infection of clean animals occurred.

The small increase in incidence in 1962-63 was due to the extension of testing to the Madang District. A herd of about 1,000

*Table* I.

Summary of Brucellosis Testing 1956-63.

| Year. | Sera tested. | Cattle under test. | Herds under test. | Infected herds. | | Positive reactors. | |
|---|---|---|---|---|---|---|---|
| | | | | No. | Per cent. | No. | Per cent. |
| 1956-57 .... .... | 3,497 | 1,938 | 23 | 10 | 43.4 | 230 | 11.86 |
| 1957-58 .... .... | 8,848 | 3,427 | 39 | 8 | 20.5 | 137 | 3.9 |
| 1958-59 .... .... | 5,704 | 2,800 | 31 | 5 | 16.3 | 43 | 1.5 |
| 1959-60 .... .... | 7,068 | 2,500 | 38 | 4 | 10.5 | 68 | 2.7 |
| 1960-61 .... .... | 8,881 | 4,724 | 51 | 2 | 3.9 | 20 | 0.4 |
| 1961-62 .... .... | 5,098 | 4,598 | 60 | 1 | 1.6 | 1 | 0.02 |
| 1962-63 .... .... | 13,759 | 9,557 | 167 | 3 | 1.8 | 24 | 0.25 |

breeders was found to be infected and 22 reactors were identified in it. On two other properties (of 60 and 24 breeders respectively), one reactor was found. The herd of 24 breeders was in the Madang District and there was contact with the large herd mentioned above. The third affected property was in the Eastern Highlands District. The one reactor identified was probably a non-specific one, since there was no evidence of either Strain 19 vaccination or of brucellosis in the remainder of the herd.

*Discussion.*

Many authorities agree on the desirability of eradication of bovine brucellosis. A report (1960) of a Technical Committee of the Australian Veterinary Association stated *inter alia* that the ultimate aim in Australia with brucellosis must be eradication. The Committee commended the cattle industry and veterinary profession in Tasmania for the progress made in that State towards eradication. Mingle (1959) stated that the economic and human health factors involved justified the fullest co-operation possible between livestock, sanitary officials, public health agencies, and the livestock industry in combating brucellosis. Bothwell (1960) reviewing human brucellosis in Britain, considered that all available preventive measures should be taken to reduce the economic loss in cattle and the incidence of the disease in man.

Eradication of bovine brucellosis is complete in Norway, Sweden and Denmark, and is well advanced in the United States, where a direct loss of $60,000,000 annually is attributed to the disease. Stableforth (1960) reported that twenty entire states of the United States had been declared as modified, certified brucellosis free areas, and that large areas of 28 others were free. In many other countries schemes have been evolved aimed at controlling and ultimately eradicating brucellosis.

In Tasmania, the control and eradication of brucellosis was commenced in 1954. In eleven of thirteen veterinary districts in the State, eradication was commenced with a test and slaughter programme. In the remaining two districts initial high levels of infection led to the use of Strain 19 vaccination of calves as an initial step in reducing the incidence of the disease to a level where test and slaughter was economically feasible. Strain 19 vaccine has successfully reduced the incidence of brucellosis in countries where it has been widely used —New Zealand, South Africa, Australia and the United States of America. Unfortunately, it will not eradicate the disease.

The use of Strain 19 vaccine has the disadvantage that it complicates any test and slaughter campaign that might follow its use. A small percentage of calves vaccinated with Strain 19 at six to eight months of age give a positive reaction to the serum test for brucellosis when they become adult. Furthermore, animals vaccinated with Strain 19 can carry the virulent organism. Consequently the interpretation of a positive serum test in a vaccinated animal is difficult. If it can be avoided economically Strain 19 vaccination is better not carried out in areas where a test and slaughter eradication scheme is operative.

The majority of countries with large livestock numbers had a high incidence of brucellosis in their herds by the time means of controlling the disease were developed. Cattle herds in the Territory of Papua and New Guinea were virtually wiped out during the second world war. After the war, the desirability of re-establishing herds free from serious diseases was realized by the Administration of the Territory. Consequently, quarantine restrictions were applied to provide for the importation of brucellosis free stock. When it was realized that brucellosis was, in fact, present in Territory herds, it was decided to adopt, as soon as possible, a test and slaughter scheme for its eradication. The successful application of this scheme to the Territory's herds is seen as some contribution towards the establishment of a successful dairying and grazing industry in Papua and New Guinea.

The successful eradication of brucellosis from beef herds with 200 to 600 breeders poses several difficulties not likely to be met in dairy herds. In the first instance, musters must be complete and the bleeding programme carried out on a whole herd basis in as short a time as possible. Identification of cattle under test must be permanent and accurate. Handling facilities were found to be inadequate in many instances and could have contributed to the breakdown on several properties. The most essential aspects of an eradication campaign are considered to be the rapid notification of field staff of positive reactors and their immediate removal from the herd. Unnecessarily high losses on two properties were attributed to the failure to remove positive reactors from the herd. It is also essential that, an infected herd having been identified, a concentrated programme should continue until the disease is eradicated. In our scheme we have found that three complete clean herd tests at intervals of 28 days were evidence of freedom from brucellosis.

Suspicious reactors to the tube agglutination test have not been found to be a serious problem. The titre of suspicious reactors in positive herds was most likely to rise to a positive level. It was found that in some herds a number of animals consistently give suspicious tests. These animals were passed if there was no evidence of rise in titre in three tests at intervals of 28 days and if there was no other evidence of infection in the herd. There has been no recurrence of infection in any herd considered to be freed of the disease and in which this policy toward suspicious reactors has been applied.

Gregory (1960) was of the opinion that suspicious or positive reactions in animals known to have been vaccinated with Strain 19 should be regarded as infected animals. This policy has been followed in Tasmania (Clark 1960). Strain 19 has not been used in the Territory of Papua and New Guinea so that this problem has rarely been met. Animals imported from Australia where Strain 19 is widely used are required to have negative serum agglutination tests before importation.

A possible Strain 19 reaction was met in one herd of 60 head. The herd in question had had no introduction more recent than when the animal which reacted had been imported with 15 other heifers five years previously. The heifers had been vaccinated in Australia. Since there was no other evidence of brucellosis in this closed herd and the titre was within the limits allowed for a reaction to Strain 19 by FAO/WHO the animal was not slaughtered. In other cases where single positive reactions have occurred in herds but in which there has been no evidence of vaccination, there has been no alternative than to class the animal as positive and slaughter it.

The test and slaughter method for the eradication of brucellosis is considered to have been successfully applied in Papua and New Guinea. The scheme will be extended to the few cattle not at present under test. After eradication is complete, the brucellosis free status will be maintained by regular testing of clean herds and the importation of brucellosis free cattle.

### *Summary.*

Progress in the eradication of brucellosis from cattle in the Territory of Papua and New Guinea is described. Incidence was reduced from 11.86 per cent. in the first year of testing to 0.25 per cent. in 1962-63. Cattle under test increased from 1,938 in 1956-57 to 9,557 in 1962-63. Herds under test increased from 23 to 167 in the same period.

(Received November, 1963.)

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# Cocoa Drying with the Lister Moisture Extraction Unit.

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### *Description of the Moisture Extraction Unit.*

BASICALLY this drying unit consists of a high efficiency axial flow fan directly coupled through a centrifugal clutch to a Lister heavy duty HA4, 40 h.p. air-cooled diesel engine fitted with electric starting, and operating at a maximum speed of 1800 r.p.m. In front of the fan blades and within the fan housing, a series of eight metal vanes are fitted to assist in the reduction of turbulence in air driven into the plenum chamber by the fan. This fan produces a very high volume of air (rated at 38,000 c.f.m. free flow) which is warmed solely by heat produced from the engine. The entire engine assembly is covered by a fibreglass hood or canopy, one end of which fits around the fan housing while the opposite end remains open to allow intake of air. In this way all air passing through the fan must pass through the enclosed space around the engine and exhaust system. Utilization of heat produced by the engine is improved by the action of a small single stage axial flow fan fitted to one side of the engine, which forces cooling air around the cylinders. Additional heat is also obtained from the long exhaust system, consisting of a flexible pipe leading from the manifold to a large exhaust silencer, thence to a long exhaust pipe leading from the silencer out through the fibreglass canopy. Exhaust gases are emitted well above the level of the engine so that contamination of air drawn in by the fan is avoided.

A valuable additional feature of the engine is the provision for a power take-off at the end opposite to the fan, which can be fitted with a generating unit, water pump or other equipment. The whole assembly is mounted on a solidly-constructed trailer chassis enabling it to be transported readily from one location to another.

### *Principle of Drying.*

Much of the hot air drying of cocoa beans in Papua and New Guinea is based on platform drying of fermented beans using temperatures of 120 degrees F. to 170 degrees F. and air volumes of 3,000-12,000 c.f.m. Under these conditions batches of 2-2½ tons dry bean equivalent can be dried in shallow layers in two to three days. However, it has been demonstrated with grain crops that large quantities can be dried over longer periods provided that a large volume of slightly warmed air at adequate pressure is available. The design of the moisture extraction unit incorporates this latter principle of drying, so that it increases the drying capacity of large volumes of air at ambient temperature by raising the temperature a few degrees and forcing it through the material to be dried.

Performance data for the unit, as submitted by the manufacturers, are presented in Table I and Figure 1. These show the relationship between air volume and temperature rise above ambient for *total* water gauge pressures of 1 inch to 7 inches at the fan, and also the relative humidity differential between air at ambient temperature and warmed air.

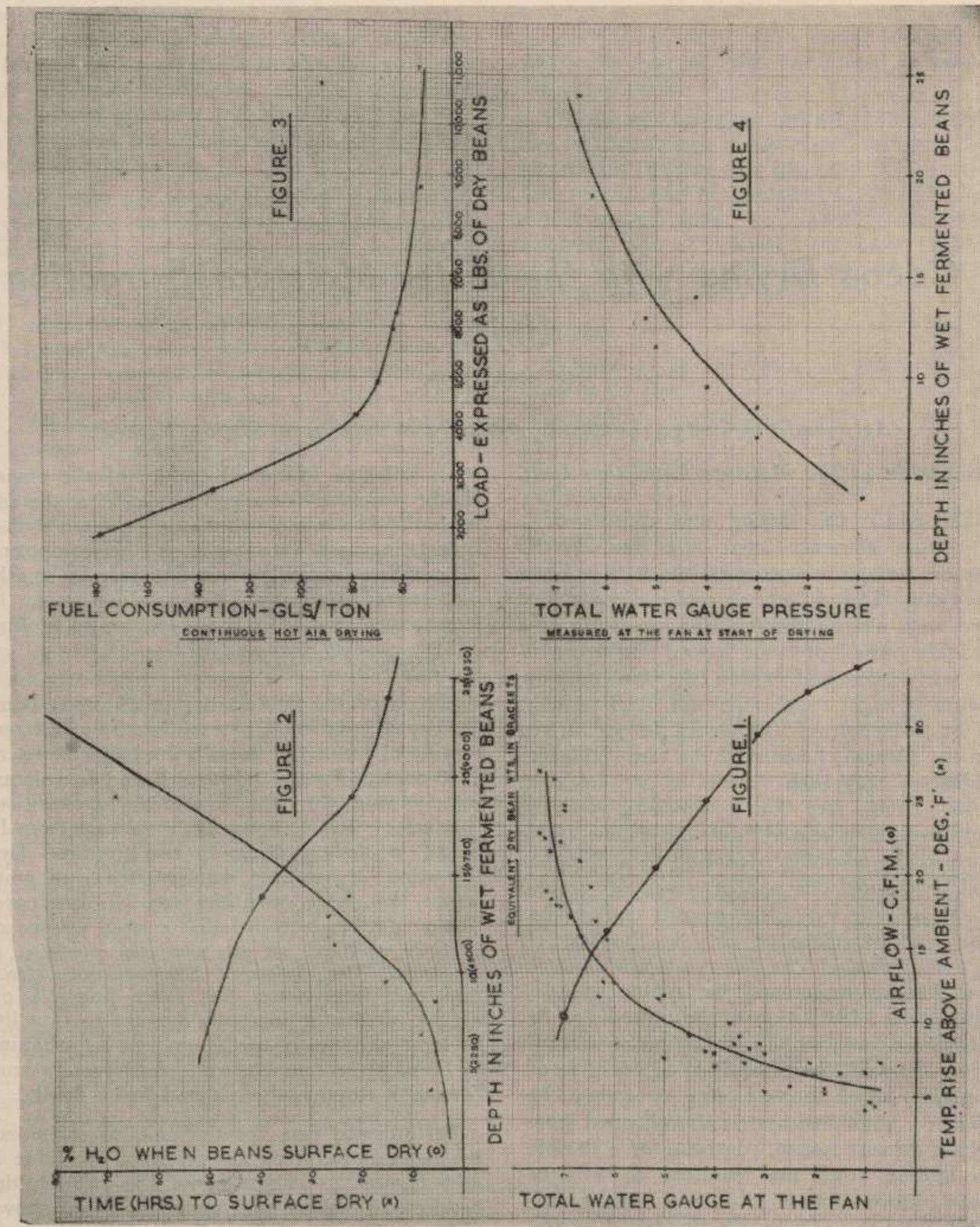
FIGURE 3
LOAD—EXPRESSED AS LBS. OF DRY BEANS
FUEL CONSUMPTION—GLS/TON
CONTINUOUS HOT AIR DRYING
FIGURE 4
DEPTH IN INCHES OF WET FERMENTED BEANS
TOTAL WATER GAUGE PRESSURE
MEASURED AT THE FAN AT START OF DRYING
FIGURE 2
DEPTH IN INCHES OF WET FERMENTED BEANS
EQUIVALENT DRY BEAN WTS. IN BRACKETS
% H2O WHEN BEANS SURFACE DRY (o)
TIME (HRS.) TO SURFACE DRY (x)
FIGURE 1
AIRFLOW—C.F.M. (o)
TEMP. RISE ABOVE AMBIENT—DEG. 'F' (x)
TOTAL WATER GAUGE AT THE FAN

(a) Nil Blanking Pieces.

*Table* I.

*Performance Data for Lister Moisture Extraction Unit.*

| Total W. G. (inches) | Air Flow (C. F. M.) | Temp. Rise (Degrees F.) | Relative Humidity Differential. (per cent.) |
|---|---|---|---|
| 1 | 34,000 | 6.0 | 15 |
| 2 | 32,300 | 6.8 | 17 |
| 3 | 29,400 | 7.2 | 18 |
| 4 | 25,000 | 7.75 | 19.4 |
| 5 | 20,500 | 8.5 | 21.2 |
| 6 | 16,200 | 12.0 | 30 |
| 7 | 10,200 | 20.0 | 50 |
| (*b*) Two Lower Blanking Pieces. | | | |
| 1 | 32,300 | 6.0 | |
| 2 | 28,500 | 7.0 | |
| 3 | 25,000 | 8.0 | |
| 4 | 22,000 | 7.75 | |
| (*c*) Two Upper and One Lower Blanking Pieces. | | | |
| 1 | 19,000 | 5.0 | |
| 2 | 17,000 | 6.0 | |
| 3 | 14,700 | 8.0 | |
| 4 | 11,700 | 9.0 | |
| (*d*) Two Lower and One Upper Blanking Pieces. | | | |
| 1 | 23,600 | 7.0 | |
| 2 | 22,000 | 7.5 | |
| 3 | 19,200 | 8.0 | |
| 4 | 17,600 | 9.0 | |
| (*e*) Two Upper Blanking Pieces | | | |
| 1 | 22,000 | 8.0 | |
| 2 | 20,300 | 9.0 | |
| 3 | 18,000 | 10.0 | |
| 4 | 16,200 | 10.8 | |
| 5 | 11,800 | 14.4 | |

From this table it is apparent that as the total water gauge pressure increases, either because of an increase in load or the utilization of blanking pieces over the fan to restrict airflow past the engine and through the fan, so the temperature rise above ambient increases, and the volume of air being delivered by the fan falls. The table also shows the effect that various combinations of blanking pieces have on these relationships.

## *Total Water Gauge.*

The general lack of exact specification by manufacturers of drying equipment and cocoa growers necessitates clarification, exact description, and location of any water gauge measurements quoted for such processing machinery. In the case of this Moisture Extraction Unit all water gauge measurements referred to are *total* water gauge readings, i.e., "velocity" water gauge plus "static" water gauge. Velocity water gauge is defined as the height in inches of a column of water which can be supported by the pressure of air resultant from air speed or air velocity. Static water gauge is the height in inches of a column of water which can be supported by the pressure of air which is not produced by velocity but maintains velocity against resistance. Velocity, static, and total pressures can be readily measured by the use of a simple manometer. On this unit the manometer is located immediately in front of the fan, and therefore all water gauge readings are total water gauge readings at the fan. Consequently they are much higher than static water gauge readings would be beneath the dryer floor under the same conditions.

## *Blanking Pieces.*

These are quadrants of strong masonite fitted with clips which allow them to be attached readily to the circular wire mesh guard on the inlet side of the fan. By using them it is possible to cover quarter circle sections of the fan and so reduce airflow as indicated in Table I.

Additional data made available by the manufacturers of the M.E.U. have been used in the compilation of Table II, which shows the drying capacities of air at given temperatures in accordance with the rated output of the dryer.

*Drying Capacity of Lister Moisture Extraction Unit.*

*Table* II.

Cwts. of water removed per 24 hours by volumes of air at the temperatures shown for four levels of relative humidity. Based on an ambient temperature of 70 degrees F. The calculations are based on the assumption that air is exhausted at a relative humidity of 94 per cent.

| Air Vol. (C. F. M.) | Temp. Rise Above Ambient (degress F.) | Relative Humidity (per cent.) | | | |
|---|---|---|---|---|---|
| | | 60 per cent. | 70 per cent. | 80 per cent. | 90 per cent. |
| 10,200 c.f.m. | at 20°F. | 45.6 | 40.8 | 36.5 | 32.4 |
| 16,200 c.f.m. | at 12°F. | 54.3 | 45.4 | 38.6 | 32.6 |
| 20,500 c.f.m. | at 8.5°F. | 58.4 | 48.0 | 38.1 | 30.8 |
| 29,400 c.f.m. | at 7.2°F. | 79.4 | 63.2 | 49.4 | 38.5 |
| 34,000 c.f.m. | at 6.0°F. | 86.7 | 68.0 | 51.7 | 38.8 |

The table illustrates that, theoretically, the machine should have a greater capacity to dry when operated at maximum air volume and minimum temperature rise, than when lower volumes at higher temperatures are used. However, this assumes that the drying air is exhausted at a relative humidity of 94 per cent., which is a difficult level to achieve with a large volume at low temperature unless the load is spread at a shallow depth over a large area. Assuming that an airflow through cocoa beans at 20 ft./minute allows the drying air to approach 94 per cent. r.h. when exhausted, then 34,000 c.f.m. would have to be pushed up through 1,700 square feet of floor space at a total water gauge of 1 in. at the fan (equivalent to a load of approximately 3-4 in. of wet fermented beans to achieve maximum drying efficiency. This system would possibly handle the equivalent of five tons of dry beans. However, as will be shown from the trial results, a three ton dry bean equivalent load can be dried on 216 square feet of floor, i.e., approximately $\frac{1}{8}$th of the area using less air at a higher temperature. Thus, the economics of dryer construction in terms of area must obviously be balanced against cost of drying for this type of machine.

### *Drying Systems.*

Potentially the unit can be used to dry cocoa beans in two ways.

(*a*) Firstly, it can be applied to a platform type drying bed and used in much the same way as most sun/hot air platform dryers are used for complete drying *in situ,* i.e., a single load or batch of fermented beans is spread evenly over the area of the drying floor and dried out completely in two to four days without being moved.

(*b*) Secondly, because of the power the fan has to push out air at high pressures, it can be used to pre-dry or surface dry small batches of beans on a continuous output basis. Each batch, once it is pre-dried, is then transferred to a deep bin where final drying of beans up to eight feet in depth can theoretically be achieved. Results from the preliminary trials indicate that this depth could probably be handled by the unit. It is emphasized at this point that no local information is available on this system of drying and that the unit might prove to be most economic when used in this way. See Appendix.

### *Drying Trials—Complete Drying* in situ. (*Method* (*a*) *above.*)

The first series of ten drying trials was designed to provide information on the capacity of the unit when used to dry completely a single load of beans *in situ.* Data recorded were fuel consumption per ton for complete hot air-drying, the maximum depth at which beans could be surface dried on a given floor area, and all associated data on water gauge readings, airflow, temperature rises, oil consumption, drying times, etc. Much of this information is summarized in Table IV, while more detailed information is available from individual trial reports.

For the trials, a temporary dryer was constructed with timber frame and plywood sides and an 18 ft. x 12 ft. floor of cocoa wire supported by 3 in. x 2 in. arc mesh. Depth of the air chamber beneath the floor was 48 in. (to eliminate cold spots), with the unit fitted into a fish tail duct which opened into one end of the air chamber. Fermented beans for drying were contained on the floor by a plywood lined wall 24 in. deep so that in effect the dryer consisted of an 18 ft. x 12 ft. x 24 in. deep bin with a cocoa wire/arc mesh floor and an 18 ft. x 12 ft. x 4 ft. deep air chamber below.

As the first two trials were carried out using a different system for blanking or baffling the fan from that used in the remaining eight trials, the results will be discussed accordingly. In the first and second trials, airflow was varied either by fitting the blanking pieces supplied by the manufacturers over the fan guard, or by reducing engine speed. By using one, two or three blanking pieces, air intake can be restricted and the c.f.m. output and temperature rise above ambient controlled to some extent. Unfortunately, as soon as the blanking pieces were fitted, total water gauge readings on the manometer located in front of the fan were affected to such an extent that they were meaningless and could not be used as a guide to the c.f.m. output of the machine, as indicated in *Table* I.

Consequently the baffling system was altered for the last eight trials by fitting on the dryer side or outlet side of the fan a sliding plywood door which could be moved across the front of the fan to restrict airflow. This not only gave excellent control of airflow with little interference to the water gauge, but also enabled output of the fan to be varied from 10,000-34,000 c.f.m. and temperatures from 6 degrees F. to 20 degrees F. rise above ambient, thus turning the unit into a far more versatile machine both for experimental purposes and as a dryer.

In the first trial, beans were dried mainly during the day and the machine turned off overnight. The object was to get some information on fuel consumption under these conditions although the final figure of 34.6 gals/ton represents drying to a level of 8.2 per cent. moisture only. When corrected for drying to six per cent. moisture, fuel consumption was estimated as 44.4 gals/ton. Tests during this trial also showed that variations in engine speed do not give any variation in air temperature, and that the reduction in c.f.m. output which results from a slower engine speed is balanced by the lower heat output from the engine, with the net result that air temperature remains about the same.

In the second trial, beans were dried continuously except for a break on the final night, and fuel consumption rose to 43.8 gals/ton (corrected to 55.1 gals/ton for 6 per cent. moisture). Continuous drying and a smaller load on the dryer were the main factors responsible for this rise.

Several combinations of blanking pieces were used with various engine speeds during the first and second trials and temperature rises for each particular combination recorded. However, as water gauge readings could not be simultaneously recorded because of the effect previously mentioned, the results are of no value for comparison with figures provided by the manufacturers. This information was not necessary for the subsequent trials, however, as the method of baffling was changed and improved.

As shown in Table IV, quantities of 4,693 lb. and 3,940 lb. of dry beans were dried in the first and second trials respectively at a reasonable cost in terms of fuel, oil and labour. Perhaps the most interesting feature was the ability of the machine to surface dry beans 8½ in. deep in a little more than five hours. The remaining eight trials provided the following information.

(1) *Temperature Rise Above Ambient.*

Throughout the series of ten trials, temperature readings at various water gauge pressures were continuously recorded. These results are summarized in Table III which shows the maximum and minimum temperature rise above ambient which was recorded for each of the water gauge readings. Table III is also graphically represented by Figure 1.

***Temperature Rise above Ambient at Varied Water Gauge Pressures.***

*Table* III.

| Water Gauge (inches). | Minimum Temp. Rise. (Degrees F.) | Maximum Temp. Rise. (Degrees F.) | Makers' Rating. |
|---|---|---|---|
| 7.3 | 22.8 | 27.0 | .... |
| 7.2 | 18.9 | 22.5 | .... |
| 7.1 | 18.4 | 21.6 | .... |
| 7.0 | 18.0 | 26.4 | 20.0 |
| 6.9 | 18.0 | 22.2 | .... |
| 6.8 | 24.3 | 24.6 | .... |
| 6.7 | 17.1 | 17.1 | .... |
| 6.5 | 15.9 | 21.0 | .... |
| 6.3 | 11.7 | 19.2 | .... |
| 6.2 | 12.6 | 16.9 | .... |
| 6.0 | 12.6 | 15.6 | 12.0 |
| 5.1 | 11.6 | 11.6 | .... |
| 5.0 | 7.5 | 11.7 | 8.5 |
| 4.5 | 9.0 | 9.0 | .... |
| 4.2 | 8.0 | 8.0 | .... |
| 4.0 | 7.0 | 7.8 | 7.75 |
| 3.7 | 9.9 | 9.9 | .... |
| 3.6 | 8.5 | 8.5 | .... |
| 3.5 | 9.0 | 9.0 | .... |
| 3.4 | 7.2 | 7.2 | .... |
| 3.3 | 8.2 | 8.2 | .... |
| 3.1 | 8.4 | 8.4 | .... |
| 3.0 | 5.2 | 7.8 | 7.2 |
| 2.5 | 5.7 | 5.7 | .... |
| 2.1 | 7.2 | 7.2 | .... |
| 2.0 | 6.3 | 6.3 | 6.8 |
| 1.8 | 5.1 | 5.4 | .... |
| 1.5 | 6.5 | 6.5 | .... |
| 1.0 | 4.0 | 6.6 | 6.0 |
| 0.9 | 4.5 | 4.5 | .... |
| 0.8 | 4.2 | 4.2 | .... |
| 0.7 | 7.2 | 7.2 | .... |

Taking into consideration the fact that the above measurements were made under field conditions, there is reasonable agreement between the temperature readings recorded and those quoted by the manufacturers. Even so, in some cases wide variations were found between maximum and minimum rises above ambient for a given water gauge. Also, in some cases the range was at a higher level for a lower water gauge reading, e.g., 6.8 in.; 24.3-24.6 degrees F., 7.2 in.; 18.9-22.5 degrees F. Consequently it must be assumed that either the water gauge is affected to some degree by the fan blanking door or else the gauge does not give readings of great accuracy. Until this can be checked by fitting a

*Table* IV.

Summary of Results of Preliminary Trials with the Lister Moisture Extraction Unit.

| | Trial 1. | Trial 2. | Trial 3. | Trial 4. | Trial 5. | Trial 6. | Trial 7. | Trial 8. | Trial 9. | Trial 10. | Means. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vol. wet beans (cu. ft.) | 195 | 155 | 352 | 273 | 440 | 170 | 205 | 245 | 80 | 120 | |
| Av. wt./cu. ft. wet beans (lb.) | 53¼ | 55 | — | — | — | — | 56 | 52.5 | — | — | 54.7 |
| Total wt. wet beans (lb.) | 10,384 | 8,525 | — | — | — | — | 11,480 | 12,862 | — | — | |
| Av. wt./cu. ft. fermented beans (lb.) | 47¼ | 47½ | 50¾ | 47 | 48½ | 51 | 48¾ | 50.4 | — | — | 48.96 |
| Total wt. fermented beans (lb.) | 9,214 | 7,363 | 17,775 | 12,842 | 23,522 | 8,670 | 9,994 | 12,348 | — | — | |
| Moisture at end of fermentation (percentage) | 51.7 | 52.2 | 56.8 | 55.6 | 55.7 | 55.6 | 55.1 | — | — | — | |
| Type of drying and duration | Interupted: day only: 7 days | First 2 days continuous 3 days | Cont. 5 days | Cont. 4 days | Cont. 6 days | Cont. 3 days | Interrupted: day only: 6 days | Cont. 4 days | Cont. 4 days | Cont. 4 days | |
| Depth of beans in dryer (ins.) | 10½ | 8½ | 19 | 14 | 24 | 9½ | 11½ | 13 | 4 | 6½-7 | |
| Total water gauge at start of drying (ins.) | ? | 3.0 | 6.25 | 4.2 | 6.5 | 4.0 | 5.0 | 5.2 | 0.9 | 3.0 | |
| Time to surface dry completely (hours) | Irrelevant | 5½ | 66½ | 21 | 75-91 | 15 | 24 | 25 | 6¾ | 8¼ | |

*Table* IV.—*continued.*

## Summary of Results of Preliminary Trials with the Lister Moisture Extraction Unit.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Time to surface dry to indicate depth (hours) | 6"/14 | 8½"/5½ | 3"/7<br>10"/23 | 14"/21 | 9"/22<br>12"/27<br>16"/43 | 9½"/15 | 11½"/24 | 13"/25 | 4"/6¼ | 6½"/8¼ | |
| Total drying time (hours) | 69 | 60 | 120 | 94¾ | 139½ | 60½ | 91¾ | 88¼ | 89 | 99½ | |
| Total fuel consumption (gals.) | 72.5 | 77 | 198.5 | 167 | 239.5 | 104.5 | 151 | 141 | 145.5 | 163 | |
| Av. fuel consumption (gals/hour) | Eng. speed varied : 1.05 | Eng. speed varied : 1.28 | Full speed 1.65 | Full speed 1.76 | Full speed 1.72 | Full speed 1.73 | Full speed 1.65 | Full speed 1.60 | Full speed 1.63 | Full speed 1.64 | |
| Engine Oil used (pints) | 11 | 6 | 26 | 14 | 24 | 6 | 14 | 15 | 11 | 24 | |
| Oil consumption/ton (pints) | | | 6.7 | 5.3 | 4.8 | 3.2 | 6.4 | 5.4 | 13.5 | 19.7 | |
| Fuel consumption/tons (gallons) | 34.6 | 43.8 | 50.8 | 63.0 | 48.3 | 55.0 | 69.5 | 50.53 | 178.0 | 133.8 | |
| Consumption/ton corrected to 6 per cent. moisture content | 44.4 | 55.1 | 52.1 | 63.0 | 52.4 | 78.0 | 69.5 | 62.0 | 178.0 | 133.8 | |
| Total man hours for turning | 10 | 9 | 42 | 6 | 26 | 6 | 12 | 13 | 4 | 2¼ | |
| Man/hours/ton | 4.8 | 15.1 | 10.7 | 2.3 | 5.7 | 3 | 5.5 | 4.6 | 5 | 2 | |
| Wt. dry beans (lb.) | 4,693 | 3,940 | 8,750 | 5,945 | 11,109 | 4,255 | 4,877 | 6,250 | 1,830 | 2,730 | |
| Dry beans/wet beans (percentage) | 35.9 | 46.2 | — | — | — | — | 42.5 | 48.6 | — | — | 45.68 |
| Dry beans/fermented beans (percentage) | 50.9 | 53.5 | 49.2 | 46.3 | 47.2 | 49.1 | 48.8 | 50.6 | — | — | 49.00 |
| Fermented beans/wet beans (percentage) | 88.8 | 86.4 | — | — | — | — | 87.1 | 96.0 | | | 89.97 |
| Wt. lb. dry beans/cu. ft. wet beans (lb.) | 24.1 | 25.4 | 24.9 | 21.8 | 25.2 | 25.0 | 23.8 | 26.1 | 22.9 | 22.8 | 24.33 |

second water gauge to the machine, readings can only be taken as a reasonable but not accurate indication of operating temperatures and c.f.m. output.

An interesting feature of the relationship between temperature rise above ambient and total water gauge as shown in Figure 1, is the pattern between 1 in. total water gauge and 6 in. total water gauge (5 degrees rise to 13 degrees rise) , and 6 in. total water gauge and 7 in. total water gauge (13 degrees rise to 21 degrees rise. Because of this characteristic of the machine's performance it is obvious that only relatively low volumes of air are available at a 20-25 degrees F. rise above ambient.

(2) *C.f.m. Output.*

Detailed information on tests carried out to check the c.f.m. rating of the machine is given in the report on trial no. 3. Results indicate that when operating at a 7 in. total water gauge the unit pushes through approximately 5,000 c.f.m., which is about half the output quoted by the manufacturers. This figure should not be taken as exact, firstly because it is compiled from records which include some estimated measurements as well as accurate measurements of airflow through the beans, and secondly because of the possibility, as mentioned, that water gauge readings may not be accurate enough for this purpose. Reference to Table I will show that as water gauge readings increase from 3 in. to 4 in. to 5 in. to 6 in., rated c.f.m. output falls at the rate of 4,300—4,500 per inch. But the fall from 6-7 in. is 6,000 c.f.m. and the graph of total water gauge against c.f.m. output in Figure 1 shows that at 7½ in. the output could be in the vicinity of 5,000 c.f.m.

A check on c.f.m. output at lower pressures or water gauge readings was not possible with the airflow meter available. This records a maximum airflow of 27 ft. per minute which, though high enough to record airflow at 7 in. total water gauge is far too low to record the higher airflows which result when the machine is operating at lower pressure and hence higher c.f.m. output.

(3) *Load Capacity.*

In trial No. 3 wet fermented beans were loaded onto an 18 ft. x 12 ft. floor to a depth of 19 in. which, with the fan blanking door fully opened and no restriction of airflow, resulted in a total water gauge reading of 6¼ in. Obviously, therefore, a 19 in. depth of beans was not the maximum load which the machine could handle, as the rated maximum of 7 in. total water gauge was not reached. Subsequently in trial no. 5 wet fermented beans were loaded onto the floor to a depth of 24 in. (final dry weight of beans 11,109 lb.) and a total water gauge reading of 6½ in. was registered—see Figure 4. It would appear, therefore, that the floor could be loaded to an even greater depth although once again the accuracy of the water gauge comes into question. Suffice it to say that the machine is capable of drying the equivalent of 5 tons of dry beans loaded onto an 18ft. x 12 ft. floor, to a depth of 24 in. Whether this is the maximum physical capacity of the unit or whether it could take a slightly greater load is not, however, relevant because the initial drying rate is too slow to prevent beans from "going off" before they become surface dry. A graph illustrating the relationship between depth of beans and time for beans to become surface dry is shown in Figure 2. In trial no. 3, drying continued for 66 hours before the whole bean mass had become surface dry and before this stage was reached an unmistakeable "off" or "foul" odour had developed which would in all probability carry through to the final dried product. Again on trial no. 5 the whole bean mass did not become surface dry until somewhere between 75 and 91 hours after the commencement of drying and a "foul" odour had developed. The odour was quite obvious and one which experience has shown generally results in a foreign flavour in chocolate prepared from such beans. Presence of a foreign odour is also one of the grounds for rejection of cocoa beans as export standard cocoa and consequently must be avoided.

Therefore, the indications are that the load capacity for this unit is limited not by the maximum depth and volume of beans through which air can be forced (i.e., the physical capacity to dry) but by the maximum depth of beans which can be surface dried quickly enough to prevent the development of any foul or foreign odours, and therefore flavours, in the final product.

What then is the maximum load capacity of the unit when used to dry cocoa at depth on a small floor area ? An exact answer to this question is not possible because of the variation which occurs in the moisture content of fermented beans and the dependence of drying efficiency on relative humidity and ambient temperature. However, Figure 2 illustrates the relationship which has been established between load capacity and time to surface dry. From this it can be concluded that approximately three tons dry bean equivalent can be surface dried in approximately thirty hours. This is roughly the maximum time allowable if the development of foreign odours is to be avoided.

Furthermore, the graph of fuel consumption per ton of dry beans against load, illustrated in Figure 3, indicates that a three ton dry bean load results in a fuel consumption of approximately 60 gallons per ton for complete, continuous hot air drying.

From the foregoing remarks it is apparent that the load capacity of the Lister M.E.U. is limited by the low availability of heat from the engine and not by the quantity of air available, i.e., the performance of the fan. The argument is best illustrated by trial no. 5 in which it was shown that the fan was sufficiently powerful to push air through 24 in. of wet fermented beans (five tons dry bean equivalent) at an estimated 5,000 to 10,000 c.f.m. Taking floor area as 200 square feet, this amounts to an airflow of 25-50 feet per minute through the floor. Had this air been hotter there is no doubt that the beans could have been surface dried more quickly and therefore the load capacity increased. In fact one of the most essential requirements for any cocoa dryer is a heat reserve which enables beans to be safely surface dried within 24 hours or less if a daily intake of fermented beans is planned.

It is possible that the load capacity could be increased by improved design of the exhaust system so that more heat is made available. During the trials the final length of exhaust pipe was continually hot. Therefore improved design of the exhaust system could trap more of the heat from the exhaust gases.

Alternatively, load capacity could be increased by the incorporation of an oil burner and combustion chamber in the fish tail duct section between the fan and the dryer floor. This could be used in the initial phase of drying to provide more heat and therefore faster drying.

Another alternative which suggests itself is the utilization of a shorter fermentation period before drying commences. Although no definite information is available, it is possible that this would offset the expected occurrence of continued fermentation in the early stages of drying a deep mass of beans and thus counteract the development of foul and foreign odours. If this were achieved, load capacity could be safely increased.

Finally, on the basis of arguments put forward from the results in Table II, it may be possible to increase load capacity by using a large floor area with beans at a shallower depth. With this arrangement a given volume of beans may become surface dry in a shorter time than they would on a small area at a greater depth. It is intended that further trials will be conducted to investigate the validity of this argument.

(4) *Handling and Turning the Beans.*

When dried at the depths which were used in these trials, cocoa beans stick together and set in a fairly solid mass. The technique for handling this mass is to leave it undisturbed until surface drying has been completed through to the top layers. At this stage the mass is set, but the adhesion of one bean to the next is not strong and the whole mass can be broken up with paddles and by hand. Once this has been done beans will remain free for the rest of the drying period and if necessary can be easily turned and mixed with shovels to get more even drying.

(5) *Rate of Drying.*

In trial no. 3 the fan blanking door was closed across the fan to give a 7 in. water gauge reading and the minimum possible air flow, on the assumption that air moving slowly through the bean mass would take up and remove a greater amount of water than air moving quickly through the beans. In trials 4 and 5 the opposite effect was tested and a higher airflow rate at correspondingly low temperatures was initially used. Beans became surface dry in 21 hours in trial no. 4 and 75-91 hours in trial no. 5, and results indicate that the rate of drying and the time which beans took to become surface dry were more a function of depth of beans than of temperature/volume effects. In trials 3, 4 and 5 the moisture content of beans at the stage when they became surface dry was 20.2 per cent., 38.3 per cent. and 13 per cent. respectively, which when compared against bean depths (19 in., 14 in. and 24 in.) indicates that this moisture content was also a function of bean depth. Therefore as depth of beans increases, so the drying rate decreases, the time taken for beans to become surface dry increases, and the moisture content of beans when they do become surface dry, decreases.

(6) *Variation in Airflow through the Floor.*

Airflow readings taken during the trials with a Casella airflow meter indicated that the rate of flow through the floor varied from spot to spot for any given load of wet fermented beans, and that the variation was greatest at the beginning of drying and least when drying was almost completed. By recording several series of readings on a grid pattern over the whole floor area, it was evident that this variation in rate of airflow was due primarily to variation in depth of beans on the floor. High flow rates were closely correlated with shallow areas and flow rates could be readily lowered by adding an extra one inch layer of beans over any given area. Obviously, therefore, care must be taken to ensure that the drying floor is loaded evenly.

(7) *Cutting Tests and Flavour Assessments.*

At the commencement of each drying trial a sample of wet fermented beans was taken from the bean mass and spread out on a wooden platform for sun-drying. At the completion of each trial a second sample was taken from the hot air dried beans. Subsequently, sun dried and hot air dried samples from each trial were forwarded to the laboratories of Cadbury Fry Pascall Pty. Ltd., in Claremont, Tasmania, where the raw beans were subjected to a cutting test. Flavour assessments on tasting samples were prepared by a panel of four experienced tasters. The results from these tests indicated that :—

(*a*) There was a general trend for beans dried by the Lister moisture extraction unit to have a slightly lower percentage of under fermented beans than those dried by sun. In seven of the ten trials (1, 2, 3, 4, 6, 7 and 10) beans dried by hot air had a lower percentage of under-fermented beans than those dried in the sun. In two trials (5 and 8) there was no difference and in one trial (9) sun dried beans were slightly better than hot air dried beans.

(*b*) No significant trends were obvious with regard to chocolate flavour score. The average figure for sun dried beans was 9.9 and for hot air dried beans 9.7. In a few of the trials, significant differences were apparent but these could not be related to duration of drying, depth of beans, rate of airflow or any other factor.

(*c*) No relationship could be established between sun and hot air dried beans on the occurrence and level of acid and bitter flavours. However, there was a general trend for hot air dried beans to be more astringent than sun dried beans. The incidence of raisin and caramel flavours was at the same level in both sun and hot air dried samples but licorice flavours were significantly higher in sun dried beans.

Hammy, smoky and earthy flavours were reported more frequently in sun dried samples, foreign and foetid flavours to the same extent in both, while harsh flavours were reported only in hot air dried samples.

## APPENDIX

### *The use of the Lister Moisture Extraction Unit with a tray/bin system for drying cocoa, as outlined by the manufacturers.*

The Lister Moisture Extraction Unit with its large air volume and low temperature rise is well suited to the drying of cocoa. Because of the low temperature, no damage due to over-drying occurs, and with the absence of any heat exchanger the machine may be safely left to run unattended overnight. The machine is mobile and can be used to dry other crops such as maize or rice when not required for cocoa.

Because of its versatility the unit can be adapted to suit almost any fermentary and the drying trays and bins can be constructed out of local materials and built with local labour.

The system of tray/bin drying is done in two stages. The first stage incorporates a shallow tray or trays where the cocoa is loaded to a maximum depth of 18 inches and skin dried.

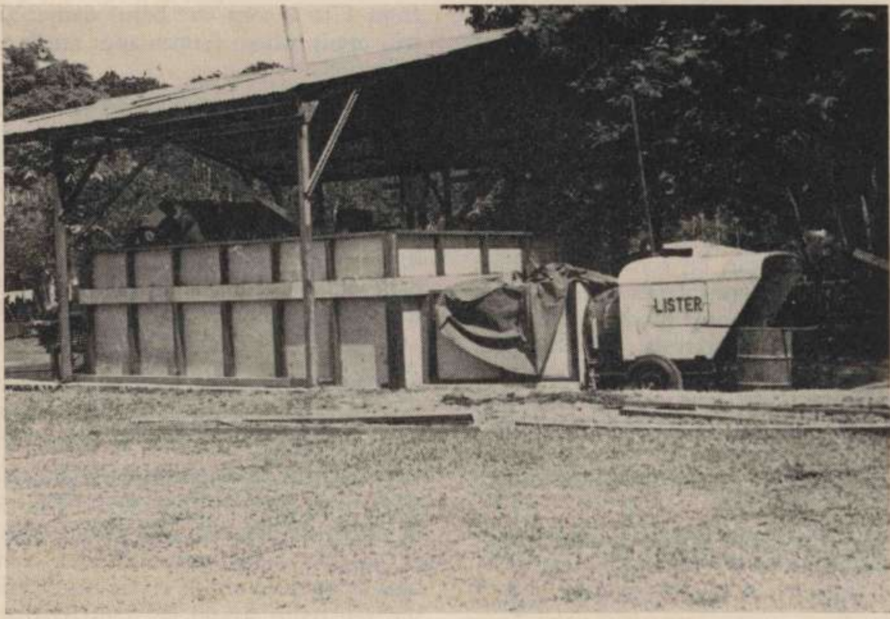


*Plate* I.—Lister Moisture Extraction Unit.

*Plate* II.—Spreading cocoa beans.

This is best done by adding layers of 3-6 inches at a time and after 12-24 hours the cocoa should have reached a stage when it will no longer stick together. In the second stage cocoa is transferred to a bin and bulked up to a depth of up to eight feet, where it will remain until dry; any beans that have tended to stick together during the skin drying stages will be separated during the transfer from tray to bin.

By varying the size and arrangement of the trays and bins units can be constructed which will be suitable for fermentaries with a daily output, or for those that only produce fermented beans at other regular intervals. Where cocoa is mainly harvested during the drier months, a system combining initial sun drying and final bulk drying can be evolved. This would cut down on the labour required for sun drying and also eliminate the need for large drying areas.

The operation of three simple systems is outlined below :—

1. *Two Units of one bin/two trays*—Capacity 4-16 tons wet beans/week. This sytem is designed to receive beans for four days a week at a rate of 4 tons of beans per day.

(*a*) Wet beans from the fermentary (about 50 per cent. moisture content) are loaded into trays (10 ft. x 9 in. x 4 in.), to a depth of up to 1 ft. This is best done by loading six inches, blowing for a short time using no baffles and full throttle, and then loading the remaining six inches.

(*b*) On the second day the air is cut off to each tray in turn, whilst the beans, which should now be past the stage when they will stick together, are transferred to the bins through the transfer doors. As soon as the floors of the bins are well covered blowing should commence. The trays are unloaded as above until the bins are full.

(*c*) Blowing through the bins will continue until the beans are dry and baffles may have to be fitted to the machine to obtain the necessary temperature rise in the final stages. The beans can be bagged off direct from the bins.

2. *Two Units of one tray/two bins*—Capacity from 1 to 8 tons wet beans daily. This system will apply where fermentaries are in continuous operation.

(*a*) Each tray 20 ft. x 10 ft. is loaded daily with up to 4 tons of wet beans to a depth of 1 ft. as described previously.

(*b*) The tray is sited adjacent to two bins and the output from the tray is transferred firstly to one bin, which when full is blown until it is dry, whilst the second bin is being filled. In this way continuous operation can be achieved.

The machine is capable of dealing with two such units (i.e., two trays and four bins) at a time, but obviously in the off peak season only one unit need be operated.

3. *Sun Drying and bulk bin drying*—Capacity from 1 to 16 tons per day. This installation is extremely flexible and would consist of six or possibly more ventilated bins alongside the sun-drying platforms. After skin drying in the sun the beans would be transferred to the bins filling each one in turn; using six bins and filling one each day should ensure that the first bin is dry before the last bin is filled.

In order to ensure that no deterioration of the cocoa takes place before leaving the plantation, cocoa could be stored in these bins and ventilated as the occasion demands. Sacking off would only take place immediately before the crop was despatched.

***Summary.***

Results from a series of ten drying trials with the Lister Moisture Extraction Unit indicate that it has the capacity to dry safely 14,500 lb. of wet fermented beans on an 18 ft. x 12 ft. floor at a depth of 15 in. to give three tons of good quality dry cocoa beans. This load can be handled by continuously drying for four full days at a cost of approximately 60 gallons of fuel and five pints of oil per ton of dry beans.

(Received November, 1963.)

# Bovine Vibriosis in Papua and New Guinea.

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### *Introduction.*

As long ago as 1913, McFadyean and Stockman reported the isolation of a spirillum from cases of abortion in sheep and cattle in England. In 1919, American workers Smith and Taylor named a similar organism *Vibrio fetus*. *Vibrio fetus* has since been shown to be a cause of abortion and infertility in cattle and sheep in many parts of the world (Lawson 1959).

Recent investigations of an infertility problem on properties near Port Moresby have established the presence of vibriosis in Papua and New Guinea.

### *Materials and Methods.*

#### *Serological Investigations.*

Vaginal mucus agglutination (V.M.A.) tests were carried out by a modification of the agar extraction method described by Laing (1956). Sterile glass pipettes were used for mucus collection. Antigen used in V.M.A. tests was supplied by the Division of Animal Health, C.S.I.R.O. A high titre donkey serum was used as a positive control.

#### *Bacteriological Investigations.*

Mucus samples obtained for V.M.A. tests were also cultured for the presence of *Vibrio fetus*. One ml. of mucus was spread as evenly as possible over the surface of tryptose blood agar plates and incubated in 10 per cent. $CO_2$ for three to six days.

Material from an aborted five and a half month foetus from a property where positive V.M.A. tests had been recorded, was inoculated onto tryptose blood agar plates. Blood peptone broth used in sub-cultures was prepared as described by Laing (1956). Catalase and $H_2S$ production tests used were those described by Laing (1956).

### *Results.*

Results of V.M.A. tests are presented in the following table :

| Date. | Herd. | No. tested. | Positive. | Suspicious. |
|---|---|---|---|---|
| 28.6.62 | A | 19 | 3 | 4 |
| 13.7.62 | B | 25 | 6 | 2 |
| 19.7.62 | C | 34 | 1 | 4 |
| 16.9.62 | D | 9 | .... | 1 |

[Positive reactions are those with more than 75 per cent. clearing in the second tube (1/20 dilution). Suspicious reactors are those with 75 per cent. clearing in the first tube (1/10 dilution).]

Herds A and B had definite serological evidence of infection. In addition, *Vibrio fetus* was isolated from vaginal mucus and an aborted foetus in herd A. The serological evidence for vibriosis in herd C was equivocal, but certainly suspicious, since there was a history of the movement of breeding animals between herds B and C. The nine samples from herd D were from a low percentage of breeders on the property and the evidence was inconclusive.

Of 87 mucus samples cultured, only one yielded an organism considered to be *Vibrio fetus*. Mucus from one animal in herd A yielded an almost pure culture of gram negative spirillar organisms. Sufficient growth was obtained on sub-culture to semi-solid thiol medium to carry out a catalase test, which was positive. The remainder of mucus samples cultured failed to yield *Vibrio fetus*. Contamination by *Bacillus, Proteus* and *Streptococcus* was common.

Culture of the liver, abomasum contents, and placenta from the foetus aborted in herd A, yielded a good growth of a gram negative, spirillar and rapidly motile organism. The growth from the abomasum was virtually pure; that from the other two sites was contaminated with *Streptococcus* and *Bacillus sp.* Initial growth was sub-cultured to blood agar plates in the case of the contaminated growths and to blood peptone broth from the pure culture.

*Vibrio fetus* was not cultured from the brain, lungs or peritoneal fluid of the foetus.

Biochemical tests showed that the *Vibrio* isolated was an active producer of catalase but did not produce $H_2S$. Newsam (1963), who examined a culture of the *Vibrio fetus* isolated from the aborted foetus, advised that it behaved exactly as the standard strain of *Vibrio fetus* (*venerealis*).

### *Discussion.*

The most usual manifestation of vibriosis in a herd is the repeated return to service of recently infected animals. Intervals between heat periods tend to become irregular and four or five services over a period of as many months is not uncommon. Eventually the infected animal will conceive and bear a normal calf. Abortion is not a common result of vibriosis infection in cattle, although resorption of implanted fertilized ova may occur.

Of the three major diseases of cattle known to cause abortion and/or infertility, namely brucellosis, vibriosis and trichomoniasis, the first two have now both been positively identified in Papua and New Guinea. Brucellosis has virtually been eradicated from herds throughout the Territory by the application of a test and slaughter scheme (Egerton and Rothwell, 1963).

Vibriosis is primarily a venereal disease, and its control is best based on interrupting the cycle of infection which occurs when a bull serves an infected cow, becomes infected, and transmits the disease to non-infected females. The best means of interrupting this cycle is to use a mating system based on artificial insemination. If a supply of *Vibrio fetus* free semen can be ensured, vibriosis ceases to be a problem. Infected females can either be removed from the herd or be inseminated artificially. Conception will occur eventually in the majority of cases. Infected females do not constitute a danger to non-infected females if there is no bull in the herd.

Treatment with antibiotics has been claimed to be effective in curing vibriosis in both males and females. The evaluation of such treatment is made difficult by the inadequacy of cultural examination in proving the efficiency of such treatment. To prove that a bull has been cured, it is necessary to test-mate him with a group of virgin heifers and to show that vibriosis is not transmitted to these animals.

It is the intention of the department to initiate artificial insemination in herd A. The identification of vibriosis in the herd accentuates the necessity for the commencement of this project.

### *Summary.*

Vibriosis has been diagnosed in cattle in Papua and New Guinea. Clinical, serological and cultural evidence has been presented to support this diagnosis.

(Received December, 1963.)

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# *Economic Chrysomelid Beetles from New Guinea, with New Species.*

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*THE following notes and descriptions concern species of the beetle family Chrysomelidae found associated with economic plants in the Territory of Papua and New Guinea. Most of the specimens were collected by Dr. J. J. H. Szent-Ivany and some by J. H. Ardley, Mrs. E. Anderson, J. H. Barrett, W. W. Brandt, W. E. Casey, A. Catley, B. G. Griffith, D. E. Hardy, F. Kingsford-Smith, T. C. Maa, C. D. Michener, J. Pendergast, J. Sedlacek and J. Sedlacek, Junior. In this paper* 23 *species are recorded, of which seven are described as new species. One new genus is described. I am indebted to Dr. Szent-Ivany for the privilege of studying the bulk of this material. I am grateful to Mrs. Maria Szent-Ivany for her painstaking preparation of the principal illustrations and to Miss Carol Nakashige for the drawings of the aedeagi.*

*Bishop Museum field workers have been assembling a large representation of this family of beetles from New Guinea. As the study of the assembled material will occupy a few years, these species of economic importance are herewith recorded in advance, to make their names available to economic entomologists and agriculturists. Only the subfamily Hispinae has so far been reported upon in our studies (Gressitt,* 1957, 1958, 1959, 1960, 1963), *and of these* 161 *species have been recorded from New Guinea proper, and about* 10 *additional from the Bismarck Archipelago and Bougainville Island. The total collections assembled in this family probably number in the neighbourhood of* 2,000 *species for New Guinea including the Bismarck Archipelago and Bougainville.*

## SUBFAMILY *EUMOLPINAE.*

### *Rhyparida arachi* Gressitt, n. sp. Fig. 1.

*Female* : Reddish brown to pitchy black, in part paler ; head reddish brown, slightly paler on labrum ; palpi quite pale but darker on apical segment of each pair ; antenna yellowish testaceous basally, gradually becoming brownish towards apex ; pronotum pitchy black, tinged with reddish on anterior margin and near base ; scutellum reddish brown ; elytron dark reddish brown with a slightly pitchy tinge ; ventral surfaces reddish brown, paler reddish on pro- and mesosterna, somewhat dull testaceous toward apex of abdomen ; legs reddish brown, darker on apices of femora and tibiae and paler on apices of tarsi. Dorsum largely glabrous ; moderate fine pale hairs on antenna and parts of ventral surfaces ; only a few scattered hairs on head.

*Head* considerably narrower than prothorax, moderately deep ; occiput broad and swollen, sparsely but distinctly punctured and micropunctulate, with a fairly deep oblique groove from edge of vertex extending in a straight line above, and close to, upper border of eye ; frontoclypeus continuous with vertex and occiput and similarly punctured, anterior margin strongly concave in middle and produced forward on each side of middle ; labrum fairly large and flattish, finely punctured and slightly emarginate apically ; gena feebly punctured, one-quarter as deep as eye. *Antenna* slender, two-thirds as long as body ; segment 1 elliptical, thickest near middle ; 2 similar in shape to 1, about four-fifths as long and less stout ; 3 quite slender, slightly thickened preapically, slightly longer than 1 ; 4 slightly thicker apically than 3 and very slightly shorter ; 5 slightly shorter and stouter ; 6 stouter, as long as 5 ;

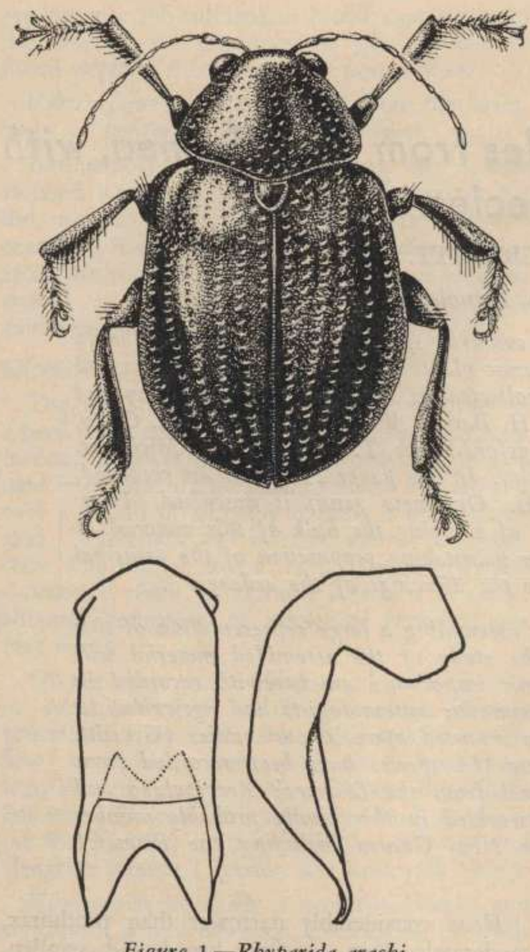

*Figure* 1.—*Rhyparida arachi.*

6-10 similar, becoming slightly stouter and more parallel-sided ; 11 longest. *Prothorax* just over three-fifths as long as broad, rounded anteriorly, narrowed at side which is rounded and strongly convex with widest portion fairly close to base ; basal margin weakly obtuse, rounded at middle ; disc evenly convex, fairly smooth, with regularly fine punctures, slightly closer at side and sparser in centre, mostly separated by two to four times their diameters, sparsest near anterior margin. *Scutellum* triangular, slightly broader than long and somewhat rounded apically ; feebly punctured. *Elytron* twice as long as broad, subevenly rounded at side, widest somewhat anterior to middle ; lateral margin slightly expanded to behind middle and gradually narrowed to apex ; disc with 10 distinct rows of punctures at middle, inner 4 rows quite fine with punctures separated by two to three times their diameters, and outer rows with stronger punctures, in part as large as interspaces in anterior one-half, all puncture-rows with finer punctures posteriorly. *Ventral surfaces* in large part rather finely frosted with vague punctures on abdomen, becoming more distinct on last sternite. *Legs* moderately stout ; femora somewhat strongly swollen in middle ; hind tibia fairly straight, deeply emarginate on outer side just before apex ; hind tarsal segment 1 slightly longer than 2 or 3, claw segment distinctly longer than 1. Length 3 mm ; breadth 2.1 mm.

Holotype ♀ (BISHOP 3585), Wewak, 25.6.1959, Gressitt ; paratype, same data, on palm ; 16 paratypes, New Settlement, nr. Wewak, Sepik Distr., N.E. New Guinea, in large masses on peanut (*Arachis*), causing shot-hole damage, 11.10.1957, J. J. H. Szent-Ivany, (H/415) ; paratype ♂ (D.A.S.F., Port Moresby), Wewak, damaging kapok (*Ceiba*) leaves, 12.10.1957, Szent-Ivany (H/416); paratype ♂ (A.N.I.C., C.S.I.R.O., Canberra), Tanbada Settlement, nr. Vareodoso Vill., Wewak, on peanut, 11.10.1957, Szent-Ivany (H/1062).

Differs from most species of *Rhyparida* in having supraocular groove rather strong and occiput more strongly raised. Similar to *Rhyparida atra* Jacoby but prothorax with a different outline.

*Rhyparida atra* Jacoby, 1894, Novit. Zool. 1 : 281 (N.W. New Guinea).

N.E. NEW GUINEA : New Settlement, nr. Wewak, causing shot-hole damage on peanuts, 11.10.1957, Szent-Ivany (H/424).

*Rhyparida basalis* Baly, 1867, Trans. Ent. Soc. Lond. ser. 3, 4 (2) : 168 (N.W. New Guinea).

N.E. NEW GUINEA : Maprik, on cacao, 1953, J. Ardley (H/342).

### *Rhyparida casuarinae* Gressitt, n. sp. Fig. 2.

*Female* : Shiny black to reddish ochraceous : head black to pitchy black with a reddish ochraceous spot on each side of occiput ; labrum reddish brown ; mandible pitchy reddish ; antenna reddish brown, testaceous on basal 5 segments ; pronotum shiny black, becoming reddish pitchy at anterior margin ; scutellum pitchy black ; elytron black with a large reddish ochraceous humeral spot reaching to end of basal third,

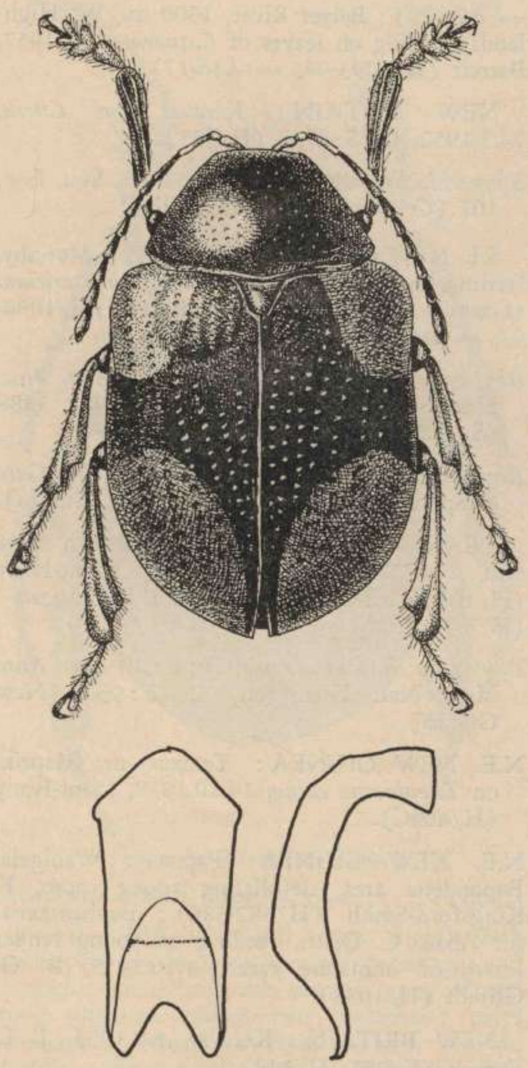

*Figure 2.—Rhyparida casuarinae.*

and a large preapical spot occupying most of discal portion of posterior half, leaving suture and external margin dark; vental surfaces lagely blackish, becoming somewhat reddish pitchy at side of abdomen; legs pitchy black, somewhat reddish on coxae, trochanters and apical portions of tarsi.

*Head* five-sixths as broad as prothorax, vertical in front, rather coarsely punctured, more densely punctured at side of postocciput; a moderately deep groove above eye, reaching to edge of frontoclypeus; frontoclypeus deeply emarginate anteriorly; labrum broader than long, weakly emarginate at middle of apex; gena about one quarter as deep as eye. *Antenna* two-thirds as long as body; segment 1 elliptical, widest in middle; 2 more slender, widest beyond middle and four-fifths as long as 1; 3 much more slender, slightly longer than 2; 4 slender, barely longer than 3; 5 slightly stouter preapically, slightly shorter than 4; 6 as long as 5, distinctly thickened towards apex; 7 slightly stouter than 6; 8-10 similar to 7; 11 slightly longer than 10, widest just beyond middle. *Prothorax* not quite two-thirds as long as broad, convex on anterior margin, weakly convex on basal margin; side widest well behind middle and strongly bowed, nearly obtuse; disc strongly convex anteriorly, depressed at side toward anterior angle, with numerous moderately fine distinct punctures. *Scutellum* subtrapeziform, slightly convex apically and feebly punctured basally. *Elytron* two-fifths as broad as long, subevenly rounded at side from humerus to sutural angle, somewhat deeply grooved parallel to lateral margin; epipleuron moderately broad to within one-sixth length of apex and then more strongly narrowed and disappearing somewhat before sutural angle; disc strongly convex, with a post-basal swelling followed by a distinct depression; surface with 11 puncture-rows at middle, 2 of these starting well behind humerus, an additional basal row reaching to slightly more than one-quarter length from base; punctures varying in size, largest near humerus and in post-basal depression, becoming fairly fine on posterior half and those of inner rows fairly fine on basal portion. *Ventral sufaces* finely frosted on metepisternum, subtransversely ridged on metasternum, and weakly punctured on much of abdomen. *Legs* fairly stout and not very long; femora moderately swollen at middle; hind tibia moderately straight, deeply emarginate preapically; hind tarsal segment 1 nearly as long as 2 + 3 and only slightly shorter than last. Length 2.9 mm.; breadth 1.6 mm.

*Male*: Antennae slightly paler, nearly three-quarters as long as body; pronotum reddish pitchy in central portion and reddish on anterior one-third; elytron with dark areas pitchy reddish; ventral surfaces somewhat reddish on metasternum and dull ochraceous on last abdominal sternite; legs largely pitchy reddish.

Length 2.75 mm.; breadth 1.5 mm.

*Paratypes* : Length 2.2-3.0 mm.; breadth 1.0-1.9 mm.

Holotype ♀ (BISHOP 3586), Moife, 2100 m, 15 km. N.W. of Okapa, E. Highlands, N.E. New Guinea, 7-14.10.1959, T. C. Maa ; allotype ♂ (BISHOP), S.E. of Korn Farm, 1600 m, Mt. Hagen area, W. Highlands, on *Pipturus,* 15.10.1958, Gressitt. Paratypes : N.E. New Guinea : 2 ♀ ♀, Aiyura, 1500 m, E. Highlands, feeding on *Casuarina equisetifolia,* 19.6.1958, J. H. Barrett (H/2051, 2052, = A108, A110) ; 6, same data as holotype ; Minj, 1700 m, W. Highlands, 3.7.1957, D. E. Hardy ; Minj, sweeping, 8-13.9.1959, Maa ; 1, Korn Farm, 15.10.1958, Gressitt ; 1, Ahl Valley, 1750 m, nr. Nondugl, 8.7.1955, Gressitt ; 1, Goiburung, E. of Korn Farm, on *Pipturus,* 16.10.1958, Gressitt ; Aiyurop-Rumpi, and Rumpi, nr. Mendi, S. Highlands, on *Pipturus* and *Melastoma,* 14.10.1958, Gressitt ; 2, Wum, 540 m, Upper Jimi Valley, 15.7.1955, Gressitt ; 1, Mobitei, 750 m, Torricelli Mts., 16-31.3.1959, W. W. Brandt ; 1, Siaute, nr. sea level, nr. Torricelli Mts., 9-17.11.1958, Brandt ; 1, Funyende, 1200 m, nr. SSaidor, Finisterre Range, 24.9.1958, Brandt ; 1, Wewak, 2-20 m, on *Pipturus,* 13.10.1957, Gressitt. N.W. New Guinea : Many, Waris, 450-550 m, sweeping, 1-17.8.1959, Maa. Paratypes in BISHOP, D.A.S.F., C.A.S., U.S.N.M., B.M.N.H., A.N.I.C., BOGOR.

Differs from *moesta* Baly in being smaller, not metallic, with elytron narrower and bearing two large pale areas, and occiput not subrugose. Differs from *quadripustulata* Jacoby in being larger, more contrastingly coloured, with large anterior and posterior pale spots on elytron, smaller elytral spots and prothorax much longer in proportion to breadth.

*Rhyparida coriacea* Jacoby, 1895, Stett. Ent. Ztg. 56 : 57 (New Guinea).

N.E. NEW GUINEA : Wau, 1050 m, causing serious defoliation to *Eucalyptus deglupta,* 26.4.1958, J. J. H. Szent-Ivany (H/404E, G) ; Tanbada, nr. Wewak, on young coconut palms, 12.10.1957, Szent-Ivany (H/4091) ; Kumbunga, nr. Maprik, damaging leaves of *Coffea arabica,* 7.3.1958, Szent-Ivany (H/408) ; Goroka, 1600 m., E. Highlands, in leaf-axils and husks of maize, 11.11.1957, J. H. Barrett (H 2007-2010, = A30-33) ; same data but on leaves of *Citrus,* 12.10., Barrett (H/2003-6 = A26-29) ; Baiyer River, 1300 m., W. Highlands, feeding on leaves of *Casuarina,* 1.8.1957, Barrett (H/1093-94, = A16-17).

NEW BRITAIN : Keravat, on *Citrus,* 24.3.1952, G. S. Dun (H/355).

*Rhyparida didyma* (Fabricius), 1775, Syst, Ent., 107 (*Cryptocephalus* ; Australia).

S.E. NEW GUINEA (Papua) : Port Moresby, feeding on seed heads of *Dichanthium sericium* (Gramineae), 3.2.1956, J. H. Barrett (H/1096-97, = A19-20).

*Rhyparida discopunctata* Blackburn, 1889, Proc. Linn. Soc. N.S. Wales ser. 2, 3 : 1485, 1488 (S. Australia) (H/1003).

*Rhyparida fasciata* Baly, 1864, Descr. N. Gen. & Spec. Phytoph., 10 (N.W. New Guinea).

S.E. NEW GUINEA (Papua) : Brown River area, on cowpea, 4.3.1959, Szent-Ivany (H/1043). Also " New Guinea, J. L. Froggatt " (H/340, KER).

*Rhyparida impressipennis* Bryant, 1949, Ann. Mag. Nat. Hist. ser. 12, 2 : 937 (New Guinea).

N.E. NEW GUINEA : Tamaui, nr. Maprik, on *Theobroma cacao,* 14.10.1958, Szent-Ivany (H/404C).

N.E. NEW GUINEA (Papua) : Wanigela, Popondetta area, defoliating young cacao, F. Kingsford-Smith (H/382-386) ; Baubauguina, nr. Abau, C. Distr., feeding on young tender leaves of immature cacao, 1.10.1955, B. G. Griffith (H/1038).

NEW BRITAIN : Kerevat, 1.8.1954, J. L. Frogatt (C/893, H/348).

*Rhyparida morosa* Jacoby, 1884, Ann. Mus. Civ. Genova 20 : 202 (New Guinea).

S.E. NEW GUINEA (Papua) : Port Moresby, feeding on seeding heads of *Dichanthium sericium* (Gramineae), 3.2.1956, Barrett (H/1098-2002, = A21-25).

*Rhyparida novaeguinensis* Bryant, 1949, Ann. Mag. Nat. Hist. ser. 12, 2 : 933 (New Guinea).

NEW BRITAIN : Rabaul, on foliage of *Ixora* sp., 11.9.1934, J. L. Froggatt (C/929, H/350).

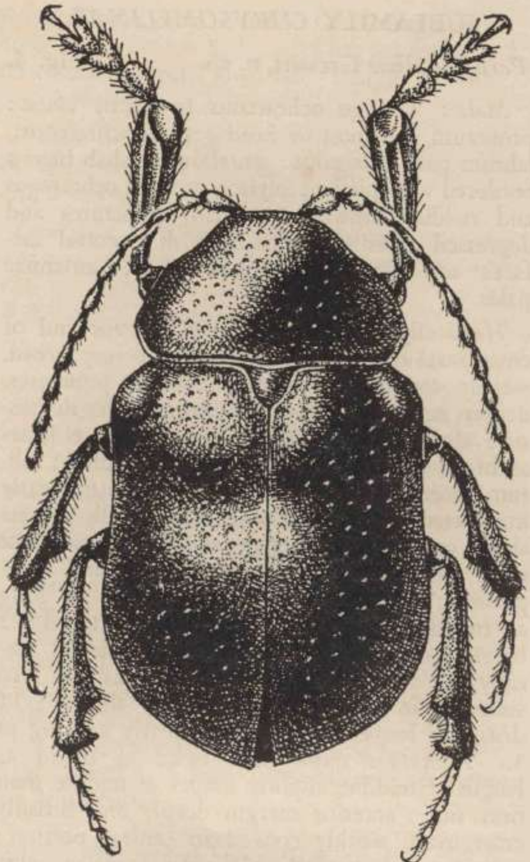

*Figure 3.—Cleoporus hibisci.*

***Cleoporus hibisci*** **Gressitt, n. s.** **Fig. 3.**

*Female* : Bright reddish brown, slightly dark reddish on pronotum except anterior margin and somewhat more brownish towards apex of elytron ; antennae entirely pale testaceous ; palpi testaceous ; ventral surfaces reddish brown, slightly paler towards apex of abdomen ; legs pale reddish brown, slightly darker just before apices of femora and slightly darkened on tibial carinae ; tarsi paler, testaceous preapically and slightly reddish on claws. Body glabrous above, with a few pale hairs on sides of head and around mouthparts ; antennae thinly clothed with fine suberect hairs ; ventral surfaces rather thinly clothed with suberect pale hairs ; legs feebly clothed on femora, with more pale hairs on tibiae and tarsi.

*Head* distinctly narrower than prothorax, strongly swollen above ; occiput slightly uneven, slightly depressed at centre, moderately punctured ; a deep oblique groove from edge of frontoclypeus extending above and behind eye ; frontoclypeus subparallel—sided, more strongly punctured than occiput, strongly emarginate at middle of apex ; labrum fairly large, smooth in centre, emarginate apically ; gena about one-third as deep as eye. *Antennae* slender, three-quarters as long as body ; segment 1 slightly arched, convex anteriorly, thickest near middle ; 2 slightly shorter and narrower than 1 ; 3 longer than 1, quite slender ; 4 and 5 decreasing in length and quite slender ; 6 as long as 5 but slightly stouter ; 6-10 subequal in length, becoming slightly stouter ; 11 slightly longer than 3. *Prothorax* two-thirds as long as broad, convex anteriorly, narrowed towards side ; lateral margin convex, oblique anteriorly and rounded obtuse well behind middle and narrowed posteriorly ; basal margin slightly obtuse, rounded at middle ; disc subevenly convex, fairly smooth, with numerous moderately fine but distinct punctures, mostly separated by two to three times their diameters, becoming sparser near anterior and basal margins and slightly denser near side ; a fairly distinct groove parallel to lateral and basal margins. *Scutellum* slightly longer than broad, rounded posteriorly and fairly smooth. *Elytron* somewhat more than twice as long as broad, subevenly convex at side, slightly widened to just anterior to middle and evenly convex to sutural angle ; lateral margin slightly flattened throughout, narrowing near sutural angle ; disc strongly convex, distinctly depressed behind mid-basal swelling ; 10 fairly regular rows of punctures at middle, inner rows with punctures a little finer, mostly just a little smaller than interspaces, and some punctures towards side slightly larger than interspaces, punctures larger in postbasal depression and smaller towards apex. *Ventral surfaces* in part frosted at sides, slightly wrinkled on metasternum, frosted to moderately punctured on abdomen. *Legs* not very stout ; femora moderately thickened and constricted preapically ; mid and hind tibiae moderately straight, deeply emarginate before apices ; hind tarsus with segment 1 slightly longer than 2 or 3, distinctly shorter than last. Length 3 mm.; breadth 1.55 mm.

Holotype ♀ (BISHOP 3587), Kerema Government Station, on *Hibiscus manihot*, 5.5.1959 (H/2041); paratype (D.A.S.F., Port Moresby), same data.

This species does not fit very well in *Cleoporus,* as the pro-epimeron does not project forward (not convex in anterior outline). It differs from *C. timorensis* otherwise in having anterior femur very weakly toothed, prothoracic angle located near base, and dorsal punctures finer and sparser. Some of the species which have been described from New Guinea as belonging to *Cleoporus* do not belong to this genus.

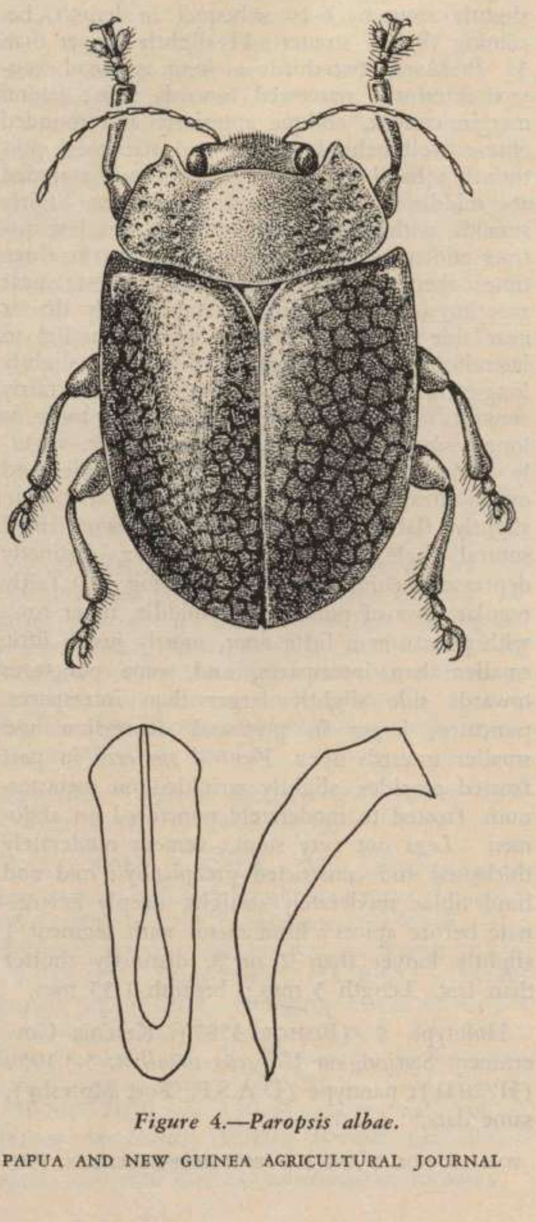

*Figure 4.—Paropsis albae.*

## SUBFAMILY *CHRYSOMELINAE.*

***Paropsis albae*** **Gressitt, n. sp. Fig. 4.**

*Male* : Orange ochraceous to pitchy black : pronotum and most of head orange ochraceous ; labrum pale testaceous ; scutellum reddish brown bordered with pitchy ; elytron mottled ochraceous and reddish brown with many punctures and depressed areas pitchy to blackish ; ventral surfaces and legs orange ochraceous ; antennae paler.

*Head* slightly narrower than anterior end of emargination of pronotum ; occiput very broad, weakly convex and with numerous punctures, denser near side ; vertex with a slight depression at centre ; frontoclypeus fully three times as broad as long, rather closely punctured ; labrum more than twice as broad as long, nearly impunctate, weakly emarginate apically ; gena about one-fifth as deep as eye. *Antennae* not quite half as long as body, slender and compressed ; segment 1 more than twice as long as broad, flattened and slightly punctured ; 2 barely half as long as 1, slightly widened apically ; 3 about two-thirds as long as 1 ; 3-10 subequal in length, but 4 slightly shorter ; 11 distinctly longer than 10 and nearly as long as 1. *Pronotum* more than twice as broad as length at middle, slightly longer at middle than near side ; anterior margin deeply and broadly emarginate, weakly convex in central portion ; anterior angle projecting slightly forward ; side strongly convex but less weakly so in middle ; disc subevenly convex, with scattered moderate and fine punctures on central portion and subrugose with fairly coarse punctures near side, but smoother near basal portion of side. *Scutellum* subtriangular, slightly convex at side, longer than broad. *Elytron* five-eighths again as long as broad, moderately rounded externally but fairly straight between humerus and slightly before middle ; disc subevenly convex with about 11 very irregular zigzag rows of punctures with irregular connections, leaving small flat areas which are pale and bare and a few weak punctures, these areas becoming more convex posteriorly and a few of them at side in basal two-fifths fairly large and weakly convex. *Ventral surfaces* largely impunctate, with a few wrinkles and sparse punctures and with a slightly arched roughened depression on metepisternum and a roughening on each side of base of abdominal segment 1. *Legs* moderately stout and sparsely punctured ; hind tarsal segment 1 shorter than 2 plus 3, 3 somewhat longer than 2 and distincly shorter than last. Length 8.7 mm.; breadth 6.6 mm.

*Female* : Antennae two-fifths as long as body ; last abdominal sternite rather flat and smooth. Length 8.4 mm.; breadth 6.8 mm.

*Paratypes* : Elytral pale patches sometimes paler and sometimes duller or disappearing, with most of surface reddish ochraceous. Length 7.8-8.3 mm.; breadth 5.5-6.6 mm.

Holotype ♂ (BISHOP 3588), Port Moresby, Papua, 25.4.1959, C. D. Michener ; allotopotype ♀ (BISHOP), on *Eucalyptus alba,* 27.4.1954, J. J. H. Szent-Ivany : 8 paratypes (D.A.S.F., A.N.I.C. U.S.N.M., B.M.N.H., BISHOP) : 2, same data as holotype, 5, same data as allotype ; 1, Lawes Road Hill, on *Eucalyptus papuana,* Szent-Ivany (H/1019-1023, 1026-1028).

Differs from *P. omphale* Blackburn in being smaller, more reddish (with less pattern) on pronotum, darker and more vaguely mottled on elytron, and particularly blacker at side, but with some larger pale areas anteriorly at side. Also, pronotal punctures are much more dense in centre, more numerous, stronger and less merged on side ; elytron is smoother, with distinct punctures throughout.

### *Paropsis andersonae* Gressitt, n. sp. Fig. 5.

*Female* : Reddish ochraceous, somewhat orange on elytron ; more reddish beneath and on legs ; antenna pitchy reddish distally. Body glabrous above ; very sparsely and briefly clothed beneath and on legs

*Head* distinctly narrower than anterior end of emargination of pronotum ; occiput very broad and somewhat densely punctured ; vertex finely grooved medially ; frontoclypeus nearly three times as broad as long, fairly densely punctured ; labrum more than three times as broad as long, slightly emarginate apically ; gena about one-eighth as deep as eye. *Antennae* slender, nearly two-fifths as long as body ; segment 1 somewhat compressed and slightly arched, sparsely punctured ; 2 about one-third as long as 1, slightly broadened apically ; 3 nearly twice as long as 2, distinctly broadened apically ; 4 slightly longer than 3 ; 4-10 subequal in length, all slightly compressed ; 11 distinctly longer than 10, nearly as long as 1. *Prothorax* twice

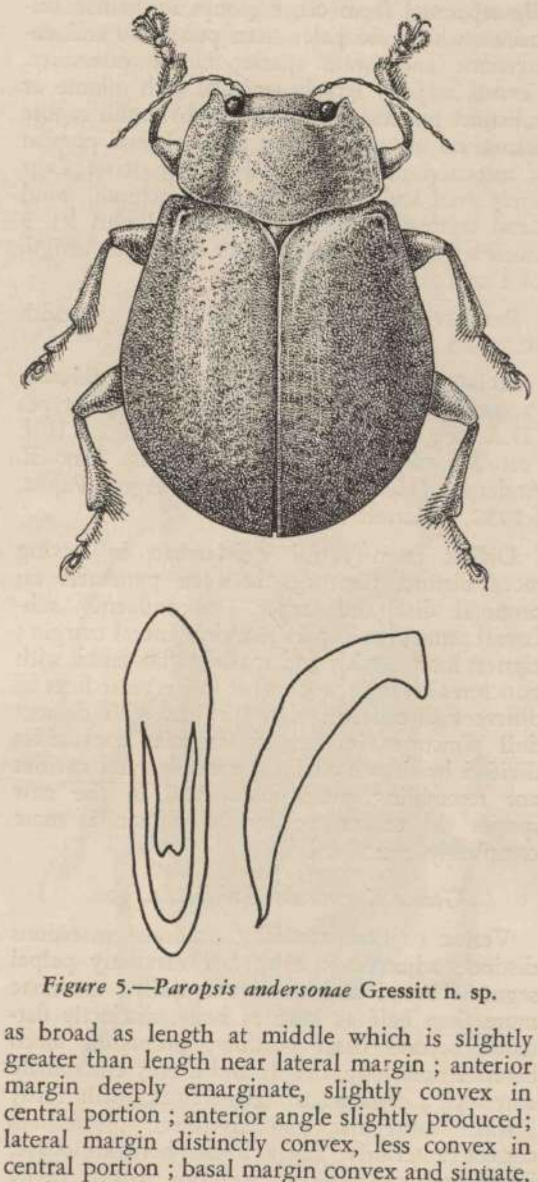

*Figure* 5.—*Paropsis andersonae* Gressitt n. sp.

as broad as length at middle which is slightly greater than length near lateral margin ; anterior margin deeply emarginate, slightly convex in central portion ; anterior angle slightly produced; lateral margin distinctly convex, less convex in central portion ; basal margin convex and sinuate, produced medially ; disc rather even on central portion with irregularly scattered punctures and minute punctules, slightly swollen and subrugose with larger punctures near side. *Scutellum* distinctly longer than broad, scutiform. *Elytron* not quite twice as long as broad, subevenly convex at side but humeral angle slightly projecting outward ; disc subevenly convex, with irregular groups of punctures over most of surface, the groups in part tending to be oblique and generally separated from other groups by flattish callosities which are paler than punctures and depressions and bears sparse minute punctures. *Ventral surfaces* largely smooth, with minute or indistinct punctures ; a broad groove with rugose bottom on metepisternum ; posterolateral portion of metasternum swollen and slightly striate. *Legs* fairly stout and short, distinctly punctured ; hind tarsal segment 1 nearly as long as 2 plus 3 ; 3 much larger than 2 and shorter than last. Length 14.2 mm.; breadth 10.7 mm.

*Paratypes* : Length 13-14 mm.; breadth 10.2-11.5 mm.

Holotype ♀ (BISHOP 3589), Port Moresby, Papua, 25.4.1959, C. D. Michener ; paratypes (D.A.S.F., A.N.I.C., BISHOP), Lawes Road Hill, Port Moresby, 20.11.1951, at lights, Mrs. E. Anderson (H/1036, 1037), and Mageri, Papua, 6.1952, J. Barrett (H/361).

Differs from *variolosa* Marshan in having more distinct punctules between punctures on pronotal disc and larger (subconfluent) sublateral punctures in part reaching lateral margin ; elytron more weakly and sparsely punctured, with punctures arranged somewhat in irregular lines in different directions ; elytral apices with distinct dull punctures instead of irregular convexities divided by depressed lines, wrinkles and cavities not resembling punctures. Also in the new species the central portion of elytron is more completely punctured.

### Genus *Kurumeld* Gressitt, n. gen.

Vertex concave medially, antennal insertions distinct, adjacent to eye ; last maxillary palpal segment broad and concave apically ; antennae more than half as long as body, distinctly flattened beyond basal portion ; pronotum much broader than long, deeply and evenly emarginate anteriorly ; elytron strongly convex, with fairly distinct subregular puncture-rows ; prosternum convex anteriorly, fairly broad between coxae, broadened posteriorly ; anterior coxal cavity slightly open posteriorly ; mesosternum broad, emarginate posteriorly ; metasternum produced somewhat forward between middle coxae, slightly produced over inner ends of hind coxae, obtusely emarginate at middle of posterior margin ; elytral epipleuron quite broad, continuing almost to sutural angle ; tarsal claws strongly bifid.

Type species : *Kurumela citri* Gressitt, n. sp., here designated.

Differs from *Phyllocharis* in having tarsal claws bifid instead of appendiculate, and from *Stethomela* in having prothorax moderately narrowed anteriorly, and parallel-sided in approximately basal two-fifths. Differs from *Augomela* in having pronotum much shorter in middle than at side and prosternum shallowly emarginate apically. The new generic name is constructed from "Kuru", an endemic disease centered at the type locality of the type species, plus "*mela*" of *Chrysomela,* said to mean sheep, presumably from the phytophagous habit.

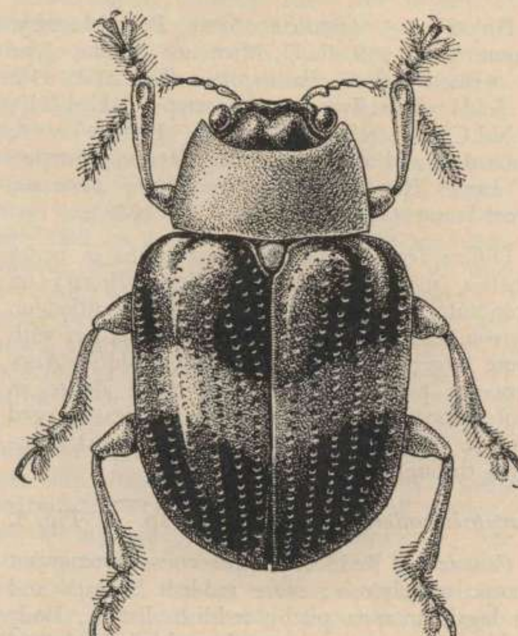

*Figure 6.—Kuromela citri* n. gen. n. sp.

### *Kurumela citri* Gressitt, n. sp. Fig. 6.

*Male* : Yellowish testaceous to bluish black : head largely greenish black with purplish reflections, slightly brownish on labrum and paler on borders of labrum and most of undersides ; antennae purplish black, partly testaceous basally; pronotum yellowish testaceous ; scutellum pitchy reddish ; elytron purplish to greenish black with central one-third yellowish testaceous ; ventral surfaces largely blackish, but mostly testaceous on prosternum, mesosternal process, part of median portion of metasternum and middle of central portion of abdominal segment 1 ; coxae largely pale ; legs largely blackish. Body glabrous above, moderately hairy on anterior portion of head, antennae, and last abdominal sternite; legs with very sparse short hairs except on tarsi and apical portions of tibiae; most of ventral surfaces with very sparse hairs, becoming more numerous towards posterior portion of abdomen.

*Head* short, concave medially on vertex, with an oblique groove extending towards antennal insertion from anterior end of median groove; frontoclypeus very short, transversely convex between anterior portions of antennal insertions; labrum fairly broad, slightly concave anteriorly; occiput impunctate posteriorly; anterior portion of head moderately punctured; gena very short; last maxillary palpal segment nearly as broad as long. *Antennae* just over half as long as body; segment 1 arched, smooth with a few punctures; 2 about three-fifths as long as 1, stouter apically; 3 nearly as long as 1, slightly widened apically; 4 as long as 3; 5 slightly longer; 5-8 similar, becoming slightly broader and flatter; 9 and 10 slightly shorter; 11 longest, quite flat. *Prothorax* just over twice as broad as long, slightly wider at side than at middle, deeply and evenly emarginate anteriorly; lateral margin weakly arcuate and narrowed anteriorly, fairly straight in basal three-fifths, basal margin moderately convex; disc subevenly convex, rather weakly and irregularly punctured. *Scutellum* slightly longer than broad, subevenly narrowed apically, impunctate. *Elytron* just over twice as long as broad, widest slightly behind humerus, slightly narrowed postmedially and broadly rounded apically; epipleuron wide and extending almost to sutural angle; disc strongly convex, with 10 subregular rows of fairly small punctures, besides sutural row; postbasal punctures partly as large as interspaces, smaller posteriorly. *Ventral surfaces* in large part sparsely or feebly punctured, more distinctly punctured on abdomen. *Legs* fairly stout; hind tarsal segment 1 somewhat shorter than 2 plus 3 and not quite as long as last. Length 6.75 mm.; breadth 4.3 mm.

*Female*: Antennae slightly shorter; anterior portion of head, legs and ventral surfaces largely pale. Length 6.7 mm.; breadth 4.5 mm.

*Paratype*: Elytron entirely purplish pitchy; legs largely pitchy black. Length 6.75 mm.;

Holotype ♂ (BISHOP 3590), Okapa, 1800 m., 64 km. S. of Kainantu, E. Highlands, N.E. New Guinea, 29.9.1959, T. C. Maa; allotype ♀ (A.N.I.C.), Goroka, E. Highlands, on *Citrus*, 12.10.1957, J. H. Barrett (H/2030 = A56); paratype ♂ (D.A.S.F.), same data as allotype.

Differs from species of *Phyllocharis* in being shorter, aside from the structural characters mentioned above.

## SUBFAMILY *GALERUCINAE*.

*Oides basalis rubra* Blanchard, 1853, Voy. Pole Sud, Zool. 4:342 (New Guinea).

N.E. NEW GUINEA: Aiyura, 1800 m., E. Highlands, on leaves of *Vitis* sp., 21.9.1957 Barrett.

S.E. NEW GUINEA (Papua): Bamu River, 1952, G. Rio (H/360, KER).

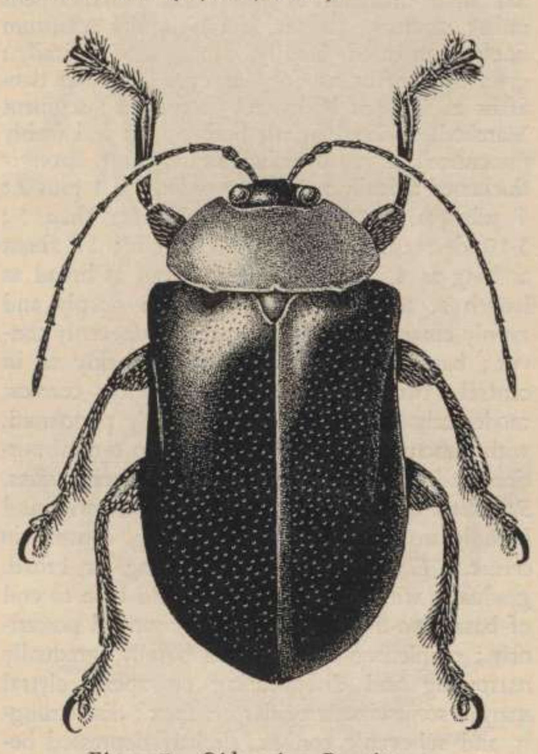

*Figure 7.—Oides vitae* Gressitt n. sp.

***Oides vitae* Gressitt, n. sp., Fig. 7.**

Orange testaceous to pitchy and black. Head black above, slightly pitchy reddish on frontoclypeus and labrum; antennae pitchy black, reddish brown on undersides of segments 1-2 and base of 3. Pronotum orange testaceous, slightly more reddish at side; scutellum dull reddish; elytron dark reddish, becoming somewhat pitchy at side; ventral surfaces pitchy to reddish, paler on mesosternum, almost entirely reddish brown on abdomen; legs pitchy black; coxae pitchy to pale brown ; trochanters testaceous. Body glabrous above ; ventral surfaces somewhat heavily clothed with pale buff hairs, antennae and legs with more adpressed shorter pale hairs.

*Head* somewhat narrower than width of emargination of pronotum ; occiput rather smooth and convex, with a fovea behind centre and a few punctures on each side, as well as a fovea near upper edge of eye ; postantennal tubercles fairly small, followed by a subtransverse groove on central portion between eyes ; antennal insertions separated by a space slightly less than diameter of insertion ; frontoclypeus rather strongly convex, subtriangular ; labrum finely punctured basally, emarginate apically ; gena three-fifths as deep as eye. *Antenna* two-fifths as long as body, not very stout ; segment 1 arched, thickest slightly before apex and feebly punctured ; 2 just over half as long as 1, strongly thickened apically ; 3 nearly as long as 1 plus 2 ; 4 subequal to 3 and slightly longer than 5 ; 5-10 decreasing gradually in length ; 11 about as long as 4. *Prothorax* 2.25 times as broad as length at middle ; anterior margin deeply and evenly emarginate ; lateral margin subevenly convex ; basal margin convex, more weakly so in central two-thirds ; disc subevenly convex, moderately and somewhat irregularly punctured, with punctures somewhat stronger on central portion and those on side of two different sizes. *Scutellum* about as broad as long, narrowed and broadly rounded apically, strongly convex in centre. *Elytron* 2.7 times as long as broad, gradually widened from just behind base to end of basal two-thirds, then evenly rounded posteriorly ; epipleuron fairly broad basally, gradually narrowing and disappearing on apex ; elytral margin somewhat irregular on apex ; disc strongly and subevenly convex, slightly depressed behind humerus ; surface with rather dense, moderately fine punctures, most punctures nearly as large as interspaces but becoming somewhat finer and sparser posteriorly. *Ventral surfaces* rather closely punctured on thorax except for a glabrous impunctate median strip which broadens posteriorly, slightly less densely punctured on abdomen. *Legs* fairly long ; hind femur somewhat elliptical and closely punctured; hind tibia fairly straight ; hind coxal segment 1 about as long as 2 plus 3 and not quite as long as last. Length 12.5 mm.; breadth 7.0 mm.

*Paratypes* : 1 specimen coloured as in holotype ; other paler with elytron orange brown, frontoclypeus and labrum partly testaceous and abdomen rather pale reddish. Length 11-12 mm.; breadth 7.0-7.55 mm.

Holotype ♀ (BISHOP 3591), Wau, 1400 m., Morobe Distr., N.E. New Guinea, 17.6.1961, J. Sedlacek ; two paratypes (A.N.I.C., D.A.S.F.), Aiyura, 1800 m., E. Highlands, 21.9.1957, J. H. Barrett. Differs from *O. rubra* Blackburn in having elytron more heavily punctured and unicolorous.

*Aulacophora rigoensis* Jacoby, 1905, Ann. Mus. Civ. Genova 41 : 495 (Papua). Fig. 8.

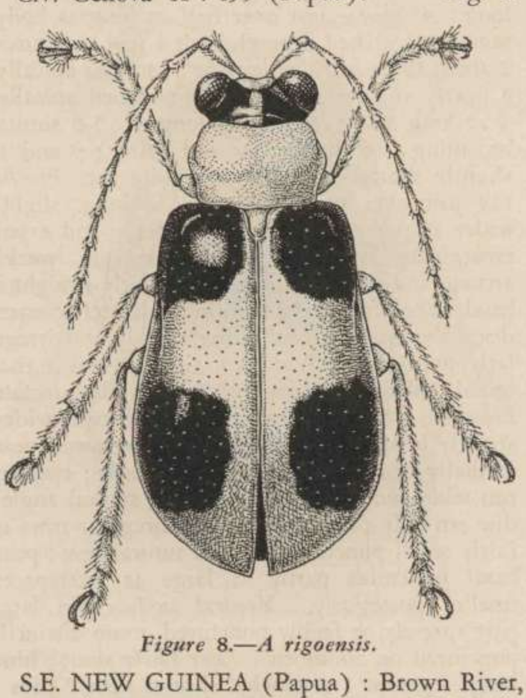

*Figure 8.—A rigoensis.*

S.E. NEW GUINEA (Papua) : Brown River, on eggplant, 31.3.1958, Szent-Ivany (H/2076). Cocolands Block, nr. Otomata, Abau Subdistr., on pumpkin, 12.3.1958, W. E. Casey (H/1051).

*Aulacophora similis* (Olivier), 1808, Entomologie 6 : 624 (Sunda Is.).

N.E. NEW GUINEA : Wewak, on pumpkin, 13.10.1957, Szent-Ivany (H/1424) : Tanbada, Sepik Distr., on castor bean (*Ricinus communis*), 11.10.1957, Szent-Ivany (H/424-26); Baiyer River, 1350 m., W. Highlands, feeding on pumpkin leaves, 1.8.1957, Barrett (H/1089-91, = A12-14).

S.E. NEW GUINEA (Papua) : Tapini, 950 m., Goilala Subdistr., on *Cucurbita pepo,* 19.8.1963, Szent-Ivany (H/2164-65); Givena Vill. Garden, 1350 m., Goilala, on *Cucurbita pepo*, J. Pendergast (H/2160-66); Laloki, C. Distr., 24.4.1959, Szent-Ivany (H/992); Cocolands Block, nr. Otomata, Abau Subdistr., on pumpkin, 12.3.1958, W. E. Casey (H/1053).

*Prasyptera antennata* Jacoby, 1886, Ann. Mus. Civ. Genova 24 : 78 (New Guinea).

S.E. NEW GUINEA (Papua): Cocolands Block, nr. Otomata, Abau Subdistr., on pumpkin, 12.3.1958, W. E. Casey (H/1052).

*Figure* 9.

## SUBFAMILY *ALTICINAE.*

*Arsipoda tenimberensis* (Jacoby), 1894, Novit. Zool. 1:297 (*Chaetocnema* ; Tenimber, Indonesia) Fig. 9.

N.E. NEW GUINEA : Aiyura, 1500 m, E. Highlands, feeding on leaves of *Ipomoea batatas,* 19.6.1958, J. H. Barrett (H/2036, 2037).

*Podagrica obliterata* (Jacoby), 1885, Ann. Mus. Civ. Genova 22 : 35 (*Nisotra ;* New Guinea) Fig. 10.

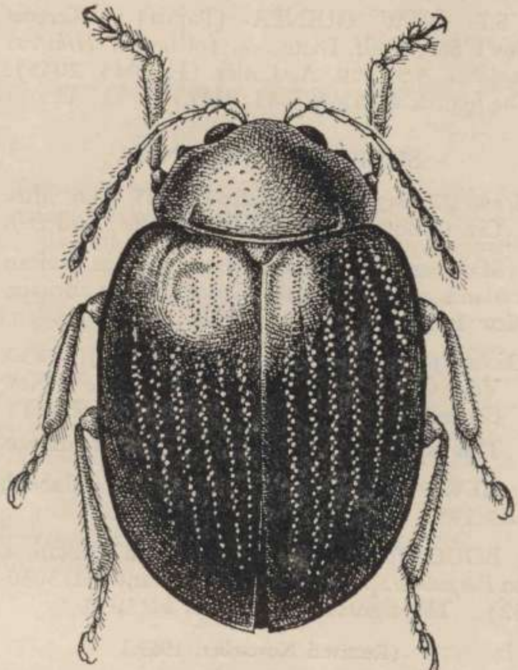

*Figure* 10.

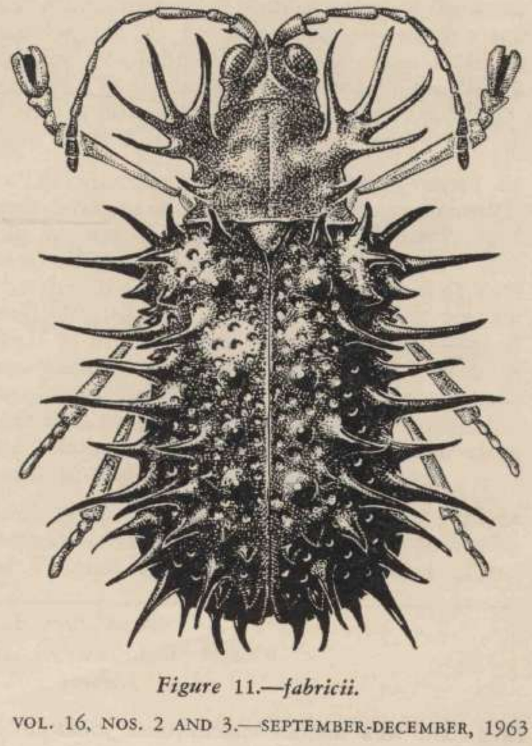

*Figure* 11.—*fabricii.*

S.E. NEW GUINEA (Papua): Kerema Gov't Sta., Gulf Distr., on foliage of *Hibiscus manihot*, 5.5.1959, A. Catley (H/2044, 2045). The figured specimen is H/3042.

## SUBFAMILY *HISPINAE.*

*Brontispa longissima* (Gestro), 1885, Ann. Mus. Civ. Genova 22 : 162 (*Oxycephala*; Aru Is.).

Many specimens from coconut from various lowland areas of New Guinea, New Britain, New Ireland and Bougainville.

*Dicladispa fabricii* (Guérin-Méneville), 1830, Voy. Coquille, Zool. 2 : 140 (*Hispa*; New Guinea). Fig. 11.

This species is a leaf-miner in Gramineae.

NEW BRITAIN: Keravat, nr. Rabaul, 16.5.1952, G. Dun (H/341, KER).

BOUGAINVILLE: Numa Numa Plantation, on *Paspalum* sp., 3.6.1956, Szent-Ivany (H/3030-32). The figured specimen is H/3030.

(Received November, 1963.)

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1963. Hispine beetles (Chrysomelidae) from New Guinea. Pacific Insects 5 (3): 591-714.

## ABBREVIATIONS.

A.N.I.C.—Australian National Insect Collection, Commonwealth Scientific and Industrial Research Organization, Canberra.

BISHOP.—Bernice P. Bishop Museum, Honolulu.

B.M.N.H.—British Museum (Natural History), London.

BOGOR.—Museum Zoologicum Bogoriensis, Bogor, Java, Indonesia.

C.A.S.—California Academy of Sciences, San Francisco.

D.A.S.F.—Department of Agriculture, Stock and Fisheries, Port Moresby.

U.S.N.M.—United States National Museum, Washington.

# Tea Production in Papua and New Guinea.

G. K. GRAHAM * A. W. CHARLES † G. R. SPINKS ‡

## INTRODUCTION.

THE possibility of commercial tea production was first envisaged in 1939 when the Highlands Agricultural Experiment Station was established at Aiyura. The Highlands in New Guinea were not at that time open to private settlement. A limited quantity of seed was imported from Sarawak and from this eighty-eight seedlings were obtained. These were planted out and from them thirteen bushes were later selected as seed bearers and allowed to develop. The remainder of the plot was kept cut back to a plucking table. From the seed produced, four acres of plucking tea was planted on the Station between 1947 and 1949 at an altitude of 6,000 feet.

Seed from the South Johnstone Bureau of Tropical Agriculture, Queensland, was planted in the nursery at Aiyura in 1941, and in 1944 a seed garden was established from this material. This was progressively culled to leave a stand of 40 to 50 seed bearers.

At the end of World War II, with the re-establishment of civil administration, further consideration was given to the possibility of commercial tea production in the Territory. To this end the Administration began an investigation of areas suitable for a pilot tea plantation. At the same time the re-establishment of administrative control in the Highlands meant that Europeans began to settle there and to investigate possible crops for the area. Small plots of tea were planted in various parts of the Highlands from seed obtained from Aiyura. No serious private tea growing ventures matured, although one company was formed for the express purpose of planting tea. The initial interest in tea coincided with the spectacular rise in world coffee prices and in the 1950's private investment in the Highlands was, with few exceptions, channelled into coffee planting.

Between 1948 and 1952, a number of overseas companies showed interest in the possibility of tea planting in the Territory and their representatives visited the Territory to determine its potential. The Australian Government also enlisted the services of overseas experts for the same purpose. While the overseas experts expressed confidence in the potential of the Territory in so far as soils and climate were concerned, it was the general opinion that labour was deficient in quantity and perhaps also in quality, and that communications were inadequate, particularly in view of the fact that air transport was obligatory, for competitive tea production.

## GARAINA TEA PLANTATION.

The decision to investigate the commercial possibilities of tea was made by the Australian Government in 1947. An experienced estate manager from Northern India was employed by the Administration to make a survey of the areas suitable for tea production and to select a site for the establishment of a pilot commercial tea garden. The area finally selected in the Waria Valley is now known as the Garaina Tea Plantation. It is 2,100 feet above sea level.

The selection of Garaina was governed by considerations of access (Garaina is approximately 30 minutes flying time south of Lae), land availability, and most importantly by the fact that the site is an old Pleistocene lake bed deposit, well drained and virtually level, thus lending itself to investigations into the mechanisation of tea planting and harvesting. At that stage it was considered that, in view of the labour position then prevailing in the Territory, commercial tea planting would be dependent on the development of suitable harvesting machinery.

In 1948, nurseries were established at Garaina with seed imported from South Johnstone Bureau of Tropical Agriculture in Queensland. From

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*Plate* I.—Part of Garaina Experimental Tea Plantation. Seed bearers in foreground and plucking areas on either side of the airstrip. The factory building is also shown.

[Photo D.I.E.S.]

these nurseries 25 acres of seed bearers and 15 acres of tea for plucking were planted. Serious planting of the main plucking areas commenced in 1954 when large quantities of seed first became available from the seed garden and official approval was given for the establishment of a trial area of 300 acres of commercial tea.

In 1951, a ten acre seed garden was established from seed imported from Boh Estate in the Cameron Highlands of Malaya. There are now 35 acres of seed gardens and 300 acres of plucking tea at Garaina. Plate I is an aerial view of part of Garaina, showing the factory, seed bearers and plucking tea.

The original intention at Garaina was to establish only about 15 acres of plucking tea and to install the minimum amount of machinery consistent with production of commercial grades of tea, the purpose being to establish rates of production and tea quality and to investigate the efficiency of native labour. Subsequently, as mentioned above, the area was extended to 300 acres and a factory built with the capacity to house sufficient machinery to process production from this area. Initially 100 acres was brought into plucking condition and the factory opened in August 1962 with equipment necessary for processing on the basis of an estimated yield of 800 lb. per acre. Yield has greatly exceeded expectations and the factory is currently being re-equipped to handle production from the full 300 acres planted, at higher production rates.

Harvesting under Garaina conditions is continuous throughout the year, with the interval between plucking rounds varying from 7 to 10 days.

### *Results at Garaina.*

Garaina was established to answer the following specific questions about commercial tea production in New Guinea.

1. Would tea grow and yield satisfactorily in New Guinea ?

2. Would the quality of New Guinean tea be acceptable on world markets ?

3. Could New Guinean workers be trained to pluck tea efficiently ?

The answers to these questions have been most satisfactory. Tea at Garaina has grown more quickly than in most traditional producing areas, probably because of the relatively high and well distributed rainfall. Small plots in the Highlands have also grown very quickly and it seems fair to assume that tea in many parts of New Guinea will come into production up to a year earlier than in the main producing areas of the world.

Overseas authorities who helped to select the area for the plantation at Garaina estimated that the yields there would be about 800 to 1,000 lb. an acre. On the basis of one year's experience this estimate will be exceeded ; yields seem certain to reach at least 1,200 and possibly 1,500 lb. an acre. The latter figure should be readily attained at the altitude of Garaina when better spacings are used ; current spacings, designed for mechanical plucking experiments, are too wide for maximum yield. Tea yields decline with rising altitude, but nevertheless, on the basis of Garaina experience, and growth in the few small plots so far established in the Highlands, 1,000 lb. per acre should be attained readily at an altitude of 5,000-6,000 feet in selected areas.

The quality of tea produced at Garaina has been most encouraging. It may be that Garaina has a particularly favourable microclimate which will not be reproduced everywhere in the Territory : nevertheless, the reports on Garaina tea indicate that the planting material available in the Territory is of high inherent quality and there is no reason to doubt that the quality of Highland grown tea will be fully acceptable.

Tea from Garaina has not been consistently sold on one market as it has been the intention of the Administration to assess its acceptance on various international markets. The principal markets have been the United Kingdom and Australia. In the former, prices (in Australian currency) to date have been as follows :— Broken Orange Pekoe (BOP) 4s. 2d. (4s. to 4s. 6½d.); Broken Orange Pekoe Fannings (BOPF) 4s. 7d. (4s. 1½d. to 4s. 9d.); Broken Pekoe(BP) 3s. 3d. (2s. 9d. to 3s. 9d.); Fannings 3s. 8d. (3s. 5d. to 3s. 10d.); and Dust 3s. 4d. (3s. 0½d. to 3s. 8d.). In Australia only BOP and BOPF grades have been marketed and averaged BOP 4s. 10d. (4s. 6d. to 5s. 6d.), BOPF 4s. 8d. (4s. 7d. to 4s. 9d.). Markets in Hong Kong, U.S.A. and South Africa are now being tested with selected grades. These teas have been produced by natural tat withering followed by conventional rolling—i.e., "orthodox" manufacture.

In spite of fears that New Guineans would need years of training and experience before they would match the output and efficiency of overseas tea pluckers, women in the Garaina area showed immediate aptitude for tea plucking. Within six months of the commencement of commercial production the daily harvest averaged 43 lb. fresh leaf with some individuals plucking 80 lb. per day. This is comparable with overseas rates, and all the plucking has been fine. Significantly, not only have the women shown an aptitude for plucking the leaf, but there has been keen competition for employment as well. The women at Garaina, when trained, will pluck on a piece-rate of 1¼d. per lb. green leaf. They are seen at work in Plate II.

Although large-scale plucking experience is limited to the women of the Waria valley, small-scale experiments in the Highlands suggest that the local men and women will pluck tea comparably, and piece rates in some parts of the Highlands may well be lower than at Garaina.

As a result of the Garaina experiment the Department has passed from a cautious attitude to one of confidence about the future of tea in the Territory. Other factors which have increased confidence in tea planting since Garaina began in 1949 have been the improved availability of labour, and the introduction of new factory procedures which have led to a lowering of factory costs.

In 1949, overseas advisers stated that a factory with an output of 1,000,000 lb. of made tea a year would cost about £250,000. With new types of machinery now available, capitalisation has fallen to about half this figure. Operating expenses have also been reduced because of lower power and factory labour requirements.

Many parts of the Highlands of New Guinea enjoy an advantage from the processing viewpoint because of the relatively high and well distributed rainfall. The peak day's production at Garaina and in much of the Highlands is likely to be only about one-third of one per cent.

*Plate* II.—New Guinea women make enthusiastic and efficient tea pluckers.

[Photo D.I.E.S.]

of the annual production. In Assam, the peak day may reach three-quarters of one per cent., and in Darjeeling where there is no production for the four coldest and driest months of the year, the peak day may reach one per cent. In Georgia, the province of Russia where tea is now produced on a large scale, the position is even more extreme with a peak day's production of more than one and a half per cent. of the annual output. Only in a few other favoured places such as the Kenya Highlands does the peak day drop below one-half of one per cent. of the annual output. A high peak necessitates a larger factory which is under-utilized for most of the year, or makeshift procedures leading to lower quality at the peak period.

## POTENTIAL FOR TEA PRODUCTION IN THE TERRITORY.

The Territory potential for tea growing in terms of total area of suitable soils has not been fully determined. However, while tea can be grown on a wide range of soils, and, so far as this Territory is concerned, at altitudes from sea-level to 7-8,000 feet, considerations such as tea quality and labour supply will probably lead to the initial development of the tea industry within the more accessible areas of the Eastern and Western Highlands Districts ; there is also the possibility of subsequent expansion into the Southern Highlands District.

Within the accessible areas of the Eastern and Western Highlands Districts, i.e., where there is a well-developed road network servicing a main air strip, are contained those areas previously reported by overseas experts as suitable for tea. These areas can be divided into three geographic units :—

(*a*) Upper Ramu area—centred on Kainantu and Aiyura.

(*b*) Asaro Valley—centred on Goroka.

(*c*) Wahgi Valley—centred on Mount Hagen.

(*a*) and (*b*) are in the Eastern Highlands District ; (*c*) is in the Western Highlands District.

The valley floor in these three areas has an elevation of approximately 5,500 feet above sea level. The average annual rainfall varies from approximately 75 inches at Goroka to 100 inches at Mount Hagen. The following table gives the average monthly rainfall distribution for three representative centres, with corresponding figures for Garaina for comparison.

| | Average Monthly Rainfall (in Points) | | | |
|---|---|---|---|---|
| | Mt. Hagen | Goroka | Aiyura | Garaina |
| January | 1010 | 915 | 930 | 835 |
| February | 1060 | 1147 | 1110 | 1212 |
| March | 1210 | 1049 | 1010 | 1022 |
| April | 1160 | 951 | 1030 | 1098 |
| May | 720 | 386 | 420 | 734 |
| June | 430 | 186 | 360 | 534 |
| July | 520 | 197 | 410 | 570 |
| August | 730 | 289 | 510 | 599 |
| September | 810 | 396 | 510 | 822 |
| October | 770 | 544 | 610 | 1030 |
| November | 840 | 644 | 780 | 1167 |
| December | 990 | 1003 | 950 | 1255 |
| TOTAL | 10100 | 7707 | 8630 | 10878 |
| No. of years recorded | 10 | 16 | 21 | 13 |

Mean maximum temperatures are in the vicinity of 75 degrees F. with approximately a 5 degree variation over the year. Mean minimum temperatures are approximately 55 degrees F., also with a variation of approximately 5 degrees over the year. As can be seen from the above table, there is a seasonal distribution of rainfall, with May to August being relatively dry months. This dry season is more marked in the Asaro Valley area than in the Wahgi Valley or Upper Ramu areas, where rainfall is generally adequate in all months of the year. In all these areas, climate is conducive to continuous tea production.

The soils of these areas fall into four distinct groups :—

(*a*) *Soils derived from mixed metamorphic material and upper Tertiary sediments.* These occur generally throughout the Highlands and predominate in the Upper Ramu area. A complex pattern of soils has developed under these circumstances, ranging from deeply weathered sandy clays developed on schists, to heavy clays with a strongly developed laterite gravel layer at the top of the "B" Horizon. No tea has been grown on these latter soils, although they have been used for coffee growing.

(*b*) *Soils developed on Pleistocene lake deposits.* These occur in the Asaro Valley and Wahgi Valley areas. They are predominantly grassland areas and, under natural conditions, poorly drained. The soils are generally clay loams, silty clay loams and peaty clays 12-18 inches deep, over-lying clays, sandy clays and silty clays, and may or may not have well developed ironstone concretionary layers. These soils respond to simple open drainage and have been successfully utilized for coffee growing.

(*c*) *Soils developed on volcanic intrusive materials.* These occur extensively in the Wahgi Valley area where they are formed on Pleistocene andesites, which have given rise to deeply-weathered acid orange and yellow clays on a rolling topography. Similar soils also occur in the Eastern Highlands and to an extensive but undetermined degree in less accessible areas of the Eastern and Western Highlands and the Southern Highlands Districts. In the Upper Ramu area also, a number of granodiorite instrusions have given rise to deeply-weathered yellow clays.

(*d*) *Peaty Swamp Soils.* These occur extensively in all areas. In their natural condition they are swamps with an almost pure stand of *Phragmites.* These soils consist essentially of a deep peaty layer overlying pale yellow and grey silty clays. When drained, they have been utilized successfully for coffee growing.

Observation plots of tea have been established successfully on typical soils within the above groups with the exception of group (*a*).

A feature of the lake bed and peaty swamp soils of the Wahgi Valley is the generally high pH levels. The range of pH is 5.5 to 7.0 with the majority falling in the range 6.0-6.5. Under the environmental conditions of the Wahgi Valley experience to date indicates that the pH may be less significant than it is usually considered to be for tea growing. A two-acre observation plot has been growing vigorously on representative soils with a pH range of 6.5-7.0.

The populations of the Eastern Highlands and Western Highlands Districts in 1961-62 were estimated at 352,000 and 280,000 respectively. The two geographic units of the Eastern Highlands District, the Upper Ramu and the Asaro Valley, are occupied by 8 and 16 per cent. respectively of the total population. The Wahgi Valley has a much heavier concentration as approximately 37 per cent. of the District population is located in this area. The resident populations of the three areas referred to above are :—

| | |
|---|---|
| Upper Ramu .... .... | 28,000. |
| Asaro Valley .... .... | 58,000. |
| Wahgi Valley .... .... | 103,000. |

## TEA PRODUCTION.

### (*a*) *Cultural Practices.*

(i) *Nurseries.*

Tea is generally grown from seed sown in nurseries. Nursery beds are usually four feet wide and are dug to a depth of two feet. Artificial shade is required and as the tea is in the nursery for 18 months, posts and wire are recommended for shade support.

Seed is germinated in well-drained germination beds, which are made of river sand and must be kept continuously moist. The seed is spread densely on the bed in a single layer and covered to a depth of one inch. Germinated seeds are planted in the nursery at a spacing of 5 inches x 5 inches.

(ii) *Drainage and soil preparation.*

Artificial soil drainage is required on flat and gently sloping ground. Open box drains are usually satisfactory though the use of mole drains may reduce the number of box drains required.

Thorough cultivation is required prior to planting tea, particularly on those grassland soils with a high organic matter content. On virgin grassland soils a crop of sweet potato is often taken off the land prior to the planting of coffee and the practice could be adopted with advantage for tea planting.

(iii) *Field planting.*

After approximately 18 months in the nursery, or less under good growing conditions, the plants are stump planted in the field. The stem of the seedling is cut 4 inches above the ground at the time of planting and the stump pulled from the previously-loosened soil. In the field the stumps are planted in holes dug some time previously at a spacing of 5 feet x 2 feet 6 inches, giving a plant density of 3,500 per acre.

Holing may be done by hand using a posthole borer digging to 18 inches. A labourer can, when trained, dig at least 300 holes per day. Alternatively, where heavy equipment is available, a trench can be opened up and the stumps planted into it. Stumps need shading with bracken fern or grass when first planted out and a temporary shade crop such as *Crotalaria* may also be desirable.

(iv) *Permanent shade.*

Light shading is normal practice in growing tea. *Albizia stipulata* is satisfactory. Under conditions at Garaina, shaded tea does not appear to be any better than unshaded tea to date. Permanent shade may prove unnecessary in the Highlands, but is recommended initially.

(v) *Maintenance.*

As with coffee, it is important that grasses be kept out of tea areas and that soft weeds be controlled regularly. Tractor-mounted row crop implements may be useful in the early stages on flat land.

(vi) *Bush formation and pruning.*

Classical systems involve severe annual cutting back in the early years to develop the shape of the bush. However, recent methods of initial bush development depend on the production of two or more shoots from each stump, which in the second year in the field are pegged down in a fashion similar to the Agobiada system in coffee. New shoots which come away from these pegged-down shoots form the basic framework, and the bush is then plucked into shape without further cutting back. No further pruning is required until the sixth year in the field, when the bush is cut back and a new, vigorous framework again built up. The pruning cycle at Garaina is three years, but a 4-year cycle will probably be possible at higher altitudes.

(vii) *Fertilizing.*

The use of fertilizer on tea in production is standard procedure. Current practice at Garaina is to apply two cwt. of Sulphate of Ammonia per annum, divided into two applications. Sulphate of Ammonia is preferred to more concentrated nitrogenous fertilizers such as urea, as there is a demonstrated sulphur deficiency at Garaina and sulphur deficiencies are suspected in other grassland areas.

### (*b*) *Processing.*

Tea factory procedures have undergone a major revolution in the postwar period, leading to substantial savings in capitalization and running costs. The Department recommends that Territory tea growers give careful consideration to some of the newer processes. In order to understand the advantages of the newer processing techniques, it will be helpful to consider orthodox manufacture first, and then the departures which have been made from it.

#### (i) *Withering.*

Traditional withering is a natural process whereby the fresh leaf, spread in thin layers, loses a percentage of its moisture and becomes flaccid, usually over a period of 18-24 hours. Over half the total area of an orthodox factory may be withering space. Tat withering at Garaina is illustrated in Plate III.

#### (ii) *Rolling.*

In orthodox manufacture, tea is rolled from 2 to 6 times, each roll taking about 30 minutes. This process has a high power requirement.

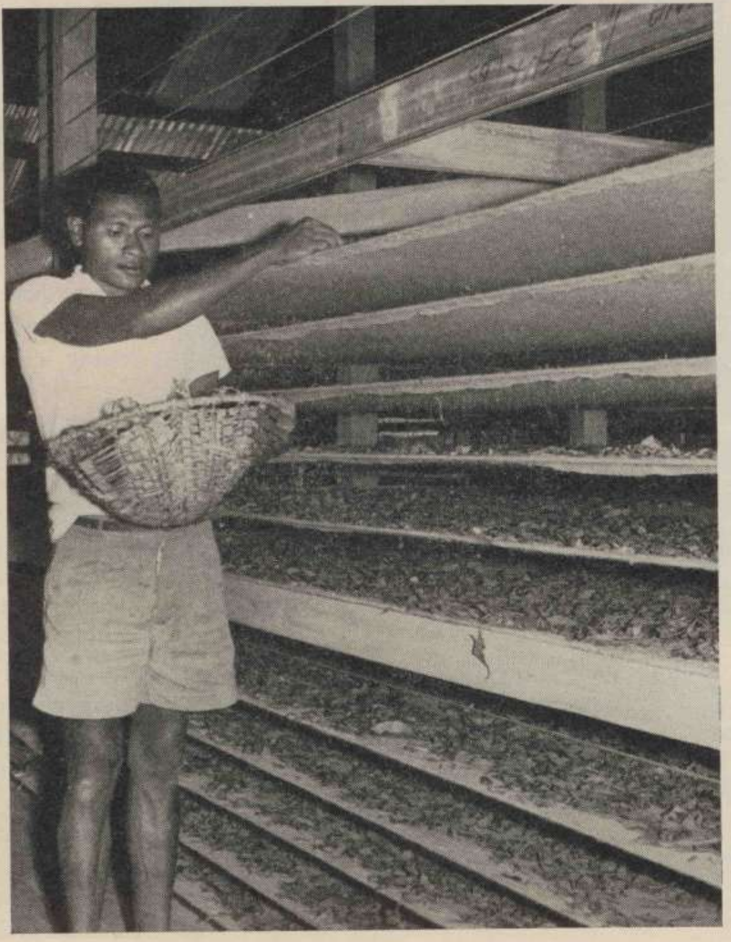

*Plate* III.—The traditional method of natural withering on hession tats has been used at Garaina.

[Photo D.I.E.S.]

(iii) *Fermentation.*

Orthodox tea requires 3 to 4 hours for fermentation, which is a chemical process.

(iv) *Drying.*

Tea is dried by hot air, the process taking 20 to 40 minutes in a modern dryer.

(v) *Sorting, Grading and Packing.*

These are the final processes and involve purely mechanical techniques.

When tea was first grown on a plantation scale in Indonesia, India and Ceylon in the 19th century, processing machinery was introduced to replace the old Chinese hand methods. Up to the early part of the 20th century, no new principles were introduced, although the design of machinery was steadily improved. A study of the nature and effect of each manufacturing process has led more recently to the adoption of entirely different processes at certain stages of manufacture. The essential part of processing is fermentation, when tea flavour is developed. However, some method of rupturing the leaf cells and releasing the juices is necessary before fermentation will begin. The firing process stops fermentation at the desired stage.

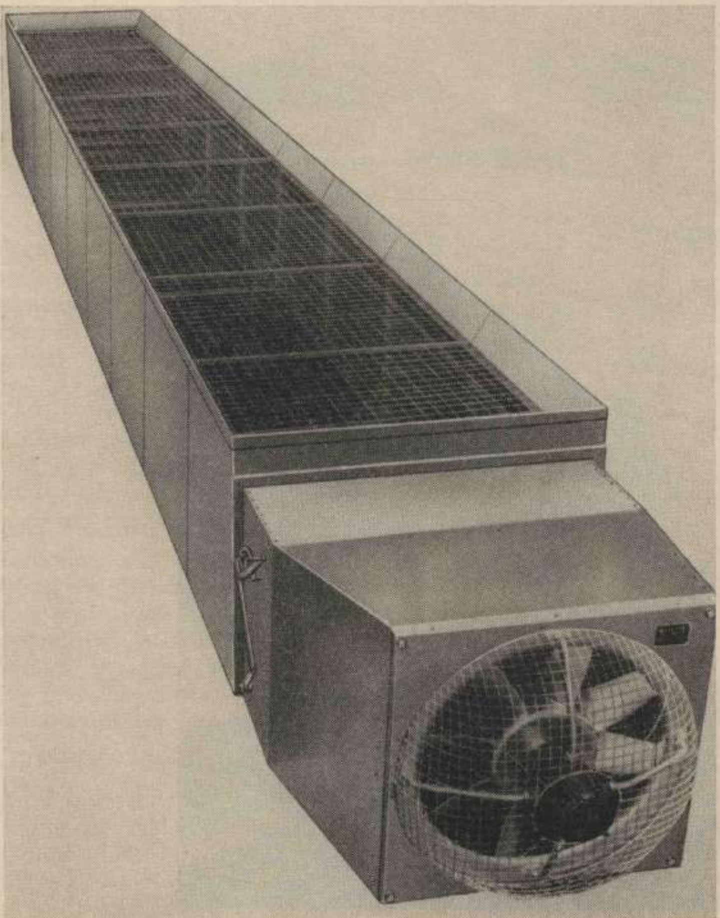

*Plate* IV.—Controlled withering in troughs of this type is superseding tat withering.

[Photo Davidson & Co. Ltd., Belfast, N. Ireland.]

The main revolution in processing has been the discovery of cheaper ways to rupture the leaf cells and initiate fermentation. There have also been major advances in withering techniques, and refinements in the drying process. The present position with regard to the five basic steps in processing is outlined below.

(i) *Withering.*

The functions of withering are to reduce moisture, thus minimising the work of final drying, and to render the leaf flaccid so that it will be capable of undergoing distortion and releasing the juices without breaking up. Although it is generally held that withering has a favourable effect on quality and some chemical changes do occur during the withering process, it is possible to eliminate withering entirely,

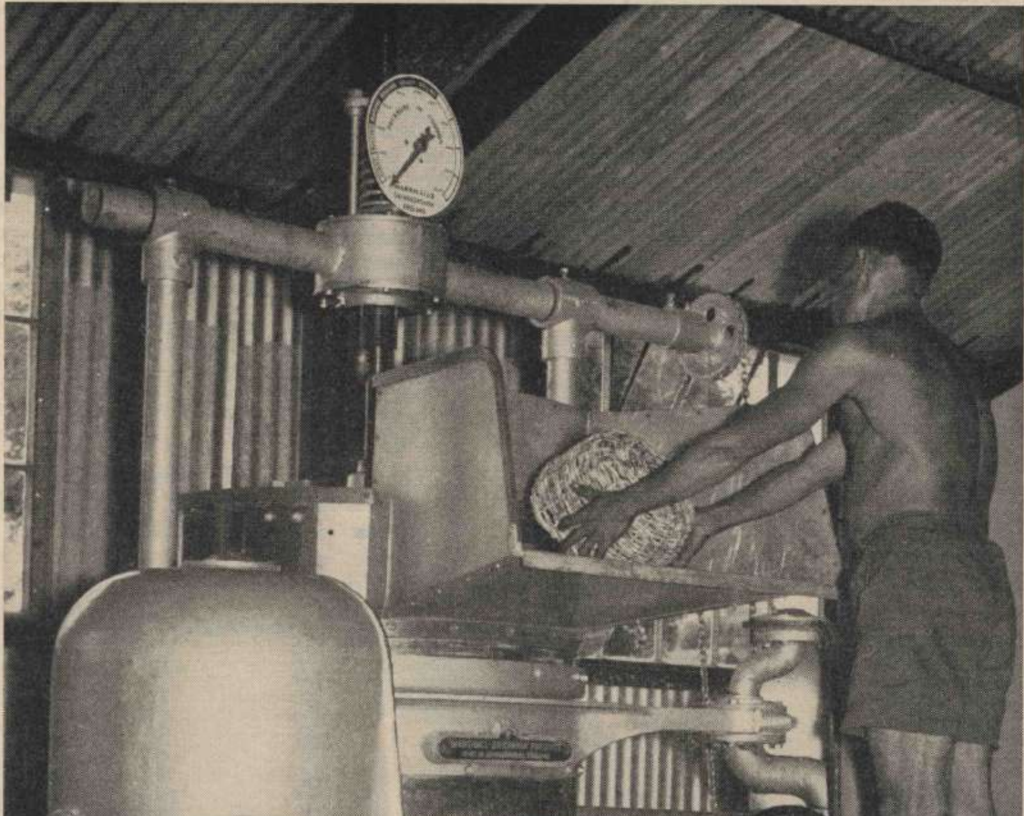


*Plate* V.—The orthodox type of roller is a heavy machine with a high power requirement.
[Photo D.I.E.S.]

and in fact about 40,000 tons of tea is produced annually in India from unwithered leaf. However, the higher moisture content of the fermented leaf necessitates a much greater dryer capacity than when withered leaf is used. On balance the elimination of withering is not recommended but, instead of the old natural wither of leaf spread thinly on tats, trough withering is now favoured. Troughs may be of various sizes, a common size being about 48 feet long, 6 feet wide, and 5 feet high. The leaf is placed in the upper part of the trough, which includes a layer of weld-mesh, wire-netting or similar material, covered with a removable sheet of hessian or nylon cloth on which the leaf is spread to a depth of eight or nine inches. The lower part of the trough is a chamber through which air is forced to effect withering.

Troughs take less space than tats, give greater control of the withering process, greatly reduce the labour required for handling the leaf, and make it possible to use carefully controlled hot or cold air, thus regulating the time schedule in the factory. Plate IV illustrates a withering trough.

Drum and tunnel withering have been tried but have certain disadvantages when compared with trough withering.

(ii) *Leaf Distortion.*

As mentioned above, there are several alternatives to rolling, which basically is merely a method of distorting the leaf and disrupting the cells. Orthodox rollers, illustrated in Plate V, are expensive, slow, and have high power requirements. Few new factories install them to-day, although one or two rollers may be installed to give a single light roll before or after alternative methods of leaf distortion. The alternatives are as follows :—

(*a*) *The Cutting, Tearing and Curling (C.T.C.) Machine.*

The C.T.C. machine was invented in 1930 but was not adopted on any scale until the postwar period. Currently about half the factories in North India and many factories in Africa use this type of machine, and more and more orthodox factories are changing over to them. The C.T.C. machine is essentially a large mangle with two fluted

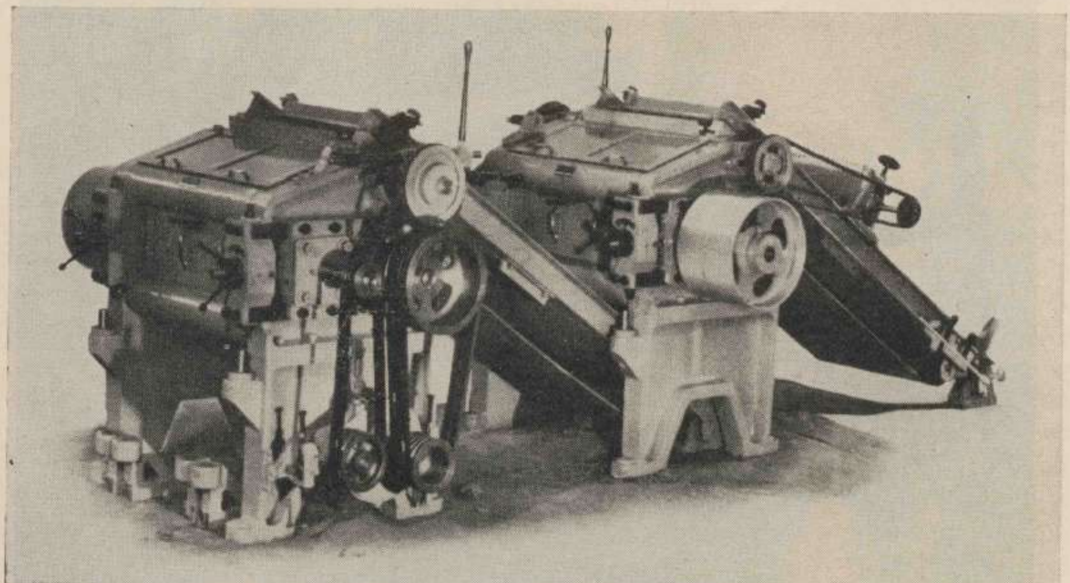

*Plate* VI.—C.T.C. machines work efficiently in tandem. The 24 inch mini-C.T.C. combination unit is illustrated.

[Photo Davidson & Co. Ltd., Belfast, N. Ireland.]

rollers operating at a speed differential of about 10 : 1. The leaf is subjected to a cutting, tearing and curling action while passing between the rollers. Greatest efficiency can be achieved by operating two machines in tandem. The leaf must be withered, and some consider it advantageous to give one light roll first, taking off about 15 per cent. of the fine leaf, and putting the remaining "big bulk" through the C.T.C. machines.

These machines have a large output and relatively low capital cost and power requirements. The main markets of the world accept C.T.C. teas as at least equivalent in quality to those of orthodox manufacture. Territory producers should give serious consideration to the installation of these machines, one of which is illustrated in Plate VI.

(*b*) *The Rotorvane.*

This machine was first produced as recently as 1958 but is already being used in a number of factories. It can handle unwithered leaf, but is better suited to receiving withered leaf. It is essentially a mincing machine, consisting of a rotor with vanes rotating inside a cylinder through which the leaf passes. Varying pressures may be applied and the speed of the rotor may also be varied. The Rotorvane has very high output together with relatively low capital cost and power requirements. Early hopes that it might supersede the C.T.C. machines do not appear to be eventuating, but present indications are that a Rotorvane feeding a C.T.C. machine, rather than tandem C.T.C. machines, might be a very good arrangement. Plate VII shows a Rotorvane.

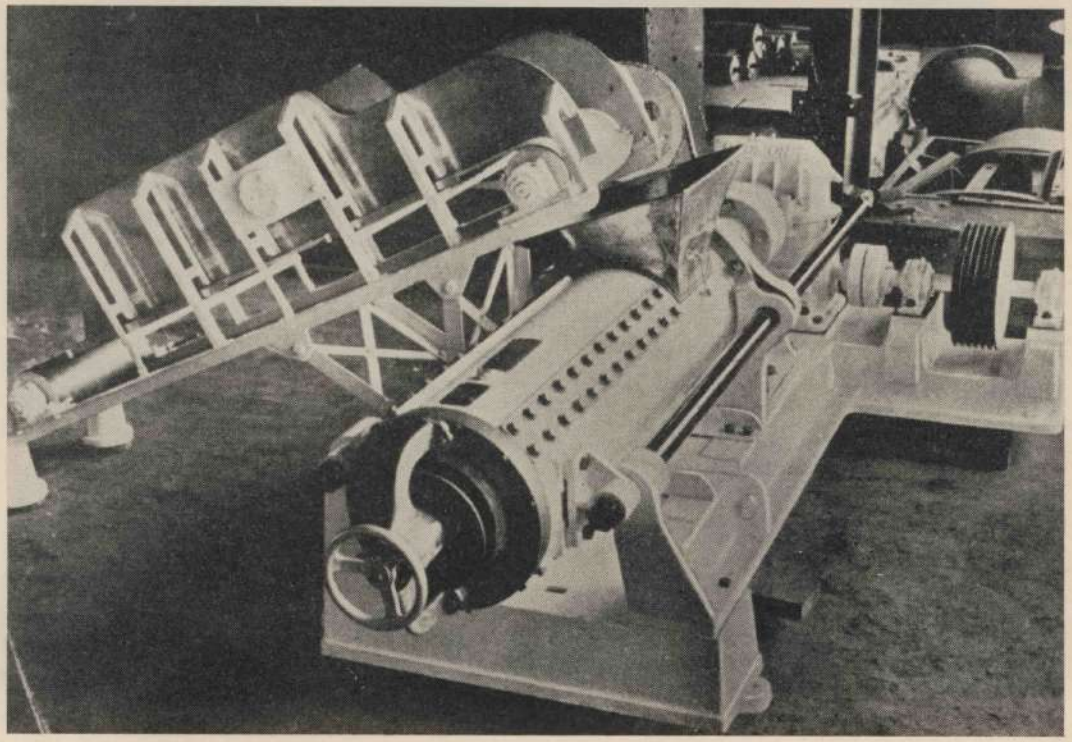

*Plate* VII.—The Rotorvane is an efficient machine for producing leaf distortion.

[Photo Davidson & Co. Ltd., Belfast, N. Ireland.]

(*c*) *The Legg Cutter.*

The Legg cutter is essentially a tobacco cutter. It shreds unwithered leaf very finely, and has attracted attention in areas where natural withering has always been difficult. After shredding, the leaf is lightly rolled. The main advantage is the saving in capital costs through the elimination of withering, but the quality of Legg cut tea is somewhat suspect and the fine shredding of the leaf necessitates a reduction in the air draught through the dryers. This, together, with the high moisture content, leads to a multiplication of dryers. The main advance in the use of Legg cutters took place before trough withering was devised in the areas where a natural wither could not be obtained regularly. This cutter is not considered necessary in Papua and New Guinea.

In brief, for leaf distortion it is suggested that the Territory producer use tandem C.T.C. machines or Rotorvane and C.T.C. machines. In a large factory, one or more rollers might be installed for a single light roll before the leaf goes to the other machines, or to produce some 'orthodox' tea for selected markets.

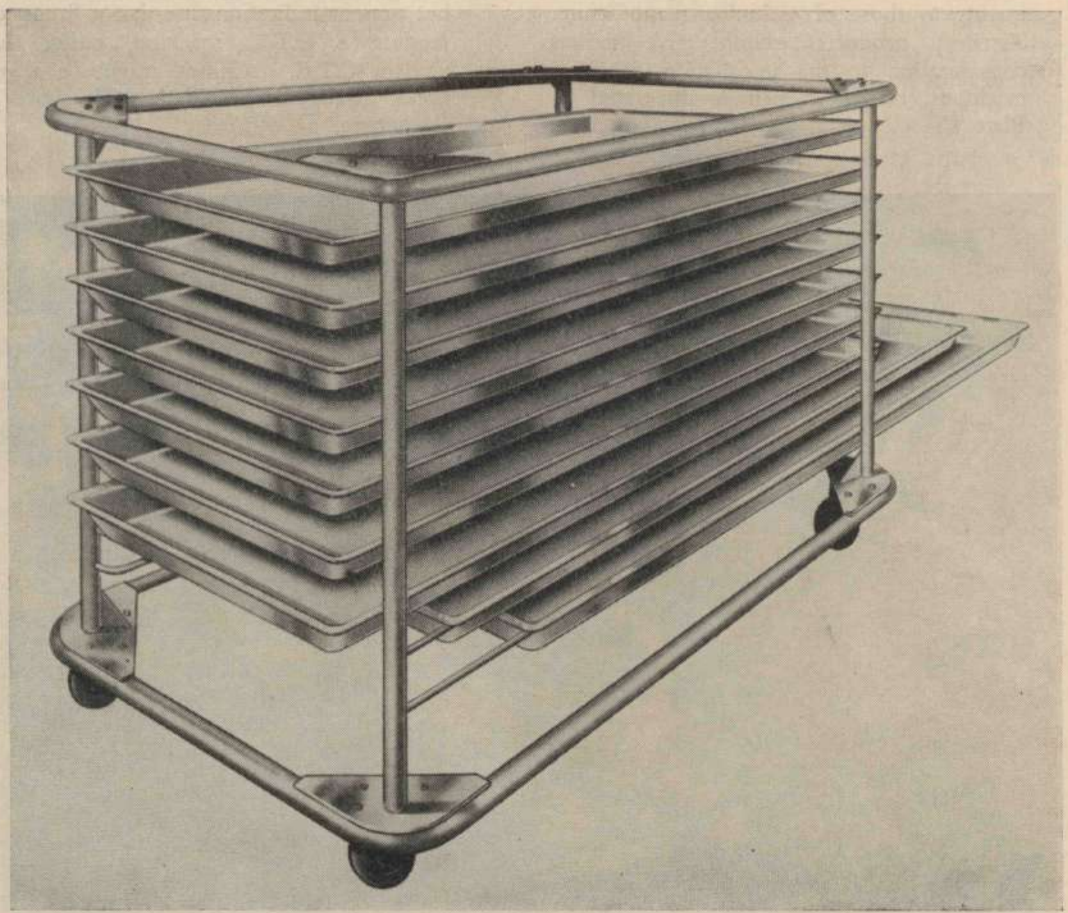

*Plate* **VIII.—Fermentation in shallow trays is standard procedure.**

[Photo Davidson & Co. Ltd., Belfast, N. Ireland.]

(iii) *Fermentation.*

The process of fermentation has not changed, although the speed of fermentation varies according to the method of leaf distortion used. The more vigorous methods of distortion such as Legg cutting, C.T.C. and Rotorvane manufacture lead to quicker fermentation.

After distortion, the green leaf is usually sifted to aerate and cool it and break up balls. It is then fermented in trays, usually of aluminium or fibreglass in modern factories, a rack of which is illustrated in Plate VIII. There it undergoes chemical changes. The first stage is an enzymic process whereby polyphenols of the catechin group are converted under the influence of the enzyme polyphenol oxidase to orthoquinones. These substances then undergo chemical condensation to the yellow-coloured bisflavanols and theaflavins which are further changed to the red and brown-coloured thearubigins, which give tea its distinctive colour. Unless the process is stopped at this stage, the thearubigins are degraded to insoluble substances.

The so-called fermentation process is chemical, not biological, and good factory hygiene is essential to prevent bacterial contamination during fermentation. Any contamination inevitably leads to a lowering of quality.

(iv) *Drying.*

There have been no fundamental changes in the drying process although a steady improvement in the design and efficiency of dryers has occurred. Oil-fired forced-draught tray dryers will probably be most useful in Papua and New Guinea. Dryers with extended chambers handle the high moisture content teas produced by modern processing more efficiently than standard models. A large, modern dryer is shown in Plate IX.

(v) *Sorting, Grading and Packing.*

A variety of machinery is available to handle the purely physical processes of grading and packing. Packing in standard foil-lined plywood tea chests is desirable in order to gain acceptability on world markets ; cardboard cartons may eventually replace the plywood chests.

Dried tea is usually passed through a stalk-extracting machine. The most useful machine of this type for use where C.T.C. tea is manufactured is the Myddleton stalk extractor. In this machine the leaf passes over a tray with raised metal bosses each with a hole at the top. The agitated leaf passes through the holes in the bosses whilst the stalk slides down between them. The leaf is then sorted into grades.

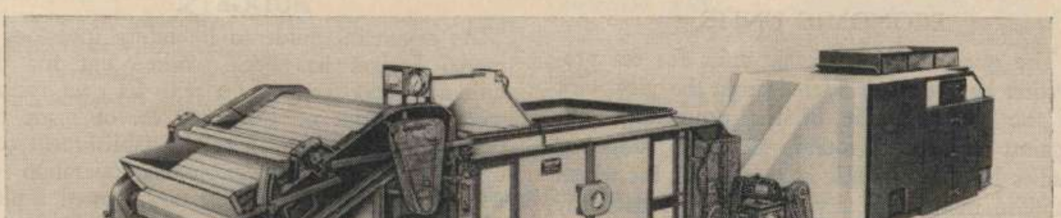

***Plate* IX.—A modern forced-draught tray drier.**

[Photo Davidson & Co. Ltd., Belfast, N. Ireland.]

### (*c*) *Future Developments.*

What of future developments in tea processing ?

With the major advances over the last twenty years, the question may be asked whether a further revolution is likely, rendering the machinery at present recommended out-dated in a few years. It is impossible to be dogmatic on such matters, but at least the Territory tea producer who equips himself with the most modern machinery will be as well placed to meet future changes as his competitors. There may be development from a batch to a continuous type of processing, which would lead to greater factory efficiency. Further experiments are taking place in many countries, including work on a technique developed in Holland whereby all processes take place in a single drum. The leaf cells are disrupted by means of a vacuum and the leaf is broken by metal balls which crush it as the drum revolves. Drying also takes place in the drum.

Instant tea is attracting a great deal of attention at the present time. The share of the world market which instant tea will eventually capture is an open question, but it seems likely that for some large plantations it will be found worthwhile to consider the production of instant tea on the plantation.

## ECONOMIC UNITS.

The question of economic units for tea production has been considered from the viewpoint of the optimum size of the processing unit. Against this background, detailed budgetary studies have been made at two levels for which standard modern factory equipment is currently available, using the basic assumption of a yield of 1,000 lb. of made tea per acre per annum—a unit based on 400 acres of plantable land with a factory designed for an output of 400,000 lb. of made tea per annum, and a unit based on 1,000 acres of plantable land with a factory output of 1,000,000 lb. of made tea per annum. These studies have indicated that the 400 acre unit would be of doubtful profitability under Territory conditions. A model budget for the 1,000 acre unit, based on the best data available at the present time, is given as the concluding section of this article and shows good prospects of profitability.

The producing component in an economic unit of this type might theoretically take a number of forms.

(1) A completely self-contained area of 1,000 acres of tea supplying its own factory.

(2) A syndicate or group whose members controlled sufficient areas of reasonable size and proximity to one another to supply their own central factory.

(3) A tea area of 400-500 acres partially supplying a factory which bought in its remaining leaf from surrounding smallholders.

Smallholdings, ranging from units combining several acres of tea with food crops and livestock up to larger specialised tea plantations under individual owner-management, would be dependent on external factories for the sale of their leaf.

No efforts at budgetary analysis have been made for the type of unit envisaged under (3) above or for the larger specialised smallholdings and sound practice would await local experience of collection costs and price structuring. Both would appear to be possibilities only in a post-establishment phase of the industry, the former being dependent on a well established smallholder component in plantings and the latter on adequate factory capacity for price competition.

## BUDGETS.

As a general guide to intending investors, a model budget has been worked out for the unit of 1,000 acres of tea with its own factory with an output of 1,000,000 lb. of made tea per annum. It shows a total establishment cost up to the point of profitable operation of £355,000 including interest on invested capital of £56,000. Profitability at full production is also calculated for three price levels.

A general budget of this nature is necessarily calculated on a conservative basis and with an eye to future trends. Thus, plucking cost is set at 2d. per lb. of green leaf, although current cost in many areas is likely to be 1½d. or even less. The land rent figure is also higher than current rentals. The experienced tea planter will see various items where he might hope to effect savings. On the other hand it is to be emphasised that, as the industry is in the very early stages of establishment, this is a purely theoretical budget and contingencies will inevitably arise which cannot be foreseen.

## MODEL TEA BUDGET

***Basic Assumptions***

Physical Data.

Area of Plantation—1,000 acres. Planted on grassland.

Nursery—Grown from seed. Seedlings remain in nursery for 18 months before transplanting into field.

Planting Density—Spacing 5 feet x 2½ feet. 3,500 plants per acre.

Bush formation—Bush formation aims at producing two or more shoots from each stump plant.

Fertilizing—Sulphate of ammonia, at 56 lb. per acre in the first year in the field increasing by 56 lb. per acre annually to 224 lb. at full rate. Applications to be made twice a year.

Planting Programme.

Year 1.

Nursery—2 acres.

Year 2

Nursery—3 acres.
Land preparation—150 acres.

Year 3

Nursery—5 acres.
Land preparation—250 acres.
Planting—150 acres.
Maintenance—150 acres.
Bush formation—150 acres.

Year 4

Nursery—5 acres.
Land preparation—300 acres.
Planting—250 acres.
Maintenance—400 acres.
Bush formation—250 acres.
Harvesting—150 acres.

Year 5

Land preparation—300 acres.
Planting—300 acres.
Maintenance—700 acres.
Bush formation—300 acres.
Harvesting—400 acres.

Year 6

Planting—300 acres.
Maintenance—1.000 acres.
Bush formation—300 acres.
Harvesting—700 acres.

Year 7

Maintenance—1,000 acres.
Harvesting—1,000 acres.

Year 8

Maintenance—1,000 acres.
Harvesting—1,000 acres.
Pruning—150 acres.

Year 9

Maintenance—1,000 acres.
Harvesting—1,000 acres.
Pruning—250 acres.

Yields.

| Year. | Yield per acre (lb. made tea) | Total production (lb. made tea) |
|---|---|---|
| Year 4 .... .... | 150 | 22,500 |
| Year 5 .... .... | 450 | 105,000 |
| Year 6 .... .... | 800 | 277,500 |
| Year 7 .... .... | 1,000 | 530,000 |
| Year 8 .... .... | 1,000 | 775,000 |
| Year 9 .... .... | 1,000 | 940,000 |
| Year 10 .... .... | 1,000 | 1,000,000 |

Conversion factor.

100 lb. green leaf equals 22 lb. made tea.

Currency.

All figures are in Australian currency.

*Table* 1.

Structural Improvements (£).

| Year. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Staff accommodation .... | 6,000 | 20,000 | 5,000 | 5,000 | .... | .... | .... | .... | .... | 36,000 |
| Ration stores and tool shed | .... | 1,500 | .... | .... | .... | .... | .... | .... | .... | 1,500 |
| Machinery shed/ workshop | .... | .... | .... | 3,000 | .... | .... | .... | .... | .... | 3,000 |
| Tea factory .... .... | .... | .... | 35,000 | .... | .... | .... | .... | .... | .... | 35,000 |
| Tea store shed .... .... | .... | .... | .... | .... | 1,000 | .... | .... | .... | .... | 1,000 |
| Fences .... .... .... | 600 | 600 | 600 | 600 | .... | .... | .... | .... | .... | 2,400 |
| Roads .... .... .... | 1,000 | 1,000 | 1,000 | .... | .... | .... | .... | .... | .... | 3,000 |
| TOTAL .... | 7,600 | 23,100 | 41,600 | 8,600 | 1,000 | .... | .... | .... | .... | 81,900 |

*Table* 2.

Plant and Equipment (£).

| Year. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Factory Machinery .... | .... | .... | .... | 66,000 | .... | .... | .... | .... | .... | 66,000 |
| Field Machinery .... | 2,000 | .... | .... | .... | .... | .... | 1,400 | 2,000* | .... | 5,400 |
| Motor Vehicles .... .... | 1,200 | .... | .... | .... | 3,000 | 1,200 | .... | .... | .... | 5,400 |
| Other .... .... .... | 400† | 150 | 50 | 50 | 50 | 50 | 50 | 50 | .... | 850 |
| TOTAL .... | 3,600 | 150 | 50 | 66,050 | 3,050 | 1,250 | 1,450 | 2,050 | .... | 77,650 |

† Includes hand tools, office equipment, wireless. Hand tools replaced at £50 per annum to keep value up to £300.

* replacement.

*Table* 3.

Labour Costs (£).

| Year. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Plantation* | | | | | | | | | | |
| Nursery .... .... .... | 1,330 | 1,995 | 3,325 | 3,325 | .... | .... | .... | .... | .... | .... |
| Land Preparation .... | .... | 4,165 | 6,940 | 8,325 | 8,325 | .... | .... | .... | .... | .... |
| Planting .... .... .... | .... | .... | 3,000 | 5,000 | 6,000 | 6,000 | .... | .... | .... | .... |
| Maintenance .... .... | .... | .... | 2,070 | 5,520 | 9,660 | 12,765 | 11,040 | 8,970 | 6,900 | 6,900 |
| Fertilizing .... .... | .... | .... | 225 | 825 | 1,250 | 2,250 | 3,100 | 3,700 | 4,000 | 4,000 |
| Bush formation .... .... | .... | .... | 3,000 | 5,000 | 6,000 | 6,000 | .... | .... | .... | .... |
| Pruning .... .... .... | .... | .... | .... | .... | .... | .... | .... | 2,000 | 2,000 | 2,000 |
| Plucking (*a*) .... .... | .... | .... | .... | 980 | 4,230 | 11,150 | 21,090 | 30,620 | 37,385 | 39,785 |
| Tractor driver (1) .... | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 |
| *Factory* | | | | | | | | | | |
| Permanent staff (*b*) .... | .... | .... | .... | 1,860 | 1,860 | 1,860 | 1,860 | 1,860 | 1,860 | 1,860 |
| Mechanic .... .... | .... | .... | .... | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Clerk .... .... .... | .... | .... | .... | 400 | 400 | 400 | 400 | 400 | 400 | 400 |
| Carpenters (2) .... .... | .... | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 |
| Tea Maker .... .... | .... | .... | .... | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 |
| Driver .... .... .... | .... | .... | .... | 130 | 130 | 130 | 130 | 130 | 130 | 130 |
| *Management/supervision* | | | | | | | | | | |
| Manager .... .... .... | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 |
| Asst. Manager .... .... | .... | .... | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 |
| Directors' Fees (*c*) .... | 500 | 500 | 500 | 1,000 | 1,000 | 1,000 | 1,000 | 1,500 | 1,500 | 1,500 |
| TOTAL .... | 5,460 | 10,790 | 25,690 | 41,795 | 48,285 | 50,985 | 48,050 | 58,610 | 63,605 | 66,005 |

(a) Includes foreman pluckers, reaching 15 at full production.

(b) Includes foremen.

(c) Includes travelling expenses.

*Financial Data.*

Field Costs. (See Table 3—labour costed at 6s. a day).

Field Costs—labour costed at 6s. per day.

*Nursery Preparation*—£665 per acre.

*Land Preparation*—includes burning, ploughing, lining, holing, shade (temporary and permanent), drainage—£28 per acre.

*Planting*—includes replacements—£20 per acre.

*Maintenance*—weeding—
£13.8 to third year in field
£6.9 subsequently.

*Fertilizing*—labour in spreading—
First year in field—£1 per acre.
Second year in field—£2 per acre.
Third year in field—£3 per acre.
Fourth year in field—£4 per acre.

*Bush Formation*—£20 per acre.

*Pruning*—plantation pruned at estimated annual cost of £2,000 after year 7.

*Tractor driver*—£130 per annum.

*Plucking*—2d. per lb. green leaf.

| Buildings—( see Table 1). | Estimated Cost. | Year of Construction. |
|---|---|---|
| Manager's house * .... .... | 6,000 | 1 |
| Asst. Manager's house * .... | 5,000 | 2 |
| Tea Maker's house * .... | 5,000 | 3 |
| Labour quarters .... .... | 15,000 | 2 |
| Married native quarters (6) | 5,000 | 4 |
| Ration stores and tool shed | 1,500 | 2 |
| Machinery shed and workshop | 3,000 | 4 |
| Tea factory (including office) 11,700 square feet (2-storey) | 35,000 | 3 |
| Tea store shed .... .... | 1,000 | 5 |
| | £76,500 | |

* Includes furniture and fittings.

| Factory Machinery—(see Table 2). | Estimated Cost. |
|---|---|
| Withering troughs (10)—40 h.p. .... | £3,600 |
| C.T.C. unit—48-inch, 3 units * plus spare roller—50 h.p. | 8,500 |
| Ball breaker and aerator—4 h.p. .... | 1,000 |
| Drier—1 x 6 feet—7 h.p. .... .... | 10,700 |
| Stalk Extractors (2)—4 h.p. .... .... | 1,300 |
| Heat exchange units (2)—14 h.p. .... | 1,500 |
| Packer—4 h.p. .... .... .... | 500 |
| Generating equipment—3 x 50 k.v.a. includes wiring, lighting, etc. | 18,000 |
| Fermenting trays (100) 3 feet x 2 feet | 1,000 |
| Racks .... .... .... .... | 200 |
| Trolleys (6) .... .... .... | 300 |
| Storage Bins .... .... .... .... | 500 |
| Scales (2) .... .... .... .... | 400 |
| Hand tools .... .... .... .... | 300 |
| Foundations—machinery .... .... | 5,200 |
| Freight .... .... .... .... | 13,000 |
| | £66,000 |

* Or equivalent Rotorvane & C. T. C. machines.

| Field Machinery (see Table 2). | Estimated Cost (£). | Year of Purchase. |
|---|---|---|
| Tractor, trailer, implements | 2,000 | 1 |
| Tractor and trailer .... | 1,400 | 7 |
| | £3,400 | |
| **Motor Vehicles.** | | |
| Small 4-wheel drive .... | 1,200 | 1 |
| Truck—5-ton .... | 3,000 | 5 |
| | £4,200 | |
| **Office Equipment.** | 100 | 1 |
| | 200 | 2 |
| | £300 | |
| Roads (2 miles). .... | £3,000 | 1, 2, 3 |
| Fences (6 miles). .... | £2,400 | 1, 2, 3, 4 |

Plant Operating Expenses.

*Fuel*—Fuel costs have been estimated at 6s. per gallon until Year 5. This figure includes freight costs. After Year 5, fuel will be flown into the area on the inward charter flights at a cost of 2s. 9d. per gallon (duty paid), Madang.

*Oils and Greases*—have been assessed at ten per cent. of the fuel cost.

*Spare parts*—to cover tyres, etc., on agricultural equipment, vehicles, etc., spare parts for this equipment together with factory equipment.

| | |
|---|---|
| Years 1-4 .... | £150 per annum. |
| Year 5 .... | £300 per annum. |
| Year 6 .... | £400 per annum. |

Fertilizer.

Estimated cost on wharf Madang £40 per ton. Freight cost (Madang-Mount Hagen) to Year 4, £20 per ton. After Year 3, freight included in charters :—

| | |
|---|---|
| Year 3 .... .... .... .... | £225 |
| Year 4 .... .... .... .... | 550 |
| Year 5 .... .... .... .... | 1,250 |
| Year 6 .... .... .... .... | 2,250 |
| Year 7 .... .... .... .... | 3,100 |
| Year 8 .... .... .... .... | 3,700 |
| Year 9 and thereafter .... .... | 4,000 |

Salaries.

| | |
|---|---|
| Manager * .... .... .... | £3,500 |
| Assistant Manager * .... | 2,500 |
| Tea Maker * .... .... | 2,500 |
| Carpenters (2) .... .... | 250 each |
| Driver .... .... | 130 |
| Clerical Assistant .... .... | 400 |
| Foreman pluckers (15) .... | 130 each |
| Mechanic .... .... .... | 300 |
| Factory foreman (2) .... .... | 130 each |
| Factory staff (16) .... .... | 100 each |

* Includes leave, superannuation, etc., where applicable.

Directors' Fees.

| | |
|---|---|
| Year 1 | £500 |
| Year 3 | 750 |
| Year 5 | 1,500 |

Packaging.

*Tea chests*—assumed equal numbers of full chests and half chests.

Average costs. c.i.f. Madang (ex Japan)—full chests —13s. 7d.

c.i.f. Madang (ex Japan)—half chests —11s. 3d.

*Stencils, etc.* 5 per cent. of cost :

| | |
|---|---|
| Full chests | 14s. 3d. |
| Half chests | 11s. 10d. |

| Cost per year. | £ |
|---|---|
| Year 4 | 130 |
| Year 5 | 620 |
| Year 6 | 1,650 |
| Year 7 | 3,140 |
| Year 8 | 4,600 |
| Year 9 | 5,570 |
| Year 10 | 5,930 |

Repairs and Maintenance.

Buildings—2½ per cent. of original cost.
Agricultural equipment—15 per cent.
Plant and machinery—5 per cent.
Motor vehicles—15 per cent.
Fences—2½ per cent.
Roads—£150 per mile per annum.
Office equipment—covered in office expenses.

Interest.

Interest has been treated as the cost of capital and has been assessed at 6 per cent. It has been assumed that the outflow of money during each year will be fairly constant and interest on the debit balance in any year has been charged at half of the annual rate. Interest on the cumulative balance brought down has been assessed at 6 per cent.

Depreciation Rates.

These have been calculated according to *Income Tax Ordinances* 1959-1961 for the Territory of Papua and New Guinea. For the machinery in the factory, average rates have been determined as some of the machinery is not listed in the Ordinance. The rates are as follows :—

| | Per cent. |
|---|---|
| Expatriate housing—timber frame and walls | 3 |
| Indigenous housing—concrete | 3 |
| Factory—concrete floors, steel frame | 4 |
| Machinery foundations | 3 |
| Machinery (averaged) | 10 |
| Sheds, etc.—concrete floor, steel frame | 3 |
| Fences—netting | 10 |
| Agricultural equipment and vehicle | 20 |
| Office equipment | 10 |

Depreciation has been calculated on the diminishing value of the asset method.

Freight.

Included in cost of items. From Year 4 no freight component included, as all items carried on inward flights of charters which carry tea out.

Charter flights—Madang/Mount Hagen/Madang estimated at £150—D.C.3 type of aircraft.

At the present time, the maximum permissible D.C.3 load from Madang is 7,500 lb. and from Mount Hagen 6,000 lb.

Land Rent.

Land rent has been estimated at 12s. per acre but this figure is subject to revision.

Formation Expense.

This item has been estimated at £300—Year 1.

General Charges.

Office expenses (including stationery, etc.)
Year 1—£100.
Year 2—£200.

Insurance.

Year 4 onwards at £1 per £100—£1,500 per annum.

Income.

Average price of tea has been estimated at 4s. 3d. (Australian) per lb. The main budget has been calculated at this price but a range of prices has been used, namely 3s. 9d., 4s. 3d. and 4s. 9d. per lb. in estimating profitability.

Marketing Costs.

Handling charges, freight (to Australia) and insurance have been calculated at 4½d. per lb. and agents' commission at 3 per cent. on selling price.

Price at factory — 4s. 3d. less 4½d. less 2d.
= 3s. 8½d. per lb.

Corresponding adjustments to agents' commission have been made for the other estimated prices ; namely

At 3s. 9d., at factory — 3s. 9d. less 4½d. less 1½d.
= 3s. 3d. per lb.

At 4s. 9d., at factory — 4s. 9d. less 4½d. less 2d.
= 4s. 2½d. per lb.

Replanting Provision.

The net cost of field establishment alone has been estimated at—

(*a*) £130,000—tea at 4s. 3d. lb. (3s. 8½d. lb. airstrip Madang).

(*b*) £137,000—tea at 3s. 9d. lb. (3s. 3d. lb. airstrip Madang).

(*c*) £116,000—tea at 4s. 9d. (4s. 2½d. lb. airstrip Madang).

On the basis of these establishment costs, replanting provision has been assessed on an estimated economic life of the plantation of 40 years.

| | Yield-lb./acre. | |
|---|---|---|
| Year 4 | 150 | |
| Year 5 | 450 | |
| Year 6 | 800 | |
| Year 7 | 1,000 | 2,400 |
| Full Bearing— | | |
| Years 8-30 at 1,000 lb. | — | 23,000 |

*Table 4*

**Establishment Costs (£) 1,000 acres of Tea.**

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total End of Year 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Formation Expenses .... .... | 300 | .... | .... | .... | .... | .... | .... | .... | .... | .... | 300 |
| Structural Improvements .... | 7,600 | 23,100 | 41,600 | 8,600 | 1,000 | .... | .... | .... | .... | .... | 81,900 |
| Plant and Equipment .... .... | 3,600 | 150 | 50 | 66,050 | 3,050 | 1,250 | 1,450 | 2,050 | .... | .... | 74,150 |
| Staff .... .... .... .... | 5,460 | 10,790 | 25,690 | 41,795 | 48,285 | 50,985 | 48,050 | 58,610 | 63,605 | 66,005 | 183,005 |
| Plant Operating Expenses .... | 370 | 820 | 820 | 820 | 1,490 | 2,070 | 3,580 | 5,060 | 6,040 | 6,400 | 6,390 |
| Fertilizer .... .... .... | .... | .... | 225 | 550 | 1,250 | 2,250 | 3,100 | 3,700 | 4,000 | 4,000 | 4,275 |
| Packaging .... .... .... | .... | .... | .... | 130 | 620 | 1,650 | 1,140 | 4,600 | 5,570 | 5,930 | 2,400 |
| Air Charters .... .... .... | .... | .... | .... | 700 | 2,800 | 7,420 | 14,000 | 19,880 | 24,920 | 28,460 | 10,920 |
| *Overhead—* | | | | | | | | | | | |
| Rent .... .... .... .... | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 3,600 |
| Office Expenses .... .... | 100 | 100 | 200 | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 | 5,500 |
| Miscellaneous .... .... | 100 | 150 | 150 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 1,150 |
| Annual Outflow .... .... .... | 18,130 | 35,710 | 69,335 | 121,195 | 61,045 | 68,175 | 75,870 | 96,450 | 106,685 | 111,345 | 373,590 |
| Income—at 3s. 8½d. at Madang .... | .... | .... | .... | 4,170 | 19,470 | 51,450 | 98,260 | 143,700 | 174,290 | 185,420 | 75,090 |
| Debit Balance .... .... .... | 18,130 | 35,710 | 69,335 | 117,025 | 41,575 | 16,725 | +22,390 | +47,250 | .... | .... | 298,500 |
| Interest: 6 per cent. ‡ .... | 545 | 1,070 | 2,080 | 3,510 | 1,250 | 500 | .... | .... | .... | .... | 8,955 |
| Total Annual Debit .... .... | 18,675 | 36,780 | 71,415 | 120,535 | 42,825 | 17,225 | +22,390 * | .... | .... | .... | 307,455 |
| Cumulative Debit b/d .... .... | .... | 18,675 | 56,575 | 131,385 | 259,805 | 318,220 | 354,540 | .... | .... | .... | .... |
| Interest on Cumulative debit b/d | .... | 1,120 | 3,395 | 7,885 | 15,590 | 19,095 | 21,270 | .... | .... | .... | 47,085 |
| Total Cumulative debit c/d .... | 18,675 | 56,575 | 131,385 | 259,805 | 318,220 | 354,540 | 353,420 | .... | .... | .... | Say £355,000 |

‡ See note on interest - all charged to nearest £5.

* Credit balance.

Decreasing Yields—

| | |
|---|---|
| 10 years at average of 700 lb.— | 7,000 |
| | 32,400 |

Total yield for 1,000 acres = 32.4 million lb.

Establishment Costs—At 4s. 3d. lb.—£130,000.

Replanting provision is—

$$\frac{32,400,000}{130,000} = 0.96\text{d. per lb.}$$

At other establishment costs for plantings—

3s. 9d. lb. .... 1.0d. per lb.

4s. 9d. lb .... 0.86d. per lb.

***Budget of Establishment Costs.***

This budget was formed to estimate the liability a company would incur before a tea estate of 1,000 acres, developed according to the plan shown, became productive. The problem is to find the break-even point, which is where the annual net inflow of money first exceeds the outflow. The establishment cost is equal to the cumulative total of net annual cash outflow plus the compound interest on the capital required, up to the break-even point.

Establishment costs will be influenced by the selling price of tea and in this budget the price has been assessed at 4s. 3d. lb., i.e., 3s. 8½d. lb., delivered airstrip Madang. Table 4 shows the establishment cost for the estate when the selling price of tea is 3s. 8½d. lb. It is estimated that approximately £355,000 is the liability a company would incur before the estate became productive. The break-even point is in Year 7, when income first exceeds cash costs. The establishment cost of the estate is reflected in the cumulative debit balance (including interest) brought down at the beginning of Year 7, which is the same as the cumulative balance carried down at the end of Year 6.

Similar budgets of establishment costs were calculated for selling prices of 3s. 9d. lb. and 4s. 9d. lb., i.e., delivered price Madang airstrip of 3s. 3d. lb. and 4s. 2½d. lb. respectively. At 3s. 9d. lb. establishment costs were assessed at about £370,000 with the break-even point in Year 8. At 4s. 9d. lb. the corresponding figure was £345,000 in Year 7.

Table 4 summarises the major items of the establishment costs at 4s. 3d. lb. Labour costs account for approximately 43 per cent. of the establishment costs, followed by structural improvements 19 per cent., plant and equipment 17 per cent., interest (annual and compound) 13 per cent.

***Principal Items of Establishment Cost.***

| | | | |
|---|---|---|---|
| Staff | | | |
| Plantation .... .... | 129,435 | | |
| Factory .... .... | 18,070 | | |
| Management/Supervision | 35,500 | £183,005 | 43% |
| Plant and Equipment .... .... | | 74,150 | 17% |
| Structural Improvements .... .... | | 81,900 | 19% |
| Interest. | | | |
| Annual .... .... | 8,955 | | |
| Compound .... .... | 47,085 | 56,040 | 13% |
| Other .... .... .... | | 34,535 | 8% |
| | | 429,630 | 100% |
| Tea Income .... .... | | 75,090 | 17% |
| | | 354,540 | 83% |
| | (say) | £355,000 | |

This is equivalent to £355 per acre of tea.

***Budgets of Income and Returns.***

The establishment cost budget shows only the estimated total liability of the estate. When income exceeds annual expenditure, it is necessary to construct a production budget.

Three prices are used in the following budgets (Tables 5, 6 and 7) which show costs for years 8, 9 and 10, together with the estimated rate of return on capital.

(Received May, 1964.)

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*Table* 5. PRODUCTION BUDGET YEAR 8.

| | Price 3s. 3d. lb. | | Price 3s. 8½d. lb. | | Price 4s. 2½d. lb. | |
|---|---|---|---|---|---|---|
| Gross Income—775,000 lb. | | | | 143,700 | | 163,070 |
| Costs— | | | | | | |
| Labour | | | 58,610 | | 58,610 | |
| Plant Operation | | | 5,060 | | 5,060 | |
| Fertilizer | | | 3,700 | | 3,700 | |
| Repairs | | | 6,700 | | 6,700 | |
| Packaging | | | 4,600 | | 4,600 | |
| Aircraft charters | | | 19,880 | | 19,880 | |
| Rent | | | 600 | | 600 | |
| Office expenses | | | 1,700 | | 1,700 | |
| Depreciation | | | 8,020 | | 8,020 | |
| Replanting provision | | | 3,100 | | 2,780 | |
| Miscellaneous | | | 100 | | 100 | |
| Gross Costs | | | | 112,070 | | 111,750 |
| Surplus | | | | 31,630 | | 51,320 |
| Interest 6 per cent. | | | 355,000 | 21,300 | 345,000 | 20,700 |
| Return to operator | | | | 10,330 | | 30,620 |
| Return to capital | | | | 26,630 | | 46,320 |
| Per cent. return to capital | | | | 7.5 | | 13.4 |

*Table* 6. PRODUCTION BUDGET YEAR 9.

| | Price 3s. 3d. lb. | | Price 3s. 8½d. lb. | | Price 4s. 2½d. lb. | |
|---|---|---|---|---|---|---|
| Gross Income—940,000 lb. | | 152,700 | | 174,290 | | 197,790 |
| Costs— | | | | | | |
| Staff | 64,605 | | 64,605 | | 64,605 | |
| Plant operation | 6,040 | | 6,040 | | 6,040 | |
| Fertilizer | 4,000 | | 4,000 | | 4,000 | |
| Repairs | 6,700 | | 6,700 | | 6,700 | |
| Packaging | 5,570 | | 5,570 | | 5,570 | |
| Aircraft charters | 24,920 | | 24,920 | | 24,920 | |
| Rent | 600 | | 600 | | 600 | |
| Office expenses | 1,700 | | 1,700 | | 1,700 | |
| Depreciation | 7,680 | | 7,680 | | 7,680 | |
| Replanting provision | 3,920 | | 3,760 | | 3,370 | |
| Miscellaneous | 100 | | 100 | | 100 | |
| Gross Costs | | 125,835 | | 125,675 | | 125,285 |
| Surplus | | 26,865 | | 48,615 | | 72,505 |
| Interest 6 per cent. | 370,000 | 22,200 | 355,000 | 21,300 | 345,000 | 20,700 |
| Return to operator | | 4,665 | | 27,315 | | 51,805 |
| Return to capital | | 21,865 | | 43,615 | | 67,505 |
| Per cent. return to capital | | 5.9 | | 12.3 | | 19.6 |

*Table* 7. PRODUCTION BUDGET YEAR 10.

| | Price 3s. 3d. lb. | | Price 3s. 8½d. lb. | | Price 4s. 2½d. lb. | |
|---|---|---|---|---|---|---|
| Gross Income—1,000,000 lb. | | 162,000 | | 185,420 | | 210,420 |
| Costs— | | | | | | |
| Staff | 66,005 | | 66,005 | | 66,005 | |
| Plant operation | 6,400 | | 6,400 | | 6,400 | |
| Fertilizer | 4,000 | | 4,000 | | 4,000 | |
| Repairs | 5,570 | | 5,570 | | 5,570 | |
| Packaging | 5,930 | | 5,930 | | 5,930 | |
| Aircraft charters | 26,460 | | 24,460 | | 24,460 | |
| Rent | 600 | | 600 | | 600 | |
| Office expenses | 1,700 | | 1,700 | | 1,700 | |
| Depreciation | 6,710 | | 6,710 | | 6,710 | |
| Replanting provision | 4,170 | | 4,000 | | 3,580 | |
| Miscellaneous | 100 | | 100 | | 100 | |
| Gross Costs | | 127,645 | | 127,475 | | 127,055 |
| Surplus | | 34,855 | | 57,945 | | 83,365 |
| Interest 6 per cent. | 370,000 | 22,200 | 355,000 | 21,300 | 345,000 | 20,700 |
| Return to operator | | 12,655 | | 36,645 | | 62,665 |
| Return to capital | | 27,855 | | 52,945 | | 78,365 |
| Per cent. return to capital | | 7.5 | | 14.9 | | 22.7 |

# Book Review.

*Second Report of the Joint FAO/WHO Expert Committee on Meat Hygiene.* (*FAO/WHO, Rome,* 1962).

The first report of the Joint FAO/WHO Expert Committee on Meat Hygiene was published in 1955. It was confined to a discussion of problems associated with domestic livestock and emphasized those meat hygiene questions mainly associated with the abattoir and the investigation and prevention of meat-borne diseases in man. The second report broadens the scope of the discussion but at the same time includes many parts of the first report so that this publication presents a complete treatment of the subject.

The report stresses the point that meat hygiene measures should cover the period from a time on the farm before the animal is transported to the abattoir, through its journey to and through the abattoir until the final meat product is consumed. It also includes a separate section on meat hygiene as it applies to poultry although it points out that the underlying principles of hygiene are the same for all types of food animals. The special problems of meat hygiene in warm weather countries are also included as well as factors that have recently developed including the use of irradiation and antibiotics for meat preservation, and the presence of radio-nuclides, insecticides and other residues of possible toxicity, including those of pharmaceutical preparations and agricultural chemicals.

The committee has concentrated on general principles, rather than on specific detailed recommendations, bearing in mind factors pertinent to both economically advanced and developing countries. Although general principles only are stated a bibliography gives further papers in which detailed information can be obtained on the various topics.

The main underlying principle in the report is that meat provides an excellent source of protein for human nutrition and that the present world scarcity of protein makes it necessary to conserve and utilize meat supplies to their fullest extent. This emphasises the need for a meat hygiene service which will ensure a wholesome product for human consumption with improved keeping qualities, and which will make an important contribution to livestock disease control.

In discussing the principles and objectives of meat hygiene in relation to quality and standards a list of controls necessary to ensure a safe meat supply is given as follows :—

1. The use of pharmaceutical preparations and agricultural chemicals on the farm.
2. Care of the animal during transport and at collecting centres and depots.
3. Examination of the animal before slaughter to ensure the elimination of unfit animals.
4. Examination of the carcase and parts of the carcase immediately after slaughter, to separate the normal wholesome product for human food from diseased or otherwise unfiit material.
5. Separation of unfit material from edible products in a way that will avoid contaminating edible products.
6. Removal and destruction of all diseased and otherwise unfit materials to ensure their elimination from the food supply.
7. Adoption of such environmental sanitation controls as will obviate the contamination of edible products.
8. Prohibition of the addition of harmful material in the handling and preparation of the edible products.
9. Adequate hygienic supervision of meat-processing plants, food stores and restaurant kitchens to ensure complete sanitation control of the meat and meat products to the point of consumption.

The fulfilment of the basic principles of meat hygiene by the rigid application of these controls should be the aim in all communities.

The report outlines the methods of reporting outbreaks of "food-borne infections and intoxications" (this phrase being recommended as the best general term describing illness due to the ingestion of contaminated foodstuffs) and also points out that in all countries the reporting of food-borne infections and intoxications is incomplete. A firm recommendation that reporting methods must be improved is included.

It is unfortunate that the Annex of the Report on the Design of Abattoirs has been simply reprinted from the earlier report of the committee because the information is out of date. However, reference is made to the later publiction of the United States Department of Agriculture which gives more up-to-date details.

In stating the special problems of meat hygiene in tropical and developing countries the point is made that good meat hygiene practices cannot be legislated into existence where there is no sound economic basis. A second point made is that meat, probably more than any other food product, is subject to the strictures, taboos and restrictions imposed by religious and other prejudices so that all good meat hygiene practices although they produce a safe and wholesome product may violate these deep rooted customs. Both these points have a bearing on meat consumption in this Territory especially the first one in relation to the slaughter of village pigs. However in some countries rapid progress has been made where new procedures have been introduced into primitive areas demonstrating greater efficiency and economy of preparation of meat for consumption. Similar progress could be expected he:e.

The report is a very valuable publication for all those involved in the preparation of meat for consumption and in particular provides a valuable addition to the small amount of current information on the broad aspects of meat hygiene.

T. L. Rothwell.

Port Moresby. V. P. Bloink, Government Printer.—12410/7.64.

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