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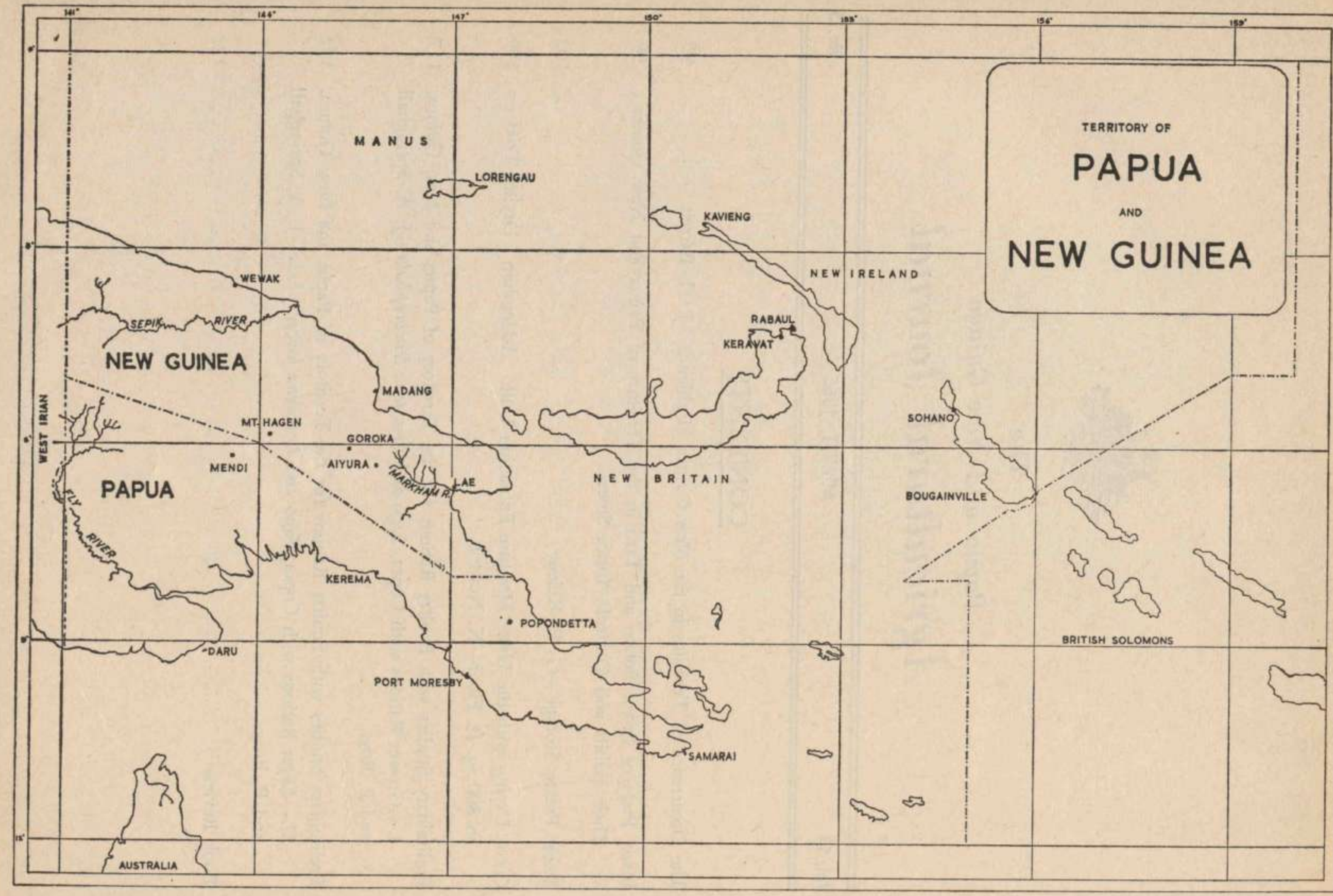

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LAE
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PAPUA
FLY RIVER
KEREMA
POPONDETTA
BRITISH SOLOMONS
DARU
PORT MORESBY
SAMARAI
AUSTRALIA

The Occurrence of Termites in the New Guinea Highlands.

J. H. BARRETT.*

Approximately fifty species of Termites (White-Ants) have been recorded from the Papuan Zoogeographical Region. A further dozen or so have been collected but remain undescribed. There are no published records of termites from the Highland areas above 5,000 *feet ; the first collection was made as late as* 1955. *Since* 1957 *some ten species have been collected in this region, and a few at lower elevations on the margins of the area. About six of these are unnamed. This paper gives information on the material collected and details of value to agricultural officers, planters and others who may have the opportunity to collect specimens of this group which is so poorly known in the Highlands.*

1. THE COLONY.

TERMITES occur in colonies consisting of workers, nymphs, lesser number of soldiers and a pair or more reproductive individuals. Undeveloped reproductives perform as workers in some species. The *workers* or the *nymphs* are usually soft and pale coloured. The *soldiers* are usually, but not always, larger and often have darker bodies than the workers. The characteristic feature of the soldier is the head which is relatively large and sometimes has large mandibles, or it may be produced to a point in front (nasute). Except in primitive species or young colonies the *queen* is large and may be enormous in size, due to distention of the abdomen with eggs. The thorax and head are darker than the rest of the body. The male is similar to the undistended female.

At certain times of the year the colony contains winged individuals (*alates*) which are the virgin reproductives. These leave the nest on a colonizing flight when outside conditions are suitable. Such flights are seen occasionally in the Highlands and numbers may come to light. After flight the wings are shed and the paired male and female (king and queen) settle down in a suitable site to form a new colony.

A colony may construct a series of galleries in a restricted area of soil, or may build extensions and develop smaller colonies in rotting logs, stumps, or debris. With many species the complete colony is in a log, or in the trunk or dead branch of a standing tree. The conspicuous nests above ground or on trees, constructed by the workers of certain advanced species, have not been noted in the Highlands.

2. SOME FIELD CHARACTERISTICS OF GENERA FROM THE HIGHLANDS AND NOTES ON COLLECTIONS.

Capritermes :

The soldiers have grotesque black asymmetrical snapping mandibles (*Figure* 1), and can be heard to "click" quite loudly when dropped into alcohol. Colonies have been found in soil, and may be expected in the open country or under logs.

The first records are of a species of *Capritermes* from Tari in December, 1955, collected by Mr. D. A. Johnstone of the Methodist Mission. He again collected them in July, 1956, and August, 1957 (with alates) at Mendi.

When the author took up duty at Aiyura in July, 1957, these were the only records of termite collections in the Highland areas above 5,000 feet. Since that time small numbers have been taken, mainly at light, at Aiyura in the Kainantu Subdistrict. A number of colonies have also been located in this area and further material has come from areas below 5,000 feet. However, the fauna is still very poorly known and odd collections sent to local agricultural officers or entomologists will be most valuable.

Colonies of two species of *Capritermes* have been found, all being in the ground. *Capritermes schultzei* Holm.: Asaranka Village, Aiyura

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(5,400 ft.) February, 1963. The alates were flying and a large series was obtained (CSA 33.).*

A nest series was collected in January, 1963, at Namoora Village, Kainantu. A further collection was made at the Baiyer River Station, Mount Hagen, Western Highlands (4,000 ft.) January, 1963, in a pasture area (CSA 36). Alates were not present.

A second species was also collected at Baiyer River—August, 1957—while sampling the airstrip area for Scarab beetle larvae.

The taxonomy of this group is under review and this generic name may not be valid in all cases. More than one genus may be involved when a definitive work is published.

Neotermes :

Species of *Neotermes* collected have been very large termites from fairly dry stumps and firewood. The soldiers have a very large reddish brown head (*Figure* 2), and the alates are large and pale brown.

Two *Neotermes* species have been collected. One was in firewood from Kefano (5,500 ft.) near Goroka (Mr. E. Wilkinson of the Department of Health) in April and May, 1958, and the specimens were passed to the entomologist by the District Agricultural Officer. The colony was maintained in the laboratory at Aiyura and alates were produced some seven months later.

A *second* species, unnamed, was collected at light at Aiyura (5,400 ft.) in October, 1957, January and February, 1960 ; at Wapenamanda, Western Highlands (5,000 ft.) in March, 1962 ; and a dry specimen, probably of this species, was taken from an electric lamp shade in a house at Kerowaghi (5,300 ft.) in January, 1963. Colonies were located at Aiyura, Kainantu and Yonke when Dr. Emerson visited the area in January, 1963. Specimens (CSA 32) were taken from a partly rotten log in the Aiyura forest in June, 1963, a large series of alates being obtained (*Plate* I).

* Numbers CSA 1—CSA 45 refer to the Aiyura collection ; duplicate series of this is being kept at C.S.I.R.O., Canberra, and some at the American Museum of Natural History, New York.

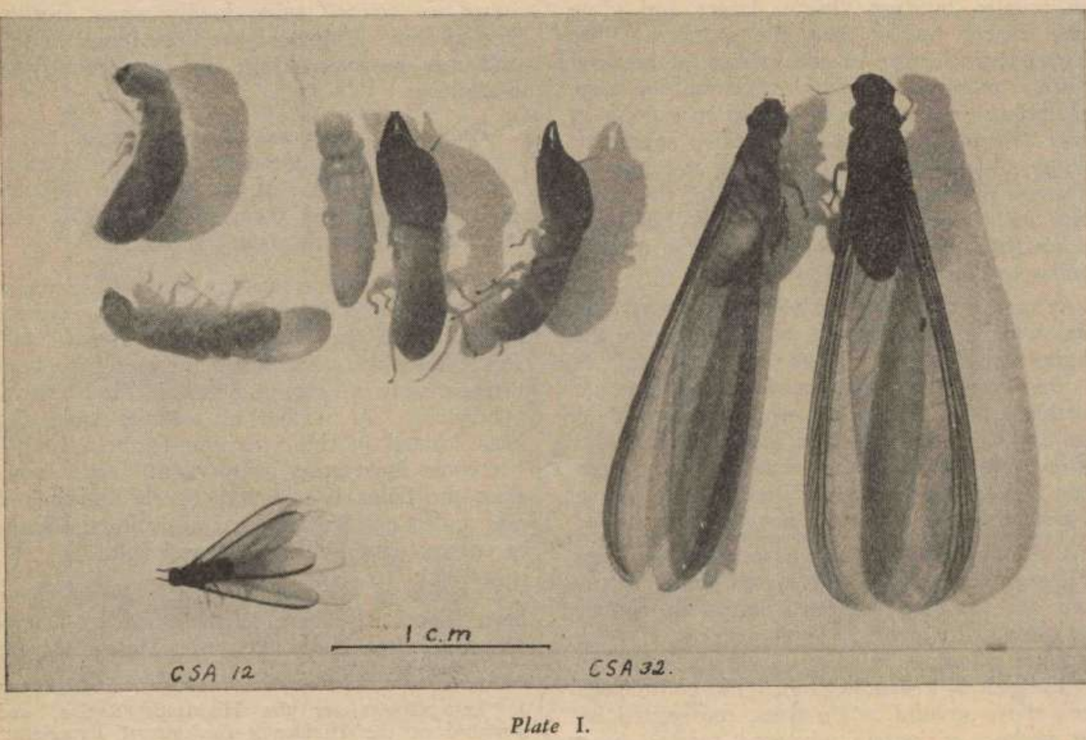

Plate I.

Fig. 1

Fig. 2

Fig. 3

Fig. 4A

Fig. 4B

Glyptotermes :

Species of *Glyptotermes* collected have been small, and rather elongate and cylindrical in form. The soldiers are dark in colour and have heads which are truncated in front. The alates are small and the wings are very dark (*Plate* I). Colonies were small and were found in the ends of logs, and may be inhabitants of dead limbs.

G. xantholabrum Hill was collected at Omaura (4,500 ft.), in the Kainantu District in December, 1958, and the alates emerged in the laboratory in August-September, 1959, (CSA 12). The nest was in the rotten base of a softwood post in a sawmill shed at the mission.

An undescribed species of *Glyptotermes* has been collected at light at Aiyura—October, 1957, November, 1957, November, 1958, and January, 1959. A colony with soldiers and workers was taken in the forest (Aiyura 5,600 ft.) in a rotten log in July, 1962. A further collection was made at Kainantu in January, 1963.

Schedorhinotermes :

Species of *Schedorhinotermes* are of average size but have two types of soldiers, a major and a minor. The *major* soldier (*Figure* 4B) has a fairly large pale brown head with strong biting jaws, but the *minor* (*Figure* 4A) is smaller and has weaker jaws and a prolonged upper lip. The queens are pale, fairly large, and distended. They seem to prefer rather wet situations in well rotted logs and stumps and usually there is very good contact with the ground. Colonies have been relatively large.

S. dimorphus robustior (Silv.) was collected in sawdust at Omaura in May, 1958.

Another species is relatively common at light and collected at Aiyura in July, 1957, January, 1959, January, 1960 (general flight), April, 1960, and February, 1963 ; at Subitana, Sogeri Plateau (1,800 ft.), Central District April, 1957 ; and at Tage, Lake Kutubu (2,800 ft.) October, 1960 (general flight at dusk). A number of colonies have been located at Aiyura. They have been found in the forest (stumps and logs), in a refuse heap, and in an old box of leaf-mould from the forest (July, 1960, September, 1962). Alates were taken from a colony in July, 1963 (CSA 29). They are not uncommon in the Kainantu-Yonke area, but alates were not found in colonies examined in January, 1963. A further nest was found at Arau (4,500 ft.) in October, 1959, by Dr. T. C. Maa.

Nasutitermes :

This group has soldiers with pear shaped heads (*nasutes*). The front of the head is produced into a long fine point (*Figure* 3) which carries the outlet of a gland producing repellant substances. The mandibles are reduced and this contrasts with the large mandibles of soldiers of other groups. Colonies have been located in stumps.

A colony was located in a small dead log on the Tairora Creek (5,000 ft.) near the Abiera Road, in July, 1958, and was again collected at the same site in January, 1963, by Dr. Emerson, and also near Kainantu. Alates of this genus came to light at Erave (3,800 ft.), Southern Highlands, in October, 1960 (CSA 26).

3. ADVICE ON COLLECTING.

Alates of various termites are occasionally seen at house lights and can be easily collected. They may be preserved in 85 per cent. alcohol, or a mixture of one part of water to $5\frac{1}{2}$ parts of methylated spirit may be used. When colonies are found they can be opened up and, besides a series of workers, soldiers should be collected. Careful searching may be necessary to collect soldiers but a dozen or so should be taken if possible. In some species there are two types of soldiers. When a nest is opened a few minutes observation will usually reveal a number of soldiers coming to openings of the broken gallery ; but this is not always the case and the retreat of both workers and soldiers may be fairly rapid. If eggs or small white nymphs are seen the queen is probably close by and may be found by a careful search. The alates may be present and are very valuable in a nest series. However, single alates, or series of workers and soldiers only, can be identified. They can be identified if a full series has been previously taken, or when associated alates, workers and soldiers are eventually collected.

All tubes should have a piece of paper inside with *date, locality, elevation, collector's name,* and a note on the *habitat*, written in *lead pencil.*

The limited distribution of the recorded species is a reflection of the small amount of collecting in particular areas and there is no doubt that much interesting material and more species are to be obtained in the Highland areas. Colonies are often difficult to find and so chance finds are very valuable if properly labelled series are collected.

4. ECONOMIC STATUS.

Of the species listed, *Schedorhinotermes* are the most common in terms of colonies. There is a general preference for partially rotten wood in damp situations and attack on wood in or on the ground could be expected.

There has been a recent report of general damage to a building at Togaba in the Mount Hagen area by termites of an unidentified genus.

At Bulolo (2,200 ft.) termites are a problem in Hoop Pine, *Araucaria cunninghamii* stands a few years after the trees are planted in new areas. The species involved are original inhabitants of the forest and attack develops as old stumps and logs decay and become unsuitable as food for the old established colonies. These species have not been collected in the Highlands and are probably restricted to areas below 5,000 ft. in elevation.

The case at Togaba is the only one reported to date in the Highland region.

Introductions of species from coastal areas are most likely but the chances of survival are considered to be small in the cooler climate. Survival of introductions from other temperate areas such as parts of Australia is possible.

An introduction to Lae is worthy of mention since it indicates the insidious nature of a termite problem. *Mastotermes darwiniensis* Frogg., the Giant White Ant of Northern Australia, was apparently brought to Lae from Darwin in the early 1940's. Its presence was not noted for well over ten years. In spite of the fact that the infested area was relatively small, eradication is not complete after some three years of work. The difficulty of the problem with this species is an example of what could develop in the Highlands should a species capable of survival be brought in.

Transport of termites is also possible in the opposite direction. Logs from New Guinea examined by the author on their arrival in Brisbane in January, 1955, carried termites determined as *Coptotermes elisae* Des., a common species at lower altitudes in New Guinea.

Collection of termites at every opportunity will give early warning of such introductions as well as provide basic data on distribution and habits of native species.

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5. ACKNOWLEDGEMENTS.

Dr. J. J. H. Szent-Ivany, Senior Entomologist at Konedobu, Papua, indicated the lack of knowledge of termites in the area and stimulated the author's interest in this group of insects. Mr. Frank Gay, Principal Research Officer, Division of Entomology, C.S.I.R.O., Canberra, examined the material and made all identifications with the exception of *C. schultzei* Holm, and gave very valuable criticism of the first draft of this paper.

Dr. A. E. Emerson, previously of the University of Chicago and now working on the termite collection of the American Museum of Natural History gave valuable comments on the first draft of this paper and provided the determination of *C. schultzei* Holm. A few valuable days were spent in the field at Aiyura in January, 1963, with Dr. Emerson. Mr. R. Carne, Agronomist-in-Charge, Highlands Agricultural Experiment Station, Aiyura, and Mr. K. van Horck of Aiyura gave general assistance and collected specimens.

Laboratory assistants Kenampi Rapoke and Mokara Mongua have done much handling of material in the laboratory.

Insect Pests of Sweet Potato and Taro in the Territory of Papua and New Guinea: Their Habits and Control.

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Most of the plants grown for food in the Territory are either indigenous or have been grown for a long period of time. Thus most pests are controlled by natural factors in the environment, except for those brief periods when they have favourable conditions, and come into prominence. It is only on these occasions that chemical control measures are required.

The plants covered in this article are sweet potato and taro, and are probably the most widely grown food crops. The most important pests of each crop are discussed and methods of control described. It must be remembered that these food plants are mostly grown in subsistence gardens, and so the use of chemicals is restricted by economic considerations.

SWEET POTATO.

Ipomoea batatas.

THE sweet potato is probably the most important staple crop in the Territory. It was introduced here from the Western Hemisphere, where it originated, but the date or manner of introduction is not known. It has two major pests and several minor ones.

1. The Sweet Potato weevil, *Cylas formicarius* F.

This weevil is sometimes known as the " Sweet potato Ant weevil ", because of the adults' ant-like appearance. It is a small slender insect, less than ¼ inch long, metallic blue and reddish brown in colour, and can fly.

Life History.

The eggs are laid in cavities which have been chewed by the female in the surface of the stem or tuber. After hatching, the larvae bore into the plant. These larvae are stout, legless and white in colour, and grow to about one-third of an inch in length. The larvae take about three weeks to reach full size and then pupate in small cavities at the end of their tunnels in the tuber or stem. The adult may live for several months and there may be as many as eight generations in a year.

Host Plants.

The sweet potato weevil can breed in a number of plants which are related to the sweet potato, e.g., Morning Glory (*Convolvulus*). Some of these are indigenous.

Damage.

The adult weevils damage the plants by feeding on leaves, vines and roots, and pit the tubers with feeding and egg-deposition cavities. The larvae feed in both stems and tubers and do the most damage. They can cause complete loss of the crop in a particularly severe infestation.

Control.

The most effective way to control this weevil is by preventing an infestation from building up to serious proportions. This is best done by crop rotation, having at least 12 months between crops of sweet potato. Long dry seasons tend to allow a greater incidence of weevil damage, as cracks develop in the soil, allowing the weevils to reach the tubers more easily. This can be minimized by mulching and working the soil to improve the soil condition.

Once a serious infestation has developed, the following steps should be taken :

(*a*) Make sure that no planting material is taken from the infested area.

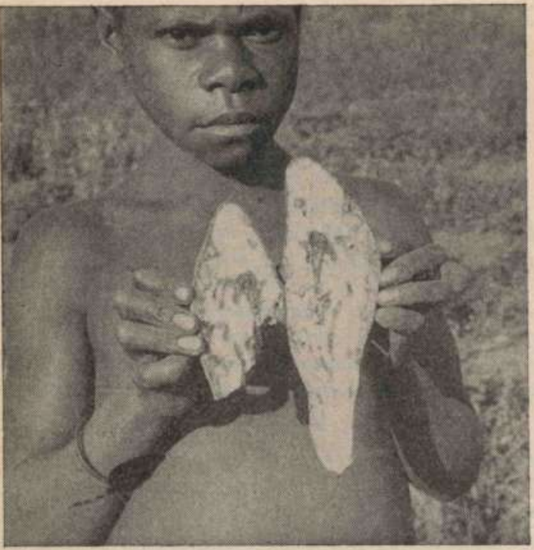

Plate 1.—Sweet Potato Tuber damaged by Sweet Potato Weevil.

[Photograph : J. J. H. Szent-Ivany.]

(*b*) Only healthy tubers should be taken away from the field ; if desired pigs can be allowed to feed on tubers remaining.

(*c*) All remaining plant material should be destroyed, and volunteer plants as well as Morning Glory should be kept under control in the proximity of the field.

(*d*) The land should not be used for sweet potato again for at least twelve months.

(*e*) New planting should be as far as possible from the infested area.

2. Sweet Potato Hawkmoth, *Agrius convolvuli* (L).

This is a typical large hawkmoth, with a robust, streamlined body and strong slender wings, spanning 4-5 inches. The forewings are grey, with various shades and with black markings. The hindwing is a lighter grey with four black bands which may be indistinct.

Life History.

The eggs are laid on the stem or leaves, on which the caterpillars feed once they have hatched. These caterpillars are green or yellowish-brown with brownish-yellow oblique stripes on the sides and with a prominent brown horn (or " tail ")—on the dorsal surface at the end of the body. When fully grown they reach a length of 4 to 4½ inches, and pupate in the soil.

Host Plants.

The only alternate host plant recorded from New Guinea, is taro.

Damage.

The caterpillars of this moth can cause severe damage to sweet potato, completely defoliating it.

Control.

The use of an 0.25 per cent. DDT emulsion is recommended for the control of this insect, when chemical control is required. It is used as a high volume spray. A 2.5 per cent. DDT mist would also be suitable.

3. Minor Pests of Sweet Potato.

The less important pests include the " Tortoise Shell Beetle ", *Aspidomorpha adhaerens* Weber, the " Spiny Weevil ", *Apirocalus cornutas* Pasc. and several small weevils in the genus *Oribius*, as well as a number of caterpillars. These insects all feed on the foliage of the sweet potato and can be controlled by the use of DDT.

TARO.

Alocasia sp., *Colocasia* sp., *Xanthosoma* sp.

There is only one genus of insects that would be considered major pests of taro. These are the beetles known as " Taro beetles ". A number of other species of insects attacking taro are considered to be of minor importance.

1. Taro Beetles. *Papuana* spp.

The most important species of *Papuana* are *P. laevipennis* Arrow and *P. huebneri*, other species (some possibly new), have not been identified, or they are of minor importance.

The Taro beetles are related to the insects known as Rhinoceros beetles, which are pests of palms (particularly coconuts), but are much smaller. They vary in size from ¾ in. to 1 in., have small horns on their heads and are usually black to dark brown in colour.

Life History.

The larvae are typical white "curl grubs", found usually in decomposing plant material in the soil around the plants, where it feeds. The life cycle of this insect varies from three to four months.

Host Plants.

Papuana sp. have not been recorded from other plants. *

Damage.

The adult beetle damages taro by feeding in the stems and roots.

Control.

0.15 per cent. Dieldrin sprayed on the ground around the taro plants, or Aldrin dust mixed in the soil will give good control.

Scoliid wasps are common parasites of the Taro beetles (they also parasitize Rhinoceros beetle). These wasps are not very efficient parasites and sometimes allow the beetle population to build up to the point where chemicals must be used to control them.

2. Minor Pests.

The most important of the minor pests include a brightly coloured small grasshopper called *Gesonia sanguinolenta* Kraus, two small bugs *Astacops villicus* Stal. and *Astacops flavicollis* Walk. and hawkmoth caterpillars (particularly *Hippotion celerio* (L) and *Agrius convolvuli* (L)).

A. convolvuli is a major pest of sweet potato. The grasshopper and caterpillars can severely defoliate the taro plants, while the bugs cause wilting of the leaves.

These insects can be controlled by 0.25 per cent. DDT or 0.05 per cent. applied as a high volume spray.

(Received March, 1965.)

* Bananas.
Potato. (Irish)
Xanthosoma sp
Colocasia sp
Coconuts.
Oil Palms
Tea Thea camellensis

Sweet Potato Storage.

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INTRODUCTION.

The sweet potato Impomoea batatas *is one of the basic food crops in the subsistence economy of the people of Papua and New Guinea, and is of predominant importance in the agriculture and diet of the Highlanders. The crop is readily propagated from cuttings or slips and under conditions of reasonable distribution of rainfall it has a growing season extending throughout most of the year. Thus, under the tropical conditions of the Territory of Papua and New Guinea the question of storage of tubers has not arisen as, with a regular planting programme, the supply of fresh tubers can be maintained. The sweet potato is essentially a plant of the tropics and sub-tropics and is very sensitive to low temperatures. Its growth is restricted by cool weather, the plant being damaged by temperatures below* 50 *degrees F. It will not withstand frosts for even short periods. It is a crop originating in the American tropics and its culture has spread into the southern and mid-western portions of the United States where it is being grown on a commercial scale. In the United States the sweet potato crop has to be harvested before it is damaged by frosts and consequently methods were developed for storing the tubers in order to extend their marketable life, to prevent gluts and to preserve planting material for the ensuing year.*

In Papua and New Guinea storage methods have not been used in the past, and there is very little knowledge of the storage requirements for tubers. It is considered, however, that sweet potato storage could be practised with benefit in those portions of the Highlands where food shortages occur when the crop is damaged by periodic frosts. These shortages are thought to have gained prominence in recent years mainly because, owing to population pressure, the area under cultivation was extended into frost affected regions, and secondly because the people are relying to a greater extent than before on the produce of the higher, frost-susceptible gardens. The sweet potato is also an important item of commerce as relatively large quantities are sold for consumption in towns and on plantations. The tubers are highly perishable, and some knowledge of the appropriate storage methods might help to reduce wastage and make possible the more economical utilization of supplies.

DIGGING THE CROP.

SWEET potato should be dug when it is fully grown. A slight yellowing of the foliage will indicate the right stage. Care must be taken when digging not to injure the tubers, which are easily cut and bruised. The tubers should never be thrown from one row to another, or into heaps or into bags. The best practice is to place them straight into baskets or boxes in which they will be stored, so that handling is reduced as much as possible. If much soil adheres to the tubers, they may be left exposed for an hour or two to allow them to dry before being placed in the containers, but in hot weather exposure might result in sunscald. Naturally, no damaged, diseased or rotting tubers should be placed in the containers intended for storage.

In California, in the San Joaquin Valley (Minges and Morris, 1953) field piles are sometimes used for temporary storage. The crop is carefully stacked in piles about 2 ft. to 3 ft. wide, 4 ft. to 6 ft. long and 2½ ft. to 3½ ft. high, containing 250 to 500 lb. of tubers. The piles are covered with wrapping paper and then a 5 in. to 6 in. thick layer of sweet potato vines or straw is placed over the paper. But these field piles are only useful for protecting the tubers from sun and rain and must not be used for curing or storage.

CURING.

Before the sweet potato can be stored successfully, it must be cured. The tuber is covered by a periderm that is effective in retarding water loss and acts as a barrier against infection. At harvest this skin is unavoidably broken. Curing hastens the healing of wounds (cuts, breaks, bruises) made during digging and handling.

If a sweet potato is cut or bruised, a heavy, sticky, milky juice exudes from the injured cells. This juice dries in a few hours and may appear to have closed the wound, but in fact several days are required for the growth of new cells that would protect the interior from infection. The wounds will heal by suberization and the development of wound periderm. These new cells are similar to periderm in their ability to prevent infection. Because of its corky nature this layer is commonly called wound cork. The layer of cork is generally five to six cells thick, covered by a layer of four to five dead parenchyma cells. The mere presence of a dried and hardened surface over a wound is no indication that it has been healed by a layer of wound cork. The dry, hardened surface offers too little protection to prevent infection. Curing is not a drying process ; in fact drying should be kept to a minimum by maintaining the humidity as high as possible.

The object of the curing process is to encourage the rapid development of the wound cork and curing involves placing the tubers in a room having the appropriate temperature and humidity for this purpose. Therefore, sweet potato should be cured as soon as possible after being dug. It is sometimes recommended that, on harvesting, the tubers should be exposed to the sun and wind in order to dry them, but no healing occurs when cuts or bruises are exposed to drying winds. If healing is to take place, the tubers must be placed in storage at the right temperature and relative humidity within a few hours of digging.

When surface cuts have healed several layers of parenchyma always remain. Under conditions unfavourable to rapid periderm development the outer cells of the wound may dry to a considerable depth so that a thick layer of dead or partly dead parenchyma is formed. The thickness of this parenchyma is indicative of wound healing conditions. In general, under conditions favourable to wound healing, a cork layer five to six cells thick forms at a depth of some four to five cells beneath the wound surface. The new cork forms a continuous uniform layer. After satisfactory healing there is no change in thickness of dead surface parenchyma and usually little change in total periderm thickness. The wound surface is smooth and nearly white in colour. Wounds that heal poorly tend to be sunken and grey in colour. Broken ends are present on all tubers. These wounds differ from bruises because the wounded surface is relatively more exposed and severs vascular tissue and laticifers. In healing, both the sieve tubes and laticifers collapse or are pinched off and the periderm layer becomes continuous across the end surface.

The optimum conditions for wound healing and hence for curing are a temperature of 85 degrees to 89 degrees F. and a relative humidity of 92 per cent. Under these conditions the growth of wound cork begins in two days and is well developed in five to six days. At lower or higher temperatures or at a lower humidity it develops less rapidly. Even if the temperature is high enough, healing will not take place promptly if the air immediately surrounding the tubers is dry, e.g., of 66 per cent. relative humidity or less. The value of curing can be illustrated by data from Hawaii (Poole, 1955), where six weeks after harvesting the percentage of sound tubers from cured and uncured samples was 99.0 and 53.9 respectively (average results from tests of four different varieties).

The length of time required for proper curing cannot be stated as definitely as can the temperature and humidity requirements. The condition of the crop at harvest, the season of the year, the weather during the curing period, the temperature of curing, the efficiency of the operation, all determine how rapidly the curing process will proceed. In practice the curing period generally ranges from five to 20 days.

In general the following curing periods are suggested :—

Curing temperature degrees F.	No. of days.
85	4 to 7
80	8 to 10
75	15 to 20
70	25 to 30

Curing for too long results in excessive sprouting. Curing temperatures below 85 degrees F. are not recommended. Practical signs that the tubers are cured are :

1. Non-slipping of the skin ;
2. The appearance of purplish buds ; and
3. The dry, spongy appearance of the skin.

It is necessary to emphasize that the object of curing is not to remove moisture, as is commonly believed. Very little ventilation is necessary or even desirable in most sweet potato storage houses. Ventilation is only necessary to prevent the condensation of moisture and for temperature control. Maintaining a relative humidity of over 90 per cent. not only promotes healing, but greatly reduces shrinkage. The healing of wounds is but one of several important changes that take place in the sweet potato tuber during curing. The main loss in weight is due to evaporation of moisture, which may cause shrinkage, although tubers that have lost five to ten per cent. of their original weight during curing do not appear shrunken or shrivelled and will remain sound and firm.

The sweet potatoes must be left undisturbed after they are placed in the curing shed until they are removed for marketing or consumption. Handling will cause new wounds or breaks in the skin through which organisms can enter and thereby destroy the effect of curing. If the original cuts and bruises have been well healed during the curing period it is inadvisable to make new bruises by sorting or by shifting the tubers from one container to another. It is even inadvisable to take out rotten potatoes during storage, if this necessitates handling the whole lot.

In a warm climate, such as California, desirable curing temperatures can often be obtained without, or with only a little, artificial heat. The generation of heat by the tubers helps to raise the temperature and to maintain it during the curing period.

All sweet potato contains an enzyme, beta amylase, which when heated converts starch into the sugars maltose and dextrin. The temperatures of curing, 80 to 85 degrees F., are sufficient to convert much of the starch, but cooking is even more effective in converting the remaining starch.

Thus the main factors in curing are :—

1. Control of moisture (humidity) ;
2. Control of temperature ; and
3. Control of ventilation.

The main effects of curing are :

1. Extension of storage period of the tubers ;
2. Even firming of flesh and toughening of skin to prevent development of storage diseases ; and
3. Increase of the sugar content and improvement in the flavour.

STORAGE CONDITIONS FOR THE TUBERS.

After the sweet potato is cured, the temperature of the storage chamber should be reduced to 60 degrees F., but not lower than 50 degrees to 55 degrees F., as rapidly as possible, preferably in one week. Continued high temperature, after curing is completed, results in excessive sprouting. If exposed to temperatures below 50 degrees F., chilling could cause injury. Similarly, keeping and eating qualities are adversely affected by temperatures below 50 degrees F., following curing. For best results during the storage period the relative humidity of the air should be maintained at about 85 to 90 per cent. If it gets too damp, i.e., there is condensation of moisture, the ventilators or doors should be opened for a brief period. If the storage temperature is above 60 degrees F. it may lead to shortened storage life, sprouting and decay. The most important requirement of sweet potato storage is the ability to maintain the desirable conditions of temperature and relative humidity.

METHODS OF STORAGE.

In the United States special curing and storage houses are recommended and are necessary for the preservation of sweet potato. Such storage houses should be well insulated to conserve heat. The wall and ceiling materials should be of a type which is not damaged by moisture. They have no windows, only top and bottom ventilators. It is usual for the storage house to have an earthen floor which helps to maintain high humidity. A slatted floor is usually 1 ft. above ground level to permit free circulation of air. The source of artificial heat is also placed below the slats. Intake ventilators at floor level and exhaust fans in the ceiling are essential for temperature and humidity control. The size of the storage house will depend on the quantity handled—a 14 ft. x 12 ft. building has a 500-bushel capacity (55 lb./bush.). One cubic foot of storage space will hold about 25 lb. of tubers in containers.

A simple storage house with adobe walls has been described for use in Arizona (Crider and Albert, 1925). It has walls 10 inches thick and a gabled roof. There are ventilation holes at the top and bottom of the walls. The adobe construction is cheap, simple to build and has high insulating properties. Heat is provided by an oil stove. The sweet potato is stored on racks.

For the storage of small quantities of tubers the Tennessee Valley Authority has obtained good results by curing and storing in insulated cabinets, installed in unheated buildings. These cabinets have floor and roof ventilators, a raised slat floor, with a thermostatically controlled 220 watt electric heater under the slat floor.

In the extreme south of the United States, e.g., in southern Louisiana, natural heat only is used. The usual practice is to store the sweet potato in a warehouse-type building. Heat is only supplied if there is danger of the temperature in it dropping below 50 degrees F. If no artificial heat is employed it is desirable for the tubers to be warm when placed in the building, which should be of such size that it could be filled rapidly, as the sweet potato itself generates heat and the temperature of a full storage house will be higher than one which is half full.

As the average temperature inside these storage houses is generally less than 85 degrees F., the curing period will be longer, perhaps one month.

The practice of curing with natural heat is practicable only where and when the average temperature at harvest time and for three to four weeks thereafter does not fall below 70 degrees F.

The recommendations of Poole (1955) for storage under conditions in Hawaii are :

1. The roots must be cured with as little handling as possible between the field and the curing shed. Shallow trays are best ;
2. A Quonset hut proved effective for curing the tubers, but was less suitable for storage ; and
3. Storage at natural room temperatures can only be done well between December and April (cool months) ; at other times artificially cooled rooms are necessary.

The above recommendations appear particularly applicable to conditions in Papua and New Guinea if large-scale storage is contemplated, e.g., at Port Moresby, where there is a large potential market for sweet potato requiring regular supplies throughout the year.

Whatever the size of the storage house an important requirement is cleanliness. All crop residues, soil, etc., must be removed. Before putting in the fresh crop of tubers the walls, partitions, ceiling, floors, racks, etc., should be thoroughly sprayed with a solution of 2 lb. of copper sulphate in 50 gallons of water, or with a solution of borax, 15 lb. in 50 gallons of water.

HOME STORAGE.

Good results have been obtained by merely wrapping sweet potato in newspaper and storing them in a cabinet in a building where the temperature is above 55 degrees F. Another storage method is in sawdust. The tubers should be held at a temperature of 75 degrees to 85 degrees F. for approximately two weeks, then stored in a cool place where the temperature does not drop below 55 degrees F. If sawdust is used, care must be taken to ensure that it is very dry ; otherwise root growth or rots might develop.

In a closed room or small shed with sunshine entering each day, the temperature may reach 80 degrees F. without extra heat. Conditions similar to commercial curing can be created by covering the boxes or baskets of tubers (preferably on an earthen floor) with sacks or a tarpaulin to keep the air moist around them. But it may be necessary at times to remove the covering if there is condensation of moisture.

PIT STORAGE.

Pit storage is only recommended when there is no opportunity for a better method. Storage pits should be located where the drainage is good. They may have board sides lined with straw, a tight fitting wooden cover, and a roof to keep off rain. Such a pit has the same temperature as the soil. Perhaps more suitable is a pile or hill. In this, the level of the bed should be several inches above ground level. Two small trenches should be dug across the bed at right angles to each other to provide for ventilation at the base—perforated boards are placed over the trenches. At the point where the trenches cross, a small box, made of boards eight inches wide and with open ends, should be placed to form a flue upwards through the pile of sweet potato. Holes should be bored in the boards forming the flue to increase ventilation. The earthen floor should be covered with four to five inches of straw, hay or leaves. The sweet potato tubers are then placed in a conical pile around the flue. An eight-inch layer of straw or hay or similar material is placed over the tubers and then a layer of soil about six inches in depth. A wooden frame 12 in. x 18 in. containing a trap door can be placed on the straw. This will make it easier to examine the tubers and to remove them from the pile. The end of the trenches and of the flue should be screened to prevent entry by rats and mice. It is also advisable to protect the pile from the weather, particularly from rain, by erecting a roof over it. It is better to make several small pits, or piles rather than a single large one, because the entire contents should be removed when the pit is opened.

The New Zealand Maoris are known to have used storage of sweet potato. Two types were described by Best (1925).

1. *Semi-Subterranean* : Rectangular excavations, often in sloping ground or on the brinks of terraces, with a timber roof. The roof was covered with earth. Tubers were placed on dunnage of dried manukau (*Leptospermum* spp.) or fern brush. The whole structure could be sealed.

2. *Subterranean* : Well-like pits dug into the ground (*Figure* 1) which, after filling were sealed. There seems to have been considerable variation of storage technique from district to district, and this is generally ascribed to variances in soil and rainfall conditions.

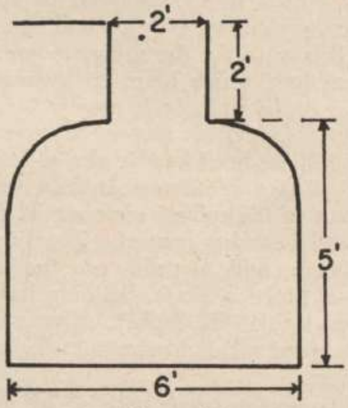

Figure 1.

The disadvantages of pit storage are :

1. Heavy loss due to decay ;
2. Inferior quality due to lack of proper curing ;
3. Limited keeping quality once removed from the pit ; and
4. Danger of rat damage in the pits.

In experiments in Barbados in 1937 (McIntosh, 1942) it was found that after a $3\frac{1}{2}$ months' storage period a total of 30 per cent. loss in weight occurred. This consisted of 18 per cent. due chiefly to loss of moisture and 12 per cent. due to actual rot. American data (Miller, 1922) give losses in pits or banks as high as 40 per cent.

It is considered that under Highland conditions, the usual kunai houses would be suitable for the storage of sweet potato to overcome shortages expected as a result of frosts. The tubers would have to be placed on racks or boxes to ensure aeration while smoke fires would ensure adequate temperature during the curing period.

CHILLING INJURY IN STORAGE.

The symptoms produced by chilling are surface pitting, increased susceptibility to decay, loss of table quality and loss of sprouting ability.

The damage to sweet potato tubers by frost or chilling has been summarized by Lutz (1945) :

Injury to freshly harvested non-cured Porto Rico sweet potato was evident after they had been held two days at 32 degrees F., four days at 40 degrees F. or 10 to 21 days at 50 degrees F. Slightly longer exposures at 32 degrees F. and 40 degrees F. were necessary to produce injury in cured sweet potato—the latter was not impaired in quality by exposure at 50 degrees F. for up to 30 days.

Decay during storage was increased in non-cured sweet potato by holding them for four to ten days at 32 degrees F. to 50 degrees F. Somewhat longer exposures were necessary to increase the decay of cured sweet potato held at 32 degrees F. and 40 degrees F. Holding cured sweet potato at 50 degrees F. did not effect decay.

A delay of 30 days or longer between harvesting the tubers and subjecting them to low temperatures prevented much of the loss from decay and injury which otherwise occurred in non-cured sweet potato.

Non-cured sweet potato stored for four to four-and-a-half months at a constant temperature of 50 degrees F. suffered practically 100 per cent. loss from decay. The loss was less in storage at 55 degrees F. and still less at 60 degrees F. Although cured sweet potato held at constant temperatures of 50 degrees F. and higher did not develop significantly more decay than comparable ones held in the storage house, culinary quality was adversely affected when held at 50 degrees F.

SUMMARY OF THE ESSENTIAL FEATURES OF GOOD STORAGE.

Sweet potato must be :

1. Well matured before digging.

2. Carefully handled to prevent bruising.

3. Well cured immediately after being put in storage—

   (i) at a constant temperature of 80 degrees F. to 89 degrees F. ; and

   (ii) at a relative humidity of 85 to 92 per cent. to promote healing and reduce shrinkage.

4. Following curing stored at a controlled temperature and humidity around 55 degrees F.—

   (i) if the temperature drops below 50 degrees F, artificial heat must be employed ; if it reaches 60 degrees F., the store must be cooled ; and

   (ii) the relative humidity in the store must be maintained at 85 per cent. to 90 per cent. If the walls, ceiling or sweet potato become wet, it may be necessary to open the ventilators to remove the excessively moist air. If the relative humidity falls below 85 per cent., water should be sprinkled on the floors.

(Received January, 1965.)

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Cocoa Drying with the Lister Moisture Extraction Unit. Addendum: Drying Trial on an 800 sq. ft. Floor.

K. NEWTON.*

Results from a single trial in which 5½ *tons dry bean equivalent were dried on a floor area of* 800 *square feet at a depth of approximately* 8 *inches. The trial was conducted at the Lowlands Agricultural Experiment Station, Keravat, between* 16*th December, and* 23*rd December*, 1963.

PRINCIPLE.

IN an earlier paper, summarizing the results of a series of ten drying trials with the Lister M.E.U., a physical description of the dryer was given and the principle of drying with this machine outlined (Newton, 1963). In this outline it was pointed out 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 ; e.g., assuming that an airflow through cocoa beans at 20 feet per 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 inch at the fan (equivalent to a load of approximately 3-4 inches of wet fermented beans) to achieve maximum drying efficiency. This system would probably handle the equivalent of five tons of dry beans maximum load ".

With the completion of the first series of trials on a relatively small platform (216 square feet) there remained a requirement to test this theoretical argument that the machine would have a greater capacity to dry over a larger floor area with beans at a shallower depth. For this reason the following trial was conducted on a specially designed 40 ft. x 20 ft. platform.

DESIGN OF THE PLATFORM.

The design of the drying platform is given in *Figure* 1. This shows that the exact measurement of the floor itself was 40 ft. x 20 ft. and that the construction of this floor was based on the utilization of a steel pipe framework over which 3 in. x 2 in. A.R.C. mesh and cocoa wire were laid. Steel pipe was used for reasons of durability, low resistance to airflow and in order that the area of contact between the framework and the A.R.C. mesh and cocoa wire would be as low as possible.

A 3 in. x 2 in. wooden framework around the edge of the floor was incorporated to support a 1 inch marine plywood facing board around the perimeter of the dryer. This was to prevent any contact between cocoa beans and the concrete wall.

Care was taken in design and construction of the dryer to ensure that the internal walls of the plenum chamber and fishtail duct were finished smooth and flush with a minimum degree of obstruction to airflow. The drawings indicate how this fishtail or expansion duct was used to connect the fan outlet on the M.E.U. to the drying floor. As will be explained in more detail in a later paper, this type of duct is the most efficient one for use in the connection of drying units to platform dryers. Design of these ducts is of paramount importance as the relationship between duct length, width and height can have a significant effect on the percentage static regain of velocity pressure. An incorrectly designed duct can give a regain as low as 30 per cent., whereas a correctly designed duct can give a regain of 70 per cent. For the floor under discussion duct length was 20 feet, width 20 feet and height 2 feet, a relationship calculated to give a 65 per cent. recovery of velocity pressure as static.

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A sliding roof was fitted to the platform although this remained closed over the floor during the trial to eliminate a variable factor in fuel consumption due to the effect of sun drying. In addition, provision was made in the design for the construction of a square concrete deck over the fishtail duct to carry a series of fermenting boxes, thus bringing fermentation and drying processes together into a practical unit.

DRYING.

1. *Method.*

In this trial a total of 520 cubic feet of wet fermented beans weighing 25,595 lb. (i.e. approximately 11½ tons) were loaded onto the platform for the purpose of continuous and complete artificial drying with the M.E.U. Throughout the drying period the machine was run at full throttle and blanking pieces were used to effect a temperature rise where indicated. The aim was to test the effectiveness of a large volume of air at low temperature in drying cocoa beans. No sun drying was incorporated in the trial, the sliding roof being closed over the floor throughout.

2. *Trial Results.*

Details of all recordings taken during the trial are shown in *Table* 1.

3. *Temperature Rise Above Ambient.*

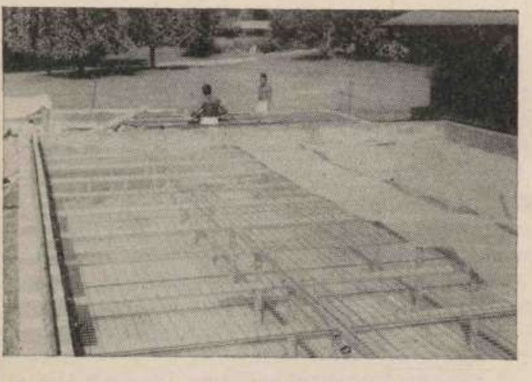
Average temperature rise above ambient with no baffle pieces fitted was 5.3 degrees F. while the average with baffles fitted over the two top quadrants of the fan guard was 8.2 degrees F.

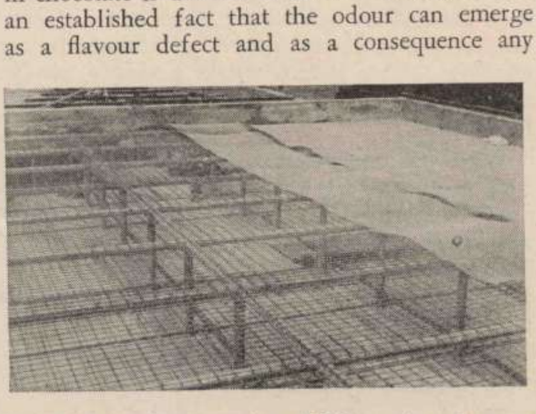
4. *Airflow.*

Measurement of airflow through the floor which were taken on the first day within 1¾ hours of the commencement of drying are shown in the results. The indication from these is that airflow at this stage was greater than 24,000 c.f.m. and could have approximated the rated output of 34,000 c.f.m. at 1 inch total water gauge ; the highest pressure recorded at the commencement of drying. Distribution of airflow readings as shown schematically in the results indicate that airflow through the whole floor area was relatively even when these readings were taken. This effect was probably resultant to some extent from the use of a fishtail expansion duct.

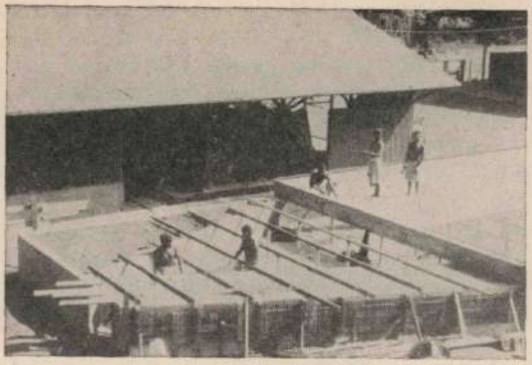
5. *Time to Surface Dry.*

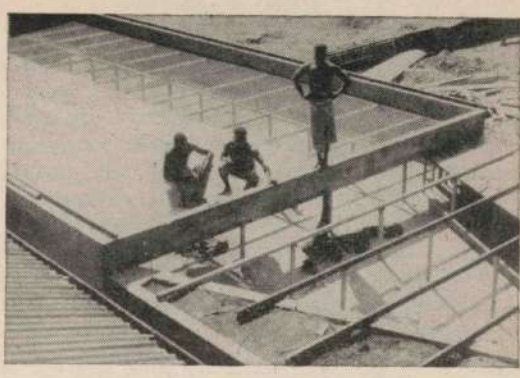
The anticipated reduction in the time taken for this 5½ ton dry bean equivalent load to reach a stage of surface dryness on the 800 square feet floor did not occur. In an earlier trial on the 216 square feet floor, an 11,109 lb. dry bean equivalent load did not become surface dry until 75 to 91 hours after the commencement of drying, by which time a "foul" odour had developed. In the current trial beans did not become surface dry until the fifth day or approximately 90 hours after the commencement of drying and a "foul" odour was again apparent although not severe. Just how much of this odour would be carried through in the manufacturing process and emerge as a flavour defect in chocolate is difficult to assess. However, it is an established fact that the odour can emerge as a flavour defect and as a consequence any





Plates I and II.—Details of construction showing steel pipe framework supporting A.R.C. mesh and cocoa wire drying floor. Note steel bolts set in concrete around the edge of the floor to take the 3 in. x 2 in. framework and marine plywood facing board.





Plates III and IV.—Details of construction showing expansion duct and end wall of drying floor. Expansion duct was later covered with concrete floor to carry fermenting boxes.

system of drying in which there lies the danger of development of "foul" or "foreign" odours cannot be supported. It must be clearly understood however that this is in reference to a 5½-ton dry bean equivalent load and that the Lister M.E.U. has ample capacity to safely dry at least a three-ton dry bean equivalent load as has been proven in previous trials.

The weakness in drying a 5½-ton D.B.E. load with large volumes at a 5 degrees F. temperature rise appears to lie in the fact that the drying rate is never quite fast enough to remove all moisture from the surface of the bean and then draw moisture from within the bean to the surface and remove it immediately so that the bean surface remains dry. Rather, it would seem that moisture is removed from the bean surface at a rate which is so slow that migration of moisture from within the bean to the surface can keep pace with removal from the surface, so that, although drying is continuing, the bean surface remains moist for a prolonged period until the rate of migration from within the bean to the surface falls to such a low level that the surface can become dry. It is obviously not a matter of air volume, which is ample, but of air temperature which is too low. Without the supply of an additional source of heat, the problem of drying five-ton loads can only be overcome by using the Lister M.E.U. to rapidly surface dry small loads and to complete drying in a deep bin. It may be argued that a 20 to 25 degrees F. rise could be obtained by restricting airflow with flow control vanes in front of the fan and this in fact could be done. There is the weakness however, that on an 800 square feet floor a minimum airflow of 20 to 25 feet per minute means a minimum requirement of 16,000 to 20,000 c.f.m. from the fan and restriction of airflow down to this rate with control vanes would only allow a temperature rise above ambient of 8 to 12 degrees F. The ability of air at this temperature to rapidly surface dry a 5½-ton D.B.E. load is very doubtful. Consequently the approach to correct utilization of the machine must be through the agency of a shallow tray/deep bin system. The basic requirement with such a system would be that the floor area of the deep bin would be no greater than 200 square feet so that either the bin could be loaded to such a depth that airflow was restricted to about 5,000 c.f.m. and 25 degrees F. rise above ambient or else control vanes in front of the fan could be closed down to restrict airflow to 5,000 c.f.m. with a 25 degrees F. rise above ambient. The area of the pre-drying floor would not be so important as it is obvious that small loads can be rapidly surface dried by the Lister M.E.U., e.g., on a 216 square feet floor, 3,940 lb. D.B.E. were surface dried in 5½ hours; 1,830 lb. D.B.E. in 6¾ hours and 2,730 lb. D.B.E. in 8¼ hours. As a consequence, innumerable combinations of shallow tray-deep bin systems could be designed around a basic 200 square feet bin unit.

6. *Fuel Consumption.*

Perhaps one of the most interesting results to come out of this trial is the tremendous reduction in fuel consumption with the 5½ ton D.B.E.

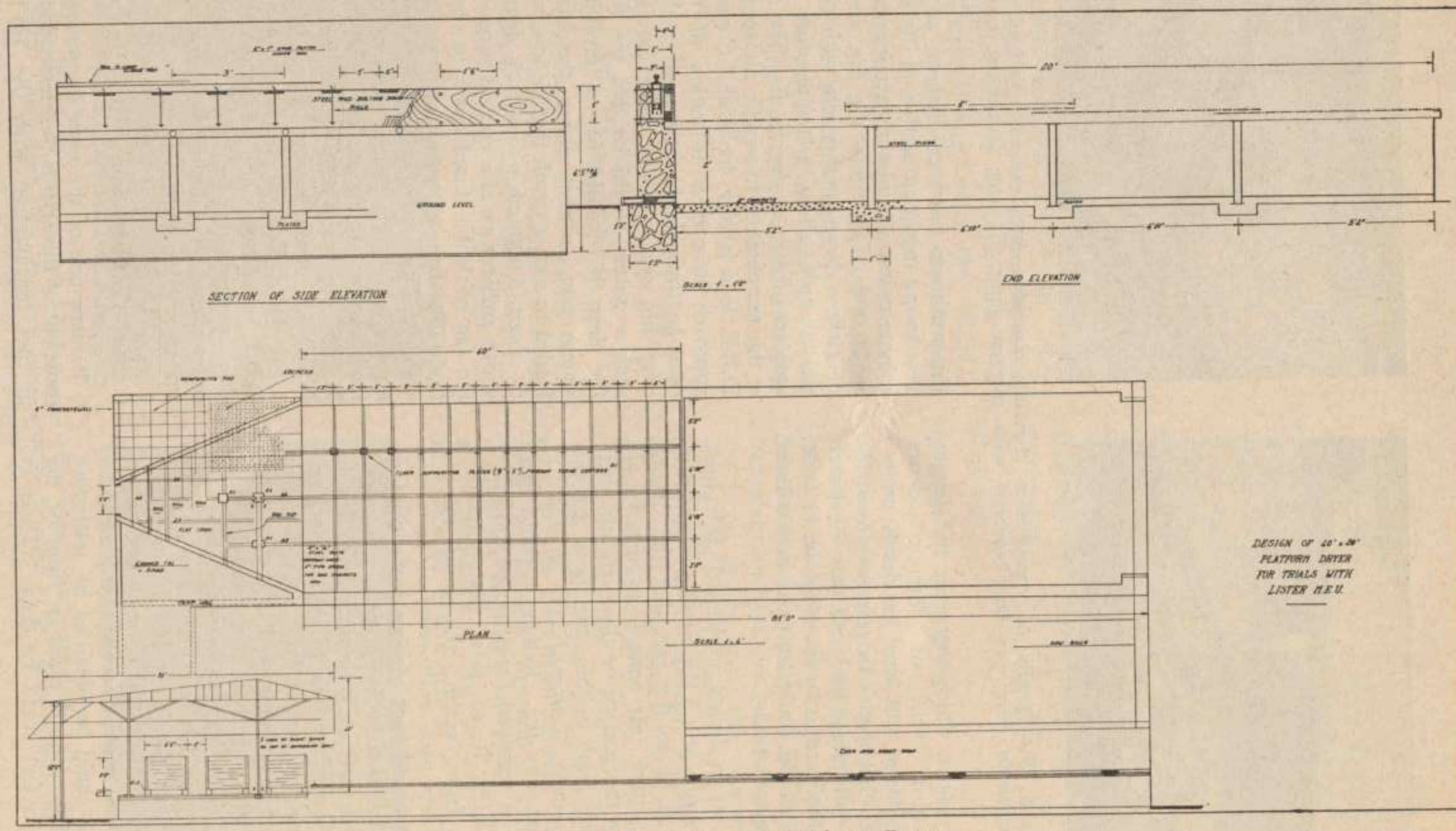


Figure 1.—Design of Platform Dryer.

load on an 800 square feet floor. In earlier trials on the 216 square feet floor the graph of fuel consumption against load indicated that a 5 ton D.B.E. load would require approximately 55 gallons of fuel per ton for complete and continuous artificial drying. The new figure from this trial is 35.8 gallons/ton.

Locating the factor responsible for this big reduction in fuel consumption is not a straightforward matter although there are probably only two factors involved.

(*a*) *Drying efficiency*. As pointed out earlier there is a theoretical argument that the machine should have a greater capacity to surface dry when operated at maximum air output with minimum temperature rise than when lower air volumes at higher temperatures are used. In practice this has been shown to occur, as is illustrated by a comparison between this trial and trial No. 5 in the earlier report. In trial No. 5, 11,109 lb. D.B.E. were dried in 139½ hours on an area of 216 square feet at a fuel consumption rate of 48.3 gallons/ton. In the current trial 12,300 lb. D.B.E. was dried in 132¾ hours on an area of 800 square feet at a fuel consumption rate of 35.8 gallons/ton. Therefore, drying efficiency appears to be greater with higher air volumes at lower temperature rise above ambient.

(*b*) *Dryer design*. Reference has been made to the importance of fishtail expansion duct and plenum chamber design on the efficiency of drying units. As the platform dryer used in this trial had a plenum chamber and fishtail duct designed specifically for the Lister M.E.U. it would be reasonable to assume that the efficiency of conversion of velocity pressure to static pressure was approaching maximum and that as a consequence drying efficiency was improved.

Obviously the contribution made by either or both of the above two factors to improve drying efficiency cannot be assessed at this juncture.

SUMMARY.

NEWTON, K. (1963). Cocoa Drying with the Lister Moisture Extraction Unit, *Papua and New Guinea agric. J.*, 16 : 91.

In a single trial aimed at testing the efficiency of the Lister M.E.U. when used on a 40 ft. x 20 ft. platform dryer, 5½ tons D.B.E. of cocoa was dried in a total time of seven days at a depth of 8 inches. Drying was effected at a cost of 35.8 gallons of fuel and 4.4 pints of oil per ton of dry beans.

For the purpose of this trial a sliding roof platform dryer was constructed as shown in *Figure* 1. The dryer incorporated a correctly designed fishtail expansion duct to allow for maximum static regain of velocity pressure. During the trial the average maximum temperature rise above ambient which was used was 8.2 degrees F. while for much of the time an average rise of 5.3 degrees F. was used. Approximately 90 hours elapsed after the start of the trial before the beans became surface dry. A foul odour was detected during drying and although this was not severe, its presence indicated that drying was too slow with such a large load on the floor. From a consideration of the factors involved the indications are that the Lister M.E.U. can be used most efficiently as a cocoa dryer when fitted to combinations of shallow trays and deep bins.

Using the machine on the larger floor area resulted in a marked improvement in drying efficiency as measured in terms of fuel consumption. This increase in efficiency was either due to a greater rate of removal of water by larger volumes of air at low temperatures or else to the design of the dryer, or a combination of both factors.

Table 1.—Notes and Records.

LISTER DRYING TRIAL No. 11.

Ferment No.—1,271.
Harvested.—4th December, 1963.
Broken.—9th December, 1963.
Weights of one cubic foot wet beans (lb.)—
58½—58¼—60½—58½—57¼—58¾—57¾—56¼.
Average weight per cubic foot (lb.)—58.2.
Total volume wet beans.—300 cu. ft.
Total weight wet beans.—17,460.

FERMENTATION NOTES.

Day 1.—

		Depth.	Volume C.F.T.
Boxes filled—4 p.m.	A	36 in.	60
	B	36 in.	60
	C	36 in.	60
	D	36 in.	60
	E	36 in.	60
			300 cu. ft.
	F		
	G		
	H		

Day 2—Turned 8 a.m.
Day 3—Turned 8 a.m.
Day 4—Turned 8 a.m.
Day 5—Turned 8 a.m.
Day 6—Turned 8 a.m.
Day 7—Turned 8 a.m.

SUN DRYING.

Day 8.—

Samples were taken as follows for sun drying and flavour assessment :

HOT AIR DRYING.

Day 8.—16th December, 1963.

(1) Portion of total ferment used.—Whole ferment.

(2) Equivalent volume of wet beans.—300 cubic feet.

(3) Equivalent weight of wet beans.—17,460.

(4) Moisture content at end of fermentation.—Not recorded.

(5) Weights of one cubic foot of fermented beans.—50—49½—47½.

(6) Average weight of one cubic foot of fermented beans.—49.

(7) Total weight of fermented beans (2x6).—14,700 lb.

(8) Volume of additional fermented cocoa beans brought in from outside sources.—220 cubic feet.

(9) Approximate weight of additional fermented cocoa (8x6).—10,895 lb.

(10) Total weight of fermented beans to dryer (7+9).—25,595 lb.

(11) Total volume of fermented beans to dryer (2+8).—520 cubic feet.

(12) Depth of beans on dryer floor.—Approximately 8 inches.

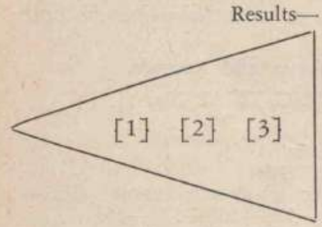
Start Stop	Time	Fuel	Amb. Temp.	Air Chamber	Engine Speed	Blanks	Total W.G.	Add Oil	Turning	Moist Per cent.
Start	2.45 p.m.	28¼	....	....	Full	Nil	0.8	....	....	....
	3.30	....	85	95	Full	Nil	....	....	....	....
	4.30	....	84½	93	Full	Nil	0.5	....	....	....
	9.30	16¾/43	75½	81½	Full	Nil	0.3	2	....	....

Day 8 (*Continued*). COMMENTS.

1. STATIC WATER GAUGE MEASUREMENTS.

At the commencement of hot air drying (2.45 p.m.) and again two hours later (4.45 p.m.), static water gauge measurements were taken at three positions along the fish-tail duct as shown :

Results—



0.5 in. (1), 0.75 in. (2), 1.0 in. (3) — 2.45 p.m.

0.25 in. (1), 0.5 in. (2), 0.7 in. (3) — 4.45 p.m.

2. R.H. MEASUREMENTS.

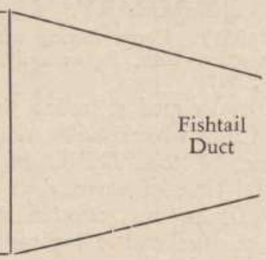
—	3.30 p.m.	4.30 p.m.	9.30 p.m.
	Per cent.	Per cent.	Per cent.
Ambient R.H.	68	74	90
R.H. in duct at Position (3)	61	67	78
R.H. of air leaving the Bed	89	93	97

3. AIR FLOW MEASUREMENTS.

The rate of airflow through the beans was measured at 4.30 p.m., i.e., 1¾ hours after the commencement of drying, using a Cassella airflow meter which had a scale of 5 to 30 feet per minute. Readings taken are shown schematically on the diagram below in relation to their approximate location on the drying platform.

As so many of the readings were greater than 30 ft./minute an average figure for airflow cannot be calculated. At an average of 30 ft./minute over the whole bed, airflow would have been 800 x 30 = 24,000 c.f.m. The M.E.U. is rated to produce 34,000 c.f.m. at 1 inch total water gauge and it is probable that actual output was close to this when the above readings were taken.

30 *	18	30 *	30 *	30	30 *	30 *	30 *	30 *	30 *
									30 *
30 *	30 *	30 *	30 *	30 *	30 *	30 *	29	29	
								30 *	
30	30 *	30 *	30	28	20	30	30 *		



* Indicates a speed of more than 30 ft/minute.

Day 9.—Tuesday, 17th December, 1963.

Start Stop	Time	Fuel	Ambt. Temp.	Air Chamber	Eng. Speed	Blanks	Add Oil (Pints)	Turning	Moist Per cent.
	a.m.								
	8.30	....	77	82.4	Full	Nil	Nil	2M.H.	....
	12.30	....	81	86	Full	Nil	Nil	.... 4M.H.	....
	p.m.								
	2.30	....	81	85	Full	Nil	Nil	....	....
	2.45	Two upper baffles fitted.							
	3.30	....	80½	88½	Full	2/0	Nil	....	....
	4.45	....	80	87.8	Full	2/0	Nil	....	....
	5.45	13/46	78	86.9	Full	2/0	Nil	....	....
	9.30	....	75	83.3	Full	2/0	Nil	2M.H.	....

COMMENTS.

N.B. 2.45 Attachment of two upper baffles raised R.H. of air leaving the beans from 80 per cent. to 90 per cent. at 3.30 and temperature rise above ambient from between 4 degrees F. and 5 degrees F. to approximately 8 degrees F.

R.H. MEASUREMENTS.

—	8.30 a.m.	12.30 p.m.	2.30 p.m	3.30 p.m.	4.45 p.m.	5.45 p.m.	9.30 p.m.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Ambient R.H.	83	72	78	81	86	90	90
R.H. in Duct at Position (3)	77	69	70	65	68	71	72
R.H. of Air leaving the bed	97	94	80	90	93	93	95

Day 10.—Wednesday, 18th December, 1963.

Start Stop	Time	Fuel	Ambt. Temp.	Air Chamber	Eng. Speed	Blanks	W.G.	Add Oil (Pints)	Turning	Moist Per cent.
	a.m.									
	8.00	....	76.5	84.2	Full	2/0	....	2	....	....
	10.00	....	84.0	91.4	Full	2/0	....	....	....	....
	11.00	....	77	87.8	Full	2/0	....	....	....	....
	12.00	....	79	87.8	Full	2/0	....	....	....	....
	p.m.									
	1.00	....	83	89.6	Full	2/0	....	....	....	....
	2.00	....	82.5	90.5	Full	2/0	....	....	....	....
	3.30	....	80.0	88.0	Full	2/0	....	....	....	....
	4.30	....	80.0	88.0	Full	2/0	....	....	....	....
	5.30	....	78.0	87.0	Full	2/0	....	....	2M.H.	....
	6.30	9/45 Baffles removed to increase airflow					....	....	4M.H.	....
	7.00	....	76.5	83.5	Full	Nil	....	....	....	....

COMMENTS.

R.H. Measurements (Percentages) :

	8.00 a.m.	10.00	11.00	12.00	1.00 p.m.	2.00	3.30	4.30	5.30	7.00
Ambient R.H.	81	84	87	80	78	77	81	82½	85	91
R.H. in Duct at Position No. 3	70	62	70	63	62	61	64	63	67	70
R.H. of Air Leaving the Bed	96½	91	91	90	90	90	91	91	88	88

Day 11.—Thursday, 19th December, 1963.

Start Stop	Time	Fuel	Ambt. Temp.	Air Chamber	Eng. Speed	Blanks	W.G.	Add Oil (Pints)	Turning	Moist Per cent.
	a.m.									
	6.30	....	72	77	Full	Nil	Nil	....	....	....
	7.30	....	71½	78	Full	Nil	Nil	....	....	....
	p.m.									
	1.00	....	77	82.4	Full	Nil	Nil	2	....	....
	4.30	12½/45	78½	84.2	Full	Nil	Nil	2	....	....

Day 12.—Friday, 20th December, 1963.

Start Stop	Time	Fuel	Ambt. Temp.	Air Chamber	Eng. Speed	Blanks	W.G.	Add Oil (Pints)	Turning	Moist Per cent.
	8.30	....	81	86	Full	Nil	Nil	2	2M.H.	....
	At 8.30 a.m. two upper baffles fitted.									
	11 a.m.	....	84	94	Full	2/0	Nil	....	....	....
	5.30 p.m.	9/42	77	85	Full	2/0	Nil	4	....	....

COMMENTS.

8.30 a.m. Beans were mostly surface dry although some 30 to 40 per cent. still retained some dampness on the skin. Internal free moisture was low to absent at this stage. External mould had developed on some beans but was not serious. Two upper baffles were fitted.

Day 13.—Saturday, 21st December, 1963.

Start Stop	Time	Fuel	Ambt. Temp.	Air Chamber	Eng. Speed	Blanks	W.G.	Add Oil (pints)	Turning	Moist Per cent.
	8.30 a.m.	....	84	89	Full	2/0	Nil	2	2M.H.	....
Stop	6.00 p.m.	6	79	88	Full	2/0	Nil	2	....	....

COMMENTS.

6 p.m. At this stage drying was stopped although it had not been completed.

Day 14.—Sunday, 22nd December, 1963.

No drying was carried out.

Day 15.—Monday, 23rd December, 1963.

Drying was completed with the machine running for 9½ hours. Fuel consumption was 14 gallons and oil consumption 4 pints.

RECORDS.

Total time beans in dryer	7 days.
Total drying time	132¾ hours.
Total Fuel Consumption	197 gallons.
Av. consumption/hour for engine	1.484 gallons/hr.
Engine oil consumption	24 pints = 4.4 pints/ton.
Wt. dry beans produced	12,320 pounds = 5½ tons dry.
Fuel consumption/ton	35.8 gallons per ton.
Total man hours for turning	12M.H.

Preliminary Studies with Poultry Rations for the Territory of Papua and New Guinea. I.—Grower Rations with Copra, Sago and Leucaena leucocephala.

J. A. SPRINGHALL and E. ROSS.*

This study is part of a continuing project to develop poultry rations for the Territory of Papua and New Guinea utilizing the maximum amount of feedstuffs indigenous to the Territory. In this connection a number of feedstuffs of potential value were collected in the Territory and tested with young chickens. Springhall (1964), *has demonstrated that a number of those materials had a high nutritional value and appeared suitable for use in poultry rations. The study reported below is an extension of this work to pullet grower rations.*

MATERIALS AND METHODS.

THREE hundred one-day old White Leghorn x Australorp pullets, obtained from a commercial hatchery, were brooded on a deep litter of wood shavings under an infra-red hover brooder for nine weeks. During this time they received the standard 21 per cent. protein ration shown in *Table* 1. At nine weeks of age the pullet chicks were distributed into four groups of 64 chicks each, and started on the experimental rations shown in *Table* 2. It will be noted from this table that approximately 80 to 85 per cent. of these experimental rations consisted of materials available in the Territory.

Ferrous sulphate was added to the *Leucaena leucocephala* (*Leucaena glauca*) in rations 3 and 4 because it had been shown to reduce the growth depressing effect of *L. leucocephala* in chick rations (Ross and Springhall, 1963).

Because of the uncertainty of shipments from the Territory, equivalent feedstuffs available in the Brisbane area were used. *L. leucocephala* was obtained from the experimental plots at Samford (C.S.I.R.O.) and on analysis was found to contain 2.3 per cent. of mimosine and 25.4 per cent. of crude protein. Cuttings of the shrub were sun dried, the leaves shaken off, then hammer milled before use. The ferrous sulphate was added as a solution to the *L. leucocephala* one week prior to the mixing of the rations.

The sago used was commercial domestic quality from Malaysia, of equivalent nutritive value to sago obtained in the Territory (Springhall, 1964). Copra meal was obtained from a local extractor, who also supplied the raw copra used during the first week of the study. Owing to milling difficulties with the copra, copra meal and coconut oil were substituted in proportions approximating the composition of copra. This was found to be, by analysis, 64 per cent. coconut oil and 36 per cent. copra meal.

The experimental groups remained on deep litter throughout the treatment period, from 9 to 22 weeks of age. All groups were vaccinated at 12 weeks of age, and individual body weights obtained periodically. Feed consumption data were also obtained.

At 22 weeks of age, 14 pullets were selected at random from each grower treatment group and placed in 15 in. layer cages, one or two birds per cage. All pullets then received the standard University of Queensland layer ration shown in *Table* 3. Daily egg production, mean egg weights, and feed consumption data were recorded over the eight-month experimental period.

Statistical treatment of the data consisted of the variance analysis (Snedecor, 1956), and the multiple range test (Duncan, 1955 ; Kramer, 1956).

* J. A. Springhall, University of Queensland ; E. Ross, University of Hawaii.

RESULTS AND DISCUSSION.

Growing Period.

The mean body weights and mortality during the growing period are shown in *Table* 4. It is apparent from these data that *L. leucocephala* retarded growth at both levels fed, the depression becoming more acute at the higher concentration. This effect on growth may be attributed to both the lower energy content of the *L. leucocephala* diets and the presence of mimosine. The relative contribution of each of these factors to the growth depression cannot be definitely evaluated, although the addition of ferrous sulphate to the *L. leucocephala* should have reduced the toxicity due to the mimosine. It would appear, therefore, that the relative growth rates of the pullets were related mostly to the energy content of their experimental diets. Palatability may also have been a factor since it was observed that considerable feed wastage occurred with some of the experimental diets. This is quite noticeable in the 9 to 22 week feed conversion values shown in *Table* 4 especially in the 15 per cent. *L. leucocephala* group.

In considering the growth rates achieved by the different experimental diets, consideration must also be given to current concepts of feeding pullet replacement stock. One of the prevailing views is that delaying sexual maturity, by limiting nutrient intake during the growing period, results in fewer small eggs at the outset of lay, and more persistent production during the laying year. In some studies, lower laying house mortality has also been observed. The sexual maturity of the groups receiving the experimental grower rations was delayed, as measured by days to first egg ; by eight days in the case of the copra-sago and 10 per cent. *L. leucocephala* rations, and by 17 days with the 15 per cent. *L. leucocephala* rations. These differences were statistically significant.

The mortality data also shown in *Table* 4 indicate a random effect since no mortality occurred among the groups making the greatest and poorest gains.

Laying Period.

A summary of the data collected during the laying period is shown in *Table* 5. In spite of the growth depression and subsequent delay in sexual maturity of the groups receiving the experimental diets, no significant differences were found in total egg production for the 8 month experimental period. It is of interest to note that the group that was most retarded (15 per cent. *L. leucocephala*) during the growing period, performed as well as the control group. Thus, even though sexual maturity was delayed by 17 days at the outset, after approximately two months of lay the experimental group had caught up with the production rate of the control group, and then surpassed it over the next four-month period. *Figure* 1 illustrates the effect of the various grower rations on overall egg production. The poorer production of the copra-sago and 10 per cent. *L. leucocephala* groups is difficult to explain inasmuch as their growth rate was satisfactory and the rations would appear to have been as fully adequate as the 15 per cent. *L. leucocephala* ration.

The average weight of eggs from all experimental groups exceeded the weight of the control eggs although none of the differences were statistically significant. This effect on egg size is probably related to age at first egg, since this phenomenon has been frequently reported in the literature.

No significant differences were found between treatments in feed efficiency although the apparent differences are related to the egg production of the treatment groups. Here again the birds receiving the 15 per cent. *L. leucocephala* ration compared favourably in efficiency of feed utilization with the control birds.

The hens which had received the 10 and 15 per cent. *L. leucocephala* rations were approximately 100 and 200 grams respectively lighter in weight at the end of the trial, than the hens which had received the control grower ration. Although these two groups which gained at a slower rate and attained a lower final weight also had a lower mortality rate, the data are too limited to warrant any conclusions. Although the weight gain differences were statistically significant, the differences in mortality were not.

SUMMARY.

Pullets fed grower rations containing up to 85 per cent. of a combination of sago, copra meal, copra and *Leucaena leucocephala* did not differ significantly in egg production, egg weights or feed conversion, although the groups receiving

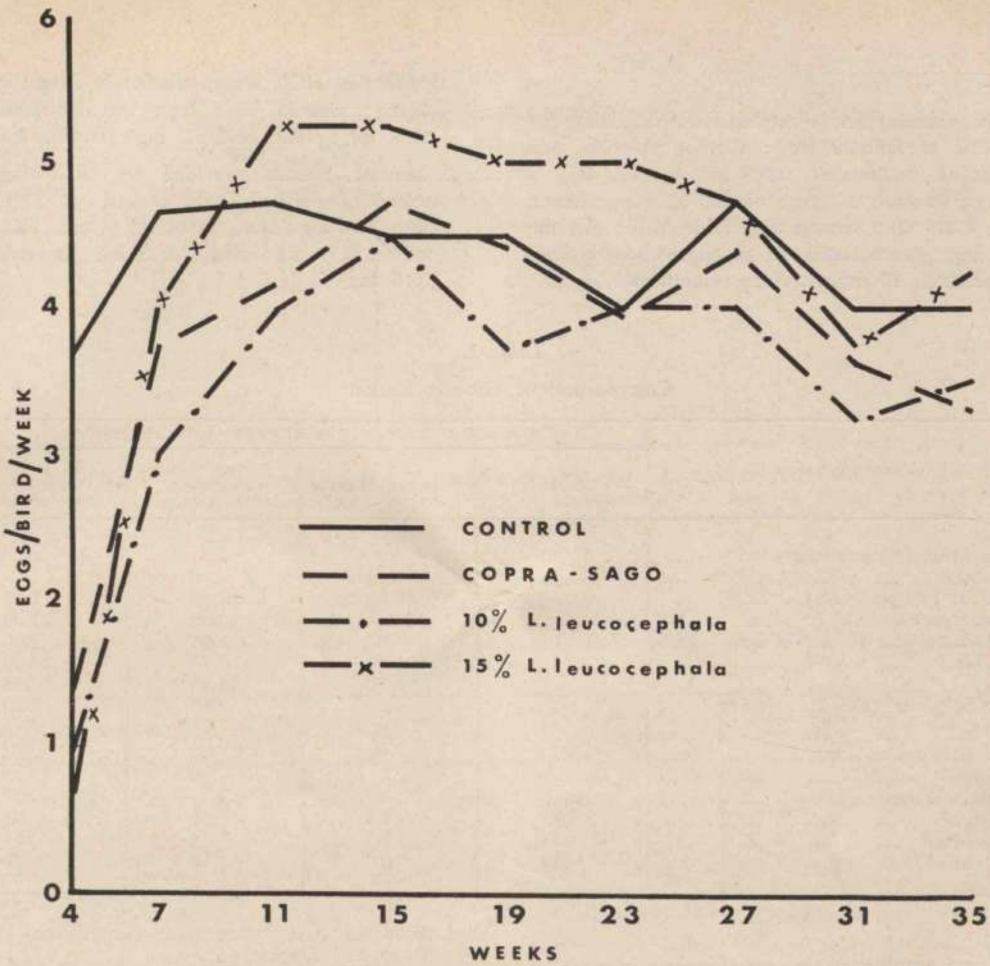


Figure 1.

the experimental grower rations took significantly longer to reach sexual maturity (days to first egg) and were significantly lighter after eight months production.

ACKNOWLEDGEMENTS.

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(Received April, 1965.)

APPENDIX.

Table 1.

Composition of Starter Ration.	lb.
Maize	64.3
Soybean Meal (50 per cent.)	30.4
Dicalcium phosphate	4
Salt	0.5
Vitamin mix[1]	314g.
Mineral mix[2]	50g.
	100 lb.

Note.—

1. The vitamin premix provided the following per pound of finished feed: Choline chloride, 500 mg; dl methionine, 0.908 g; vitamin B_{12}, 8 mcg; inositol, 50 mg; niacin, 32 mg; vitamin A, 8,125 IU; vitamin D_3, 1,200 ICU; thiamin, 12 mg; ascorbic acid, 10 mg; menadione sodium bisulphite, 10 mg; calcium pantothenate, 8 mg; pyridoxine HCL, 8 mg; riboflavin, 4 mg; PABA, 4 mg; vitamin E, 6 mg; procaine penicillin, 2.25 mg; folic acid, 2 mg; biotin, 0.3 mg.
2. Mineral premix provided the following per pound of finished feed: manganese, 27.2 mg; zinc, 20.4 mg; iron, 9.09 mg; copper, 1.12 mg; iodine, 0.59 mg; cobalt, 0.23 mg; molybdenum, 0.16 mg.

Table 2.

Composition of Grower Rations.

Ingredient.	RATION (QUANTITIES EXPRESSED AS PERCENTAGE).			
	Control.	Copra-Sago.	10 per cent. Leucaena leucocephala.	15 per cent. Leucaena leucocephala.
Soybean Meal (50 per cent.)	10.90	....	....	....
Maize Meal	83.80	....	....	....
Meat Meal (50 per cent.)	....	15.00	16.40	11.60
Leucaena leucocephala	....	....	10.00	15.00
Copra[1]	....	5.00	5.00	5.00
Copra Meal	....	25.00	10.00	15.00
Sago	....	53.70	56.40	50.58
Ferrous Sulphate ($FeSO_4 . 7H_2O$)	....	....	.60	1.00
Salt	.50	.50	.50	.50
B.H.T.	....	.02	.02	.02
Methionine	....	....	.20	.30
Tricalcium Phosphate[2]	4.00	....	....	....
Amprolium[3]	.05	.05	.05	.05
Vitamin Mix[4]	.65	.65	.65	.65
Mineral Mix[4]	.10	.10	.10	.10

Note.—

1. Owing to milling difficulties, 1.8 per cent. copra meal and 3.2 per cent. coconut oil were substituted after the first week on experiment.
2. Contained 32 per cent. Ca and 16 per cent. P.
3. Provided 0.0125 per cent. Amprolium (Merck Sharp and Dohme).
4. For composition of vitamin and mineral mixes see *Table* 1.
5. All rations were calculated to contain 15 per cent. crude protein.

Table 3.

Composition of Control Layer Ration.

Ingredient.	(Quantities Expressed as Percentage).
Meat Meal (50 per cent.)	12
Liver Meal (65 per cent.)	3
Lucerne Meal	4
Buttermilk Powder	5
Ground Limestone	5
Sorghum Meal	45.50
Wheat Meal	25
Salt	0.5
Premix[1]	0.02

Note.—

1. Premix contained the following per lb. of mixed feed, Vitamin A, 3,040 IU; Vitamin D_3, 567 IU; riboflavin, 1.31 mg; menadione sodium bisulphite, 0.51 mg; calcium pantothenate, 1.5 mg; manganous oxide, 57.5 mg.
2. Ration was calculated to contain 15 per cent. crude protein.

Table 4.

Mean Body Weight, Feed Conversion and Mortality During Growing Phase.

Treatment.	Average Weight in Grams.				Feed Conversion.	Days to First Egg.	Mortality (Per cent).
	9 WKS.	13 WKS.	17 WKS.	22 WKS.			
Control	728	1,120	1,450	1,800	6.82	169	0
Copra-Sago	602 *	1,043	1,276	1,666	6.77	177	8
10 per cent. *Leucaena leucocephala*	700	1,035	1,124	1,402	7.44	177	5
15 per cent. *Leucaena leucocephala*	735	882	908	1,175	13.67	186	0

* All groups were of uniform weight at eight weeks of age when distribution was made. In the intervening week this group failed to gain, possibly due to inaccessibility of feed or water. However, the group gained rapidly on the grower ration and appeared unaffected by the setback.

Table 5.

Hen Day Production, Mean Egg Weight, Feed Conversion, Body Weight and Mortality During Laying Phase.

Grower Treatments.	Hen Day Production.	Mean Egg Weight.	Feed * Conversion.	Final Body Weight.	Mortality.
	Per cent.	Grams		Grams	Per cent.
Control	59.2	55.7	5.63	2,621	14.3
Copra-Sago	52.4	56.6	7.05	2,612	14.3
10 per cent. *Leucaena leucocephala*	48.2	56.4	7.42	2,509	7.1
15 per cent. *Leucaena leucocephala*	59.2	57.1	5.73	2,401	7.1

* Pounds of feed required to produce a dozen eggs.

Preliminary Studies with Poultry Rations for the Territory of Papua and New Guinea. II.—Layer Rations with Copra, Sago and Leucaena leucocephala.

J. A. SPRINGHALL and E. ROSS.*

INTRODUCTION.

This work represents the third phase in a study to develop poultry rations using materials indigenous to the Territory. Studies with chicks and developing pullets have been reported by Springhall (1964) *and Springhall and Ross* (1965). *The present study deals with the feeding of high levels of indigenous feedstuffs to laying hens.*

MATERIALS AND METHODS.

TWO hundred and twenty-four, 22-week old White Leghorn x Australorp pullets used in a previous study (Springhall and Ross, 1965) were divided into 16 groups of 14 birds each in the manner shown in *Table* 1. Thus, an equal number of pullets, selected at random, from each grower treatment were fed each experimental layer ration shown in *Table* 3. The housing of the pullets, the source of feed ingredients, and their preparation were the same as previously described. (Springhall and Ross, 1965). In the case of the layer rations, however, coconut oil was added in varying amounts in an attempt to make the rations isocaloric. Since the energy values of several of the ingredients were not known, only a rough estimation of the caloric content could be made. Feed and water were provided *ad libitum* and artificial light was used to extend the total light period to 16 hours.

Egg production for eight calendar months, feed consumption, mortality, and body weight data were recorded. After three months egg production, eggs from each group were broken into petri dishes placed on white paper, and yolk colour measurements were carried out in direct sunlight using a Roche colour index fan. After six months production, hatchability data were collected to obtain a more critical evaluation of the experimental layer rations. At this time all birds were artificially inseminated twice at three-day intervals, and all eggs collected during a six-day period following the second insemination. The insemination was carried out in such a way that semen from each male was used to inseminate one or two hens from each layer treatment, thus obviating the necessity of testing the sperm and insuring that the same number of hens in each treatment group received sperm from the same males. After 17 days incubation the eggs were candled and the infertile eggs removed. Both fertility and hatchability data were calculated.

The data were analysed statistically using the variance analysis (Snedecor, 1956), and the multiple range test (Duncan, 1955 ; Kramer, 1956).

RESULTS AND DISCUSSION.

Table 2 summarizes the egg production for the eight-month experimental period. It is evident from these data that the observed differences are small, and no significant differences were found in the production rate of the birds fed the experimental rations, and those receiving the control ration. It will be noted from *Table* 3, that the control ration was the standard University of Queensland laying ration containing liver meal, lucerne and dried buttermilk in addition to grains and meat meal, while the experimental rations contained approximately 80

* J. A. Springhall, University of Queensland ; E. Ross, University of Hawaii.

to 85 per cent. of materials available in the Territory. The fact that the experimental rations yielded such good results would indicate a reasonable balance of nutrients. However, egg size as determined by egg weight of birds fed all three experimental rations was significantly smaller than those of hens receiving the control ration, averaging about three grams lighter. Since proteins probably have the greatest influence on egg weight of all dietary constituents, it is possible that either the protein or amino acid levels in the experimental rations was marginal.

There were no significant differences in per cent. fertility of eggs set (*Table* 4) or in hatchability of fertile eggs (*Table* 5) attributable to either grower or layer treatments, confirming the general nutritional adequacy of the experimental diets.

Table 6 summarizes the effect of layer treatment on yolk colour. It is obvious from these data that *L. leucocephala* has a pronounced effect on yolk colour, confirming the observations of Sandoval (1955). While it seems reasonable to expect a further increase in yolk pigmentation when the diet included 10 per cent. of *L. leucocephala*, this was not the case. It may be that the hens have reached the maximum of their ability to transfer the pigments from 5 per cent. of *L. leucocephala* into the yolk. Although vitamin A determinations were not made, it is reasonable to assume a high correlation between yolk pigmentation and vitamin A content (Romanoff and Romanoff, 1949) since *L. leucocephala* is known to be a rich source of carotene (Palafox and Reid, 1964).

The mean body weights of the hens receiving the experimental diets was 2 to 300 grams lower than that of the control group (*Table* 7). The birds receiving the 10 per cent. *L. leucocephala* made significantly lower gains than all other groups, while the birds receiving the copra-sago and 5 per cent. *L. leucocephala* rations gained significantly less than the control birds. This slower rate of gain is most probably related to the energy value of the layer rations which were probably less than the estimated values. Further evidence of this is seen in the feed efficiency data shown in *Table* 8.

While there appears to be considerable random variation in feed consumed to produce a dozen eggs between the various grower and layer treatments, the layer means shown in the bottom line indicate poorer feed conversion by the hens receiving either 5 or 10 per cent. of *L. leucocephala* in the ration. It is difficult to determine whether this effect is related to the lower energy value of this feedstuff or to the presence of mimosine, or to the mixture of ingredients used. In any event, the observed differences were not statistically significant.

Laying house mortality is shown in *Table* 9. Since there were originally 14 birds in each treatment group the values shown in the body of the table represent the loss of a maximum of three birds in any one group. While there appears to be no pattern in mortality related to the layer treatments, the data in the right hand column suggests a trend noted previously (Springhall and Ross, 1965) of decreasing mortality associated with delay in sexual maturity. None of these differences, however, was significant.

SUMMARY.

Laying rations containing 80 to 85 per cent. of copra meal, sago, coconut oil and *Leucaena leucocephala* were fed to pullets for an eight-month period. There were no significant differences noted in egg production, feed conversion, fertility, hatchability or mortality. Eggs laid by hens fed the experimental rations were significantly lighter in weight than the controls, and the hens laying these eggs gained significantly less than the control hens.

ACKNOWLEDGEMENTS.

The authors wish to acknowledge the financial assistance of the Reserve Bank of Australia, Rural Credits Development Fund ; and invaluable technical assistance provided by Mr. I. S. Burgess, Q.D.A.H.

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APPENDIX.

Table 1.

Distribution of Birds on Laying Rations.

Group.	Ration.	Number of Birds.
Grower Ration 1 (64)	Layer Ration 1	14
	2	14
	3	14
	4	14
Grower Ration 2 (64)	Layer Ration 1	14
	2	14
	3	14
	4	14
Grower Ration 3 (64)	Layer Ration 1	14
	2	14
	3	14
	4	14
Grower Ration 4 (64)	Layer Ration 1	14
	2	14
	3	14
	4	14

Note.—Figures in brackets represent numbers of birds.

Table 2.

Average Egg Production and Egg Weights During Eight Calendar Months of Lay.

Treatment.	Average Egg Production.	Hen Day Rate of Lay.	Egg Weight Grams.
Control	133	53	58.8
Copra-Sago	129	52	55.8
5 per cent. *Leucaena leucocephala*	126	50	55.6
10 per cent. *Leucaena leucocephala*	123	49	55.6

Table 3.

Composition of Layer Rations.

Ingredient.	RATION (QUANTITIES EXPRESSED AS PERCENTAGE).			
	Control.	Copra-Sago.	5 per cent. Leucaena leucocephala.	10 per cent. Leucaena leucocephala.
Meat Meal (50 per cent.)	12	18	15.7	13.3
Liver Meal (65 per cent.)	3			
Lucerne Meal	4			
Buttermilk Powder	5			
Ground Limestone	5	4	5	6
Sorghum Meal	45.5			
Wheat Meal	25			
Leucaena leucocephala			5	10[1]
Copra Meal		30	30	30
Sago		43.75	38.75	33.65
Coconut Oil		3.2	4.5	6
Salt	0.5	0.25	0.25	0.25
Vitamin Mix[2]		0.65	0.65	0.65
Mineral Mix[2]		0.1	0.1	0.1
Premix C[3]	0.02			

Note 1.—302.5 g of $FeSO_4$ dissolved in 1,750 ml of water, were mixed with 10 lb. of *Leucaena leucocephala,* and allowed to stand 7 to 10 days before mixing with the other ingredients.

2. The vitamin premix provided the following per pound of finished feed : Choline chloride 500 mg ; dl methionine 0.908 g ; vitamin B_{12}, 8 mcg ; inositol, 50 mg ; niacin, 32 mg ; vitamin A, 8,125 IU ; vitamin D_3, 1,200 ICU ; thiamin, 12 mg ; ascorbic acid, 10 mg ; menadione sodium bisulphite, 10 mg ; calcium pantothenate, 8 mg ; pyridoxine HCl, 8 mg ; riboflavin, 4 mg ; PABA, 4 mg ; vitamin E, 6 mg ; procaine penicillin, 2.25 mg ; folic acid, 2 mg ; biotin, 0.3 mg.

Mineral premix provided the following per pound of finished feed : Manganese, 27.2 mg ; zinc, 20.4 mg ; iron, 9.09 mg ; copper, 1.12 mg ; iodine, 0.59 mg ; cobalt, 0.23 mg ; molybdenum, 0.16 mg.

3. Premix C contained the following per lb. of mixed feed, vitamin A 3.040 IU, vitamin D_3, 567 ICU, riboflavin 1.13 mg, menadione sodium bisulphite 0.51 mg, calcium pantothenate 1.5 mg, manganous oxide 57.5 mg.

4. All rations were calculated to contain 15 per cent. crude protein.

Table 4.

Per cent. Fertility of Eggs Set.

Grower Treatments.	Layer Treatments.				Total Grower Treatment.
	Copra-Sago.	Control.	5 per cent. Leucaena leucocephala.	10 per cent. Leucaena leucocephala.	
Control	94(36)	94(50)	96(24)	91(45)	94(155)
Copra-Sago	90(42)	77(52)	95(37)	86(44)	87(175)
10 per cent. *Leucaena leucocephala*	90(48)	89(38)	90(42)	94(50)	91(128)
15 per cent. *Leucaena leucocephala*	91(53)	88(42)	88(41)	89(44)	89(180)
Total Layer Treatment	91(179)	87(182)	92(144)	90(183)	688(638)

Note.—Figures in brackets represent number of eggs set.

Table 5.

Percentage Hatchability of Fertile Eggs.

Grower Ration.	Layer Ration.				Total (Grower Treatment).
	Control.	Copra-Sago.	5 per cent. Leucaena leucocephala.	10 per cent. Leucaena leucocephala.	
Control	97(34)	94(47)	91(23)	98(41)	95(145)
Copra-Sago	89(38)	93(40)	89(35)	100(38)	93(151)
10 per cent. *Leucaena leucocephala*	93(43)	88(34)	89(38)	91(47)	91(162)
15 per cent. *Leucaena leucocephala*	90(48)	97(37)	94(36)	85(39)	91(160)
Total (Layer Treatment)	92(163)	93(158)	91(132)	93(165)	92(618)

Note.—Figures in brackets represent number of fertile eggs set.

Table 6.

Yolk Colour Index.

Group.	Treatment.	Number of Eggs Measured.	Colour Index Range.	Mean Colour Index.
1	Control	40	6-7	6.36
2	Copra-Sago	28	2-3	2.22
3	5 per cent. *Leucaena leucocephala*	62	7-8	7.29
4	10 per cent. *Leucaena leucocephala*	20	7-8	7.15

Note.—Group 3 = 4 (N.S.) ; Group 2 < 1, 3, 4, (P < 0.001) ; 1 < 3 (P < 0.01) ; 1 < 4 (P < 0.05).

Table 7.

Mean Body Weights at Start of Experiment and After Six Months of Egg Production.

Treatment.	Initial Body Weight.	After six Months Production.	Mean Gain.
	Grams	Grams	Grams
Control	1,527	2,535	1,008a
Copra-Sago	1,533	2,359	826b
5 per cent. *Leucaena leucocephala*	1,550	2,382	832b
10 per cent. *Leucaena leucocephala*	1,557	2,226	669c

Note.—Figures with different superscripts are significantly different, P < .05.

Table 8.

Ratio of Feed Consumption (lb.) per Dozen Eggs for a Period of Six Months.

Grower Rations.	Layer Rations.				Grower Means.
	Control.	Copra-Sago.	5 per cent. Leucaena leucocephala.	10 per cent. Leucaena leucocephala.	
Control	5.63	5.96	6.75	6.68	6.26
Copra-Sago	7.05	6.68	6.25	7.12	6.80
10 per cent. *Leucaena leucocephala*	7.42	6.10	6.51	6.88	6.73
15 per cent. *Leucaena leucocephala*	5.73	6.70	7.34	6.59	6.59
Layer Means	6.46	6.39	6.71	6.82	6.51

Table 9.

Per cent. Mortality During Laying Period.

Grower Rations.	Layer Rations.				Grower Means.
	Control.	Copra-Sago.	5 per cent. Leucaena leucocephala.	10 per cent. Leucaena leucocephala.	
Control	14.3	14.3	14.3	21.4	16.1
Copra-Sago	14.3	7.1	21.4	14.3	14.3
10 per cent. *Leucaena leucocephala*	7.1	21.4	21.4	0	12.5
15 per cent. *Leucaena leucocephala*	7.1	0	21.4	7.1	8.9
Layer Means	10.7	10.7	19.6	10.7	12.9

Book Review.

***Towards a New Trade Policy for Development* (*United Nations, New York*, 1964).**

This is a report to the United Nations by Dr. Prebisch, an Argentinian economist, who acted as Secretary-General to the three-month 120-nation Conference on Trade and Development at Geneva in 1964. It attempts to provide a background to discussion on steps to be taken to improve world trading procedures and relationships, for the benefit more particularly of developing countries, and thereby to assist their general economic development. The text follows closely a previous report compiled by Dr. Prebisch for the third meeting of the conference's preparatory committee following his visit to a number of participating countries including Australia, and discussions with them on world trade problems.

In three parts the book (1) sets out the trade problems facing developing countries; (2) suggests broad solutions ; (3) states responsibilities for, and obstacles in the way of the implementation of the broad solutions.

(1) Industrialized economies have expanded more rapidly than the developing economies until for the first time since the Industrial Revolution annual world increases in imports of raw materials (currently 1 per cent.) have fallen well below increases in exports of manufactures (3 per cent.). Contributory factors have been policies in industrialized countries of subsidized agricultural self-sufficiency, and the substitution of synthetics for, and greater efficiency in the use of raw materials. Additionally, as standards of living rise in the advanced countries a falling proportion of income is spent on primary products and in fact per capita saturation is approached in some cases. Concurrently prices of industrial goods are rising with growing world demand and rising industrial wages so that overall the real income available to developing countries to pay for imports fails to keep up with real income in the world as a whole. (Recent favourable price trends for tropical products are not considered permanent.) The growing wage-labour force in developing countries needs therefore to find occupations more and more in secondary industry and services. Import substitution has provided a basis but the limits are soon reached—local markets are small, costs tend to be excessive due to diseconomics of small scale, and high protective tariffs are needed to help the new industries towards viability. Incentives to efficiency are thereby reduced while imports of raw materials rise with consequently increasing danger from falls in export earnings.

(2) Dr. Prebisch's three broad answers to the economic plight of the developing countries lie in commodity agreements, encouragement to exports of manufactures and compensatory financing.

The main obstacle to international agreements is the lack of will to formulate national policy and so is political rather than technical. Agreements must provide for long-term stability and the removal of tariff barriers in addition to the traditional provisions. Measures to stimulate exports of manufactures from the developing countries and the development of export-mindedness are regarded as more important than access to markets for the manufactures, the latter requiring sympathetic treatment on the part of industrialized countries. Compensatory financing is seen as a transfer by industrialized countries to exporters of primary products of the extra income which should rightfully accrue to the former to compensate for unduly low prices for raw materials. While retaining current aid programmes, the fundamental aim should be to maintain intact the power of developing countries to purchase external resources through the sale of their exports. International prices for agricultural products need to be supported at levels higher than those prevailing in the absence of international regulation with due regard for maintenance of demand and undue stimulus to over-supply. However continuing agricultural surpluses are regarded as desirable to counter future shortages.

Any solution must include consideration of an international forum for trade and development matters. GATT is unacceptable, being unduly biased towards the trading patterns of advanced economies, too tariff centred, requiring a reciprocity of tariff treatment unacceptable to the developing countries, and not geared to supervise international commodity agreements or aid programmes.

(3) This section appears hurried and scrappy perhaps because of the need for specific detailed proposals to be put forward, whereas at the time the report was originally conceived Dr. Prebisch lacked a definite charter to guide him.

Since the trade gap is estimated to reach 20,000 million dollars by 1970, a staggering total from the viewpoint of the developing countries, but representing only a few per cent. of the total value of goods imported by the advanced countries it appears a responsibility of the industrialized countries to help bridge the gap by giving preferential access to developing countries' manufactures to the extent of these few per cent. International monetary reserves and gold need to move more freely. Trade and finance policies need designing specifically to give the developing countries a share in the advanced economies.

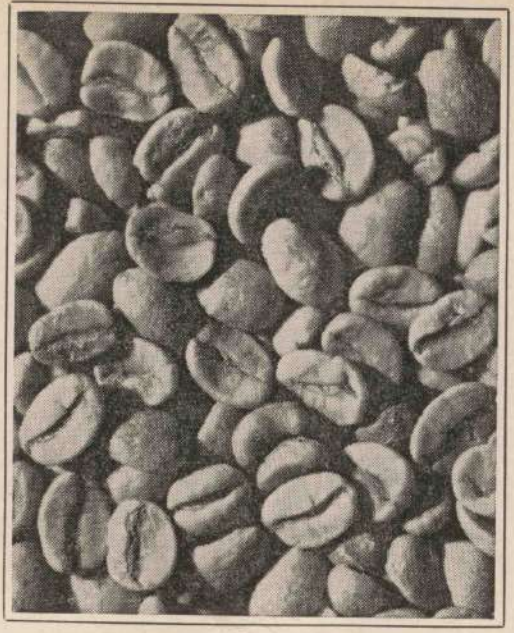
The developing countries' responsibilities lie in such measures as land reform, training, more equitable distribution of national income, and encouragement to birth control.

It may be commented that though some criticism was made of Dr. Prebisch's work in the press and elsewhere as being unduly idealistic, using biased samples and so forth, and though the ideas expressed are not new to development theory, the Conference through his ideas and guidance did finally draw the developing countries together. Towards the end of the conference when failure appeared imminent the unity of the " 75 " (developing countries) forced a decision to establish the U.N.T.A.D. as a regularly meeting assembly of United Nations, with the 53-member Trade and Development Board as a permanent organ.

Dr. Prebisch's ideas may not appear as applicable to Papua and New Guinea as to some other developing countries. Although it has suffered from fluctuating export prices, and pricewise from the growing output of synthetic rubber, the impact on the economy has been softened by the annual grant and a reasonably assured market in Australia, at least while our output remains small. Nevertheless any attempt on our part to move towards viability requires constant attention to current thought on the problems of developing countries and the solutions offered. It behoves us to keep in touch with moves towards international commodity agreements, price support schemes and compensatory financing.

Perhaps from the Territory's viewpoint undue importance is attached by Dr. Prebisch to stimulating industrial development in developing countries even prior to assuring access to markets for the manufactures' produce. However it appears essential in this country to consider industrial along with agricultural development to help maintain real income levels, to mop up the surplus labour made available by education, mechanization, and improved technical efficiency, and to utilize raw materials more fully.

Port Moresby: V. P. Bloink, Government Printer.—16297/11.65.



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