The

Papua and New Guinea

Agricultural Journal

Vol. 15 June—September, 1962 Nos. 1 and 2

CONTENTS

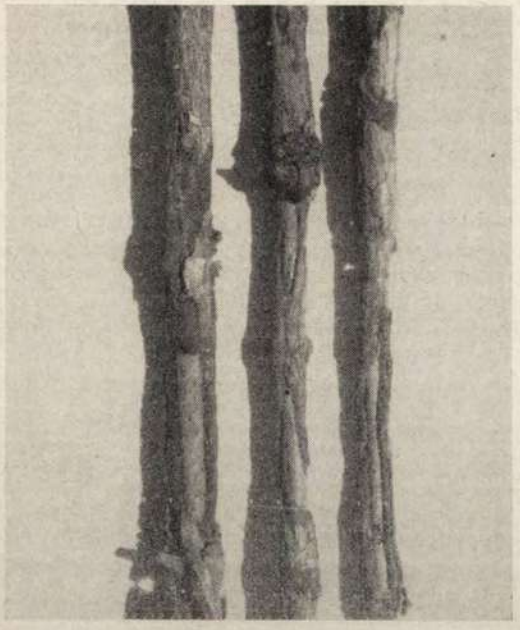


Plate II.—Stem girdling and callus formation of Arabica coffee caused by *Corticium salmonicolor.*

Occasionally the sexual stage of the fungus will form on the pink crust, but the spores are colourless and very small and cannot be detected on the crust with the naked eye. These spores can be wind-borne, however, and therefore constitute a source of inoculum for new infections at a distance. Often, however, the crust is sterile.

Occasionally the asexual spore form (once thought to be another fungus called *Necator decretus*) forms on the branches on the opposite side of the crust, i.e., on the upper side exposed to bright light. The spores occur in pustules which resemble orange pin heads, protruding through the bark. These spores are not wind-blown but are carried by water. In the Territory the "Necator" stage has only been recorded on coffee at elevations over 4,500 feet.

Branches infected with Pink Disease should be cut out and burnt. Because of the slow rate of growth of this fungus, outbreaks should be easily noted and brought under control before much damage occurs. Spraying with Bordeaux Mixture or other copper fungicides in cases of multiple infection has given good results. Heavy shade increases humidity which favours the fungus, so judicious thinning might be necessary.

As well as the economic plants mentioned above as hosts to this fungus, the following common shade plants and ornamentals are susceptible :

Crotalaria anagyroides, Cajanus cajan (pigeon pea), *Tephrosia candida, Eryobotrya japonica* (loquat), *Grevillea robusta* (silky oak), *Cordyline* spp. and *Justicea gendarussa,* the common hedge plant.

It will be noted that many of the above, and citrus, are grown in and around coffee plantations, and every care should be taken to eradicate the disease on these plants, otherwise they will provide inoculum for the coffee.

The disease occurs in both Arabica and Robusta coffee in the Territory.

LEAF AND BERRY SPOT.

(Caused by *Cercospora coffeicola* Berk & Cooke)

This fungus produces white circular spots with a brown margin on leaves, often surrounded by a slight yellow halo. With a hand lens a few minute black points can sometimes be noticed in the white centre. The fungus can

Plate III.—Leaf spot caused by *Cercospora coffeicola.*

Plate IV.—Thread blight caused by *Pellicularia koleroga.*

also attack berries, causing small brown blotches, sometimes depressed, which can spread and damage the whole berry. Occasionally the minute black pin points can also be seen on the berry lesions. The black pin points are seen under the microscope to consist of small clumps of light brown fungal stalks on which are borne the numerous spores of the fungus.

The disease causes very little damage in healthy coffee, but if leaves are yellowish through over-exposure or nitrogen deficiency, the leaf spots will increase. If seedlings are attacked in the nursery, the disease can also build up and defoliation and dieback can occur.

Control measures are usually not required for this disease, especially if shade management is satisfactory and the coffee is not showing any deficiency symptoms, but if seedlings are attacked in the nursery, spraying with copper fungicides will be found efficaceous.

In the Territory this disease is rarely found on Robusta coffee, but occurs to a small extent on most Arabica coffee in the Highlands, although it seldom builds up on leaves or berries to any degree.

THREAD BLIGHT.

(Caused by *Pellicularia koleroga* Cooke)

This fungus, which was once known as *Corticium koleroga,* grows on the undersurface of leaves and fruits. It appears first as a fine

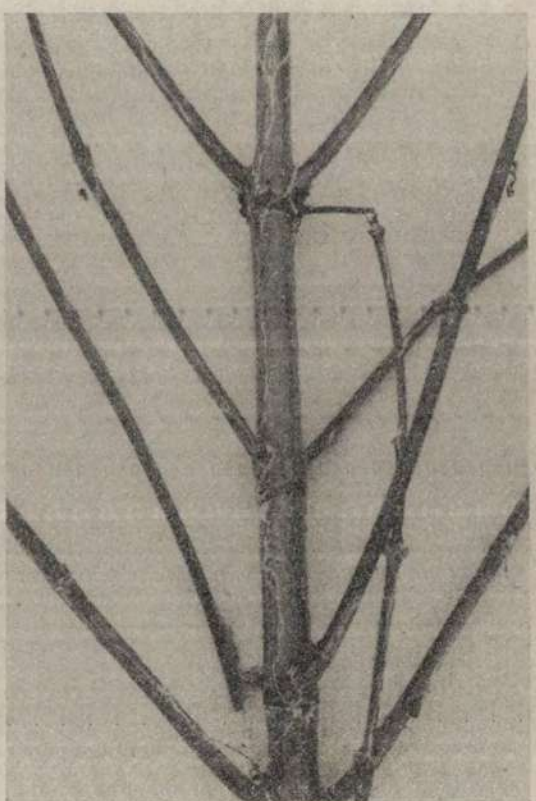


Plate V.—White thread blight of Robusta coffee.

silvery web, and causes a black rot of leaf or stem tissues. At a later stage, the fungus appears as light brown strands spreading over the undersurface of the leaf, running along the petioles and down the stems. The petiole dies and the leaf would fall from the tree except that it usually remains hanging vertically attached to the branch by the fungal threads or pellicle.

The fungus prefers warm, moist conditions, and is therefore usually found in the Territory on Robusta coffee in the lowlands in the wet season or in plantations under heavy shade.

The disease can be controlled by judicious shade management and by cutting out and burning infected branches. Chemical control is usually not warranted in a well run plantation.

WHITE THREAD BLIGHT.

White thread blights occasionally occur on Robusta coffee in the Territory, but are never serious. The fungi causing white thread blights are usually species of *Marasmius* or *Corticium*—the genus cannot be identified unless the spores are present, and to date no spores have occurred on the few Territory collections available for examination.

The disease can be controlled by reducing humidity by careful thinning of shade and by cutting out infected branches and burning.

ROOT ROT.

A few specimens of root rot have been reported in the Territory, but to date all the specimens have lacked fruiting bodies which are necessary for the identification of the fungi.

If a tree wilts and dies, the collar, taproot and laterals should be dug out, and inspected for signs of broken bark (perhaps caused by crickets on the stems and cockchafer larvae on the roots) or other signs of insect damage. If injury by insects is not applicable, inspect the roots and collar for fungal threads, strands, sheaths, or crusts. These might be white, grey brown or black or sometimes other colours. Occasionally, however, it is difficult to detect the fungus externally. The collar and taproot should be split once longitudinally and the two newly-exposed faces examined for signs of rot (change of colour of the wood, change of texture, collapse of tissue) or the presence of black fungal lines in the wood.

If root rot is determined, the laterals should be dug out and all material burnt, so that the fungus will not spread in the ground along the diseased roots.

If root rot is suspected, the taproot and collar cut off about one foot above soil level can be forwarded to Headquarters for examination.

SOOTY MOULDS.

Sooty moulds occur commonly on Territory coffee, particularly on Robusta. The sooty moulds include many species of fungi, all with dark coloured fungal threads, which are superficial on the leaf surface, attached to the leaf cuticle by tiny pegs or holdfasts or which send

Plate VI.—Lichen colonies on upper surface of Arabica coffee leaf.

haustoria or feeding organs into the host tissues The sexual fruiting stages consist of spherical black bodies containing the spores, but they are so small that they cannot be seen with the naked eye.

The large group which is quite superficial on leaves lives mostly on honeydew or excretions of aphids and scale insects.

The sooty moulds are of no economic importance.

LICHENS.

Coffee leaves bearing colonies of lichens are often received for identification, being suspected of causing disease. However, they are quite superficial on the leaves and cause no damage whatsoever.

The lichens on coffee leaves resemble small white circular crusts from 1-3 mm. in diameter. They can be easily removed from the leaves with the fingernail, a match, or knife blade, without any damage to the underlying tissue.

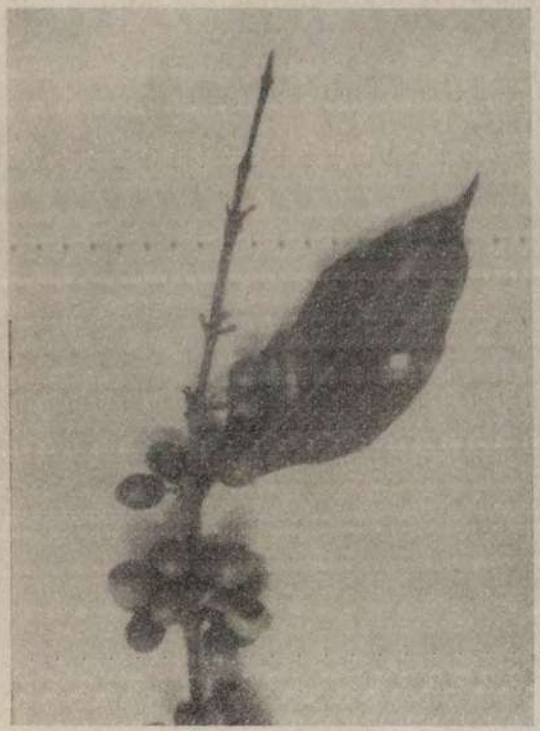


Plate VII.—Overexposure dieback of Arabica coffee.

A lichen colony consists of a fungus and alga (many different species) growing symbiotically, and because both prefer humid conditions, the colonies are usually most abundant in heavily shaded plantations or near the protected basal leaves of the plant. They are of no importance themselves but their abundance can be taken as an indication that humidity is very high and discreet thinning of shade might be desirable.

OVER-EXPOSURE DIEBACK.

In those plantations where shade is deficient and cloud cover is inadequate, dieback of tips of branches, particularly of Arabica coffee, is sometimes experienced. The tips appear black and the berries do not mature. Even if the tips do not die back, berries on over-exposed

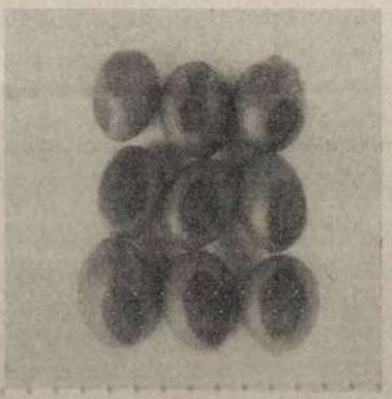


Plate VIII.—Overexposed berries with sun-scald on upper surface.

bushes are liable to sun scald. Miscellaneous saprophytic fungi can be found on the moribund tissues, but no pathogenic organism has been isolated to date. Adjustment of shade by planting rooted Leucaena cuttings or other quickly growing shade will correct the position.

EFFECT OF LOW TEMPERATURE.

Occasional low temperatures occur in the Highlands and effect the new shoots of Arabica coffee. The effect is usually not noticed until weeks later, when pairs of leaves, all about the same distance back from the tips of the branches, are found to be reduced in length and width, and with decrease in chlorophyll, giving the leaves a white look. Subsequent leaves are quite normal, and there is no effect on yield.

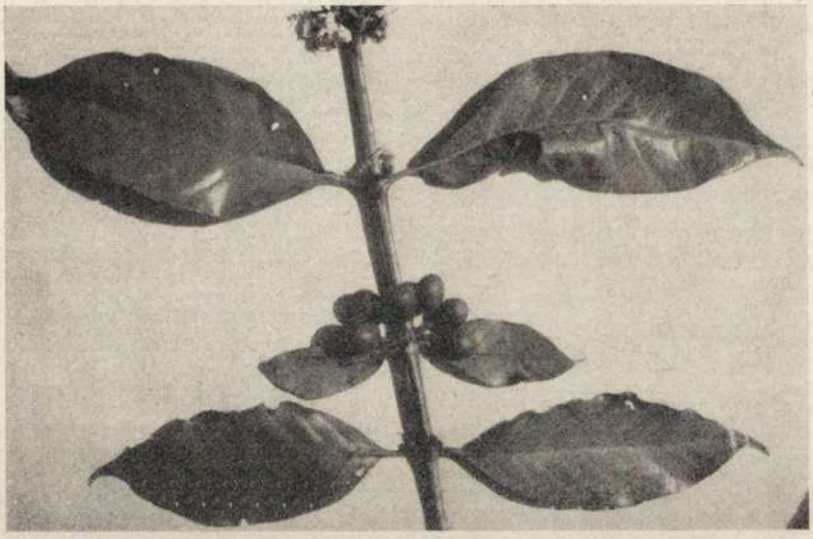


Plate IX.—Pair of small leaves on Arabica coffee, caused by low temperatures.

HORMONE WEEDICIDE DAMAGE.

Hormone weedicide damage on coffee consists of malformations of the leaves, the extent of the damage depending on the concentration of the spray and the amount falling on the leaves. The commonest effect is reduction in the size of leaves, and their tendency to be elongated or sickle-shaped. Effects of the spray may be localized on a bush, and may persist for some time. To date no damage has been observed on the fruit, and no changes have been noted in the colour of the tissues.

DISEASES CAUSED BY SOIL DEFICIENCIES.

Dieback, malformed leaves and other abnormalities of coffee caused by soil deficiencies are not featured herein.

The Origin and Introduction of the Basic Food Crops of the New Guinea People.

G. P. KELENY.

Plant Introduction Officer, D.A.S.F., Port Moresby.

This Paper was presented at the UNESCO Symposium on the Vegetation of the Humid Tropics, Goroka, September, 1960. Also published in the Proceedings of the Symposium. Now slightly revised.

Introduction.

IN this section of the Symposium we are considering the influence of plant introduction on the food habits of early man. One might be inclined to assume that relatively primitive communities, living under fairly isolated conditions and practising subsistence agriculture are likely to be utilizing mainly locally occurring, endemic species of food plants. This, however, is not so. Even a cursory glance will reveal broad patterns of food utilization over a wide area of South-East Asia and the Pacific, indicating a considerable dispersal or exchange of the basic subsistence crops.

Phytogeographical Regions.

On examining the geographical distribution of plants in this part of the world one notices the strategic position and special importance of the Malay Archipelago in acting as a land bridge between various phytogeographical regions, and also as a focus for the dissemination of plants. To the north of the Archipelago lies the Continental South East Asiatic Region, comprising Southern Burma, tropical South China, Formosa, Thailand, Annam and the Malay Peninsula. The endemic genera of this area are estimated at over two hundred but its flora is essentially part of the Malay Archipelago. Many cultivated economic crops, rice, tea, some members of the Genus *Citrus* and *Cinnamonum* probably originate from this region.

Van Steenis in his work on the montane florae of the Malay Archipelago traces two distinct routes for the distribution of species between the Asiatic mainland and the Archipelago, one via India, Malay Peninsula, Indo-China, Java and Sumatra and the other by way of China, Japan, Formosa, the Philippines and North Celebes. But there is also a third element contributing to the richness of the flora; from Australia by way of New Guinea, Celebes, Borneo and the Philippines. Geographical proximity has not always resulted in a similar flora, e.g., Java is much closer to the Australian continent, yet has very few Australian types in its flora compared with the Philippines where numerous Australian genera are found fairly well distributed even to Northern Luzon.

Geographically, the Malay Archipelago has three zones, Asiatic in the west, Australian in the east and an intermediate zone. It is also evident that the flora and fauna show similar divisions. Generally speaking, in the island region, the Asiatic and continental types become less dominant as one proceeds to the south and east, and at the same time Australian species which are strongly represented in New Guinea become less dominant as one progresses north and west.

The vegetation of the Malay Archipelago is probably the richest and most luxuriant in the world. Growing conditions favour plant growth and contributions were received from many sources on the Asiatic continent, yet the number of endemic genera is very large, probably in excess of five hundred. The degree of endemism varies from island to island. New Guinea has the highest, it is variously estimated at 150 genera or 85 per cent. of the total; Borneo and the Philippines are considered to have approximately 100 genera each or approximately 50 per cent. followed by Java and Sumatra, the latter having only about 20 genera. Some of the more important species originating from this region are *Areca Catechu, Arenga saccharifera, Artocarpus integer, Artocarpus incisa, Boehmeria nivea, Calamus* sp., *Canarium Luzonicum, Colocasia esculenta, Curcuma* sp., *Durio zibethinus, Eugenia* spp., *Garcinia mangostana, Mangifera indica, Metroxylon Rumphii, Musa textilis, Myristica fragrans, Nephelium lappaceum, Piper betle, Piper cubeba, Zingiber officinale.*

In contrast to the above regions, Melanesia, Polynesia and Micronesia, except for Hawaii and New Caledonia, have essentially a flora derived almost entirely from the Malaysian and Australian zones. Even in Hawaii the majority of indigenous genera are of Malaysian origin, although most of the species in these genera are different from those that occur in the Western Pacific region. Micronesia has six endemic genera listed, while twenty-three were recorded for Polynesia. Fiji has perhaps 50 per cent. of endemism, Tahiti 35 per cent. and Samoa rather less.

Considering the high degree of endemism of the flora of New Guinea and the supposed isolation of its people, who, prior to the arrival of Europeans, lived in a state of constant warfare with each other, one would expect that the majority of the basic subsistence food plants would be indigenous to the area. However, of the major basic foodcrops of the New Guinea peoples only the *Musa* spp., *Saccharum* spp. and sago *Metroxylon* spp. could be regarded as originating there. All the others : taro *Alocasia* spp., *Colocasia* spp., yam *Dioscorea* spp. and the sweet potato *Ipomoea batatas*, must be considered to have been introduced at one stage or another. Moreover, human agency is the most likely means by which they were distributed. Who were the people and where did they come from ?

Origin of the New Guinea People.

There is no certainty of the origin of the peoples of the island of New Guinea, who are extremely diverse in their physical type and language. At the time of the arrival of the first Europeans they were using only stone, wood or bone implements but no metal of any kind. Several hypotheses were advanced, yet the views of Strong (1920) though written forty years ago, still seem to be valid. It is generally held that there are three main constituents in the native population of Papua and New Guinea. The original inhabitants called Negritoes—allied to the Negritoes of the Andamanese Islands and the Malay Peninsula—are short or dwarfish, live in isolated communities towards the centre of the island, e.g., the Jimmi River, the Kuku-Kuku, and around Mount Yule. Although taller, the aboriginal population of Tasmania is supposed to have been related to the Negritoes.

It is supposed that after the Negrito, came a race spoken of as " Papuans ". They are a medium tall, fairly dark race. Allied races can be found in some of the Malayan Islands. In some far off prehistoric time the primitive " Papuan " drove the still more primitive Negrito to the central mountains. The result is that the mountains are populated by people tending towards the Negrito type, whilst at lower levels the population is tending toward the " Papuan " type.

The " Papuans " were followed by at least one major invasion—the Melanesians. They have settled along the coast and are now so mixed with the " Papuans " that it would be difficult to distinguish them, but for the fact that they have retained their own type of language. The Melanesians are found in many areas along the coast of Papua and New Guinea and the adjacent islands extending to the Solomons, New Caledonia and Fiji. The immigrants or invaders have, in many cases, imposed their language and probably their culture on the " Papuan ", but their numbers were comparatively small and they have inter-married with the " Papuans " to such an extent that, physically they have approximated the " Papuans ". Nevertheless, they tend to be lighter in colour. The original Melanesian was probably straight-haired and relatively light-coloured, more comparable with the present day Malay or Polynesian.

The original home of the Melanesians is placed somewhere in Southern Asia. From there they have spread both east and west and their descendants can be traced in the languages from Madagascar to the Malay Peninsula and Archipelago right to Polynesia. The early Melanesians were probably the first seamen of the Pacific, travelling in outrigger canoes, which are typical of the area of their influence. The migration of Melanesians or Malays has continued until comparatively recent times, e.g., the culture hero of the Motu people living at Port Moresby is Hedai Siabo, a Malayan, who taught them the building of the large trading canoe and organized the annual trade journey, the Hiri, towards the west to obtain sago. Similarly, the Hula people, living about seventy miles east of Port Moresby show distinct signs of their Malay ancestry, being light-skinned, straight-haired and having the characteristic eye-fold.

The Negritoes are still mainly hunters and gatherers of roots, leaves, nuts, berries of the forest. Agriculture plays only a small part in

their economy, so it is unlikely that they were responsible for the introduction of food plants into New Guinea. Therefore the "Papuans" and Melanesians are probably the people who brought in most of the basic food plants used today.

Origin and Distribution of the Basic Foods.

Starchy foods form the basic subsistence diet of the people of New Guinea and the plant supplying it varies from district to district. It may be taro *Alocasia* and *Colocasia* spp, yam *Dioscorea* spp., banana *Musa* spp., sago *Metroxylon* spp., or sweet potato *Ipomoea batatas*. One or more of the above might be present in the same area, but the dominant subsistence crop is invariably well defined.

Degener (1946) gives India as the type habitat of *Dioscorea* sp. while *Alocasia* and *Colocasia* originate probably from Malaysia, thus their introduction into New Guinea may be explained through the migration of the people. The name of a crop throughout a region is often a good indication of its origin and dispersion, e.g., throughout the Malay archipelago to the Philippines and New Guinea the yam *Dioscorea* sp. is called by names such as ubi, uebi, uwi huwi, while in Polynesia as far east as Hawaii and the Marquesas, the same name appears as ui, ufi, uhi, pahui. For taro *Colocasia esculenta* we find throughout Indonesia names such as: tale, talo, talas, taleh talos, taleus, gelo, tales, talak, which are comparable with dalo used in Fiji.

The bread fruit *Artocarpus* sp., is not as important as a food crop in New Guinea as it is in Polynesia, but being a plant of the Malay Archipelago its introduction follows the same pattern. Similarly, the coconut, *Cocos nucifera* is seldom the principal item of the diet, as it is on many atolls in Polynesia, but is mentioned because it is regarded as one of the most characteristic plants and crops of the Pacific. It is a Pan-Pacific species with its origin probably along the shores of the Indian Ocean. Man is considered the agent of its distribution, reaching Madagascar on the one hand and Hawaii on the other. The name for the coconut throughout the Malay Archipelago and Polynesia comes within the niu, -nia, -niue, -niog series of names, demonstrating how the name was transmitted by man along with the plant throughout his travels. This view is supported by de Candolle (1882) who comments that "the uniformity of nomenclature in the archipelago as far as Tahiti and Madagascar indicates a transport by human agency since the existence of known languages". Incidentally both Dampier and Moresby recorded the palm as growing in abundance along the shores of New Guinea and on the Islands of Torres Strait. In the Western Hemisphere, in tropical America, the name of the palm is based on "coco"—its Portugese name, demonstrating that they were probably the human agents introducing it to that part of the world.

Ridley (1930) advances the theory that the original home of the coconut must have been in Costa Rica and Panama. He is relying mainly on an account by the Spanish traveller Oviedo who visited Panama in 1515 and claims to have seen the coconut there. Peter Martyn in *Hakluyt's Voyages* 1520 describes the coconut from both the Moluccas and in Panama. A much earlier record is that of Marco Polo who mentions the occurrence of the coconut in Sumatra, Nicobar, Andamans and in Madras and Malabar in 1280. Coconut palms are represented in the carvings of both Angkor-Wat in Cambodia and the Borobodur in Central Java, dating from the Tenth to Twelfth Centuries. Ridley (1930) considers that the coconut must have reached Polynesia from America through nuts carried by ocean currents, and has spread from there to Malaysia and the Asiatic mainland by both sea-drift and human agency some thousands of years ago. However, he seems to overlook that most of the migration of the people was from the Asiatic mainland towards the islands of the Pacific and not vice versa, and that the American flora is barely represented in Polynesia, whereas those of Malayan origin are predominating. Ridley's hypothesis, though interesting, represents an earlier view, which is largely superseded.

The distribution of the sweet potato *Ipomoea batatas* which is the basic foodcrop of the people of the New Guinea Highlands presents an interesting problem in plant geography. In the whole of the island, population densities reached their highest level in the Highlands—and this is attributed to the presence of the culture of the sweet potato—in other words, there is a symbiotic relationship between man and the sweet potato. The question is when and how was the sweet potato—a species of the new world—introduced into the Highlands

of New Guinea ? If it is only a recent introduction, following European contact with Malaysia, then the population in their present densities must have developed only recently. It is interesting to note that throughout New Guinea, and particularly in the Highlands, stone pestles and mortars are unearthed from time to time. These stone implements are not part of the culture of the present population and they know nothing of them, neither do they utilize them in their everyday life. These stone mortars must be a relic of a previous population or perhaps the ancestors of the present people used them before the introduction of the sweet potato, following which their use was no longer necessary and was forgotten. These mortars are of various sizes with a diameter of a few inches to about three feet, rather indicating a culture which used them extensively for a variety of purposes, not just, say, for the pounding of the basic item of the diet. It is obvious that before the advent of the sweet potato, the Highland people must have subsisted on a diet of various wild roots, berries, nuts, etc., just as some of the still nomadic Negrito tribes exist, even today, in the region between the highland mass of people and the coastal inhabitants. A possible pre-sweet potato " staple " is the mountain *Pandanus* sp., whose nuts are still highly favoured.

Massal and Barrau (1956) state that the sweet potato was brought to Europe in 1495 and was taken from there to India, the Philippines, China and Japan. Candolle (1882) quotes Dr Breitschneider that according to Chinese sources the sweet potato is of foreign origin to China and introduction took place between 1573 and 1620. This points to the American origin of the species. It is listed by Rumphius in his " Herbarium Amboinense " indicating that it reached the borders of Melanesia by 1650. He says positively that according to general opinion, sweet potatoes were brought by the Spanish to Manila and the Moluccas, whence the Portugese diffused it throughout the Malay Archipelago. It is noteworthy that in many parts of East Indonesia, e.g., Menado, Gorontalo and other parts of North Celebes, also in Timor, Lombok, West Sumbawa and Ambon the local name for the sweet potato is similar to its botanical name, e.g., batata, batatas, potatas, watata, indicating a possible distribution from the Eastern regions, probably from the Philippines. The Spaniards also introduced it into Micronesia. From the Moluccas or Ambon it is easy to picture the introduction of the crop into New Guinea through well developed trading routes. For example cowrie and gold lip pearl shells from Thursday Island in the Torres Strait are still used as currency and means of personal adornment throughout the Highlands and the sweet potato could have been brought in by the same route.

The above description might explain the introduction of the sweet potato into New Guinea, but it does not explain its presence in Polynesia. If the crop had not reached Malaysia until 16th Century it could not have been taken by the Polynesians on their journey eastward across the Pacific. It might be also remarked that of the Polynesian communities on islands close to New Guinea, the Trobriand Islanders have a staple diet of yams and those at the Mortlocks eat taro. Massal and Barrau (1956) state that when the first Europeans reached Polynesia they already found the sweet potato growing there. This suggests a pre-European contact between the people on the West coast of South America and Polynesians. It could be, as Peter Buck suggested, that Polynesians visited America and brought some tubers with them, or that some American Indians travelled across the Pacific, from the West towards the East, the feasibility of which was proved by Heyerdahl. The name of the sweet potato in Polynesia, Kumara, or Kumala, also suggests contact with Peru, Colombia or Ecuador where similar names are used. Whatever the means of introduction, the sweet potato has spread throughout Polynesia, reaching Hawaii in the North and New Zealand in the South, becoming the staple food of the Maoris.

Candolle (1882) suggests two additional hypotheses for the distribution of *Ipomoea batatas*. One assumes a prehistoric communication between Asia and America. The other considers that, in view of the wide distribution of Convolvulaceae, the species may well have existed further north before the extension of glaciers and prehistoric men may have transported it southward when the climatic conditions altered. These hypotheses would certainly help to explain the presence of the sweet potato in Polynesia.

Two other new-world plants, maize *Zea mays* and tobacco *Nicotiana tabacum* were also widely distributed in New Guinea including the

Highlands, prior to the exploration of the island during the last century. It seems that the Philippines and Ambon might have been important centres for the distribution of American species in Malaysia and Melanesia. Rumphius records maize in his Herbarium and notes that it was cultivated in the Philippines. My own view is that maize could have been introduced by shipwrecked Portugese or Spanish sailors who are known to have frequented the New Guinea shores in the 16th and 17th Centuries. Later, with additional European contact, fresh strains and varieties were introduced. Massal and Barrau (1956) state that it was grown by Quiros on Santa Cruz and the Marquesas as early as the 15th Century and later cultivated on Guam. According to Yen (1959), the earliest recorded introduction into New Zealand is in 1772, (a little after the introduction of potatoes *Solanum tuberosum* attributed to De Surville in 1769).

Gilmour (1931) studied the forms of tobacco occurring in New Guinea and concluded that they are all *N. tabacum,* disproving an earlier claim by Maiden that New Guinea tobacco might have been derived from *N. suaveolens* which is indigenous to Australia. According to Comes (quoted by Gilmour) the Spaniards cultivated tobacco in the Philippines in 1600. In 1601 the Dutch imported tobacco into Java and introduced it into Timor in 1613. By 1615 it was recorded as being cultivated in a number of islands north of New Guinea. Merrill (1946) in his paper "Tobacco in New Guinea" supports this view. He points out that Amboina was first visited by the Portugese in 1511 and was definitely colonized by them in 1521 and that this island was the first important centre in Malaysia for the introduction and dissemination of American plants. The Portugese were soon followed by the Spaniards operating through the Philippines. *Nicotiana tabacum* is also clearly described in Rumphius' Herbarium Amboinense, so it seems that the first introduction of tobacco into New Guinea might have been from Amboina, followed by other introductions along trade routes on the north shore of the island from the Philippines and the Moluccas.

Merrill (1946) draws attention to the use of place names in indicating possible sources of distribution for the new-world plants, "Manila" in particular seems to occur frequently, e.g., *Pithecolobium dulce,* a plant of Mexican origin, is called Manila tamarind in India, the tree having been introduced there from the Philippines shortly after the middle of the 18th Century. In Java the American sapodilla *Achras sapota* originating in Central America is claimed to be known as sawo manila, the peanut *Arachis hypogaea* as Katiang manila, the soursop *Anona muricata* as langka manila. In the Philippines *Cassia alata* is known as Kapurko or Akapulko, having been introduced from Acapulco in Mexico, while in Java it is known as Ki manila.

Discussion.

Our survey of the pre-European introductions of basic food plants into New Guinea poses several questions. First, why were these plants introduced—were they the diet of the people concerned who brought their food plants with them as they migrated to new lands or were the crops introduced subsequently through trade routes and through contact of the people with their neighbours? Or perhaps were the food plants already growing in the new environment and subsequently utilized by the immigrants? All people, whatever the state of their civilization or culture, are conservative in their food habits and it is reasonable to expect that they prefer the foods they are used to consuming. Conversely they could be expected to take with them the basic items of their diet. This might apply to the old world plants, but it is obvious that food crops originating in the Western Hemisphere must have been imported, subsequent to the arrival of the people, the sweet potato and maize changing the agriculture of Malayans and Melanesians, just as the potato and maize revolutionized the agriculture of Europe.

The second pertinent question is: if the Malay Archipelago and Ambon in particular, played such an important part as the source of plant material for New Guinea, why were some crops introduced, or why some found their way into a new country, and not others? The most important exception being rice *Oryza sativa,* even though some wild forms, e.g., *O. schlechteri; O. perennis, O. minima,* are known to occur in various parts of the Territory such as Ramu and Sepik River valleys. Surely rice, being an easily storable product would have appealed to travellers. This question is not easy to answer. There is evidence in the pattern of land settlement in various parts of Indonesia that rice culture is the result of Malayan influence

and that the intensive system seen today is only a relatively recent development due to pressure of population growth. Further, that rice tended to displace an older system, based on root crops which might have been the only standard food crops the Melanesians knew at the time of their migration.

The second possible reason why rice has not found its way to New Guiena is that most contacts were with the Eastern part of Indonesia where rice is barely grown, even today. Sago is the basic food crop in Ambon and the Moluccas, while approximately from Lombok eastward, maize and cassava are the principal foods grown. Thus there was no direct contact with rice eaters and rice growers.

The first rice grown in Papua was by members of the Sacred Heart Mission at Yule Island at the turn of the 20th century ; Brother Kala from the Philippines was responsible for the first planting. (Private communication from Bishop A. Sorin, March, 1951.) It is also rather peculiar that examples of the very rich tropical fruit flora of the Malay Archipelago were not gradually introduced into these islands. Mangoes *Mangifera indica* are an introduction by Europeans, while other delicious fruits such as the mangosteen *Garcinia mangostana*, rambutan *Nephelium lappaceum*, durian *Durio zibethinus*, etc., are practically unknown and non-existent even today. As against this, the papaw *Carica papaya*, which is of American origin, is ubiquitous. If it is correct that some of the important basic food crops such as the sweet potato and maize are the result of contact, subsequent to the advent of Europeans to the Eastern portion of the Malay Archipelago, it seems remarkable that the main objective and interest of the presence of Europeans in those days, namely the spices, were not imported as well. None of these spices sought after by the European traders, and the subject of wars between the Portugese, Spaniards and Dutch, pepper *Piper nigrum*, nutmeg *Myristica fragrans*, cinnamon *Cinamomun zeylanicum*, cloves *Eugenia aromatica* are present in New Guinea, even though other members of the genera have a widespread occurrence.

Recent Introductions.

Of the more recent introductions cassava or tapioca *Manihot utilissima*, is of major importance. It is native of tropical America, Mexico, Brazil and Peru, and was grown there as a food plant before the arrival of the Europeans. Massal and Barrau (1956) report that it was taken to Africa by the Portugese whence it spread to Madagascar and the Asiatic continent. It was introduced into Polynesia in the fist half of the last century, reaching New Caledonia from Samoa or Tonga in 1852. According to Terra (1958) cassava became established in the Gunung Kidul region of Central Java only during the Governor-Generalship of Daendels during the Napoleonic Wars. Since then it has become wide-spread throughout Indonesia and is one of the most important food crops in areas having a pronounced dry season. In New Guinea it is planted in mixed food gardens in many parts of the island, but is only a subsidiary, if important, food crop even in the drier regions.

Another more recent introduction, originating in America is *Xanthosoma* spp. It was probably brought to the Pacific in the 19th Century. In New Guinea it is called Kong-Kong (Chinese) taro, in New Caledonia " New Hebrides taro " in the New Hebrides " Fiji taro " giving some indication of its dissemination or supposed distribution. In New Guinea it is becoming of ever increasing importance as a standby food reserve for droughts and supplementing the diet in areas having a taro staple crop.

Of the introductions made during the past fifty years, peanuts *Archis hypogaea* and potatoes *Solanum tuberosum* are of the greatest importance. Both reached this popularity only after the second world war and are being accepted into the dietary of the indigenes. Peanuts are one of the many pulses and legumes introduced in an effort to increase the protein component of the diet. They seem to be fairly readily consumed though the high fat content can cause a stomach upset. Although the average food garden, particularly of the Highland people, contains a wide variety of pulse crops, e.g., *Psophocarpus tetragonolobus, Phaseolus lunatus, Dolichos lablab, Vigna sesquipedalis*, (the Chimbu people are said to use more than 100 types of various greens) more recent introductions such as *Vigna sinensis, Phaseolus mungo, Phaseolus calcaratus, Canavalia ensiformis, Cajanus cajan* have not been readily accepted so far. Perhaps more time and more intensive effort at popularizing them is needed.

The potato *Solanum tuberosum* is rapidly gaining importance in high altitude areas where sweet potato crops are killed by periodic frosts.

Due to a rapidly increasing population, the people are becoming increasingly dependent on crops from areas subject to frosts. In these areas potatoes, particularly short-day varieties or those tolerant of short-day conditions, can be expected to supplement or even gradually displace sweet potatoes. Since the advent of European missionaries and government officials, a wide range of vegetables was introduced to New Guinea including beans, tomatoes, cabbage, chinese cabbage, lettuce, etc. Some of these, particularly beans *Phaseolus vulgaris*, tomatoes *Lycopersicum esculentum*, chinese cabbage *Brassica chinensis* and pumpkin *Cucurbita maxima* have been readily accepted into the diet and gardening practices.

Conclusion.

We have seen that although New Guinea has a very large endemic flora, the majority of the basic food plants, forming the subsistence diet of the inhabitants were introduced at varying times in history. The dependence of the people on introduced species and the success of the plants in their new environment would suggest a considerable scope for future systematic plant introduction. It is unlikely, however, that new food crops could be imported which would displace the existing major basic subsistence foods. Perhaps a major change would come with the acceptance by the people of grain crops such as rice and sorghum. Rice is already widely consumed, but post-war efforts at encouraging its culture have not been too successful. Perhaps eventually population pressure will demand a more intensive system of food production to replace shifting agriculture. Similarly, sorghum might prove to be the ideal crop for the drier regions, if methods of consumption could be developed and popularized, but both rice and sorghum are already grown in the Territory so would no longer be initial introductions. There is, however, still a fairly wide field for introducing and disseminating further subsidiary crops rich in proteins or protective foods for the improvement and diversification of the diet.

The stage is being rapidly passed when much success could be expected from introducing a few seeds or plants from here and there. The future role of plant introduction will be more to provide the basic collections for specialists working on crop improvement, e.g., sweet potatoes from the Andes which migh possess frost resistance ; short-day potato and soy-bean varieties ; collection of *Colocasia* for breeding resistance to *Phytophtora colocasiae*. In other words, plant introduction is no longer the pastime of the naturalist, but the field for systematic research to find the type of material most suited for the new environment or required for research projects.

REFERENCES.

DE CANDOLLE A. (1882). (Reprinted 1959) *Origin of Cultivated Plants*. Hafner Publishing Co., New York.

DEGENER, O. (1946). *Flora Hawaiiensis Books* 1-4.

GILMOUR, J. S. L. (1931). *The species of tobacco grown in New Guinea*. Anthropology Report No. 11, Territory of Papua.

GOODE, R. (1947). *The geography of flowering plants*. Longman's, Green & Co., London.

HEYNE, K. (1950). *De Nuttige Planten van Indonesie*. W. van Hoeve, S-Gravenhage.

MASSAL, E., & BARRAU, J. (1956). *Food Plants of the South Sea Islands*. Technical Paper No. 94. South Pacific Commission, Noumea.

MERRIL, E. D. (1946). *Plant Life of the Pacific World*. Macmillan Co., New York.

RIDLEY, H. N. (1930). *The Dispersal of Plants throughout the World*. L. Reeve & Co., Ltd., Ashford, Kent.

STRONG, W. M. (1920-21). First Annual Report by Anthropologist. *Annual Report* 1920-21. Territory of Papua, p. 31.

TERRA, G. J. A. (1952-53). Some Sociological Aspects of Agriculture in South-East Asia. *Indonesie*. Vol. VI, No. 4 and 5, 297-316, and 439-455.

YEN, D. F. (1959). The use of Maize by New Zealand Maoris. *Economic Botany*. Vol. 13, No. 4.

Tiracola plagiata *Walk. (Lepidoptera : Noctuidae) A Serious Pest of Cacao in Papua.*

A. CATLEY.

Entomologist, D.A.S.F., Port Moresby.

Distribution.

Tiracola plagiata Walk. is distributed from India to Australia. Commonwealth Institute of Entomology records (in litt. Dec., 1961) include Darjeeling, Bombay, Canara, Ceylon, Sarawak, Java, Moukin, Assam, Central Ceram, New Guinea, Queensland and the Philippine Islands. Tams (1935) lists its occurrence also in Tonga and the Samoan Islands. It is also recorded from Murwillumbah on the north coast of New South Wales (N.S.W. Dept. Agric., 1961).

New World species of *Tiracola* are *T. grandivena* H.S. (South America), *T. lilacea* Dogn. (Colombia) and *T. nonconformens* Dyar. Dr. E. L. Todd has kindly advised (in litt. March, 1962) that *T. grandivena* has often been commonly identified as *T. plagiata* but it is genitalically distinct from the Old World species.

The first published record of *T. plagiata* from the Territory of Papua and New Guinea was by Froggatt (1938) who reared adults from larvae found feeding on cacao. No locality was given with this record but it is believed to be from Keravat, New Britain. Szent-Ivany (1956) described a heavy infestation of the larvae at Ninoa Plantation, Central District of Papua and in 1960, Szent-Ivany and Catley recorded it from Popondetta, in the Northern District of Papua.

Host Plants.

The host range of *T. plagiata* is extremely wide. Weddell (1930) lists 56 hosts from Queensland, Ceylon, Malaya, India, Formosa and the Dutch East Indies. Additional hosts are given by Corbett and Gater (1926), Tams (1935), Froggatt (1938), Kalshoven (1950), Szent-Ivany (1956) and Szent-Ivany and Catley (1960). A complete list of the recorded host plants is given in Appendix I.

Popondetta Outbreak.

Despite occasional local infestations of *T. plagiata* in Papua and New Guinea, it was not considered to be a pest of major status (Szent-Ivany, 1961) until early 1960 when it appeared in plague proportions in new agricultural settlement blocks in the Popondetta area of Papua. Since that time, the caterpillars have continued their attacks with only minor fluctuations in severity and investigations carried out indicate that naturally occurring controlling factors are not exerting any appreciable influence in controlling the pest.

The history of the Popondetta outbreak of *T. plagiata* is similar to that of other outbreaks described in the literature. In Malaya, Corbett and Gater (1926) observed it migrating in army formation from secondary jungle growth into cleared areas where there was an abundant supply of food on the new growth. An outbreak in Queensland in 1927 began on weeds and then spread to cultivated crops (Weddell, 1930), and Kalshoven (1950) mentions that it typically breeds in enormous numbers in young secondary bush and when the native hosts are defoliated, the caterpillars move on to other host plants.

At Popondetta, extensive areas of virgin rain forest were felled for cacao planting. The practice of burning after initial clearing provided ideal conditions for the growth of weeds and soft secondary bush species, and also doubtless, upset the population balance of parasites and predators which are normally found in the primary forest.

After felling and clearing, many weed species including the thistle *Erechthites hieraciifolia* Rafinesque and the milk-weed *Euphorbia cyathophora* Murr. soon became established and these proved admirably suited for the development of *T. plagiata.* The legumes *Leucaena glauca*

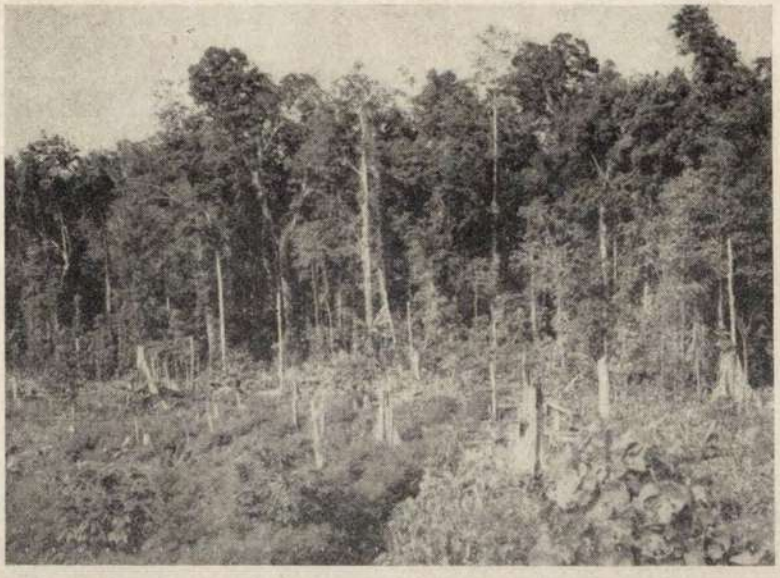


Plate I.—Land cleared for cacao planting. Primary forest in background with secondary growth in right foreground and *Leucaena glauca* planted at left.

Benth. and *Crotalaria anagyroides* H. B. & K. were planted as shade trees for cacao and unfortunately these also proved to be suitable hosts for *T. plagiata* and in a very short time, populations of caterpillars built up to enormous proportions and when cacao was planted under the shade trees, they moved on to them as yet another host tree (Plate I).

The peril from insect pests resulting from a monocultural system of agriculture was recognized by Schneider (1939) when he described an outbreak of the drepanid caterpillar *Areta carnea* Btlr. in a plantation of gambier (*Uncaria gambier*) on the east coast of Sumatra. In this instance effective control of the pest by indigenous species of parasites and predators [mainly *Brachymeria euploeae* Wesw. (Chalcididae) and *Cantheconidea acuta* Vollen (Pentatomidae)] was confined to the bush boundaries of the plantation. He expresses the view that a monoculture creates a labile biocoenosis which can be maintained only by continued application of control measures.

Sir Boris Uvarov (1961) makes similar observations and suggests a thorough ecological study should be made before any large scale land development schemes are undertaken and in this way, crops may be selected and agricultural practices adopted to lessen the possibility of providing conditions favourable to the build up of insect pests. The reason for this is borne out in his statement—

> "Any wild fauna is composed of a variety of insects with different ecological requirements, and there are always in it such elements that are able to take advantage of a change, while others go down. In this way, man introduces large scale selection experiments wherever he begins to exploit the land."

Description of Damage.

At Popondetta, the damage to *Leucaena glauca*, although extensive is not serious and only very young seedlings are likely to be destroyed by caterpillar attacks. Very serious damage to cacao does occur under *Leucaena* shade but the feeding is rather selective and only the softer tissues of the plant are damaged—the old hardened leaves and bark are not attacked.

Most feeding takes place on the soft flush growth and growing points, but it has also been noticed on the flowers and young pods. It is at the growing point that the greatest damage is done to the plant. Mature trees are not greatly damaged by caterpillars unless the attacks

are continually recurring. Younger unramified trees, however, often have their growing points completely destroyed when the flush leaves are all eaten and the resulting spindly growth leads to grossly misshapen trees which require extensive pruning and appreciably more maintenance (Plate II). The age at which trees come into bearing is also deferred for varying lengths of time depending on the severity of attack.

Plate II.—Two-year-old cacao tree damaged by repeated attacks by *T. plagiata*.

There are few instances of cacao trees dying from caterpillar attack but it is conceivable that fungi or bacteria could enter the wounds and cause further damage.

The larvae are voracious feeders at all stages of development and begin feeding as soon as they emerge from the eggs, which are laid in batches of up to 1,200 on the leaves of the host plants. The effect of this multiple feeding by several hundred caterpillars is to remove the epidermal tissues leaving only the veins which are presumably too tough for the tender mandibles to penetrate (Plate III).

The appearance of a mature leaf on which a cluster of larvae has fed is very characteristic; with the hardening of the leaf, the attacked surface becomes brown and a delicate lacy pattern is produced on which is to be seen specks of dried faeces produced in large amounts by the young caterpillars. Older caterpillars are able to devour all parts of the flush leaves without any difficulty and frequently all that remains after a wave of caterpillars is the stem and the old hardened leaves.

On papaw, *T. plagiata* feeds on leaves, fruit and even the stems of the plant. The fruit is particularly attractive to the caterpillars and large numbers are often seen clustered about fallen fruit on the ground. Tapioca plants are attacked only infrequently but complete stripping

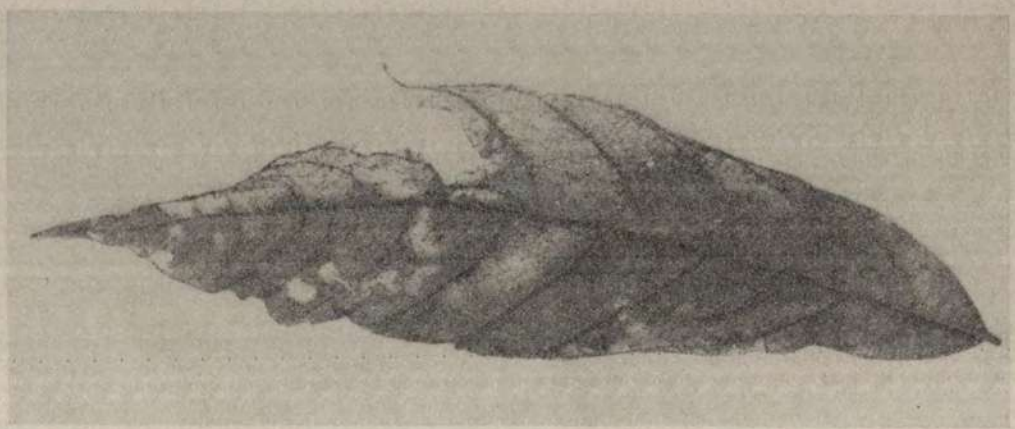


Plate III.—Young cacao leaf damaged by cluster of first instar *T. plagiata*.

of the leaves generally follows. On bananas, the larvae have been found feeding only on the skins of the fruit, as is the case in Queensland (Weddell, 1930).

Parasites and Predators.

Throughout its range of distribution, *T. plagiata* has many recorded parasites and predators and Kalshoven (1950) states that during plagues, the percentage of caterpillars attacked by parasites, particularly tachinids, can be very high but it varies greatly in different localities.

Temperley (1930) records the ichneumonids *Lissopimpla semipunctata* Kirby and *Paniscus testaceus* Grav. as larval parasites and the eulophid *Euplectrus kurandaensis* Girault as a pupal parasite from Queensland in the 1927 outbreaks.

In addition, Thompson (1947) lists the parasites, *Apanteles tiracolae* Ashm. (Braconidae) from Ceylon ; *Sisyropa thermophila* Wd. (Tachinidae) from Malaya ; *Sturmia inconspicua* Mg. (Tachinidae) from Malaya[1] ; *Sturmia inconspicuoides* Bar. (Tachinidae from Malaya ; *Tachina civiloides* Bar. (Tachinidae) from Malaya ; *Trichogramma minutum* Riley (Trichogrammatidae) from Dutch East Indies.

Dr. L. P. Mesnil (in litt. 1962) also includes *Exorista fallax* Meig.-(*civiloides* Bar.) and *Sisyropa thermophila* Wk., the latter from Northern Australia, as parasites of *T. plagiata*.

A thorough search for natural enemies of *T. plagiata* was made in 1961 and 1962 at Popondetta but none was found in significant numbers.

A mite, *Caloglyphus* sp. (Tyroglyphidae) is commonly found associated with the egg masses of *T. plagiata* and they sometimes attach themselves to newly emerged larvae but they have only been observed to feed on decaying eggs and dead larvae. They could prove to be of value in disseminating pathogenic organisms from diseased to healthy insects.

The most active larval predators are *Hexacentrus unicolor* Walker (Tettigoniidae), *Platynopus melacanthus* Boisd. (Pentatomidae) and *Pristhesancus femoralis* Horv. (Reduviidae). Others noticed in fewer numbers were *Helenotus exsugiens* Stal. (Reduviidae), *Nerthra ampliata* Montr. (Gelastocoridae), *Maira* sp. (Asilidae), *Eumenes pyriformis petiolaris* Schulz. (Vespidae), *Sceliphron laetum* Sm. (Sphecidae), the ants, *Pheidole megacephala* (Fabr.) and *Anoplolepis longipes* (Jerdon) and the spiders *Oxyopes striatus* (Dol.) (Oxyopodidae) and *Mopsus mormon* Karsch (Salticidae). Another suspected predator is the brown tree ant, *Oecophylla smaragdina* F., although it has not actually been seen feeding on *T. plagiata* larvae. It is significant, however, that extensive damage has not been noticed on trees colonized by this ant and its reputation as a vicious attacker of any intruder supports the view that it could prove to be a useful predator in cacao plantations.

Very dense populations of *Nerthra ampliata* sometime occur but it is a strictly terrestrial species and hence its value as a predator is limited.

The only parasites collected at Popondetta were the tachinid *Exorista fallax* Meig. and the ichneumonid *Echthromorpha insidiator* Smith. The former species is one of the most important parasites of the "Poinciana moth", *Pericyma cruegeri* Butl. (Noctuidae) in the Port Moresby area (Szent-Ivany, personal communication). Up to three larvae of *Exorista fallax* have been found in a single *T. plagiata* larva and specimens of adults are frequently collected on the wing in cacao plantations but they do not exert much controlling influence. Dr. J. J. H. Szent-Ivany reared only 12 specimens from 500 pupae during experiments conducted at Popondetta in 1961.

In November and December, 1961, a total of six consignments of *Drino inconspicuoides* puparia were introduced to Popondetta from the Commonwealth Institute of Biological Control station at Bangalore but they failed to survive the journey and none was released in the field.

Occasionally, specimens of larvae killed by a mycosis caused by the fungus, *Spicaria rileyi* (Farlow) Charles have been found but it too is of no significant value in controlling *T. plagiata*. Dr. E. A. Steinhaus detected weak to moderate growth of *Mucor* sp. on the body of a moth submitted for study but in his opinion it was a saprophyte and did not contribute to the death of the insect. An unidentified species of *Fusarium* was also isolated from batches of unhatched eggs but this too is not considered an insect pathogen.

There do not appear to be any prospects of naturally occurring organisms exerting an appreciable degree of control in the immediate future

[1] Dr. L. P. Mesnil advises that *Drino* is now the valid name for the genus *Sturmia*, and *Sturmia inconspicua* is probably a wrong identification since it does not occur outside Europe.

and until such times as that does occur, planters will have to rely on insecticides for control of the pest. Since December, 1961, the severity of attacks by the caterpillars has diminished and the outbreaks have settled down to virtually a "one stage" condition in which generally only one or at the most two successive stages of development (eggs, larvae, pupae, moths) are present in an area at any one time. Although this one stage condition is general throughout the district, there may be a difference of up to ten days between the appearance of an individaul stage in separated areas. This indicates that no large scale migration occurs, otherwise the "one stage" condition would be upset by the influx of the "stragglers" from areas where the insects are a little later in development. Outbreaks can thus be more or less accurately predicted so that planters can time their insecticide applications to obtain the maximum effect.

ACKNOWLEDGEMENTS.

Thanks are expressed to Dr. L. P. Mesnil, Commonwealth Institute of Biological Control, Switzerland; Dr. E. L. Todd, U.S. Department of Agriculture; Professor E. O. Wilson, Harvard University; and the Director and staff of the Commonwealth Institute of Entomology, London, for the determination of the insect species mentioned. Professor E. A. Steinhaus, University of California, determined the entomogenous fungi and plant specimens were identified by Mr. J. S. Womersley, Department of Forests, Lae, New Guinea. Dr. J. J. H. Szent-Ivany of Port Moresby provided many valuable data and helpful suggestions.

REFERENCES.

ANDREWS, E. A. (1921). On Caterpillar Control by Collection of Chrysalides. Qtrly. Jl. Sci. Dept. Ind. Tea Assoc., Calcutta, pt. 4, pp. 175-194 (Cited by Weddell, 1930).

CORBETT, G. H. (1934). Gen. Ser. Dept. Agric. S.S. and F.M.S. 19, pp. 38-54 (Cited by Commonwealth Institute of Entomology (in litt., 1962)).

CORBETT, G. H. and GATER, B. A. R. (1926). Miscellaneous insects of 1925. *Malay Agric. J.* 14 : 242-265.

DE JONG (1927). *Meded. algem. Proefst, Avros* No. 32, 40 pp. (Cited by Weddell, 1930).

DEPARTMENT OF AGRICULTURE, CEYLON (1923). A preliminary list of the Pests of Cultivated Plants in Ceylon, Bull. No. 67. (Cited by Weddell, 1930.)

DEPARTMENT OF AGRICULTURE, MALAYA (1921). Agric. Bull. F.M.S., Kuala Lumpur, 9, No. 1, p. 3 (Cited by Weddell, 1930).

FROGGATT, J. L. (1938). Pests of cocoa in the Territory of New Guinea. *New Guinea agric. Gaz.* 4 (4) : 66-68.

GATER, B. A. R. (1926). A preliminary list of Food plants of some Malayan Insects; Bull. No. 38 Dept. Agric., F. M. States and Straits Settlement, Kuala Lumpur. (Cited by Weddell, 1930.)

GREENSTREET, V. R. and LAMBOURNE, J. (1933). Gen. Ser. Dept. of Agric. S.S. and F.M.S. 13; pp. 1-76.

HAMPSON, G F. (1894). Moths, Vol. 2, Fauna British India, London, (Cited by Weddell, 1930.)

HUTSON, J. C. (1924). Ceylon Entomology. *Trop. Agriculturist* 63 (2) : 91-93. (Cited by Weddell, 1930.)

JEBARATRAM (1926). Ceylon Admin. Repts. Dept. Agric. 1925; pp. D19-D20. [Cited by Commonwealth Institute of Entomology (in litt., 1962).]

KALSHOVEN, L. G. E. (1950). De Plagen van de Cultuurgewassen in Indonesie. Vol. 1 : pp. 1-512.. ('S--Gravenhage/Bandoeng).

NEW SOUTH WALES, DEPARTMENT OF AGRICULTURE (1961). Insect Pest Survey for the year ending 30th June, 1960 : 68 pp. (Sydney).

SCHNEIDER, F. (1939). Ein Vergleich von Urwald und Monokulture in bezug auf ihre Gehardung durch phytophage Insekten, auf. Grund einiger Beobachtungen an der Ostkuste von Sumatra. *Schweiz Z. Forstwesen* nos. 2-3 repr. 22 pp., 11 figs. Berne, 1939. (Rev. appl. Ent., 27(A) : 385-386.)

SHIRAKI, T. (1920). Insect Pests of the Tea-plant in Formosa. (Preliminary Report). Rept. Proc. 3rd Entom. Meeting, Pusa, Feb. 1919 : pp. 629-669. (Cited by Weddell, 1930.)

SUSAINATHAN, P. (1924). Some important pests of the Malay Peninsula—Rept. Proc. 5th Entom. Meeting, Pusa, Feb., 1923; pp. 28-33. (Cited by Weddell, 1930.)

SZENT-IVANY, J. J. H. (1956). New Insect Pest and Host Plant Records in the Territory of Papua and New Guinea. *Papua and New Guinea agric. J.* 11 : 82-87.

SZENT-IVANY, J. J. H. (1961). Insect Pests of *Theobroma cacao* in the Territory of Papua and New Guinea. *Papua and New Guinea agric. J.* 13 : 127-147.

SZENT-IVANY, J. J. H. AND CATLEY, A. (1960). Host Plant and Distribution records of some Insects in New Guinea and Adjacent Islands. *Pacific Insects* 2 : 255-261.

TAMS, W. H. T. (1935). Insects of Samoa and other Terrestrial Arthropoda. Part 3; Fasc. 4, (British Museum (Nat. Hist.); London).

TEMPERLEY, M. E. (1930). Life History Notes on the Banana Fruit-eating Caterpillar (*Tiracola plagiata* Walk.). *Qld. agric. J.* 33 : 251-261.

THOMPSON, W. R. (1947). A catalogue of the Parasites and Predators of Insect Pests (Imp. Agric. Bureaux; Imp. Bureau of Biological Control; London). Sect. 1, Part 9, p. 581.

UVAROV, BORIS SIR (1961). Insect hazards in land development. *Span* 4 (4) : 154-157. (Shell Chemical Co., London.)

VAN HALL, C. J. J. (1926). Ziekten en Plagen der Cultuurgewassen in Nederlandsh-Indie in 1925. Meded. Inst. Plantenzieketen, No. 70. (Cited by Weddell, 1930).

WEDDELL, J. A. (1930). Field notes on the Banana Fruit-eating Caterpillar (*Tiracola plagiata* Walk.). *Qld. agric. J.* 33 : 186-201.

Appendix I.

Host Plant Records of *Tiracola plagiata* Walk.

Locality.	Host Plant.		Recorded by.
	Common Name.	Botanical Name.	
Ceylon	Brinjal or Egg Plant	*Solanum melongena* L.	Hutson (1924)
	Tea	*Camellia theifera* Dyer	Department of Agriculture, Ceylon (1923)
	....	*Erythrina lithosperma* Bl.	
	Plantain	*Musa* sp.	
	Lima Bean	*Phaseolus lunatus* L.	
	French or Kidney Bean	*Phaseolus vulgaris* L.	
	Wasteland weeds	* N.B.N.	Jebaratram (1926)
	Cassava	* N.B.N.	
	Coffee	* N.B.N.	
	Rubber	* N.B.N.	
Malaya	Castor Oil	*Ricinus communis* L.	Department of Agriculture, Malaya (1921)
	Castor Oil	*Ricinus communis* L.	Gater (1926)
	Castor Oil	*Ricinus communis* L.	Susainathan (1924)
	Lime	*Citrus medica* L. var. *acida*.	Gater (1926)
	Tapioca	*Manihot utilissima* Pohl.	
	Para rubber	*Hevea brasiliensis* Muell-Arg.	
	Banana	*Musa* spp.	
		Melastoma polyanthum Korth.	
	Cassava	* N.B.N.	Greenstreet & Lambourne (1933)
	Coffee	* N.B.N.	Corbett (1934)
Dutch East Indies	....	*Ballota* sp.	de Jong (1927)
	Tobacco	*Nicotiana* sp.	van Hall (1925)
	Tobacco	*Nicotiana* sp.	Palm (1926)
	....	*Trema amboinensis*	
India	....	*Emilia* sp.	Hampson (1894)
	Tea	*Camellia theifera* Dyer.	Andrews (1924)
Formosa	Tea	*Camellia theifera* Dyer.	Shiraki (1920)
Queensland	Banana	*Musa* spp.	Weddell (1930)
	Maize	*Zea mays* L.	
	Pumpkin	*Cucurbita pepo* L.	
	Watermelon	*Citrullus vulgaris* Schrad.	
	Cabbage	*Brassica oleracea* L.	
	Cauliflower	*Brassica oleracea* L. var.	
	Tomato	*Lycopersicum esculentum* Mill.	
	Cape gooseberry	*Physalis peruviana* L.	
	Passionfruit	*Passiflora edulis* Sims.	
	Beetroot	*Beta vulgaris* L.	
	French bean	*Phaseolus vulgaris* L.	
	Papaw	*Carica papaya* L.	
	Pear	*Pyrus communis* L.	
	Pigweed	*Portulaca oleracea* L.	
	....	*Sloanea australis* F. v. M.	
	Red Ash	*Alphitonia excelsa* Reissek	
	Tulipwood	*Harpullia pendula* Planch	
	....	*Eucalyptus* sp.	
	White Passionfruit	*Passiflora alba* L. & O.	
	Native Bryony	*Bryonia laciniosa* L.	

Host Plant Records of *Tiracola plagiata* Walk—*continued.*

Locality.	Host Plant.		Recorded by.
	Common Name.	Botanical Name.	
Queensland—*continued.*			
	Cobblers Pegs	*Bidens pilosa* L.	Weddell (1930)
	Stinking Rodger	*Tagetes glandulifera* Sch.	
	Milk Thistle	*Sonchus oleraceus* L.	
	Scotch Thistle	*Cnicus lanceolatus* Hoffm.	
	Black Currant	*Solanum nigrum* L.	
	Wild Tobacco	*Solanum auriculatum* Ait.	
	Wild Tobacco	*Solanum verbascifolium* Ait.	
	Wild Gooseberry	*Physalis minima* L.	
	Wild Tobacco	*Nicotiana suaveolens* Lehm.	
	Lantana	*Lantana camara* L.	
	....	*Amarantus viridis* L.	
	Inkweed	*Phytolacca octandra* L.	
	....	*Kibara macrophylla* Benth.	
	Kamela Tree	*Mallotus philippinensis* Muell-Arg.	
	Peach-leafed Poison bush or Poison peach	*Trema aspera* Bl.	
	....	*Pseudomorus brunoniana* Bur.	
	....	*Pollia macrophylla* Benth.	
	Cunjevoi	*Alocasia macrorhiza* Sch.	
Samoa	Castor Oil	* N.B.N.	Tams (1935)
	Sisal hemp	* N.B.N.	
	Tapioca	* N.B.N.	
	Tobacco	* N.B.N.	
	Banana	* N.B.N.	
	Limes	* N.B.N.	
	Rubber	* N.B.N.	
New South Wales	Banana	* N.B.N.	N.S.W. Department of Agriculture (1961)
Indonesia	....	*Trema* sp.	Kalshoven (1950)
	....	*Zingiberaceae*	
	Wild bananas	* N.B.N.	
	Tobacco	* N.B.N.	
	Rubber	*Hevea brasiliensis*	
	Sumatra Pine	*Pinus* sp.	
	Pepper	* N.B.N.	
	Coffee	* N.B.N.	
	....	*Passiflora* sp.	
	Wild Amaranthus	* N.B.N.	
	Spinach	* N.B.N.	
	Beetroot	* N.B.N.	
	Flax	* N.B.N.	
	Derris	* N.B.N.	
	....	*Aleurites* sp.	
New Guinea	Cacao	*Theobroma cacao*	Froggatt (1938)
Papua	Rubber	*Hevea brasiliensis* Muell-Arg.	Szent-Ivany (1956)
	Sweet Potato	*Ipomoea batatas* Poir.	
	Cassava	*Manihot utilissima* Pohl.	
	....	*Alstonia* sp.	

Host Plant Records of *Tiracola plagiata* Walk—*continued*.

Locality.	Host Plant.		Recorded by.
	Common Name.	Botanical Name.	
Papua—*continued*	Crotalaria	*Crotalaria anagyroides* H. B. & K.	Szent-Ivany & Catley (1960)
Papua (Popondetta)	Cacao	*Theobroma cacao* L.	
	Leucaena	*Leucaena glauca* Benth.	
	Momordica	*Momordica charantia* L.	
	Pumpkin	*Cucurbita pepo* Lith.	
	Coffee	*Coffea canephora* Pierre ex Froehner	
	Banana	*Musa* sp.	
	Fig	*Ficus* sp.	
	Cassava	*Manihot utilissima* Pohl.	
	Milkweed	*Euphorbia cyathophora* Murr.	Catley (New records)
	Thistle	*Erechthites hieraciifolia* Rafin.	
	Papaw	*Carica papaya* L.	
	Sweet Potato	*Ipomoea batatas* Poir.	
	Pipturus	*Pipturus argenteus* Wedd.	
	Native Passionfruit	*Passiflora foetida* L.	
	Taro	*Colocasia* sp.	
	Croton	*Codiaeum variegatum* Blume	
	Beans	*Vicia faba* L.	
	Zinnia	*Zinnia* sp.	

* N.B.N.—Signifies that no botanical names were recorded.

The Barramundi in New Guinea Waters.

D. J. DUNSTAN *

Marine Biologist, D.A.S.F., Port Moresby.

(Manuscript received 20.11.61.)

Summary.

BARRAMUNDI is the most abundant large commercial species in the waterways of Papua west of Port Moresby and it reaches maximum abundance in rivers, swamps and lagoons discharging into the Gulf of Papua where it is the dominant species. The Fly River and its tributaries support the largest stocks and barramundi have been recorded 600 miles above salt water and 450 miles above tidal waters.

The species is restricted to rivers discharging into the Southern Coastal Plains of Papua. It is a catadromous fish and spawning occurs from November to early March in the back waters of bays and estuaries out of the main run of the current, when very large catches are made. Subsequent to spawning the bulk of the stock moves away from coastal waters into brackish and fresh water. Small coastwise migrations occur during spawning and during flooding when the salinity of the sea water is reduced.

Male barramundi mature at a smaller size than the female and the sex ratio in favour of the male is approximately two to one. The male fish appears to be the more active.

Set mesh nets made from synthetic twines are highly satisfactory for the capture of this species. The more saline the water the more powerful is the fish and the stronger the net required for its capture. In fresh water the fish are much less active and light gill nets are sufficient.

Introduction.

The occurrence of barramundi or giant perch [*Lates calcarifer* (Bloch)] in the estuaries and swamps on the southern coast of Papua has long been known to the local fishing population who call it by the Motu name of "Anama" meaning "Chief".

However, it was not until after intensified investigations by the Division of Fisheries of the Department of Agriculture, Stock and Fisheries, that a satisfactory understanding of the distribution, abundance and biology of the species was obtained. The investigations commenced in 1957 and consisted of fishing surveys in remote areas, and concentrated fishing at shore bases.

The majority of the rivers of Papua and New Guinea have been fished with strong mesh nets, and biological examination of netted barramundi was carried out in all cases. Marking of the species with opercular gill tags has also been commenced. Although to date no tagged fish have been captured and the movements and abundance of the species in the huge system of waterways in the Western and Gulf Districts are not fully understood, it is considered that the findings to date should be put on record and an interim report is justified.

Occurrence.

Barramundi occur in all the rivers and estuaries of the Western and Gulf Districts and in most of the waterways of the Central District. It has been recorded at the eastern extremity of the Central District at Loupom (longitude 149 degrees 25 minutes East) but as yet has not been taken in any of the rivers discharging further east. Barramundi have not been taken in any of the rivers of the New Guinea mainland nor in any of the offshore islands.

In the Western District barramundi have been taken in small tidal creeks on the southern side of Bristow Island, eight miles offshore, and above Kiunga, approximately 600 miles from the mouth of the Fly River and 450 miles above tidal waters. Large numbers have also been taken in Lake Murray, 300 miles from the Fly River mouth.

* Present address: Fisheries Division, Chief Secretary's Department, Sydney.

Distribution and Abundance.

The barramundi are not evenly distributed throughout the waterways of the Southern Coastal Plains of Papua. Their abundance in part depends on the area of freshwater swamps, lagoons and rivers available for colonization. This freshwater acreage is influenced by the physiography of the coastline, the rainfall and the amount of run-off.

The southern coastal area of Papua can be divided into the Daru and Moresby coasts.

The Daru coast extends from the border of Papua and Netherlands New Guinea to the head of Deception Bay. It includes the Oriomo plateau which extends from the border to the Fly River and the Delta Embayment which extends from the Fly to the head of Deception Bay. The Moresby coast extends from Deception Bay eastwards almost to the China Straits. (The Resources of the Territory of Papua/New Guinea, 1951.)

The Delta Embayment is composed of the vast deltaic plains of the Fly, Strickland, Aramia, Bamu, Aworra, Turama and Purari Rivers. The various rivers have associated with them extensive systems of swamps and lagoons—Lake Murray which is 40 miles long and 3-4 miles wide is a huge lagoon draining into the Strickland River. This vast deltaic region, dominated by the Fly River, has formed one of the largest estuaries in the world. The lower reaches of the rivers are exceptionally low lying and there are great areas of mud. Nipa and sago are the dominant plant species above the mangrove areas at the mouth.

The catchment area and the rainfall of the Oriomo River are less than those of the Delta Embayment and the extensive system of swamps, lagoons and estuaries has not developed. The Moresby coast consists mainly of rocky headlands alternating with sandy beaches ; the mountain range closely approaches the coastline and the rivers are generally fast flowing.

Barramundi are very plentiful and are the dominant large inshore and river species from the Netherlands New Guinea border to the head of the Gulf of Papua. It is in the Delta Embayment, particularly the Fly River, its tributaries and associated lagoons and swamps, that greatest numbers are found. The smaller rivers of the Oriomo Plateau support lesser numbers of barramundi.

Barramundi are generally not plentiful along the Moresby coast but some fair catches have been recorded at Abau, Marshall Lagoon, Galley Reach, Hall Sound, Kerema and Port Romilly where the estuaries are large and there is a constant discharge of fresh water (Table I).

In estuaries of similar size and discharge best catches have been recorded where the tidal variation is greatest. This increases from east to west and reaches 13-ft. 6-ins. at Daru. It is interesting to note that barramundi have not been recorded in the waterways of the Sepik District where the tidal variation is very slight.

Habitat of the Fish.

The barramundi is found in salt, brackish and fresh water. Except during spawning movements, it is rarely taken in waters where the salinity exceeds 30 parts per 1,000. The major part of its life is spent in brackish and fresh water in rivers, lagoons and swamps, but during the spawning season the adult barramundi move down to coastal waters where they make small coastwise migrations. Some immature fish may also be taken in coastal waters during this period but apparently the majority remain in the freshwater swamps and lagoons.

Barramundi taken in the upper reaches of the rivers have a darkish colouration and they are sluggish and prefer slow moving or stagnant waters. The body cavities contain large amounts of fatty tissue and the flesh from such barramundi has a distinct muddy or earthy taste. In contrast, the fish taken near the mouths of rivers and in coastal waters have yellowish fins, are very active and the flesh is of first class quality.

Movements.

During both spawning and non-spawning movements the bulk of the netted catch is taken during neap tides in very shallow water. At high water during the spawning season the barramundi move out from the mouths of the rivers and feed actively amongst the mangroves which are usually exposed at low water.

Adult fish approaching spawning occur in greatest numbers near shallow muddy outcrops in the back waters of bays or near the mouths of certain rivers. Examples of such rivers are the Aroa River, Keuru Creek, and the Oriomo River which are situated some distance from

Table I.

Some Daily Barramundi Catches

From Netting Surveys in Papuan Waters.

Date.	Locality.	District.	Catch lb.	Nets used.			Remarks.
				yds.		In. mesh	
12.1.1959	Aroa River	Central	153	60	x	7	Snagging during day.
1.9.1959	Marshall Lagoon	,,	269	120	x	7	Overnight set.
4.9.1959	,, ,,	,,	152	120	x	7	,, ,,
13.12.1959	,, ,,	,,	163	200	x	7	,, ,,
15.1.1960	,, ,,	,,	146	120	x	7	,, ,,
7.5.1960	,, ,,	,,	150	200	x	7	,, ,,
				100	x	4½	
17.6.1960	Katatai Creek	Western	402	70	x	4½	Net set for 2 hours across tidal creek
2.8.1960	Marshall Lagoon	Central	134	120	x	7	Overnight set during minor flood
13.8.1960	Binature River	Western	347	120	x	7	Overnight set.
				120	x	4½	All fish taken in 7 inch net.
14.8.1960	Marshall Lagoon	Central	216	120	x	7	Overnight set.
26.10.1960	Oriomo River	Western	287	120	x	7	,, ,,
12.11.1960	,, ,,	,,	364	120	x	6½	,, ,,
				120	x	8	
22.11.1960	,, ,,	,,	1,000	120	x	6½	Snagging during day—13 barra. Daytime set—39 barra. Overnight set—21 barra.
24.11.1960	,, ,,	,,	1,647	120	x	6½	109 barramundi taken, 14 during daytime.
				120	x	7	
				120	x	8	
27.11.1960	Hall Sound	Central	175	120	x	7	Overnight set.
				120	x	4½	
28.11.1960	Oriomo River	Western	2,440	120	x	6½	126 barramundi taken overnight.
				120	x	7	
				120	x	8	
6.12.1960	,, ,,	,,	1,325	120	x	6½	Overnight set.
				120	x	8	
9.12.1960	,, ,,	,,	2,029	120	x	8	,, ,,
31.12.1960	,, ,,	,,	561	120	x	8	,, ,,
4.1.1961	,, ,,	,,	800	120	x	8	,, ,,
6.1.1961	,, ,,	,,	1,183	120	x	8	,, ,,
22.2.1961	,, ,,	,,	900	120	x	6½	,, ,,
				120	x	8	,, ,,
23.2.1961	,, ,,	,,	528	120	x	6½	,, ,,
				120	x	8	,, ,,
7.3.1961	,, ,,	,,	1,366	120	x	6½	32 barra. taken during day set. 32 taken during night set.
				120	x	8	
9.3.1961	,, ,,	,,	914	100	x	7	30 barra. taken during day set. 42 taken during night set.
				170	x	8	
11.3.1961	,, ,,	,,	170	50	x	7	Overnight set.
				120	x	8	
21.6.1961	Lake Murray	,,	635	50	x	7	,, ,,
24.6.1961	June River	,,	636	50	x	7	,, ,,
28.6.1961	Lake Murray	,,	1,066	50	x	7	,, ,,
29.6.1961	,, ,,	,,	618	50	x	7	,, ,,
13.7.1961	,, ,,	,,	698	50	x	7	,, ,,
15.8.1961	Balimo	,,	624	100	x	8	,, ,,
16.8.1961	,,	,,	559	100	x	8	,, ,,
20.8.1961	,,	,,	472	100	x	8	,, ,,

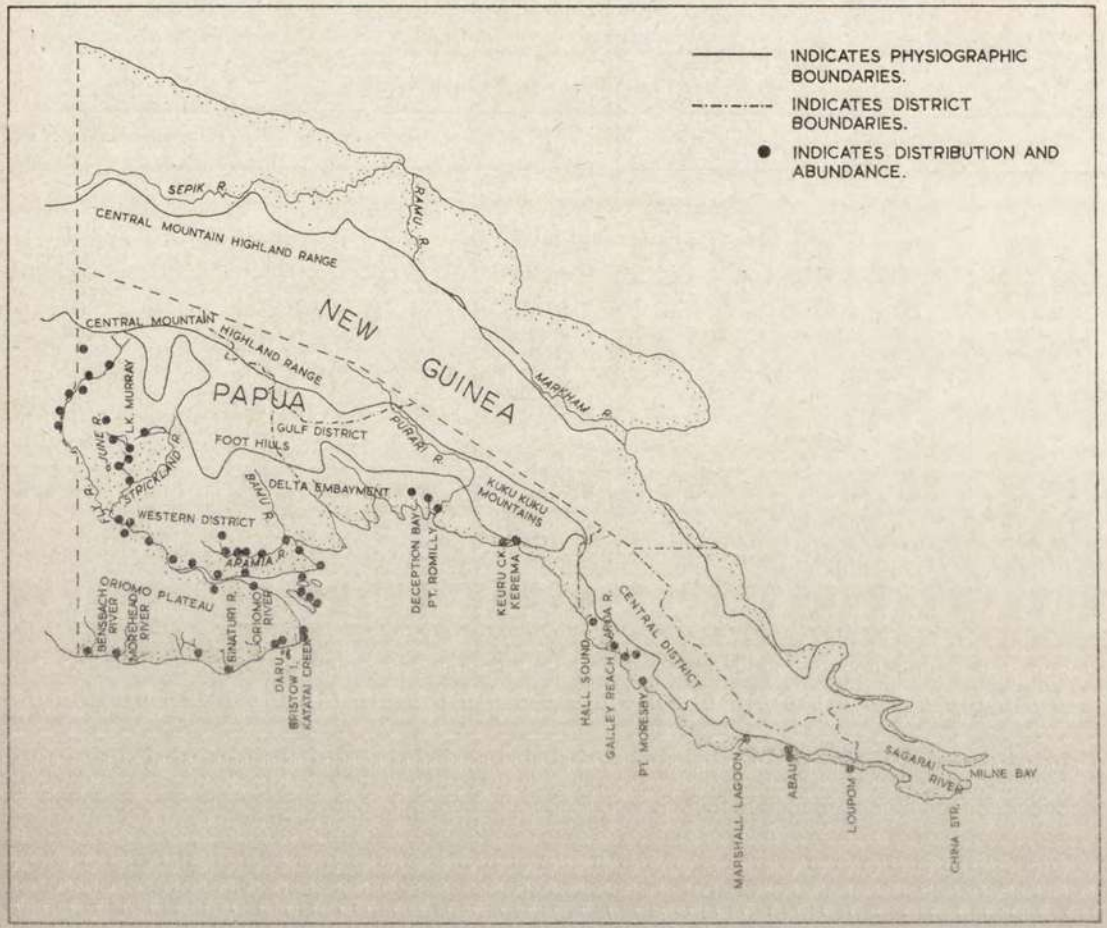


Figure 1.—Distribution of Barramundi in Papua.

the usual habitat of all the adult fish. This coastwise migration associated with spawning takes place against the set of the current.

Size.

Due to the high selectivity of mesh size of the nets used, it is not possible to give average sizes for barramundi in particular waters. In August, 1960, one set in a tidal creek near the mouth of the Oriomo River with a 4½ inch mesh net yielded 84 fish weighing 402 lb. At the mouth of the Oriomo River during the spawning run, three nets with mesh sizes of 6½, 7 and 8 inch captured 308 fish weighing 5,087 lb. and in Lake Murray the weight of 234 fish taken with a 7 inch net was 4,219 lb.

Biology.

During the period of investigation 1,261 barramundi taken by the Division of Fisheries were examined for the following biological factors—total weight, cleaned weight, total length, standard length, sex, gonad stage and stomach contents. In the majority of cases scale samples were also collected. The fish were captured in a wide variety of habitats over an area extending from the Netherlands New Guinea border to the eastern extremity of its range.

(*a*) *Description.*

(i) *Size.*—The bulk of the catch to date falls within one size group from 14 to 19 pounds. The smallest barramundi taken weighed less than

1 lb. and the largest 54 lb. although there are reports of much bigger fish having been caught on hand lines and by spearing. With stronger and larger mesh nets bigger fish will undoubtedly be captured.

(ii) *Colour and shape.*—Owing to the diversity of habitats of the barramundi, well marked differences in colour and shape are found and these are particularly noticeable when specimens from salt and freshwater are compared. In Thailand these two types are known locally by different names (Yingthavorn 1951). It is therefore not surprising that a large number of synonyms for this species has been listed (Fowler & Bean 1930). The description given by Weber & de Beaufort (1929) and by Dunstan (1959) is applicable to Papuan specimens. However, the following differences and additional points have been noted for both Papuan and Australian specimens :—

1. Rudimentary teeth are also present on the third and fifth basibranchials and in patches on the pharyngobranchials.
2. In larval and immediate post larval fry up to 4 inches long the maxillary reaches only to the vertical through the anterior border of the eye.
3. First year fish are characterized by a white stripe running antero-posteriorly from the tip of the snout on the dorsal surface, combined with a blotchy appearance on the flanks. This has been observed only in fish from fresh and brackish water. The presence of the white stripe is not permanent, the normal colour of the dorsal surface being dark.

(*b*) *Age Determination and Growth Rates.*

(i) *Petersen's method.*—The samples used in this investigation were based upon catches with mesh nets. In length, frequency, and distribution studies, multimodal curves of high variability are obtained, and inaccurate conclusions may be expected owing to the selective actions of these nets.

The action of a net of specified mesh depends on :—

(*a*) the size and abundance of the population being sampled,

(*b*) the strength of the mesh, and

(*c*) the position of the net, whether sunken or floating.

The strength of the nets used for the capture of barramundi is related to the size of the mesh, the larger the mesh the stronger the net. The effectiveness of a net of specified mesh and strength is related to locality and salinity, the less saline and the cooler the water, the weaker is the fish and the more effective is the net.

Length frequency studies based on mesh net catches for approximately 2,000 barramundi taken over the whole of its Papuan range do not reveal any progression of monthly modes. Fifty per cent. of the total length of all barramundi taken fell within the 33 to 36 inch group. This was due to the selective action of the mesh, the sizes of which were 6½, 7 and 8 inches.

(ii) *Tagging.*—To date 300 barramundi (average length 33 inches) have been marked with opercular type clip tags over an area extending from the Bensbach River near the Netherlands New Guinea border to the Aramia River, including specimens taken in Lake Murray, Balimo and the Fly River. This work was commenced in early 1961 and is continuing. No tags have yet been returned.

(iii) *Scale reading.*—Representative scale samples have been collected from specimens captured. The structure of the individual scale, and scale anuli or breaks, are similar to those of *Mugil cephalus,* as described by Kesteven (1942). No determination of growth rates from scales has been attempted to date.

(*c*) *Spawning Season and Sex Ratio.*

(i) *Spawning.*—In Table II the seasonal distribution of gonad stages for 765 barramundi of both sexes is given, based on standard mullet maturation classification (Kesteven 1942) and determined by visual observation. Although in May, September and December, no fish were examined, it can be seen that maturation of the gonads commenced in August and spawning in November. In January and March near-spawning and spawning fish were taken in the backwaters of bays and estuaries, and in April, although only six fish were examined, the highest percentage of spent fish (Stage 8) was taken. The spawning season thus commences in November and lasts until March when the spent fish commence moving up-river away from coastal waters.

On the 13th February, 1960, a beach seine hauled in Marshall Lagoon took an 18½ lb. running ripe female barramundi during the full

Table II.

Seasonal Distribution of Gonad Stages.

		I.		II.		III.		IV.		V.		VI.		VII.		VIII.		Total.		
		M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	Totals
January	No.	11	9	11	2	5	6	12	5	6	8	7	6	7	7	8	12	67	55	122
	%	16.4	16.4	16.4	3.5	7.4	11.0	17.9	9.1	9.0	14.4	10.5	11.0	10.5	12.6	11.9	22.0			
February	No.	1	3	2	4	1	4		1							3	8	7	20	27
	%	14.3	15.0	28.6	20.0	14.3	20.0		5.0							42.8	40.0			
March	No.			32	12	12	6	14	8	11	7	2	1	2	7		1	73	42	115
	%			43.9	28.5	16.4	14.3	19.1	19.0	15.1	16.7	2.7	2.4	2.7	16.7		2.4			
April	No.	1							1							1	3	2	4	6
	%	50.0							25.0							50.0	75.0			
May	No.																			
	%																			
June	No.			125	3	1				1						1	10	128	13	141
	%			97.6	2.3	0.8				0.8						0.8	7.7			
July	No.			79	14													79	14	93
	%			100.0	100.0															
August	No.					10	8											10	8	18
	%					100.0	100.0													
September	No.																			
	%																			
October	No.	10	7	18	15	6	7	1	5						1		1	35	36	71
	%	28.5	19.5	51.4	41.4	17.3	19.5	2.8	14.0						2.8		2.8			
November	No.	38	5	20	3	23	6	15	5	18	16	9	3		1			133	39	172
	%	28.4	12.7	15.0	7.7	17.2	15.2	11.2	12.7	21.0	14.4	6.7	7.7		2.6					
December	No.																			
	%																			

moon period. The eggs were small (0.7 to 0.8 mm. in diameter) with a single oil globule 0.3 mm. in diameter and were demersal. There were no markings on the egg membrane and the perivitelline membrane was small or non-existent (A. M. Rapson).

There was no sign of gonad development in 128 adult specimens examined in Lake Murray. All mature fish and fish approaching maturity were taken in brackish, tidal and coastal waters. In some areas, particularly Balimo, a number of the lagoons are connected with rivers discharging into coastal waters only during exceptionally heavy wet seasons. During a poor wet season there may be insufficient flood water to release land-locked barramundi and consequently the number of spawners is less. A delayed wet season will result in a prolonged spawning season.

(ii) *Size at Maturity.*—The smallest male barramundi taken with enlarged gonads weighed 8 lb. and the smallest female 10 lb. Dunstan (1959) working on Queensland specimens and Yingthavorn (1951) in Thailand recorded similar figures.

(iii) *Sex ratio.*—Of 881 barramundi for which sex could definitely be determined, 619 were males and 262 were females, giving a ratio of 2.3 to 1 in favour of the male fish. The numbers and proportions for both sexes taken in brackish, salt and fresh water are given in Table III. The male barramundi appear to be the more active, the ratio of males to females moving the 300 miles to Lake Murray being approximately 11:1. In addition, at the commencement of the spawning season, the ratio of males to females was 3.4:1. During the spawning season this ratio was approximately equal, indicating that a greater proportion of females remain in coastal waters for a longer period after spawning. Subsequent to spawning the sex ratio of adult barramundi was approximately equal.

(*d*) *Feeding Habits.*

Barramundi are carnivorous and predacious throughout the whole of their life cycle. Generally, they will prey on any fish or crustacean species smaller than themselves. Detailed stomach content analysis is often difficult owing to disgorging of ingested food after capture.

In Table IV the stomach contents of 1,001 barramundi are given. Fifty-eight per cent. of all stomachs examined were empty, twenty-nine per cent. contained teleost species and the remainder contained crustaceans. The greatest percentage of barramundi which had disgorged their prey and whose stomachs were empty were taken in salt water, the highest precentage containing crustaceans in brackish water, and the highest percentage containing unrecognizable fish remains in fresh water.

Detailed stomach content analysis for identifiable teleost and crustacean remains for the three different bodies of water are shown in Table V. The most common prey species for barramundi taken in salt and fresh water was the unicorn fish and in brackish-tidal water the ox-eye herring. Approximately fifty per cent. of all recognizable prey species identified were crustaceans, the highest percentage being recorded in brackish water.

(*e*) *Parasites and Earthiness.*

In addition to trematode larvae present in the pyloric caeca, the great majority of barramundi contained larval trypanorhynch cestodes. The degree of infestation is related to the age of the specimen and the medium in which it is found ;

Table III.

Sex Ratio of Barramundi Taken in Papuan Waterways.

Locality.	Type of Water.	Season.	Males.		Females.	
			Total No.	Ratio.	Total No.	Ratio.
Waterways of the southern coastal plains of Papua	Fresh, Brackish, Salt	Spawning and non-spawning	619	2.3	262	1.0
(*a*) Lake Murray	Fresh	Non-spawning	307	11.4	27	1.0
(*b*) Estuaries and lower river reaches	Brackish-salt	1. Onset of spawning	133	3.4	39	1.0
,, ,,	,, ,,	2. Mid-spawning	74	1.0	71	1.0
,, ,,	,, ,,	3. Non-spawning	105	0.8	125	1.0

Table IV.

Stomach Contents of Barramundi.

Stomach Content.	Salt water.		Brackish-tidal water		Fresh water.	
	No. of stomachs examined.	Per cent. of stomachs empty or containing prey species.	No. of stomachs examined.	Per cent. of stomachs empty or containing prey species.	No. of stomachs examined.	Per cent. of stomachs empty or containing prey species.
Empty	369	68.0	92	36.0	117	57.3
Fish remains	81	15.0	74	29.0	72	35.3
Identifiable fish	32	6.0	21	8.2	8	4.0
Crustacea	60	11.0	68	26.8	7	3.4
Total	542	100.0	255	100.0	204	100.0

Table V.

Stomach Content Analysis.

Prey Species.		Per cent. of stomachs containing prey species.		
Common Name.	Specific Name.	Salt.	Brackish-tidal.	Fresh.
Unicorn fish	*Naso* sp.	19.9		20.0
Ox-eye herring	*Megalops cyprinoides* (Broussonet)		12.4	20.0
Sardine	*Sardinella* sp.	2.1		
Trevally	*Caranx* sp.	2.1	2.2	
Garfish	*Hemiramphus* sp.	2.1	1.1	
Threadfin Salmon	*Polynemus sheridani*		2.2	
Leatherskin	*Chironemus lysan* (Forskal)	1.1		
	Parapercis sp.		1.1	
Wolf herring	*Chirocentrus dorab*		2.2	
Whiting	*Sillago* sp.		1.1	
Catfish	Fam. *Tachysuridae*	1.1	1.1	
Pony fish	*Leiognathus* sp.	1.1		
Indian anchovy	*Stolephorus indica* (Van Hasewt)	2.1		
Archer fish	*Toxotes* sp.	1.1		6.7
Herring	*Haringula* sp.	1.1		
Freshwater mullet	*Cestraclys, Mugil* sp.			6.7
Prawns, including greasy back, banana and tiger	*Penaeid* sp.	49.9	52.9	
Crab	*Matuta* sp.	14.2	19.2	
Mantis shrimp	*Squilla* sp.	2.1	4.5	
Freshwater prawn	*Macrobrachium* sp.			46.6
	TOTALS	100.0	100.0	100.0

the older the fish and the more saline the water the heavier is the infestation. In many of the specimens from salt water larval stages were isolated from the liver and musculature. The parasitism of such organs indicates very heavy infestation (Dolfus 1942).

Specimens examined from stagnant freshwater lagoons showed little or no trace of cestode parasitism but in waters containing large amounts of decaying organic matter a definite earthiness was apparent in the flesh. When the barramundi

migrates into tidal or salt water the earthiness which is thought to be due to *Actinomyces* (Thaysen 1936), disappears after about three days.

Future Development.

The development of a commercial fishing enterprise must be based upon fish taken in non-stagnant water. These fish are most easily available during their spawning run at the mouths of rivers and in the estuaries.

With modern gear catches of barramundi can be substantially increased in all the major rivers and estuaries within the range of the species. This particularly applies during the spawning season in the Western and Gulf Districts where the agricultural potential is poor.

A freezer has been erected at Daru and it is anticipated that large quantities of barramundi will be available for air-freighting to Port Moresby from November to March. During the nine months of operations by a fishing team based at Daru, ending in March, 1961, a total of 50,000 lb. of barramundi and shark was taken. Eighty per cent. of the barramundi catch was taken during the spawning season (22nd November, 1960, to 9th March, 1961). With increased local knowledge, more highly skilled fisheries trainees and improved gear, larger catches are expected.

4,219 lb. of barramundi were caught with one short length of net in a fishing survey of Lake Murray of eleven days duration (18th to 29th June, 1961). However, the development of an industry, except for smoked fish, does not appear feasible in this and similar areas because of their isolation and the earthy taint apparent in barramundi taken from stagnant fresh water. The introduction and distribution of European fishing gear in these areas would, however, result in increased protein consumption and general improvement in health standards.

In some waters the strong current will prevent the use of set nets throughout most of the year. However, backwaters and connecting creeks can normally be fished with safety. These waters can only be found by trial. In Central and Northern Queensland and in the Northern Territory, fishing for barramundi is not seasonal, and during the non-spawning period operates on barramundi taken in fresh, brackish and tidal waters. The tremendous area of such waters in rivers discharging into the Gulf of Papua and the virgin stock must support sufficient fish for the establishment of an all-the-year-round fishery. Owing to the large tidal variation, the great numbers of waterways and the high fecundity of the species, it would be many years before overfishing would result in depletion of stocks.

ACKNOWLEDGEMENT.

The author wishes to acknowledge the assistance given by both European and indigenous Fisheries Fieldworkers, in particular by Mr. J. A. Quinlan who carried out many of the surveys in remote areas.

REFERENCES.

Australia, National Development Ministry of *The Resources of the Territory of Papua/New Guinea.* Canberra, 1950.

DOLFUS, R. Ph. (1942). Arch. Mus. Hist. Nat., Paris, 19, 1-466.

DUNSTAN, D. J. (1959). *The Barramundi in Queensland Waters.* C.S.I.R.O. Aust. Div. Fish. Oceanogr. Tech. Paper No. 5.

FOWLER, H. W. and BEAN, B. A. (1930). *Fishes of the Philippine Islands and Adjacent Seas.* Bull. Amer. Mus. Nat. Hist. (10) : 177-179.

KESTEVEN, G. L. (1942). *Studies in the Biology of Australian Mullet Account of the fishery and preliminary statements of the biology of Mugil dobula Gunther.* C.S.I.R. Aust. Bull. No. 157 : 36-42.

THAYSEN, A. C. and PENTELOW, F. T. K. (1936). *The Origin of an Earthy Taint in Fish. II. Effect on Fish of the Taint Produced by an Odoriferous Species of Actinomyces.* Ibid. 23 : 105-109.

YINGTHAVORN, P. (1951). *Notes on Pla-Kapong (Lates calcarifer Bloch) Culturing in Thailand.* I.P.F.C./C511 Technical Paper No. 20.

Host Plants and Distribution of Some Grey Weevil Species of the Tribe Celeuthetini in Netherlands New Guinea.

R. T. SIMON THOMAS *
Entomologist, Department of Economic Affairs, Hollandia.
and C. M. VERLOOP †
Agricultural Officer, Department of Economic Affairs, Hollandia.

(Manuscript received 4.6.1962.)

FOR a long time considerable damage has been caused to several crops in Netherlands New Guinea by different species of grey weevils of the tribe Celeuthetini. The damage caused by these species has not been previously described.

Recent identifications by the Commonwealth Institute of Entomology (London) have made it possible to carry out specific studies of the damage caused by the various species.

The following list shows the different species with their host plants and the places where they were collected.

Apirocalus cornutus Pasc.

Wedelia biflora ; Dojo (Hollandia) 19th September, 1961 ; Kota Nica, 24th December, 1961 ; Ajapo (Hollandia) 31st December, 1961. Unknown hosts : Genjem April, 1956 (coll. G. den Hoed), Ifar (Hollandia) 18th October, 1957.

Idiopsis grisea Fst.

Ipomoea sp. : Mokmer (Biak) 21st July, 17th August, 1961. *Merrenia peltata* Merr. : Sausapor (W.N.G.) 24th July, 1961.

Idiopsis perplexa Fst.

Merrenia peltata Merr. : Kota Nica 24th December, 1961. *Musa paradisiaca* L. : Kota Nica 10th October, 1960. *Wedelia biflora* : Ajapo (Hollandia) 31st December, 1961. Unknown hosts : Hollandia March 12th, 1956 (coll. G. den Hoed). Genjem April, 1956 (coll. G. den Hoed), Kepi (S.N.G.) 17th October, 1957.

Oribius immitis Pasc.

Amaranthus sp. : K. P. Landbouw (Biak) 4th January, 1957. *Brassica rugosa* Prain. : K. P. Landbouw (Biak) 28th February, 1956. *Colocasia* sp. : Fakfak 20th October, 1956 (coll. A. M. Cramer).

Oribius leucostictus Pasc.

Vigna sinensis Endl. : Saoka, near Sorong, 10th February, 1960. *Merrenia peltata* Merr. : Jangkate, near Sorong, 27th July, 1961.

Oribius* sp. aff. *immitis Pasc.

Unknown hosts : Kepi (S.N.G.) 17th October, 1957, Getenteri (S.N.G.) 11th October, 1957, Tanahmerah (S.N.G.) 7th April and 18th June, 1957, February 1958, Mandabo (S.N.G.) 9th November, 1957.

Oribius* sp. aff. *improvidus Mshl.

Acacia auriculiformis : Kota Nica 24th June, 1961. *Anona muricata* L. Kota Nica 10th May, 1956, 26th May and 16th June, 1961. *Arachis hypogaea* L.: Kota Nica 3rd November, 1961. *Asystasia intrusa* Bl.: Kota Nica 24th June, 1961. *Boehmeria nivea* Gaud. Kota Nica 12th June, 1961. *Brassica rugosa* Prain.: K. P. Landbouw (Biak) 29th February, 1961. *Calopogonium mucunoides* Desv.: Kota Nica 21st October, 1961. *Carica papaya* L.: Kota Nica 24th June, 1961. *Cassia spectabilis* : Kota Nica 24th June, 1961. *Centrosema pubescens* Benth.: Kota Nica 24th June, 1961. *Citrus* spp.: Kota Nica 26th May and 16th June, 1961. *Coffea arabica* L.: Kota Nica 7th January, 1960. *Coffea liberica* Bull., seedlings : Kota Nica 24th June, 1961, *Endospermum* sp. Kota Nica 2nd November, 1960, 6th June and 16th June, 1961. *Glycine max* Merr.: Kota Nica 30th June, 1961. *Grevillea robusta* A. Cunn.: Kota Nica 24th June, 1961. *Hevea brasiliensis* Muell. Arg.: Kota Nica 30th June, 1961. *Hibiscus rosa-sinensis* L.: Kota Nica 30th June, 1961. *Indigofera hirsuta* L.:

* Present address : Oranjelaan 28, Nunspeet, Holland.
† Present address : Not known.

Kota Nica 2nd November, 1960, 9th and 16th June, 1961. *Ipomoea batatas* Poir.: Kota Nica 26th May and 16th June, 1961. *Ixora* sp.: Kota Nica 24th June, 1961. *Mangifera indica* L.: seedlings : Kota Nica 24th June, 1961. *Merrenia peltata* Merr.: Kota Nica 16th June and 24th December, 1961. *Musa paradisiaca* L.: Kota Nica 10th October and 28th October, 1960, 26th May and 16th June, 1961. *Mussaenda frondosa* L.: Kota Nica 24th June, 1961. *Nephelium lappaceum,* seedlings : Kota Nica 24th June, 1961. *Ochroma* sp.: Sentani 22nd June, 1961. *Passiflora quadrangularis* : Kota Nica 24th June, 1961. *Passiflora foetida* L. Kota Nica 30th June, 1961. *Persea gratissima* Gaertn.: Kota Nica 26th May, 1961. *Phaseolus* spp.: Kota Nica 21st December, 1957. *Pueraria javanica* Benth.: Kota Nica 24th June, 1961. *Ricinus communis* L.: Kota Nica 30th June, 1961. *Sesbania* sp.: Kota Nica 19th February, 1958. *Solanum melongena* L.: Kota Nica 16th June, 1961. *Theobroma cacao* L.: Sewan near Sarmi, 11th March, 1958, seedlings, Kota Nica 24th June, 1961. Unknown hosts : Hollandia 12th March, 1956, Rhijnauwen near Hollandia, May 1956 (coll. G. den Hoed), 14th September, 1957, Dojo near Hollandia, August 1956 (coll. G. den Hoed), 1st November, 1956, 15th April and 12th July, 1957, Genjem April 1956 (coll. G. den Hoed), Sewan near Sarmi, 12th March, 1958, 22nd June, 1959, Jeraswir near Sarmi, 13th March, 1958, Biak, 4th January, 1957, K. P. Landbouw (Biak) 12th June, 1959.

***Oribius* sp.**

Merrenia peltata Merr.: Weroer (W.N.G.) 25th July, 1961, Sausapor (W.N.G.) 24th July, 1961, *Brassica rugosa* Prain.: K. P. Landbouw (Biak) 29th February, 1956, 4th January, 1957.

***Sphaeropterus albolineatus* Guer.**

Amaranthus sp.: K. P. Landbouw (Biak) 28th February, 1956. *Coffea canephora* Pierre et Froehner : Manokwari 13th December, 1955. *Theobroma cacao* L.: Manokwari 14th December, 1955, Wosi near Manokwari, 4th April, 1959. Unknown hosts : Fak-Fak, 23rd November, 1959.

The species *Apirocalus cornutus* Pasc. is easily recognized by the thorn-shaped protrusion on each elytron. The other species are very much alike and can only be distinguished by the structure of the male genitalia (Fig. 1).

Figure 2 shows the geographical distribution of most species throughout Netherlands New Guinea. *Apirocalus cornutus* Pasc. which was found only at Hollandia, is not included in this map. The map still shows many blank spaces

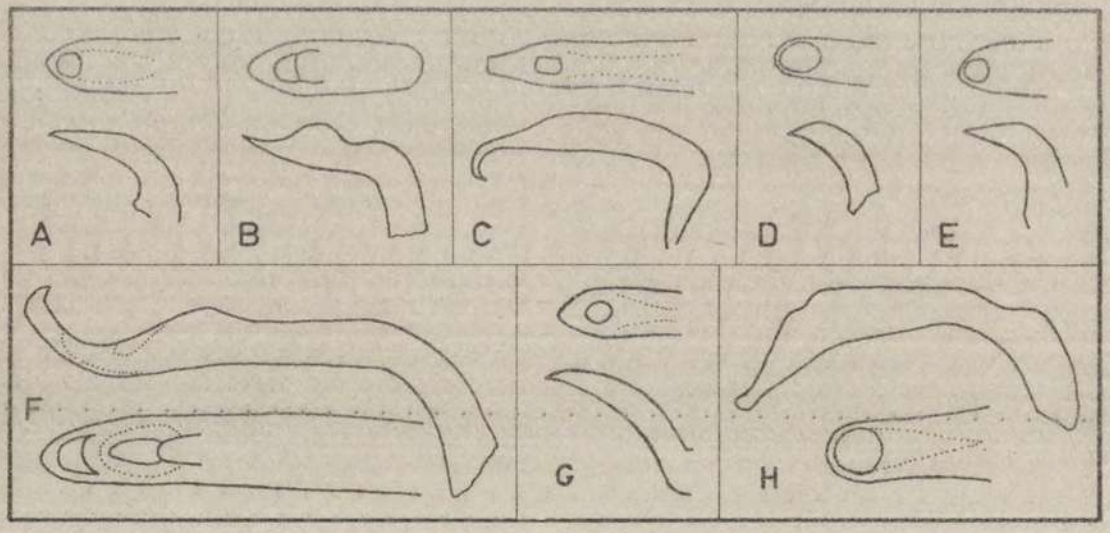


Figure 1.—Male genitalia of A. *Sphaeropterus albolineatus* Guer., B. *Idiopsis perplexa* Fst., C. *Oribius immitis* Pasc., D. *Oribius* sp., E. *Oribius leucostictus* Pasc., F. *Oribius* sp. aff. *improvidus* Mshl., G. *Idiopsis grisea* Fst., H. *Oribius* sp. aff.—*immitis* Pasc.

from which observations have not been made. There is little doubt, however, that several species also occur in these areas.

The foregoing list shows that at Kota Nica *Idiopsis perplexa* Fst. has only been found on two crops. This is in striking contrast with *Oribius* sp. aff. *improvidus* Mshl., which is a polyphagous insect. Its polyphagous nature is clearly reflected in the list of 35 host plants. Yet *Oribius* sp. aff. *improvidus* Mshl. reveals a certain preference for various parts of its host. On bananas it is mainly the young fruit (Plate I) which is attacked, and in the second instance the leaves (Fig. 3A), especially the young, rolled ones. On sour-sop only the leaves are attacked (Fig. 3B). On citrus this species shows a special preference for the leaves and secondarily for the bark of young shoots. On cacao and coffee it only attacks the young leaves of seedlings, whereas on rubber it feeds only on the young petioles, causing the leaves to fall off.

It seems that the degree of damage caused by these weevil species is dependent on the cover crop. All observations are summarized in Table I, which at the same time shows the cover crops and the degree of damage. The cover crops listed are : *Centrosema pubescens* Benth., *Calopogonium mucunoides* Desv. and *Pueraria Javanica* Benth. (indicated respectively by *Cen.*, *Cal.* and *Pu.*)

It is probable that the larvae of the weevils feed on the roots of the cover crops. Larvae of Celeuthetini weevils are recorded as boring into thick roots or attacking the epidermis of small roots. The food plants of the larvae require special study and will therefore not be discussed in this article.

To correlate the degree of damage with the kind of cover crop, the numbers of specimens of *Oribius* sp. aff. *improvidus* Mshl. and *Idopsis perplexa* Fst. (indicated on Table II by the abbreviations *O. imp.* and *I. per.*) found on banana plants were counted. The trial plot was

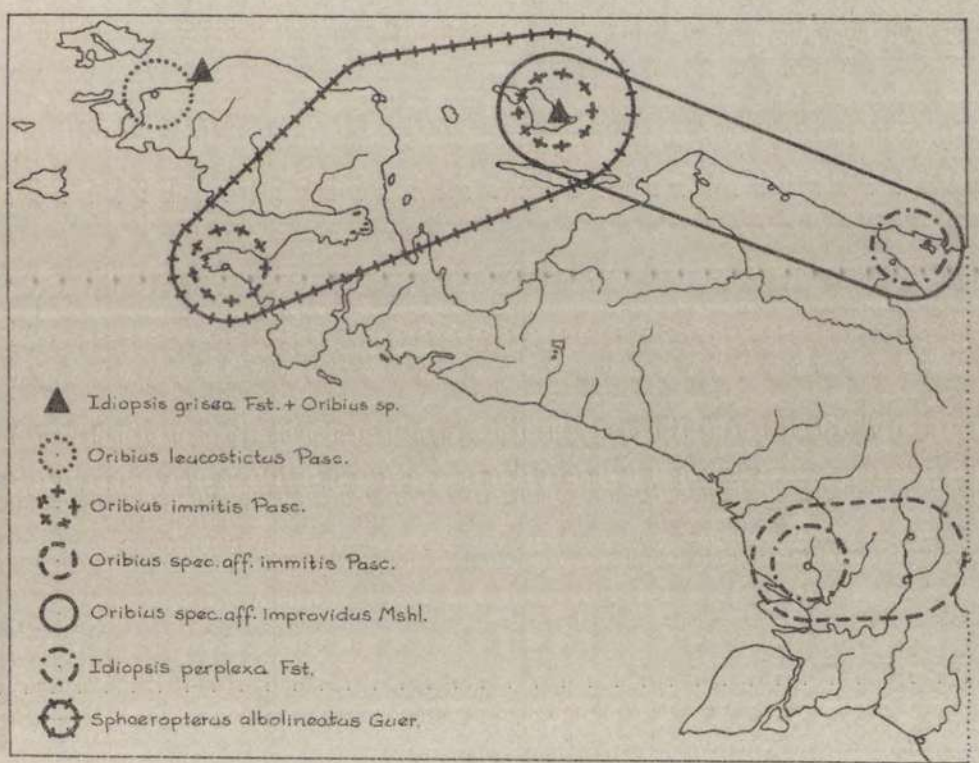


Figure 2.—Geographical distribution of some grey weevil species.

planted with *Musa paradisiaca* L. and various cover crops. The banana plants were shaken over a white sheet (this sampling method is based on the habit of these weevils to drop from the tree when disturbed and to feign death for a short period of time). In this manner the weevils can be easily caught. This method provides a fairly accurate quantitative picture.

Plate I.—Damage on banana fruit by Celeuthetini weevils.

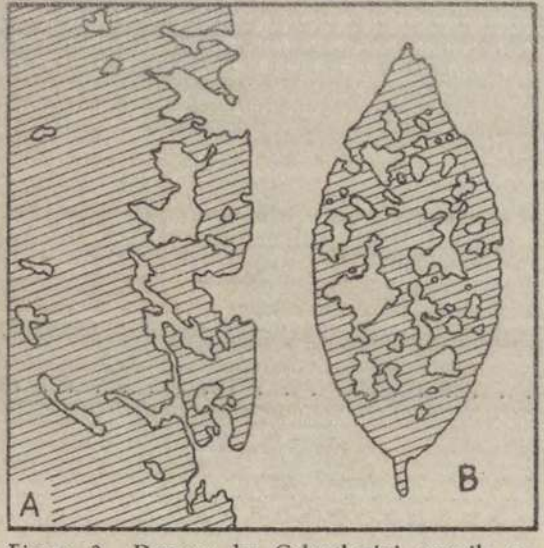


Figure 3.—Damage by Celeuthetini weevils on (A) banana leaf and (B) sour-sop leaf.

Table II shows clearly that an undergrowth of *Calopogonium* and *Pueraria,* and to a minor degree *Centrosema,* promotes the occurrence of the two weevil species.

After removing the cover crop *Calopogonium,* it takes months for the pest to disappear completely, since it is extremely difficult in practice to remove all parts of the roots around the banana stools. Table II shows an example of this phenomenon. The first and fourth lines indicate the numbers of grey weevils per tree in Section 6D. Total weevil numbers per plant fell from (267 + 108) ÷ 5 — 75 to (56 + 34) ÷ 7 — 13 within six months following the removal of the cover crop.

The weevils are apterous and can only reach their food plants by walking. One heavily damaged clump of banana plants was found in Section 12E (Table II). Here there was no cover crop, but the infestation proved to have originated in a hedge of *Calopogonium* and *Centrosema* at a short distance from the stools The banana plants farther away in this section remained undamaged.

Table I.

Host Plant.	Cover Crop.	Degree of Damage.
Anona muricata L.	*Cen. Cal. Pu.*	Badly damaged.
....	*Cal.*	Completely stripped.
....	*Cucurbita* sp.	No damage.
Persea gratissima Gaertn.	*Cen.*	Badly damaged.
Artocarpus integra Merr.	*Cen. Cal. Pu.*	No damage.
Citrus spp.	*Cen. Cal. Pu.*	Badly damaged.
....	*Cucurbita* sp.	No damage.
....	No cover crop	No damage.
Musa paradisiaca L.	*Cen. Cal. Pu.*	Badly damaged.
....	*Cen.*	Badly damaged.
....	Grasses	No damage.
....	No cover crop	No damage.
Leucaena glauca Bth.	*Cal. Pu.*	No damage.
Theobroma cacao L.	*Cen. Cal. Pu.*	No damage.
....	Forest shade	A few weevils.
Cassia spectabilis	*Cen. Cal.*	Badly damaged.

Table II.

Date.	Section.	Cover Crop.	No. of Plants.	Nos. of O. imp.	I. per.	Particulars.
2nd November, 1960	6D	*Cen. Cal Pu.*	5	267	108	Thick layer of cover crop.
2nd November, 1960	6D	*Cen. Cal.*	5	174	0	*Cen. Cal* = 9:1
2nd November, 1960	12F	None	3	16	6	2 months ago still grown with *Cal.*
2nd June, 1961	6D	None	7	56	34	6 months ago still grown with *Cal.*
9th June, 1961	12F	Grasses	5	35	3	*Cen.* + *Cal.* along edge of plot.
9th June, 1961	12E	None	1	42	0	Near a *Cal.* plant.
2nd November, 1960	12E	None	5	3	1	None.

Prospects for Tropical Agricultural Products in International Trade.

G. R. SPINKS,
Agricultural Economist, D.A.S.F., Port Moresby.

THE economic development of the world's underdeveloped countries is intimately connected with future trade prospects for tropical agricultural products. Trends now becoming apparent indicate that the economic progress of these countries will be seriously limited by the export earning capacity of the major tropical products. The changing pattern of international trade has worked against primary producing countries, although tropical nations have not fared as badly as their counterparts in the temperate regions. Additionally, despite the increasing political power of the underdeveloped countries, their economic bargaining strength is declining rapidly. The economic gap between the underdeveloped countries of the tropics, relying almost solely on the export of tropical agricultural produce, and the industrialized countries is widening, despite current world opinion on the need to foster economic development of the former.(1) The population growth is constantly contributing to this gap as its rate is greater than that of economic development.

The early 1950's were characterized by particularly favourable demand conditions for agricultural products. Many of the newly independent tropical countries accumulated large reserves of foreign exchange and were able to implement economic development programmes. However, by the mid '50's, the price relationship between agricultural and industrial products was changing so that the terms of trade became adverse for agriculture.(2)

For many centuries world trade in tropical agricultural products has been of importance to the Western European countries. The range of products has continuously altered owing to changes in demand in the importing countries, and not many of the principal tropical agricultural products entering world trade to-day were exchanged 100 years ago. Only a few of the considerable number traded is of real significance in international commerce. The regions producing them are fairly well distributed throughout the tropics, and in each case, one or a few countries dominate production and exports. The most important agricultural products in terms of export values are shown in Table I.

Recent developments in international trade suggest that the terms of trade will continue to move against agricultural products. Declining terms of trade have been arrested in some cases by international commodity agreements, as in the case of sugar, and the yearly coffee agreement. World demand has shifted towards industrial goods. Trade in agricultural produce has declined and will decline in importance, relative to manufactured commodities. The tendency will be reinforced because of the low elasticity of demand for agricultural commodities. As world income increases, the proportion spent on foodstuffs will not increase by the same amount once essential food needs are met. Furthermore, as the underdeveloped countries advance economically they will embark upon programmes of self-sufficiency in foodstuffs.

World trade in agricultural products which can be readily produced in some or all industrialized nations has declined in volume—as shown in Figure 1. At the same time, commodities not easily produced in the industrialized nations, consisting mainly of tropical agricultural products, have increased in importance in international trade. However, the rapid increase in the number of newly independent countries of the tropical world has meant that each must attempt to earn as much foreign exchange as possible through trade to finance development

(1) The basic theory explaining this development is contained in a challenging book by Gunnar Mydral, *Economic Theory and Underdeveloped Regions*, Duckworth & Co. Ltd., London, 1957, 168 pp. One of the main arguments is that international trade instead of being the means of economic growth for all participants is causing international economic inequalities to widen.

(2) A 1961 F.A.O. publication stated that "the terms of trade for agricultural exports declined for the sixth year in succession". *The State of Food and Agriculture* 1961. F.A.O. Rome, 1961, p. 4.

Table I.

Main Food Products in International Trade 1953-1957 *

(Approximate Export Values in Million U.S. Dollars)

Commodities	1953	1954	1955	1956	1957	
Wheat	2,015	1,610	1,630	1,955	1,900	Including flour.
Barley	335	285	285	385	325	
Maize	340	330	285	360	405	
Rice	710	610	555	605	635	Milled equivalent.
Butter	410	405	435	440	385	
Meat	1,175	1,265	1,310	1,315	1,500	Beef, mutton, pork including prepared and canned.
Sugar	1,325	1,205	1,265	1,335	1,705	Beet and cane, centrifugal.
Tobacco	755	760	830	820	930	Unmanufactured.
TOTAL	7,065	6,470	6,595	7,215	7,785	
From Industrial Countries	3,670	3,195	3,350	3,795	4,110	
From non-Industrial Countries	3,395	3,275	3,245	3,420	3,675	
Coffee	2,290	2,335	2,095	2,360	2,160	
Cocoa	485	730	570	440	430	Bean.
Tea	460	625	600	605	565	
Bananas	330	320	305	300	280	Excl. plantains.
TOTAL	3,565	4,010	3,570	3,705	3,435	
TOTAL ABOVE	10,630	10,480	10,165	10,920	11,220	
Other Food	6,090	6,400	6,965	7,600	7,930	
TOTAL FOOD (a)	16,720	16,880	17,130	18,520	19,150	

* Exclude trade between USSR, Eastern Europe and mainland China.

(a) *International Trade* 1957-58, GATT, July, 1959, p. 38.

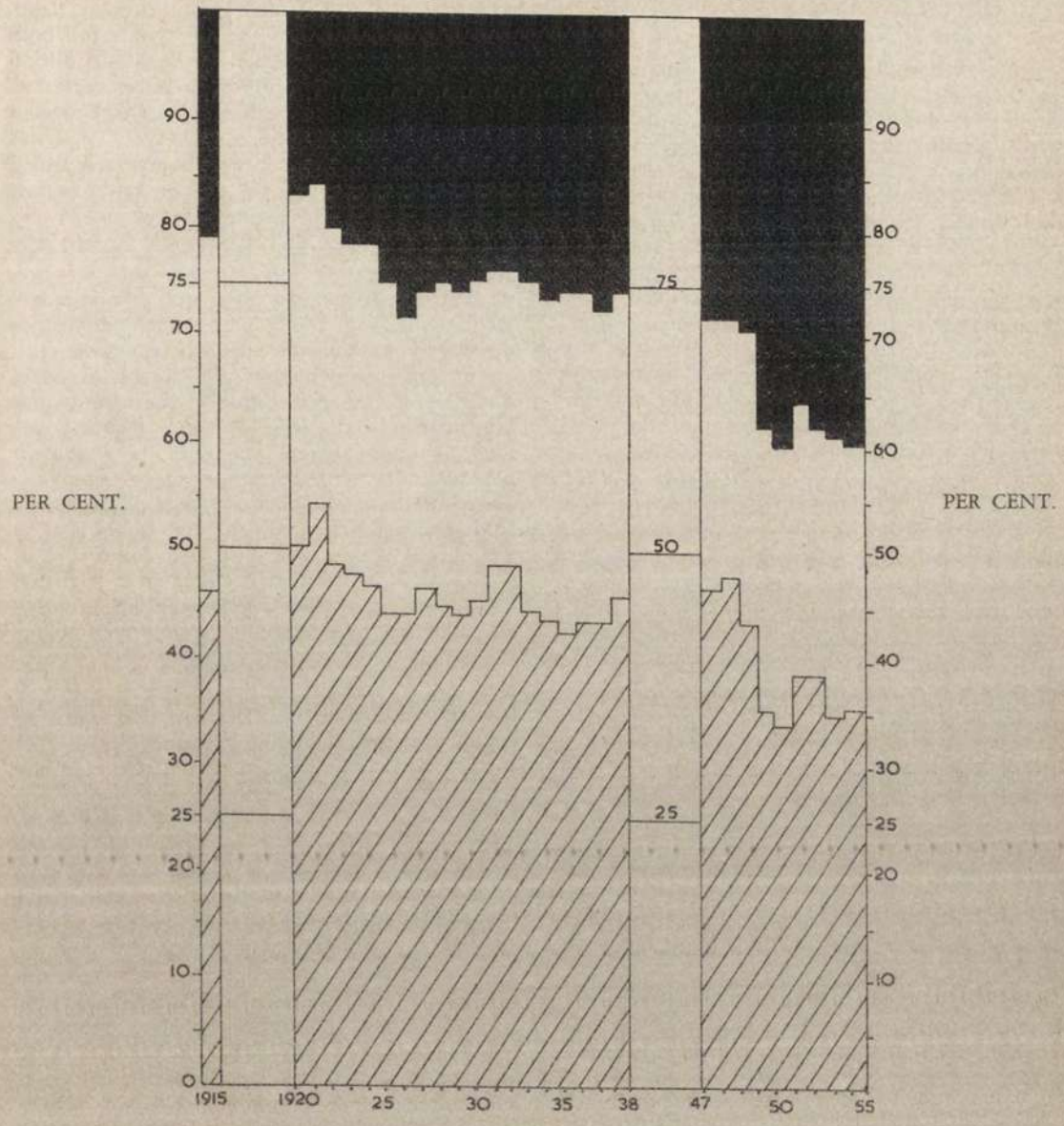
plans. This trend could easily result in over-production of a number of tropical agricultural commodities, leading to declining world price levels and increased pressure for international commodity agreements.(3)

Continual technological advances in the industrialized countries are causing synthetics and substitute commodities to threaten the natural products of the tropical countries. In addition economies in the use of raw materials are reducing world demand. The commercial and agricultural policies of the industrialized nations (particularly the U.S.A.) are tending to merge as the attempts at self sufficiency in foodstuffs and some raw materials have become more important.

(3) Some interesting comments on international commodity agreements have been made by Professor G. Haberler. Haberler G. "Terms of Trade and Economic Development". Howard S. Ellis and Henry C. Wallich. Edit. *Economic Development for Latin America* Macmillan, London 1961, p. 296.

Figure 1.

Per cent. changes in the Composition of World Trade in Agricultural Products



Commodities not readily produced in the main industrial countries (coffee, cocoa, tea, bananas, pepper, rubber, jute and wool).

Commodities readily produced in some but not all of the industrial countries (edible oilseeds and oils, oranges, wine, dried raisins, tobacco, cotton and oilcake).

Commodities readily produced in the main industrial countries (cereals, sugar, livestock products, linseed and apples).

Source. *The State of Food and Agriculture* 1956. F.A.O. Rome p. 82.

THE CHANGING STRUCTURE OF INTERNATIONAL TRADE.

The Nineteenth Century is commonly regarded as the ideal towards which world commerce should be re-directed. Trade was virtually free and the international transfer of capital and labour was a common feature. The volume of world trade increased greatly, mainly as a result of technological advances in transportation with the successful development of the steamship and the opening of the Suez Canal. This trade was centred on Western Europe with Great Britain as the pivot. Overseas colonies, including the newly European-settled colonies in the temperate regions of the world, and the U.S.A. supplied much of the basic foodstuffs and raw materials for the home countries.

During the Nineteenth Century, particularly in the latter half, the pattern of world trade changed considerably. Foodstuffs (mainly cereals and livestock products) dominated commerce, with fibres and coal being the principal raw materials. However, by 1913, the emphasis had swung to ores, iron and steel. Between 1870 and 1913, the volume of international trade trebled.

The outbreak of World War I dealt the first serious blow at the established pattern of world trade. A number of new industrialized nations emerged, each challenging the supremacy of the United Kingdom. The war also showed the dangers of being too reliant on overseas food supplies and revealed the advantages of some degree of national self-sufficiency in foodstuffs. After 1913, the volume of world trade decreased from the high levels of the previous decades and between that year and 1953, it rose by only about 66 per cent. Most of the increase occurred after World War II.

The inter-war period was one of rapid change in international trade. The gold standard disappeared and exchange rates of many countries experienced great fluctuations. Because of the depression, the total value of world trade in primary products fell from $19,000 million in 1929 to $7,500 million in 1932. After a slow recovery, the total value managed to reach $15,000 million in 1937 only to collapse again to $12,000 million in the following year.(4)

This earlier decline was mainly due to changes in prices which dropped by over 50 per cent. in the period 1929-32 and to a lesser extend to a fall in volume of trade. On the other hand, the slump in 1938 was the effect of a fall both in prices and volume. Individual agricultural products experienced different price decreases. Of the tropical commodities, rubber was affected most, falling by 75 per cent. between 1929 and 1932. The slump in 1938 also lowered world prices and cocoa fell by 40 per cent. Coffee, rubber and oilseeds declined by about 25 per cent. but the price of bananas and tobacco rose slightly.

As a consequence of price and volume movements in world trade, serious difficulties developed in the international payments and receipts of many nations. In order to offset these and to protect themselves against dwindling markets, countries deliberately imposed barriers to international commerce. Government policies were radically changed as emphasis moved to relieving unemployment within their national boundaries. By the end of the 1930's the future of international trade seemed uncertain and despite some economic recovery, trade restrictions and special trading arrangements became part of national commercial policy.

The Second World War resulted in more complete and comprehensive governmental control of nations' foreign trade. The restrictions arising out of the 30's became a permanent feature of world trade. There was to be no return to any system of unregulated multilateral exchange.

The post-war developments in world commerce have had marked effects on the attitude of the newly independent nations as these were their formative years. The early 1950's witnessed recovery in the volume of trade from the generally low levels of the late 1930's. Values of primary products rose much faster than the volume of trade and tropical agricultural products benefited considerably. Their terms of trade were particularly favourable so that many of these new underdeveloped countries accumulated large reserves of foreign exchange. However, despite this increase, the volume of trade only exceeded the 1929 level by about 25 per cent. in the mid '50's. Throughout this decade, fluctuations in price levels were less than those of the 1930's in spite of the Korean War and Suez Crisis.

There were several recessions in the industrialized countries in the late 1940's and throughout the 50's, most of them originating in the U.S.A. The first occurred in that country in

(4) *Trends in International Trade.* GATT Geneva, October, 1958, p. 13.

1948-49 and was cushioned to some extent by the strong world demand for the capital goods which were procurable only in the U.S.A. Nevertheless, prices for agricultural raw materials and foodstuffs fell slightly. The next slump occurred in 1953-54 and was more severe than its predecessor. However, the overall prosperity within the industrialized nations of Western Europe shielded the rest of the world from the full impact of the drop in economic activity in the U.S.A. Prices of agricultural products were generally maintained while those of coffee and cocoa rose.

In 1957-58, the U.S.A. again suffered a mild slump and the rate of economic growth in Western Europe was slowing down. Since then, the industrialized nations have experienced a series of mild slumps but generally the level of world trade has risen. In common with the 1957-58 recession, the decline in the growth of economic activity in the industrialized nations had little effect on the demand for foodstuffs, although a number of agricultural raw materials, such as rubber, suffered.

Despite gloomy forecasts, world trade quickly increased after World War II. Industrial articles dominated world trade and in the immediate post-war period, much of this was due to the large amount of U.S. economic aid. Throughout the remainder of the 50's, the relative importance of manufactured products continued to expand. At the same time, the direction of world trade altered so that the exchange of goods between the industrialized nations increased. The volume of industrial commodities in international commerce will continue to expand as the import needs of the underdeveloped countries rise with their economic development.

COMMON CHARACTERISTICS OF UNDERDEVELOPED NATIONS.

The underdeveloped nations of the tropical regions have a number of common characteristics which place them at a disadvantage to the industrialized countries in world commerce.

Agriculture is their principal economic activity, but the export products, the main source of international revenue, are only a minor sector of their economies. In many instances, over 70 per cent. of the foreign currency is earned from the sale of one product. For the four years 1956-59, exports of coffee accounted for more than 70 per cent. of the total export proceeds of Colombia, El Salvador and Guatemala, while in Brazil the corresponding figure was about 60 per cent. Sales of cocoa made up about 66 per cent. of export revenue for Ghana; sugar 72 per cent. for Cuba; cloves 74 per cent. for Zanzibar; rubber 63 per cent. for the Federation of Malaya; bananas 74 per cent. for Panama; and groundnuts 93 per cent. for Gambia. Many more of the tropical underdeveloped countries rely upon one agricultural export for more than 50 per cent. of total receipts. In each case domestic consumption of these products is very small so that exports and production tend to be at about the same level.

Because the import demand of the industrialized nations is extremely sensitive to small variations in their levels of economic activity, the underdeveloped countries find their economies greatly influenced by any change in the rates of economic growth in the industrialized nations. In addition to these short term fluctuations of the business cycle in their principal markets, variations in the supply of agricultural products occur in the underdeveloped countries because of climatic conditions, biennial production cycles of some of the tropical tree crops, and pest and disease infestations. Single countries often supply a major proportion of total world production and the principal production centres are usually small geographical regions of the countries. Therefore, local climatic conditions and pest or disease damage have widespread effects on the volume of world trade and prices. The heavy concentration of Brazilian coffee in the State of Sao Paulo and the Ghanaian cocoa in the Ashanti are two illustrations of this problem.

Furthermore, the supply of agricultural products is relatively inelastic in the short run and this is particularly so for tree crops which make up a considerable proportion of tropical agricultural produce. The long pre-maturity period for tropical tree crops means that the current supply position is usually a reflection of the demand conditions of some previous years. The present situation in the world coffee market is an illustration of this phenomenon.

For political reasons, each of the underdeveloped nations is irrevocably committed to programmes of economic development. Such programmes are closely connected with the supply

of foreign exchange from exports for the purchase of the necessary imports. However, with the terms of trade moving against agricultural products on world markets, export earnings from agriculture are normally insufficient to finance all the imports of capital equipment for the continuation of economic development plans. This is further complicated by changing demand from the industrialized countries owing to fluctuations in their levels of economic activity. Such events have far-reaching implications on the attitude of the underdeveloped nations towards the role of international trade in their economic development.

Added to the above problems are the commercial policies of the industrialized nations, which are not conducive to freer multilateral trade and often work against the long term goals of the underdeveloped nations. Such policies have prompted a panel of experts set up by the contracting parties of the General Agreement on Tariffs and Trade (GATT) to state in their conclusion to a report, " We think that there is some substance in the feeling of disquiet among the primary producing countries that the present rules and conventions about commercial policies are relatively unfavourable to them."(5)

MAIN FACTORS AFFECTING THE TERMS OF TRADE OF TROPICAL PRODUCTS.

World trade is dominated by the industrialized nations and with the increasing proportion of manufactured products in trade, this domination will continue for many years. Two main factors are contributing to the adverse terms of trade for agricultural products, firstly technological advances in the industrialized countries, and secondly their trading and agricultural policies.

A. *Technological Advances.*

The major long term threat facing the tropical agricultural nations is the continuing rapid development of technology in the industrialized nations. The inelastic supply of tropical agricultural commodities, particularly in the short run when prices rise, has been an important spur to the development of synthetic materials and economies in the use of raw materials.

(i) *Development of Synthetics and Substitute Products.*

During the 1950's considerable advances in the field of synthetic materials occurred. These were largely based upon progress within the growing petro-chemical industry. The advances have had and will continue to have very serious implications for the demand for agricultural produce from the tropical areas of the world.

Rubber offers perhaps the best known example of a synthetic material challenging the natural product. Although world consumption of rubber has steadily increased since 1913, the production of synthetic materials has made inroads into traditional markets of natural rubber. In 1951, synthetic rubbers made up 35 per cent. of world consumption but by 1960 the percentage had increased to 47 per cent. Within individual countries increased use of synthetic rubbers has been more marked and at the end of 1960 these materials made up 69 per cent. of the total utilization of all rubber in the U.S.A. With the present world political situation the production of synthetic rubbers will further expand. For instance, under the present Seven Year Plan the USSR hopes to be self sufficient in rubber by 1963. Furthermore, all the industrialized countries possess extensive rubber reclaiming plants which reduce their demand for the natural product.

Synthetic detergents have also seriously affected the demand for soaps both for domestic and industrial purposes. As a result, the demand for vegetable and animal oils and fats has fallen.

Cotton has for many years been facing the threat of synthetic fibres. However, this product has made a partial recovery mainly owing to scientific advances in the industrialized nations. Other natural fibres used in the manufacture of cordage have had their demand retarded by the development of nylon cordage. The demand for some minor tropical agricultural crops has also been damaged by the development of synthetics, for example, vanilla has been seriously affected.

Substitute products are not as serious a problem as synthetics although world demand for coffee has suffered through these products. It has been stated that Europe's " total consumption of coffee substitutes may be tentatively estimated

(5) *Trends in International Trade.* A Report by a Panel of Experts. GATT Geneva, October, 1958, Item 62, p. 11.

at 300,000-375,000 metric tons. In addition, another 30,000 tons may be used in Near Eastern and African countries."[6]

Like synthetic materials, these substitute products are developed mainly as a response to high prices for the natural commodity. However, for coffee in some of the European countries, internal taxes artificially raise the retail price so that the substitutes become attractive. With stable world price levels it is possible that the developments of synthetic and substitute products would be slowed down.

Throughout the 50's, synthetic materials emerged largely in response to the inelastic supply of the natural product. Heavy demand (often coinciding with decreasing supply) caused world prices to rise to levels where alternative cheaper sources of supply were sought, preferably within national boundaries. However, these advances in synthetic materials have also assisted the natural product through the maintenance of a more stable world price level. Although it has been argued that no synthetic materials have stopped the output of a natural product but only supplemented it, the long run threat cannot be ignored. Many manufacturers prefer to use the synthetic materials as in some cases they can be developed for specific purposes and their stability in price permits planned production. Violent fluctuations in the world price level for many tropical commodities have made manufacturers wary of holding stocks.

(ii) *Economies in the Use of Raw Materials.*

Economies in the use of raw materials have also played an important part in decreasing world demand for a number of agricultural products from the tropics. Bulk shipments of cargo have led to important savings in the use of packaging materials such as jute. The development of "instant" coffee has resulted in more cups per unit weight of raw material, as has "instant" tea. It is stated that the high world prices for coffee because of severe frost damage in the Brazilian States of Parana and Sao Paulo in 1954 gave considerable impetus to the development of instant coffees in the U.S.A.

A more recent advance in the processing of cocoa beans has been reported from West Germany, "The new process which may roughly be designated as a warm water treatment .... is said to have been developed enough to be used industrially. Chocolate production time is said to be reduced to half when de-bittering is done by this process and cheaper beans can be used with the addition of far less sugar. Beans processed by this method are expected to be storable for years."[7]

In practically all cases the underdeveloped nations of the tropical world compete directly with each other as all tend to produce similar products. High prices of one commodity cause nations to respond quickly by increased plantings. High prices for coffee in the mid 50's caused greatly increased plantings, resulting in the present over-production. Unfortunately the degree of competition between the underdeveloped countries of the tropical world will become more intense as each of the increasing number of newly independent nations commences to carry out its development plans. Foreign exchange for financing these programmes will mainly come from the export of agricultural products (the petroleum producers of the tropical regions are excluded) so that all will push their exports to the limit.

Where agricultural commodities from the underdeveloped nations are in direct competition with the same or substitute products from the industrialized countries, the former tend to lose markets to the latter. The tendency is largely caused by the widespread application of science to the domestic agriculture of the industrialized countries. Exports of cotton, rice and edible vegetable oils from the U.S. have already taken over some of the traditional markets of the tropical countries.

B. *Agricultural and Trading Policies of the Industrialized Countries.*

The character of world trade was greatly changed as a result of the depression of the 1930's. Although gloomy forecasts were made about the future of world trade, the end of the last war saw a rapid revival. The dominance of the industrialized nations in international commerce has been greatly enhanced by their home agricultural and trading policies. The USA provides an excellent illustration of the amalgamation of protective domestic agri-

(6) *The World Coffee Economy*, FAO Rome, November, 1959, p. 60.

(7) *Foreign Agriculture Circular*, Cocoa Bean Crop, USDA, March, 1961. p. 8.

culture and trading policy. World trade has also tended to be split into definite economic groups which have not encouraged a widening of international commerce.

(i) *Agricultural Protection in the Industrialized Countries.*

In all the industrialized nations, domestic agriculture is heavily protected and subsidized. This has resulted in a decline in the volume of agricultural commodities entering world trade. "Agricultural protectionism in the highly industrialized countries is now a major factor restricting the world trade in such products."(8)

In most cases this protection has been directed at the primary producing countries of the temperate regions but the protection of the beet sugar industry in Western Europe has had serious consequences on those countries producing cane sugar.

The significance of this protection is shown in Figure 1. In 1929 the percentage of agricultural produce which could be grown in all the main industrial countries entering world trade was about 50 per cent. but by 1955 there had been a steady decline to slightly more than 35 per cent. A similar, but not so rapid fall, also occurred for those agricultural commodities which can be produced in some but not all of the industrial countries. Taking these two groups together, the percentage has fallen from about 85 per cent. in 1920 to slightly more than 60 per cent. in 1955.

The results of heavy subsidization of agriculture and scientific advances in agriculture have created serious problems in the U.S.A. Despite government measures to restrict agricultural production, huge surpluses of unsold primary commodities have accumulated. Although this is not a recent phenomenon, the most spectacular increases in these surpluses occurred in the 1950's. Attempts at disposal of these have to date accomplished little.

In 1954 the U.S. Congress passed the Agriculture Trade Development and Assistance Act or Public Law 480, which permitted surplus agricultural produce to enter world trade under special conditions. Payment could be made in the currency of the importing country, or shipments of surplus commodities could occur for emergency and relief programmes in foreign countries or as a method of economic aid. Although it first appeared as a temporary measure to ease the accumulation of agricultural produce, the continued growth in surplus products has made this form of trade a permanent feature of U.S. commercial policy. The favourable conditions under which these commodities can be traded has dislocated established world trading connections especially those of the primary producing countries of the temperate regions. However, a number of these surplus products do compete directly with agricultural commodities from tropical underdeveloped nations. Shipments of edible oils and oilseeds to Western Europe under the favourable conditions of Public Law 480 have disrupted market prospects for other edible oils from the tropical countries. Sales of surplus rice and cotton have also affected market prospects in industrialized nations for these crops from the underdeveloped countries.

The 1958 GATT Report has stated "that economic aid from the richer and more developed, to the poorer and less developed countries, should as far as possible take the form of direct financial aid from the former to the latter."(9)

However, the U.S. government has continued to dispose of agricultural surplus commodities in the form of economic aid. A recent article(10) suggests that this is now accepted as a permanent part of economic aid. The U.S. Government has not been able to solve its own domestic agricultural problem and some surplus production has been placed in world trade without, at times, much real consideration of the effects.

(ii) *Division of World Trade into Economic Communities.*

Because of political tension and the recurring currency crises of the post-war period, world trade has tended to split into a number of economic groups. This has caused international commerce to be diverted into specific channels and has not resulted in any tendency for increasing trade among countries.

Of these groups, the European Economic Community (E.E.C.) is the most widely known, and its unexpected success has set the pattern for the economic grouping of other countries, par-

(8) Ibid GATT, 1958, p. 87.

(9) Ibid, GATT, 1958. Item 265 pp. 96-97.

(10) *The Strategy of Food Aid*, Sherman E. Johnson, *Foreign Agriculture*, U.S.D.A. Foreign Agriculture Service, January, 1962, pp. 3-22)

ticularly among some of the underdeveloped nations. The E.E.C. has resulted in increased agricultural protection so that further encouragement will be given to the production of beet sugar and oil seeds. Both these products compete directly with tropical agricultural commodities.

Attached to the Community is the Association of Overseas Territories, mainly former French dependent territories in Africa. These countries are given favoured trading arrangements over imports of tropical agricultural products from other underdeveloped areas. In the past those underdeveloped countries trading in " sheltered " channels, that is linked economically to the main importing countries, have enjoyed more favourable export earnings than those which did not have the benefit of a privileged position in their main export markets.(11)

This factor has no doubt influenced many of the underdeveloped nations to strengthen their economic bonds with their principal markets. However, such arrangements do not encourage the spread of freer multilateral trade and are basically " trade diverting ".

The Communist group of nations, which in in the past has largely withdrawn from international trade, has also attempted to create an economic community, resting on political considerations. The techniques of trading are mainly on a government-to-government barter basis, both within and without the group. Some of the underdeveloped countries have already become partners to these barter agreements. Over recent years there have been signs that the Communist group of nations is willing to enter more freely into world trade and this could benefit many of the underdeveloped countries. However, to date, trading experience between these two groups has not been favourable to the underdeveloped nations.

CONCLUSIONS.

Overall it appears that there is little hope for any real improvement in the terms of trade of tropical agricultural commodities. Individual products will benefit for short periods but competition between the nations will reverse the trend. The success of economic development plans will be constantly in jeopardy and each nation will be forced to export as much as possible despite the dangers of over-production and declining world price levels. Furthermore, periods of high prices will quickly lead to greater emphasis on the development of synthetic and substitute materials in the industrialized countries.

The underdeveloped countries must continually seek new products and enlist the aid of the developed nations in finding new uses for their agricultural products. It may be asked if it is economic for all the underdeveloped nations to attempt programmes of industrial development, or if they would be better off economically if free multi-lateral trade were to return. The underdeveloped countries could specialize in the output of these goods which they are most suited to produce, i.e., tropical agricultural commodities.

Although the industrialized nations can assist by maintaining stability in their rate of economic growth, this alone will not solve the problem. World demand has shifted towards manufactured products which underdeveloped countries cannot produce. These nations with their rigid economies will find it extremely difficult to adjust to changing patterns in international trade.

It is often argued that in the long run the adverse terms of trade can be solved through a process of growth within the economy but this traditional approach is not appropriate to the underdeveloped nations. Population increases alone may be too great to permit this. These countries do not have time as an ally; their development must be carried out in the shortest possible period. The economic and social gap between the " have and have not " nations will become wider. Although total world trade will increase, this will be for manufactured commodities and agricultural products will decline in relative importance.

(11) Ibid GATT, 1958, Item 13, p. 4.

Maintenance of Farm Machinery in Papua and New Guinea.

A. W. JEFFORD.

Senior Mechanical Equipment Inspector, D.A.S.F. Port Moresby.

Introduction.

MANY Territory farmers, both indigenous and European have spent large sums of money on agricultural mechanization. The machinery however is seldom looked after and money is wasted on costly replacements and repairs. Had some thought been given to the correct operation and maintenance of the machinery, this expense may have been avoided.

Whilst conditions in the Territory are improving, and specialist maintenance services are available in most major centres, replacement parts are still expensive and many farmers have to rely upon their own resources to keep their machinery in working order. When we consider the lack of trained mechanics and operators, the difficulties of the language barrier and the inability of the indigenous people to understand the technical terms, we realize it is the responsibility of the owner or manager of the machinery to understand fully the operation and maintenance of the machinery and also to ensure that his employees are properly trained and carry out his instructions.

Owner's responsibilities.

Booklets are usually supplied with items of machinery. These are the maker's instruction manual and the parts list.

The instruction manual usually covers not only the general principles of operation but also the special points applicable to the machine in question. Study of the book will acquaint the owner with the correct operating and routine maintenance procedures and will also assist him to decide when or if he will require the services of a mechanic to carry out the major repairs at the proper time.

The manual will also indicate the time when certain items will require replacement. Some items such as fuel filters and lubricating oil filters must be held in stock so that replacements can be made when required. The description and part numbers of these items may be found in the parts list.

The parts list is well worth studying. Many engines and machines often have modifications or alterations not readily apparent and unless the part required is properly identified and the correct part number quoted, the wrong part may be supplied and repairs to a machine held up for some considerable time.

The parts book may also show that some parts quoted will serve for other machines in use on the property. Such interchangeability may save holding excessive stocks of parts.

The owner should therefore study both the instruction manual and parts list, summarise the most important recommendations and purchase a stock of the replacement parts that will be required.

It is also essential to keep a log book for all engines and machines, recording the engine hours and operation of the machine, the fuel and oil usage and service details. From these records deterioration of performance can be checked before it seriously affects operating costs.

TRACTOR MAINTENANCE.

Fuel.

Fuel and fuel tanks should be kept clean, and free from water. If fuel and oil are stored in drums, the drums should be tilted to one side so that the two bungs are above any water that may accumulate on the top of the drums. Whenever possible fuel tanks should be filled in the evening after work. This will prevent condensation of moisture within the tank overnight. When pouring from a full container the aperture should be turned to the top. In this way much less will be spilled than when the aperture is turned to the bottom.

Cleanliness of fuel is very important for all engines and especially for diesel engines, in which particles of grit and moisture are the chief reason for breakdowns of fuel pumps and injectors. Diesel engines are fitted with several fuel strainers or filters through which the fuel passes before reaching the fuel pump. These filters must be cleaned and replaced strictly

according to the maker's specifications. Glass sediment bowls should be cleaned when required and care should be taken to clean and replace the gauze filter screens in the bowl.

Fuel pressure gauges should be checked regularly as a drop in the pressure is an indication of clogged filters.

Lubrication is required for the diesel fuel pump camshaft and governor. This is effected by filling the oil reservoir to the level mark on the dipstick. An S.A.E. oil of the same viscosity as the engine oil should be used.

FUEL INJECTION SYSTEM.

The three general types of Injection Systems in use are :—

(1) Common Rail System ;
(2) Pump or Direct Injection System ; and
(3) Distributor System.

(1) *Common Rail.*

This system uses only one pump and distributes the fuel under pressure through a pipe or manifold to the injectors fitted to each of the cylinders. The injection is controlled by spring loaded valves which are operated by a separate mechanism or valve gear that controls the injection timing.

(2) *The Pump or Direct Injection System.*

Each cylinder is fed by an individual pump. Metering of fuel and injection timing is done by the pump and the engine controlled by varying the stroke and the volume of fuel delivered by the pump to the cylinder.

(3) *Distributor System.*

This differs from the conventional systems of one pump and injector cylinder in that it has one low pressure pump delivering fuel to a rotating disc assembly which delivers the fuel in much the same manner as a distributor on a petrol engine delivers electricity in rotation to the spark plugs. The fuel in this instance arrives at the injector under low pressure, the high pressure delivery being a function of the injector.

LUBRICATION.

Engine Oils. These have three main functions :—

(1) The reduction of friction between moving parts ;
(2) The cooling of rubbing surfaces ;
(3) Sealing the cylinders to maintain engine compression.

Engine Oils may be classified under two headings :—

1. Straight Mineral Oils.
2. Detergent Oils.

The fluidity of the oil is directly related to :—

(*a*) Easy starting ;
(*b*) Quick acceleration ; and
(*c*) Amount of oil passed through the bearings.

The lighter the oil the greater the fluidity. Straight mineral oils are highly refined, and contain no additives. Their use in engines, especially diesel engines has been superseded by the detergent type of oil.

Detergent type oils contain additives to combat impurities derived from combustion. Other additives give resistance to oilfoaming ; and the formation of oxidization material and sludge.

Oil is usually referred to by its viscosity rating or S.A.E. number. The lower the number the lower the viscosity and more highly fluid the oil.

Viscosity varies with temperature and it is important that the type of oil used should have the right viscosity for the range of operating temperatures and the type of engine for which it is used. It is therefore important to check the engine manual to ensure the correct grade and type of oil is used in the engine.

Detergent and non-detergent oils should never be mixed. Should it be necessary to change from mineral to detergent oil the engine sump should be carefully drained and flushed out with a clearing oil before filling with a detergent oil. It is necessary to drain all the oil from the engines at the times recommended by the manufacturer. The object of this is to keep the engine clean, so the engine must be drained before the foreign matter collected in the oil begins to settle or form into particles. Such materials are not normally collected by the oil filter, neither will they settle out by gravity but will oxidize and cause the piston rings to gum up and allow the compressed gases to blow past the rings into the sump.

GEAR OILS.

These are of two main types :—

(1) Straight gear oils ; and
(2) E.P. or extreme pressure oils.

Straight gear oils are specified in a few instances but the extreme pressure oils contain certain additives which maintain the lubricating qualities required for surfaces under pressure. Gear box and transmission oils do not require changing as frequently as engine oils. However, circumstances will indicate when an oil change apart from the routine change should be made. The fording of rivers, use in tropical rain storms, and muddy conditions have to be considered.

Oil Filters should be changed as recommended by the manufacturers' manual.

Greases. These may be classified as follows :—

(1) Semi fluid or chassis grease ;
(2) Ball bearing grease ; and
(3) Special purpose grease.

Greases are a mixture of soap, oils and additives to give such characteristics as power of adhesion, heat and oxidization resistance, and resistance to climatical conditions.

Chassis Grease. Designed for use on slow moving plain bearings, track rollers, spring hangers and steering rods. It may also be used on implements such as disc harrows, ploughs and other agricultural implements.

Ball bearing grease. A more solid heat resisting grease recommended for ball and roller bearings, clutch bearings, and bearings provided with the Alemite type of fittting.

Special Purpose greases. For specified mechanisms such as water pump spindles.

The recommendations for both quality and quantity are important. Over lubrication by greasing can cause as much damage as insufficient greasing. Grease left on the outside of a nipple or grease point will collect dust and create an abrasive action detrimental to the machine.

The owner of machinery should familiarize himself with the lubrication requirements of his equipment and ensure that the operators of such equipment carry out the lubricating services when required, using the proper methods and correct grades of oils and grease. Hand oil cans should be clearly marked as to their contents and oil cans containing hydraulic fluid or penetrene kept quite apart from the oil cans containing engine or transmission oils. The grades of oils and greases to be used should be entered in the engine log book.

Hand grease guns are made in various sizes from the 8 oz. push type hand gun to the lever type 16 oz. high-pressure gun. The handle and pump assemblies are all of similar construction, but different methods of loading the guns are used for the various types. High pressure bucket pumps are also available. These are designed to clamp onto the 45 lb. grease drums, and are ideal for greasing crawler type tractors and agricultural implements. Grease nipples are made in various designs. Among the more common types are the push-on nipples, the pin type, the hook-on type and the button head type of nipple as used on tractor track rollers. Such nipples are designed with a spring loaded ball which is depressed by the force of the grease entering the nipple and springs back on to a seat to prevent the grease from returning through the nipple. To ensure maximum efficiency of the nipple it is necessary to wipe all dirt from the nipple before attaching and using the grease gun.

Any dirt that may be forced into the nipple will contaminate the grease and either clog the hole in the nipple or affect the spring and ball.

Keep a stock of grease nipples handy and replace the damaged nipples at the first opportunity. Make sure the connector fits the nipple and where possible use a high pressure bucket in preference to a hand gun. Never grease to excess as besides wasting grease you may damage the inner seals by forcing them from their seats.

AIR.

Between 8,000 and 10,000 lb. of air are needed to burn one gallon of fuel, and depending upon the conditions under which the engine is operating this volume of air could contain sufficient dust to cause damage to the engine in a very short space of time.

To combat the dust menace, it is essential an air cleaner be fitted to the engine. This is a standard practice by manufacturers, but it is the responsibility of the owner to ensure the air cleaner is maintained in a serviceable condition.

Some air cleaners are fitted with a sight glass or bowl and the condition of the cleaner may readily be seen. Others rely upon the operator

of the machine taking into consideration the conditions under which the machine is working and cleaning the filter as the occasion demands. Besides cleaning the filter it is necessary to ensure all rubber connections are tight and in good condition. A choked air cleaner will lead to a loss of engine power and overheating.

COOLING SYSTEMS.

These may either be water cooling or air cooling systems. With *water cooling* the radiator must be kept full, and the radiator cap firmly in place. Should the water in the radiator be allowed to drop below the minimum the thermo syphon circulation of the water is broken and overheating will take place. Hose connections should be kept tight and not allowed to leak. Leaks may also occur at the water pump. Special water pump grease should be used for lubrication as other types of grease may cause clogging of the radiator tubes as well as failing to seal the water pump shaft or lubricate the pump bearing. The cooling system should be flushed out twice a year using a strong solution of washing soda. Run the engine for a few hours with the solution in the cooling system. Drain while the engine is hot and then let the engine cool before filling with clean rain water.

Keep the case of the radiator clean from grass and other foreign matter to allow the air free passage between the radiator tubes.

The fan belt should be kept at its correct tension. It should not be possible to depress the middle of the belt more than one inch.

Should an internal leak be suspected, fill the radiator to the brim and crank the engine over. If bubbles appear on the water, air is passing from the cylinders into the cooling system. Water, of course, will pass the other way during the intake stroke of the piston. To test for leakage into the sump, unscrew the drain plug all but the last thread. If there is any water in the sump it will come out before the oil. There will always be evidence of some water, especially if the oil has not been changed for some time, due to the condensation of vapour entering the engine breather. An internal water leak would, however, show a greater accumulation of water than would be from condensation only.

AIR COOLED ENGINES.

These have a cooling system composed of a direct coupled fan from which the air is directed around the engine. The engine and fan are enclosed by a shroud of metal duct work to guide the air around and over the hotter parts of the engine. The cylinder has fins integrally cast on to the outside to dispose of the heat generated. Such engines should be sited for maximum air flow. The shroud should be kept tight and free from obstruction. Air-cooled engines driving barn machinery should be so sited that they are afforded an unrestricted flow of cool air.

ELECTRICAL SYSTEM.

Regular attention and care of the battery will pay dividends in the form of many hours of useful service. When a battery is put in service with a truck or tractor care should be taken to ensure the battery support plate and holding down clamps are in good condition. A loose battery may jump about in its cradle with disastrous results, or if the holding clamps are too tight they may crack or warp the battery case. Avoid trouble here by carefully tightening the clamp wing nuts sufficiently to hold the battery firmly, and check the clamp at regular intervals.

Failure to keep the water level above the tops of the separator plates can seriously damage a battery, as plates exposed to the air become hardened and lose their ability to take a charge. Separators exposed to air will crack or split permitting active material to fall across and short circuit the plates. Little or nothing can be done for a battery badly damaged through lack of water.

Acid fumes or acid spilled on terminals and cell connectors will cause corrosion. The accumulation of this corrosive material sets up a high resistance to the passage of the current. The remedy is to keep the battery clean, wash off the corrosion with a soda solution and coat the terminals and connectors with petroleum jelly or mineral grease.

When fitting replacement battery always examine the old one and find out what caused it to fail. The fault may be mechanical or just pure laziness on the part of the operator. However, by finding the cause you stand a good chance of curing it.

The battery cables can give trouble for which the battery is often blamed. Frayed or corroded cables, poor connections or undersized cables will prevent quick starting and may cause damage to the coil or generator.

Spark Plugs. In a four-cycle engine running at 1250 RPM the plug sparks 600 times a minute or 36,000 times an hour and works in a temperature of 1,500 degrees Fahr. which is seven and a half times hotter than the water in the tractor radiator when it has reached its proper operating temperature of 200 degrees.

So it may readily be seen that the spark plug is designed to operate under extreme conditions. Always fit the recommended spark plug, as there are many different types and each type is designed for a specific duty. Clean and reset spark plugs after every 200 hours. Set the points to the specified gauge and make sure the copper sealing gasket is in good condition as this gasket plays a major part in conducting heat from the plug. The colour of the porcelain core and general condition of the plug will in many cases indicate the state of the engine.

TYRES AND TUBES.

Tyres and tubes may become expensive items if proper care is not exercised. All tyres should be checked at least once a week. Besides checking the inflation of the tube the valve should be inspected for tightness and to ensure that a valve cap is fitted. Under-inflation may cause as much damage as over-inflation. Under-inflation produces ragged irregular wear, increases flexing of the side walls and generates excessive heat. Over inflation causes faster wear to the centre of the tread, creates excessive pressure on both tyre and tube with the danger of a blow-out.

Some types of service in which tyres are used, subject the sidewalls of the tyre to a folding action when the correct inflation pressure is not maintained. A common condition causing this type of failure is in ploughing, where one tyre runs in the furrow and is distorted by the tilt of the tractor. The tilt of the tractor causes a side thrust of the weight against the tyre, which, combined with the heavy pull of the plough, causes the inner wall of the tyre to buckle. Continuous buckling or folding causes the cords to separate and the inner wall to split or tear.

The furrow wheel tyre pressure should be 4 lb. greater than that in the land wheel, provided that the maximum pressure is not exceeded. The plough hitch should be adjusted laterally so that the tyre does not crowd the furrow wall.

FARM IMPLEMENTS.

The chief causes of deterioration of agricultural machinery are abuse and neglect. Both may be the result of ignorance but are usually the result of laziness or irresponsibility.

Territory conditions are far more exacting than those in temperate regions for which in many cases agricultural machinery is designed. These conditions coupled with the fact that the indigenous operator has little or no mechanical knowledge may prove a high cost of turning from hand labour to mechanized agriculture.

A point that is often overlooked, is that implements if not protected from rust and climatic conditions will deteriorate almost as fast when not in use as those that are abused in use. Agricultural equipment most commonly used in the Territory is disc harrows, ploughs, rotary slashers, and trailers. With these the first duty of the farmer or owner is to ensure that the equipment is properly adjusted and attached before usage. Here once again it is advised to study thoroughly the operator's manual or manufacturer's recommendations.

With the three point linkage implements rapidly gaining favour in the Territory it is most essential that the sequence of operations for attaching, using and detaching the implement be strictly adhered to.

The Disc Harrow.

The disc harrow is more harshly treated than other implements. It is often expected to do more than it is designed for, and often, to effect better penetration, is overloaded with stones or logs. The implement requires frequent and thorough lubrication, the bearings being subjected to severe jolting pressure both vertically and laterally in addition to the pull of the tractor. The implement is constantly used in dusty or muddy conditions which make it imperative to grease the machine at least once every four hours. The discs should be kept tight to the shaft and sharpened, particularly when working in heavy trash. All bolts and nuts should be kept tight, and when storing

the implement it should be carefully cleaned, inspected for damage and finally treated with a rust preventative.

Disc Ploughs.

A disc plough must be set to suit the conditions under which it is to operate. The manufacturer supplies the implement set to suit average conditions and whilst these settings will provide a basis from which to start it will be found that the suggestions in the operator's manual can be applied to improve the work done by the plough. Ploughs should be lifted clear of the ground when turning a sharp corner or bend. Some types of trailed ploughs turn more readily to the left than the right. The discs are mounted on bearings protected from the dirt by oil seals. Their daily maintenance will include lubricating the furrow wheel, axle and disc bearings. After use the discs should be cleaned and coated with a rust preventative.

Rotary Grass Cutters or Slashers.

These may be either a trailed or semi-mounted implement designed to cut or slash grass or heavy undergrowth, and are used on plantations and holdings throughout the Territory. They range in size from the multiple head machine with a cutting width of eight feet down to single cutter hand propelled machines with a cutting width of eighteen inches. Most types employ a cutter head which consists of a horizontal rotating disc with blades mounted on the periphery of the disc. The tractor driven models may be operated over a wide range of forward speeds. Chains may be used in place of the cutting blades and are preferred by some for the eradication of grasses and bracken, as the chain will lacerate and shred the stalk whilst the cutter makes a cleaner cut but does not materially assist in the eradication of the bracken or grass.

Rotary cutters are dangerous tools when in the hands of an inexperienced operator. Before using the implement it is essential the cutter be checked for secure attachment to the tractor. The P.T.O. shaft should be properly attached and locked in place, and the shaft guard secured in position. Should the unit have a series of belts and pulleys to revolve the cutting head, these should be set at the correct tension, the idler wheels set into position and the cover guard replaced and secured. The cutters or chains should be inspected for security and the side guards checked.

Protection should be ensured for the driver and people who may be close to the machine, by fitting guards to prevent the chains or cutters throwing out stones and sticks.

After use the machine should be cleaned down and all grass and trash removed from beneath the cover. Trash will collect around the cutter spindles and lodge under the frame and unless this is removed the frame and guard plates will deteriorate and in time rust away. Trailed models will require greasing at the wheel bearings, the height adjusting screw and gearbox.

The Trailer.

Most accidents in the Territory involving tractors and trailers have been caused by incorrectly hitching the trailer to the tractor. With two-wheeled trailers the danger is greater than with the four-wheel trailers, as the weight transference is located down and behind the rear of the tractor and giving both units the tendency to "Jack-knife". The weight behind the rear tractor wheels causes the front wheels to rise off the ground; so ensure that the hitching point is safe for both tractor and trailer. Check the tyres for correct inflation and make certain that the braking system functions correctly.

As mentioned earlier the chief causes of implement deterioration are abuse and neglect. Instances of neglect in the Territory are :—

(1) Machinery is seldom cleaned after use.

(2) Greasing is haphazard and left to the whim of the operator.

(3) Tyres are seldom checked for correct pressures and quite often allowed to go flat when the equipment is not required.

(4) Machinery is left in the open and quite often is overgrown by grass or vines.

(5) Winnowers and harvesters left with the trash in the seives and body of the machine. The resultant corrosion leads to the expense of repairs and replacement parts.

(6) Tins of grease are left with the lids off and grease guns and oil containers thrown in the dust.

These examples are but a few of the costly causes of implement deterioration. The life of most agricultural implements is indefinite but with proper care most machinery of this nature should have a useful life up to ten years, but the increasing changes in design and consequent

lack of replacement parts plays an important part in the economic life of agricultural machinery.

TOOLS.

Most tractors and implements are supplied with the tools required to carry out small adjustments to the machines. These in many instances are crudely made and poorly designed. It will be necessary, therefore, before minor overhauls are to be made to any major items of plant, to invest in some items of workshop equipment and hand tools. Before any such purchases are made examine the machinery and list the probable work to be done.

Satisfy yourself whether open ended, ring or socket spanners will be required. Tool kits may be purchased containing ring spanners, socket sets with articulated handles and braces, screw drivers, pliers and hammers. Other requirements may be listed as follows :—

(1) Pliers. Wire cutting. Long nose. Slip Jaw.
(2) Screw Drivers. Stub handle. Insulated sets.
(3) Punches and cold chisels.
(4) Hammers. Ball pein. Sledge. Mallet.

For the Workshop.

Jacks, Hydraulic.
Block and tackle. Chain hoist.
Vice, 4-inch jaw. Offset.
Tap and Die sets, British and American.

Miscellaneous.

Hacksaws, feeler gauges, files, wire brushes, carborundum stones, bench grinder, oil cans, tin snips, tyre repair outfit.

The Coffee Industry of Papua and New Guinea.

A summary of a report, issued by the Bureau of Agricultural Economics, Canberra, A.C.T., Australia entitled "*The Coffee Industry in Papua-New Guinea. An Economic Survey*", published February, 1961.

ALTHOUGH coffee was first introduced into New Guinea late in the last century by the German Administration, no serious commercial production occurred until 1950. High world prices in the immediate post-war years were the main stimulant for the industry which has concentrated on the production of arabica coffees. At the time of the survey[1] the industry was still mainly in the pioneering stage of development, but nevertheless playing an increasingly important role in the economic development of the Territory. Pre-war exports of coffee from the Territory constituted about eight per cent. of total Australian imports[2].

Native growers, operating very small groves, accounted for approximately 60 per cent. of the total acreage of 17,640 acres in 1960. However, their production amounted to only about 25 per cent. of the total output of coffee. It was estimated that by 1970 more than half of the Territory's production of about 12,000 tons would come from native producers.

Although accurate production figures were difficult to obtain because of the large number of native growers, export figures provided a good indication of trends within the industry—Table I.

Table I.

Coffee Exports.

Territory of Papua and New Guinea.

Year ended 30th June.	Volume. Tons.	Value. £A'000.
1952	34	11
1953	47	31
1954	87	60
1955	107	75
1956	171	94
1957	274	183
1958	385	225
1959	969	456
1960	1,487	717

The two main economic species of coffee, *Coffea arabica* (highland coffee) and *Coffea canephora* (Robusta or lowland coffee) were grown in the Territory. Arabica coffee was by far the more important. Two varieties of this species were grown, typica and bourbon, but the former made up about 75 per cent. of the total tree numbers.

The recent development of the industry was illustrated by the fact that at the end of March, 1960, 52 per cent. of the total number of coffee trees on European plantations were under five years of age.

Production Areas.

Approximately 93 per cent. of the total area under coffee at the end of March 1960 was in the Western and Eastern Highlands and the Morobe Districts of New Guinea.

Basic Characteristics of the Coffee Plantations.

Size of Holdings.

In 1960, plantations within the main production area, averaged 253 acres but of this only about 56 acres was under coffee. Very few plantations had 100 acres or more under coffee.

Management.

The most common form of management found in the survey was the owner operator. The second most common was the company controlled by a manager or director. The general pioneering stage of the industry was shown by the fact that only just over seven per cent. of those engaged in management had previous experience in coffee growing.

Cultural Practices.

The coffee industry developed too quickly for research findings to keep pace, and plantation managers were forced to experiment with cultural

(1) The field work for the survey was carried out between March and May, 1960. A total of 100 plantations out of the 166 growing coffee at the end of March, 1959, was included but those with less than 20 acres of coffee were omitted from the survey.

(2) These exports were mainly robusta coffee coming from several large plantations in the Bismarck Archipelago and the native robusta project in the Northern District of Papua; established in 1931. Buoyant conditions in the cocoa market during the post-war period resulted in the more important robusta plantings in the Bismarcks either being abandoned or replaced with cacao. The 1951 eruption of Mount Lamington wiped out the native coffee project in Papua which had been practically rehabilitated. Thus robusta production was virtually eliminated by 1951 and subsequent development showed concentration on arabica coffee in the Highlands of the Territory. Interest in robusta was renewed in the late 1950's.

practices. This resulted in a wide range of methods being used. However, as the rate of expansion slowed down, cultural methods became more uniform.

Clearing.

Most of the coffee plantations in the Highlands were situated on land with a dense natural cover of grass, and clearing had been carried out by teams of natives using bush knives. In some instances, the grass was first fired. After initial clearing, the area was cultivated mostly with a tractor and plough but hand labour was sometimes employed.

Planting.

The coffee seed had usually been obtained from research stations. The most common practice was to strike the seed in nurseries and to transplant at one year of age on a nine-foot triangle spacing.

Shading and Windbreaks.

Practically all holdings provided permanent shade for the coffee and a wide range of trees was used. For temporary shade *Crotalaria* spp. was most common, while *Leucaena glauca* and *Albizzia stipulata* were most used for permanent shade. In the Eastern and Western Highlands, temporary shade was normally planted with the young coffee, which was followed within one year by permanent shade.

Pruning.

Although many planters experimented with pruning techniques, the multiple stem system was the most common.

Mulching.

Only about 65 per cent. of the planters in the survey mulched their blocks.

Weeding.

Hand weeding was most commonly employed but some chemical and mechanical control methods were used.

Fertilizing.

Approximately 75 per cent. of the plantations used fertilizer and of these about 40 per cent. applied it only to mature trees. The rate of application varied from 0.25 to 1.5 lb. per tree.

Pests and Diseases.

At the time of the survey the coffee industry in the Territory was free from serious economic pests and diseases.

Pulping and Processing.

The "wet" method of processing was universally used, comprising the pulping and washing of the cherry to produce dry parchment, and from the dry parchment to the finished green bean.

Some plantations carried out the complete process of hulling and polishing but on those lacking the necessary facilities, final processing was done by central mills or other plantations with the necessary equipment.

Financial Data.

In the developing coffee industry, the examination of financial data posed serious problems. It was difficult to find holdings at the same level of development, and financial and production data maintained by managers were usually inadequate for detailed analysis. Nevertheless, 30 holdings possessed sufficient information to allow some examination of capital investment in coffee holdings within the Territory, although these data covered only one year.

Total Investment—30 Plantations.

The total investment in holdings varied greatly, ranging from £10,000 to £71,000. However, more meaningful indicators of investment showed that capitalization per acre of planted coffee averaged £444, with a range from £277 to £853. Investment per productive acre averaged £570, varying from £378 to £862.

Coffee plantings comprised the largest single investment on these plantations. Coffee land and plantings accounted for an average of 70 per cent. of the total investment on the holdings, the remainder consisted of plant and machinery, 12 per cent.; structures, ten per cent., and eight per cent. in land not planted to coffee.

Table II.

Average Income, Costs and Returns per Acre—30 Holdings—Mature Coffee.

Coffee Area Ac.	Prodn. lb.	Income			Gross Operating Costs	Pltn. Surplus £	Return to Operator £	Total Capital Value £	Return to Capital £	Per cent.
		Coffee £	Other £	Total £						
32	1,150	212.0	1.8	213.8	115.4	98.4	68.5	570	64.7	11.5

Income, Costs and Returns per Acre.

The average area under mature coffee on these holdings at the time of the survey was 32 acres but this was only about 46 per cent. of the total area planted—Table II.

Yield averaged 1,150 lb. per acre—Table II—but individual production for the year varied from 360 to 2,540 lb. Estimates of a normal long term average yield of coffee on reasonable soil and without a fertiliser were reported to be in the vicinity of a half ton per acre(3). Approximately 60 per cent. of the holdings had yields for the one year in excess of this figure.

The average income per acre for the year—Table II—was £213.8 but there was considerable dispersion and individual figures ranged from £62.7 to £485.5 per acre.

Gross Operating Costs.

These costs averaged £115.4 per acre, ranging from £17.1 to £259.7 (Table II). The largest single cost within this figure was native labour which constituted approximately 40 per cent.—Table III.

Table III.

Average Gross Operating Costs Per Acre—30 Holdings.

Item.	£	Per cent.
Native labour (*a*)	45.8	39.6
Other labour	8.1	7.0
Vehicle and Machinery	11.4	10.0
Maintenance of structures	4.9	4.2
Hand tools	0.7	0.6
Fertiliser	13.8	12.0
Bags, twine, stencils	1.7	1.5
Insurance	0.6	0.5
Office expenses	2.1	1.8
Land rental	0.3	0.3
Freight	1.4	1.2
Undefined	10.7	9.3
Depreciation—Structures	4.4	3.8
Plant and machinery	9.5	8.2
TOTAL	115.4	100.0

(*a*) The cost of native labour was charged at the appropriate rate under the Native Employment Ordinance and Regulations. These labour costs varied considerably between the 30 plantations.

Depreciation of Plantings.

The lack of data on the life of coffee trees prevented any suitable figure for depreciation being calculated. However, most managers were well aware of this cost, and generally, provisions were made for the replacement of coffee and shade trees. Furthermore, the distinct possibility of more productive varieties of coffee trees becoming available from research stations was an important factor influencing the amortization of coffee plantings.

Returns.

The profitability of the plantations was considered in relation to management and capital—see Table II.

(*a*) *Plantation Surplus.*

The plantation surplus was calculated as the difference between income and operating expenses and represents the return to the operator's labour, management and capital. It averaged £98.4 per acre—Table II. For the individual holdings, the corresponding figure varied from minus £8.7 to plus £239.9 per acre.

(*b*) *Return to Operator.*

Return to the operator was estimated by subtracting the interest charge on capital investment from the plantation surplus. The average return to operator for these 30 holdings was £68.5—Table II—ranging from minus £37.9 to plus £201.4 per acre.

(*c*) *Return to Capital.*

This figure was arrived at by deducting an assumed allowance of £2,000 per annum—the allowance the manager—from the plantation surplus. The average was £64.7 per acre—Table II.

The average percentage return to capital was 11.5.—Table II. The latter figure over the 30 holdings ranged from minus 15.4 to plus 27.2 per cent.

Costs of Establishment—18 Holdings.

The stage of development of the coffee industry in the Territory raised many problems in determining the actual cost of establishing a coffee holding. The long period between the original investment and the first returns, and the wide range in the development stages of the various holdings made the assessment of establishment costs extremely difficult.

Of the total of 100 plantations in the survey only 18 possessed sufficient data to permit some analysis of these costs. These varied from £11,000 to over £43,000, while the costs per acre of planted coffee ranged from £145 to £495 per acre.

(3) Since the survey, further experience, and assessment of production statistics for the 1960 and 1961 crops indicate that this estimate may be a little high. The indications are of a biennial yield pattern developing with an average yield of 8 cwt.

The principal item was the operator's allowance of £2,000[4] which made up about 27 per cent. of the total. The other items were native labour, 17 per cent.; purchase of plant and machinery, 13 per cent. However, where a processing factory was established, machinery costs became more important. Formation costs averaged ten per cent. and varied more than any other cost as land purchases were included. The remaining items were interest, nine per cent., structures six per cent., and undefined costs five per cent.

The small proportion allotted to structure underestimated the full importance of this cost as holdings reach full development. In a number of cases, temporary structures were being utilized but these were eventually to be replaced by permanent buildings.

Capital for establishment came, in most instances, from within the Territory of Papua and New Guinea but larger companies raised considerable sums of money in Australia. One of the most interesting features of the industry was the number of holdings which were originally financed out of personal savings, often supplemented by income from trade stores and outside work. Unfortunately, the amount of funds for full development was sometimes underestimated, and once personal savings were exhausted, development was suspended until further capital became available.

Marketing Expenses.

Almost all the coffee produced in the Territory was sold in Australia but some small quantities have been exported elsewhere. There was no control over markets on which growers could sell and they were completely free to dispose of their crops where and how they pleased. Voluntary agreement between growers and agents in Australia set ruling prices for the season's crop[5].

The survey showed that native growers preferred to sell their crop for cash rather than to pay to have it hulled and then await payment until the crop was sold. Price paid depended upon quality, transport costs and competition among purchasers. In areas where private buyers were not operating, the Administration bought parchment coffee.

Transport to the main ports, Madang and Lae, was usually by air although coffee grown in Wau was transported to Lae by road.

In 1960, it was estimated that marketing costs, from the plantation to Sydney were close to 6d. per lb.[6].

Budget—Establishment of a Coffee Holding.

As data on the cost of establishing a coffee holding were inadequate the only alternative method of gauging total capital requirements was to construct a comprehensive budget covering the period from initial clearing to full production.

The budget—Table V—covered nine financial years for a holding of 100 acres managed by an owner-operator having experience in coffee growing under Territory conditions.

The basic assumptions of the budget were :—

1. The holding was situated in the Eastern or Western Highlands and produced arabica coffee for the Australian market.
2. The holding was leasehold.
3. Two blocks of 40 and 60 acres were to be planted out in the first three years ; the 40 acre block in year two, the remaining 60 acre block in year three.
4. A processing factory was to be completed for the first crop in year five.
5. Work commenced in July, and access roads, preliminary accommodation, store facilities and a coffee nursery were completed by November.
6. *Interest.* Interest was charged at 5¼ per cent.
7. *Vehicle.* A small four-wheel drive vehicle was allocated to the holding, effective life being estimated at five years, when its trade-in value would be £400.
8. *Hand Tools.* These were replaced to maintain their value at £300 per year.
9. *Yield.* A half ton to the acre was accepted as a reasonable long term yield—first full production year, year eight—Table IV.

(4) This allowance of £2,000 was assumed to cover all personal expenses of the manager such as pay, leave fares, medical benefits, etc.

(5) Coffee from the Territory enters Australia free of duty. On 8th August, 1961, the Minister for Territories, the Hon. Paul Hasluck, announced that the existing duty of 3d. per lb. on overseas raw and kiln-dried coffee would be remitted under By-law where 28 per cent. of coffee requirements are purchased from coffee produced in the Territory of Papua and New Guinea. This remission would operate for the year ending 30th April, 1962.

(6) Since the survey, marketing costs have risen.

10. *Prices.* The price of 3/6 per lb. net for processed and bagged coffee on the plantation was used in the budget. This was equivalent to 4/- lb. delivered to the buyer in Sydney. In the budget, this price was accepted as "a suitable long term projection in which to base returns in the budget." (p.83)

Establishment Costs.

Table IV.
Production and Income.

	Year 5	Year 6	Year 7	Year 8
Production lb.	11,200	42,933	84,000	112,000
Income £	1,960	7,513	14,700	19,600

Full production was reached in year eight with an average yield of a half ton to the acre.

Estimating Establishment Cost.

The budget of establishment cost—Table V—revealed that it was not until year seven that income became in excess of cash costs. In previous years, cash costs exceeded income and a debit was added to the cumulative balance carried forward. In year seven, income was greater than the interest on the cumulative balance which was then reduced. The cumulative cost of the holding was the cumulative debit balance brought down at the commencement of year seven, which was the same as the cumulative balance carried down at the end of year six. This balance of about £56,000 was the estimated liability that an owner-operator possibly incurred before a plantation of 100 acres, developed according to the envisaged plan, was in full production—Table V.

The major component of the establishment costs was native labour—Table VI. The net establishment cost of £55,722—Table VI—was equal to £557 per acre of planted coffee for 100 acres.

Table VI.
Major Component of Establishment Costs.

	£	%
Native Labour	21,320	32.7
Owner-operators allowance	12,000	18.4
Plant and equipment	9,260	14.2
Standard improvement	7,730	11.9
Interest—Annual £1,230 Compound £7,625	8,855	13.6
Other Expenses	6,030	9.2
	65,195	100.0
Less Income	9,473	14.5
	55,722	85.5

The next step in the budget was to examine the current costs of production, including interest and depreciation. The previous budget, the cost of establishment, showed only the total costs of assets.

Year eight was the first year of full production. In this year, the plantation surplus as a return to the operator and his capital was £9,290. After assuming an amount of £2,000 for the operator's allowance, the return to capital would be £7,290 or 13.1 per cent—see Table VII

Table VII.
Budget Year 8—Production (a).

	£	£
Income (1,120 lb. per acre—100 acres 112,000 lb. at 3/6 lb.)		19,600
Gross Costs		
Labour	7,330	
Plant operating expenses	990	
Repairs	105	
Bags, twine, stencils	250	
Hand tools	50	
Miscellaneous	50	
General Costs		
Land rent	30	
Office expenses	40	
Depreciation		
Structural .... Plant and equipment	1,461	
Total Gross Costs		10,310 (*b*)
Plantation Surplus		9,290
Interest—5¼% on £55,720		2,930
Return to Operator		6,360
Operator's Annual Allowance		2,000
Return to Management		4,360
Interest—5¼% on £55,720 (*c*)		2,930
Return to Capital		7,290
Per cent. Return to Capital		13.1

(*a*) This budget does not include depreciation of trees.

(*b*) Rounded.

(*c*) See Tables V and VI. This is the net establishment cost or the estimated liability to bring a plantation of 100 acres, developed as suggested to full production.

Table V.

Budget of Establishment Costs.

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Total to end of Year 6
Land (leasehold) Purchase ...	NIL									
Land Improvements	300									300
Structural improvements	1,650	920	210	3,630	1,260	60	80	100	100	7,730
Plant and equipment	3,630	150	60	90	3,950	1,380	50	50	50	9,260
Labour	1,570	3,770	4,010	3,110	3,410	3,410	6,630	7,330	7,610	21,320
Plant operating expenses	670	790	770	830	840	900	960	990	990	4,800
Packing expenses	....	....	....	....	25	95	190	250	250	120
Miscellaneous	100	80	80	80	50	50	50	50	50	440
Overheads—Land rent	30	30	30	30	30	30	50	30	30	180
—Office expenses	30	30	30	30	30	40	40	40	40	190
—Operator	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	12,000
Annual money outflow	9,980	7,770	7,190	9,800	11,595	10,005	10,030	10,840	11,120	56,340
Less annual income	....	....	....	....	1,960	7,513	14,700	19,600	19,600	9,473
Debit Balance	9,980	7,770	7,190	9,800	9,635	2,492	+4,670(a)	+8,760(a)	+8,480(a)	46,867
Interest (5¼%)	262	204	189	257	253	65				1,230
Total annual debit	10,242	7,974	7,379	10,057	9,888	2,557	+4,670(a)	+8,760(a)	+8,480(a)	48,097
Cumulative debit b/d		10,242	18,754	27,118	38,599	50,513	55,722			
Interest on cumulative debit b/d		538	985	1,424	2,026	2,652	2,925			7,625
Total cumulative debit b/d		18,754	27,118	38,599	50,513	55,722	53,977(b)			55,722

(a) Credit Balance.

(b) Total included cumulative debit balances brought down plus interest on that balance less credit balance in year 7.

Book Reviews.

The Measurement of Grassland Productivity.

(Proceedings of the University of Nottingham's Sixth Easter School in Agricultural Science, 1959).

Ed. J. D. IVINS.

Butterworths, London, 1959. 217 pp. 35s. Stg.

This publication is the fifth of a series of useful editions which bring together information on the latest research in particular fields of agricultural science. The Sixth Easter School was concerned with grassland productivity and the techniques available for its measurement.

The book is divided into five parts. 1. General Aspects ; II. Herbage Growth ; III. The Consumption of Herbage by Livestock ; IV. Animal Production from Grassland ; and V. Farm Scale Measurements. Nineteen authors contributed to the twenty chapters of the book, each comprising a paper read at the School. At the end of each part is a summary of discussions which arose from the papers read, and many important points are found therein.

The opening speaker, Dr. W. Davies, outlined the historical evolution of grassland research techniques. It is noteworthy that the use of the animal for measuring grassland productivity is essentially a recent development. Most evaluation has been by various cutting techniques, supported by chemical analyses to estimate the nutritive value of the various components of the sward. Information on persistence under grazing, palatability and selection by the grazing animal is not brought to light by these methods, but subsequent chapters explain why grassland workers have had to use this approach, even though the results are often not completely satisfactory. Such "artificial" measurements of productivity will continue to form the basis of much pasture research for many years.

Although all the information presented is based on results from temperate environments, some of the techniques can be related to subtropical and tropical conditions ; for example, the relation of ley pastures to crop productivity. Knowledge of the latest techniques used in the agronomic assessment of temperate pasture species will assist in the proper evaluation of tropical species.

It is in the nutritive values of herbage that important differences between tropical and temperate pastures are known to exist. Techniques recently developed for measuring the quantity and quality of feed consumed by free-grazing animals in temperate environments have limited value in the tropics. Workers in Queensland and East Africa have confirmed this for the faecal nitrogen and faecal crude fibre techniques. Feeding standards based on starch equivalents and total digestible nutrients are highly inaccurate when applied to tropical and subtropical species, and the serious limitations of these relationships even in temperate environments is noted in Chapter 16.

Although confined to research on temperate pastures, this well edited and very readable book should also be on the bookshelves of those engaged in tropical pasture research.

C. S. Edwards.

The Wild Species of Gossypium and their Evolutionary History.

J. H. SAUNDERS.

Oxford University Press, London, 1961. VIII + 62 pp. (illus.) Price in Australia 28s.

"The Evolution of Gossypium and the Differentiation of the Cultivated Cottons" by Hutchison, Silow and Stephens, has, since its publication in 1947, been the definitive work on the classification, differentiation and genetical relationships of the species of *Gossypium*, both wild and cultivated. In "The Application of Genetics to Cotton Improvement", published in 1959, the senior author elaborated further on the origin and development of the cultivated cottons and discussed prospects for future improvement. The monograph here reviewed supplements these two volumes by revising and expanding the section on the wild species in "The Evolution of Gossypium".

According to the dust cover, Saunders' book comprises a "set of botanical drawings of the wild species of *Gossypium* . . . . accompanied by notes on the sections into which the genus is divided cytogenetically, and on its world distribution and evolutionary history." As with the other two volumes mentioned above, the work was carried out under the auspices of the Empire Cotton Growing Corporation.

Part I contains the botanical drawings and notes on the genomes. Saunders' division of the genus *Gossypium* is made on a strictly cytogenetical basis, the lintless wild species being grouped into four genomes, B, C, D and E. Hutchinson *et al.* used a morphological and geographical basis for delineating the Sections, while recognizing that the genomes, for which the nomenclature had already been proposed by Beasley, could be regarded as representing the Sections if it were a fair assumption that morphological similarity in *Gossypium* indicated cytogenetic affinity. At that time, many of the wild species had not been grown in culture and the validity of this assumption had not been thoroughly tested, but Saunders has now confirmed cytologically the essential soundness of the morphological classification.

The two species *anomalum* and *triphyllum* of Hutchinson's Section Anomala comprise the Saunders B genome, whilst *areysianum* has been removed to the E genome ; *G. areysianum,* known to Hutchinson *et al.* only from Defler's original collection, is the only species which Saunders has reclassified into another Section. Hutchinson's *G. sturtii* and *G. robinsonii,* grouped together in the Section Sturtiana, now make the C genome together with *G. australe* von Mueller, which was erroneously transferred by Lewton in 1915 to the genus *Notoxylinon,* where it remained until Saunders re-examined it in 1961. The three American Sections Erioxyla, Klotzschiana and Thurberana (species *aridum, armourianum, harknesii ; klotzschianum* and its variety *davidsonii, raimondii ; thurberi, trilobum, gossypioides*) with the addition of the new species *G. lobatum* Gentry and the deletion of Hutchinson's *G. trilobum* of the Section Thurberana, make up the D genome. The Section Stocksiana, comprising *stocksii* and *somalense,* becomes the E genome by the addition of *areysianum.* transferred from the B genome, and, tentatively, the newly-described species *incanum* and *longicalyx.*

The notes on each genome cover the cytogenetical evidence for the genome classification, and briefly touch on the morphology, habitat, distribution, variability and possession of characteristics of commercial value of some of the species.

The botanical drawings (by the author) are particularly clear and the descriptions concise but complete.

Part II contains a brief account of the world distribution and evolutionary history of the genus *Gossypium.* It is suggested that the ancestral stock from which the genus arose was itself polyploid, that the ancestral allopolyploid with 13 chromosomes underwent evolutionary change leading to the differentiation of the five genomes in Central Africa, and that the present inter-continental distribution of the genomes may be accounted for by Wegener's theory of continental drift. No mention is made of opposing theories such as migration through an Antarctic sub-continent or via alternative land bridges. Saunders considers it probable that man was responsible for an A genome diploid cotton reaching the New World, where it hybridized with a wild D to produce the allotetraploid ancestor of the modern New World cottons, although he does not entirely discount the possibility of an ancient natural overlap in habitat between A and D genome species.

The book concludes with a botanical drawing and description of *G. herbaceum* race *africanum,* a primitive diploid with linted seeds, belonging to the A genome and considered to be the closest modern relative to the original forebear of the diploid cottons.

As would be expected from the Oxford University Press, the production of this slim volume is of high standard. It is printed on heavy art paper and the clear line illustrations are excellently reproduced. One wonders, however, whether anything is gained by stating the scale of each part of an illustration in the drawing itself and again in the legend. The author, in the brief narrative sections, has not a particularly felicitous style and is occasionally clumsy in expression or even ambiguous—e.g., the first sentence on page 18 where it is stated that " The D genome . . . . comprises eight species and the variety of another "—*davidsonii* is, of course, the variety of one of the eight species in question. The not-infrequent adverbial usage of the phrase " due to " might also be queried.

Printers' errors are few ; there is occasional inconsistency in the use of italics for plant parts in the botanical descriptions, as on page 33 where " stems " in line 2 should read " *stems* " and " Seeds " in line 16 should read " *Seeds* ". In the References on page 60, line 24, " *Bot.*" should read " *bot.*"

None of these criticisms is of any substance and the book will be welcomed by all geneticists and plant breeders working with cotton, and indeed by tropical agriculturalists and botanists generally.

A. W. Charles.

The Economic Development of Uganda.

International Bank for Reconstruction and Development. The Johns Hopkins Press, Maryland. 1962 xviii + 475 pp. (paper) $4.00 U.S.

It is difficult to resist the temptation to draw an analogy between the recommendations made by this International Bank for Reconstruction and Development's mission to Uganda, and those which a similar mission might submit for this Territory. However, the following review is presented with a bias for Territory readers and as such may raise a number of questions which should be carefully considered by all engaged in policy decisions affecting this Territory.

The IBRD mission to Uganda was charged with the task of drawing up a development programme, based on "practical recommendations" for the five year period, 1961/62-1965/66. However, the recommendations of the mission rest firmly on basic economic principles. The main limiting factor to economic development, which is of course capital, has been located, and the mission has proceeded to show how available resources of this factor can be used to obtain the greatest return to the economy as a whole.

Agriculture has been accepted as the mechanism by which further economic development of Uganda can be initiated. The report is liberally spread with statements showing this; "the developmental potential lies largely in agriculture"; "in spite of everything possible in manufacturing and mining, the main opportunity for economic growth in Uganda in the next five years is in agriculture"; "in our view that, in present circumstances, investment in agriculture will bring greater returns, in terms of expanded output and incomes, than comparable investment in almost any other sector of the economy".

The economy of Uganda has reached the stage of development where the mission considered that governmental control of agricultural development should decrease. Normal market forces should now operate more fully in allocating resources. The two main exports, coffee and cotton, are examined in this context and present marketing difficulties for coffee are seen as extending beyond the last year of the plan 1965-66. For this reason greater emphasis on cotton is advocated.

Low productivity of labour is also suggested as an important factor preventing increased agricultural production in Uganda. Detailed studies are needed to verify this fact and the mission states that these should be undertaken immediately. Increased productivity of labour rests upon widespread changes in the methods of production in agriculture. Therefore, extension services must be more fully developed and more appropriate methods must be adopted.

Capital infusion is also essential, and this can be carried out by better credit facilities and wider use of subsidies to farmers. Land tenure must also change but the mission takes a very realistic approach to this problem. Short run changes in the present system should be "modest and largely based on modifying rather than altering the fundamental structure of the land system". However, in the long run land must become a negotiable factor of production with its value determined by productive capacity.

The remaining sectors of the economy are discussed but the place of secondary industry in an underdeveloped economy is seen in its correct perspective. Successful development depends upon a prosperous agriculture and "as purchasing power grows so will the demand for manufactured goods, to the point where local production of additional commodities may become viable".

Previous so-called "development plans" do not escape scrutiny. It is suggested that agriculture in the past has been largely overlooked while social development has tended to be favoured. The advantages of the latter type of development are acknowledged but future investment should be more carefully examined. The "development plans" of previous years are described as lists of expenditure determined in most cases by the personal interests of Governors, the bargaining strength of the various government departments and what happened in other years. The mission states that "it is probably fair to say that in none of the development plans has there been the weight of effort on agricultural development that, in the opinion of the mission, it deserves in Uganda"; "the Government of

Uganda has not been equipped to undertake effective forward planning for the economy as a whole".

At the end of reading this excellent report, one is moved to wonder just how many of this mission's recommendations have been made previously by public servants and private individuals in Uganda but are now gathering dust in files. Perhaps some can now say "I told you so" but the reward is small and uninviting.

G. R. Spinks.

Economic Bulletin for Africa.

Vol. 1. No. 1.

United Nations Economic Commission for Africa. Addis Ababa, Ethiopia—January, 1961. pp. 104, 5s. Stg.

This Bulletin maintains the high standard of previous publications by the various Economic Commissions covering the world. It is the first of the series on Africa and although issued some time ago it should be brought to the notice of all interested in world economic events. Its issue is particularly timely in that the rapidly changing political, social and economic conditions in the continent have focussed world attention on Africa.

The publication is divided into two sections covering the current economic trends throughout Africa and three special articles surveying financial conditions, development programmes and policies in selected countries, and economic developments in the Republic of the Congo (Leopoldville), 1957-59.

The first section of current economic trends within the continent follows similar lines to those in other Economic Commissions' publications by giving a brief but comprehensive survey of world economic conditions. These are related to the events within Africa. Trends in African trade are surveyed showing the importance of the Franc Zone and the European Economic Community and the Sterling Area. Although the volume of African exports rose between 1958 and 1959, no increase in income occurred as world prices for major exports fell. The high propensity for African countries to import is expected to continue as economic development progresses.

The principal exports are dealt with individually. The success of the African countries in penetrating world markets with low quality tea and coffee has been a major achievement over the past decade. But world marketing problems are envisaged for all the agricultural exports.

Of the minerals, gold and copper are the most important. Despite the fact that the world price in U.S. dollars of gold has not changed since 1934, investment in mining has continued. Considerable confidence is also shown for copper, as investments are being maintained even though world price fluctuations have been most pronounced. The marketing of diamonds is controlled by a world wide cartel so price is stabilized.

The three special articles are the most interesting. The first covers financial conditions throughout the continent. Most space is given to examining the effects on countries within the Franc Zone and the Sterling Area when granted independence. The greater trading freedom within the Sterling Area means that financial institutions do not need as much modification as those within the more centralized Franc Zone.

The second article deals with development programmes and policies within selected African countries. The two main techniques in economic planning, the programming and project approaches, are briefly described. In none of the countries are these techniques employed as the so-called development plans are usually capital expenditure programmes. As such they do not cover projections, objectives or targets for the private sector of the economies. However, the wider approach to economic planning is now being considered as the economy of several countries is reaching the stage where this is possible and also essential.

The last article covering economic developments in the Republic of the Congo (Leopoldville) 1957-59 provides excellent background to conditions prior to independence. It is shown that the transfer to independence did not occur in a period of economic expansion and prosperity.

G. R. Spinks.

Port Moresby: V. P. Bloink, Government Printer.—8983/3.63.

STOP TERMITES

and timber borer too with

dieldrin concentrate (15%)

Termites have a taste for timber and their ability to live on it is unique among insects. If you let them set tooth on your buildings you'll soon be faced with expensive repairs. "Dieldrin" is being used throughout the world today to stop both termites and timber borers by big pest control operators and it has proved its long lasting effectiveness on both new and old dwellings. Just add water to dieldrin and apply to the soil around foundations. An impregnable barrier will remain for years. For timber borer "dieldrin" is applied with kerosine, by brush or spraying. Ring Shell Chemical or write for an illustrated folder on termite control with dieldrin.

SC5836/24R

SHELL
AGRICULTURAL CHEMICALS

SHELL CHEMICAL

(AUSTRALIA) PTY. LTD. (Inc. in Victoria)
Melbourne • Sydney • Brisbane • Adelaide • Perth • Hobart
An Affiliate of the Shell Co. of Aust. and registered user of its trade marks.

GOLLIN

YOUR KEY TO UNLIMITED MARKETS !

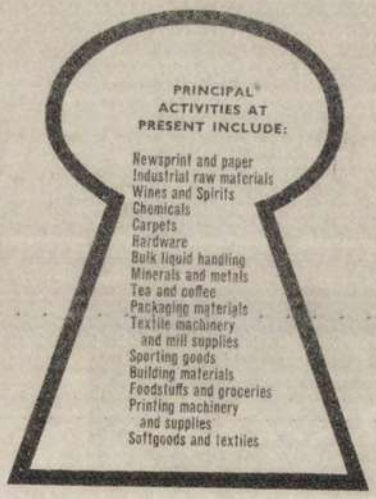
For more than a century Gollin & Co. Ltd. has been one of the leaders in Australian and New Zealand commercial growth and is your key to the successful expansion of your business. Operating through a network of branches in the main cities the principal activities of Gollin & Co. Ltd., include :—

IMPORTING :

A wide and varied range of products and capital equipment are imported annually to supply the ever increasing demand.

EXPORTING :

A comprehensive range of products of primary and secondary industry is shipped to the four corners of the world.



DISTRIBUTION AND AGENCY REPRESENTATION :

Complete distribution and agency services are available at all times to meet the needs of oversea and local manufacturers of existing or new products that require new markets. A market research service is also available to advise manufacturers.

MANAGING AGENTS :

For companies who wish to establish new industries or expand their existing organization in Australia and New Zealand, Gollin & Co. Ltd., has the facilities to act, if required, as managing agents as well as attending to distribution. Co-operation could also be considered at the financial level.

MARKET TRENDS :

Trends in local and world markets are constantly being received from a network of branches in Australia and New Zealand, the U.K., and Associates in most capitals of the world.

For further details consult :—

GOLLIN & CO. LTD.

Musgrave House, Musgrave Street, Port Moresby.

(Head Office—561 Bourke Street, Melbourne.)

or any other branch offices—

Brisbane, Adelaide, Perth, Townsville, Sydney.

N.Z.—Auckland, Dunedin, Wellington, Christchurch.

U.K.—London, Bristol, Liverpool.

Cable Address—GOLLIN for all branches, except London—HUMIDITY.

Shell Chemical

to control
Insect Pest, Disease
and Weed problems
on plantations and
farms

SHELL DIELDRIN 15% CONCENTRATE
SHELL ALDRIN 40% CONCENTRATE
SHELL ENDRIN 20% CONCENTRATE
SHELL DDT 25% EMULSION
SHELL DIAZINON 16% CONCENTRATE
SHELL DIELDRIN 1½% DUST

SHELL ALDRIN 2½% DUST
SHELL WHITESPRAY
SHELL GRAFTING MASTICS
(Pruning Compound)
SHELL COPPER OXYCHLORIDE
SHELL MICRONISED SULPHUR
SHELL WEEDKILLERS

Concentrates and Emulsions : Packed in 4 gallon, 1 gallon and pint containers.
Dusts : Packed in 56 lb., 28 lb., and 5 lb. lined bags.
Grafting Mastics : Packed in 5 lb. and 1 lb. tins.
Fungicides : Packed in 56 lb. and 8 lb. bags.
Weedkillers : Packed in 44 gallon, 4 gallon and 1 gallon containers.

SHELL
Agricultural Chemicals

Shell Chemical

(AUSTRALIA) PTY. LTD. (Inc. in Victoria)

Melbourne • Sydney • Brisbane • Adelaide • Perth • Hobart

An Affiliate of The Shell Co of Aust. and registered user of its Trade Marks.

SC604/24

MP61/11R

What's the good of water...

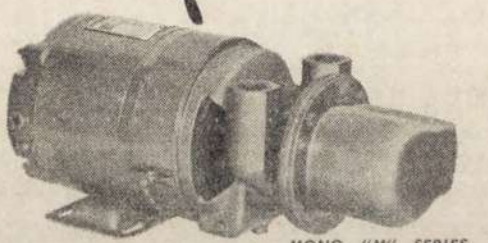
unless you've got it where you want it?

WATER — your most priceless commodity — isn't worth a ha'penny unless you've got it at the right place at the right time.

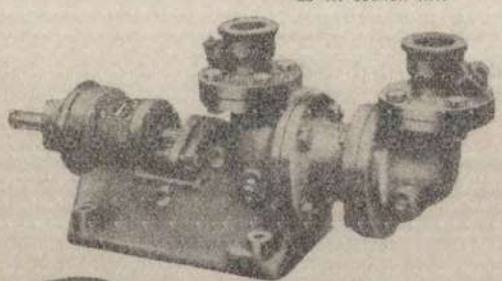
That's where Mono scores with the most efficient, most dependable range of Pumps and Automatic Water Pressure Systems money can buy.

Why is Mono so vastly different? . . . Mono employs the world's simplest, most effective, most efficient positive displacement system. With only one moving part—without valves, gears or the need for lubrication — Mono creates a powerful **continuous** sucking action that stops only when you switch it off.

Without interruption — without interference from air, slush or solids in solution — your self-priming Mono continues to draw liquids while there's liquid there to get. Sand, silt and abrasives create no hazard, for Mono is built to withstand rough usage. Ask any owner. He'll tell you Mono is undoubtedly your best pump investment. Then see your Mono dealer: he will give you all the interesting facts and figures.



MONO "M" SERIES. From 105 to 860 g.p.h. 25 ft. suction lift.



Above:—
MONO "D" SERIES. 25 ft. suction lift. 100 to 8,000 g.p.h. capacities against heads of up to 300 ft.

At Left:—
MONO "D" SERIES. Water Pressure Systems. Series "M" with horizontal tank also available. 150 to 8,000 g.p.h. at pressures of from 30 to 100 p.s.i.

The MONO pump

MONO PUMPS (Australia) PTY. LTD.

HEAD OFFICE: 132 BURWOOD ROAD, BURWOOD, VICTORIA. 28 0291

• 982 ROCKY PT. RD., KOGARAH, N.S.W. • 119 WAYMOUTH ST., ADELAIDE, S. AUST.

Q'LD: Alfred Snashall, Anthon Pty. Ltd. W.A.: Atkins (W.A.) Ltd. TAS.: J. R. Stephenson. N.Z.: Dalhoff & King Ltd.

Complete Banking Services in Papua and New Guinea

Port Moresby Branch

- Current accounts (cheque accounts)
- Savings accounts with Bank of New South Wales Savings Bank Limited
- Interest-bearing deposit accounts
- Accommodation by way of overdrafts and loans
- Gift cheques
- Banking by mail
- Safe custody of securities and valuables
- Purchase and sale of bonds, stocks, and shares
- Finance of oversea trade
- Remittances to all important cities throughout the world
- Purchase and sale of oversea currencies
- Forward exchange contracts
- Special facilities for assisting travellers
- Travellers' circular and other personal letters of credit
- Travellers' cheques
- Trade introductions
- Economic and trade information
- Administration of investments

Residents and visitors are invited to avail themselves of these services.

Branches

PORT MORESBY (Papua)
BULOLO (New Guinea)
MADANG (New Guinea)
RABAUL (New Guinea)
SAMARAI (Papua)
GOROKA (New Guinea)
LAE (New Guinea)

Agencies

KONEDOBU (Papua)
WAU (New Guinea)
BOROKO (Papua)
KOKOPO (New Guinea)
NATIVE MARKET, LAE (New Guinea)

BANK OF NEW SOUTH WALES

Over 1,100 branches and agencies throughout Australia, New Zealand, Fiji, Papua and New Guinea, and three branches in London.

(INCORPORATED IN NEW SOUTH WALES WITH LIMITED LIABILITY)

AB5875

TERRITORY OF PAPUA AND NEW GUINEA

Minister for Territories :

The Hon. Paul Hasluck, M.P.

Administrator :

Brigadier Sir Donald Cleland, C.B.E., O.St.J.

Director of Agriculture, Stock and Fisheries :

F. C. Henderson, Esq., B.Sc. Agr.

Notes to Contributors

The Papua and New Guinea Agricultural Journal deals with recent advancement of tropical agriculture and acts as an extension medium for the dissemination of agricultural information to the Territory planting and farming community. All articles submitted for publication in the *Journal* should be typed with double spacing. Carbon copies should not be sent. Authors are requested to avoid the use of abbreviations and not to underline either words or phrases.

References to articles and books should be carefully checked. In a reference the following information should be given : initials of author, surname of author, full title of article, name of journal, volume, full date, number of first and last pages of the article. If a reference is made to an abstract of a paper the name of the original journal, together with that of the journal in which the abstract has appeared should be given with full date in each instance.

Authors who are not accustomed to preparing drawings or photographic prints for reproduction are invited to seek the advice of the Editor.

Technical papers should commence with a summary which could be used by overseas abstracting journals.

Communications. Advertising Rates

All communications, and applications for advertising space, should be addressed to the Editor, *The Papua and New Guinea Agricultural Journal*, Department of Agriculture, Stock and Fisheries, Konedobu, Papua.

Subscription Rates

The Annual Subscription is 6s. Aust. per volume of four numbers.

Former Issues of Gazette and Journal

All numbers of *The New Guinea Agricultural Gazette* from Volume 1, Number 1, to Volume 7, Number 4, are out of print. Copies are available of *The Papua and New Guinea Agricultural Gazette*, Volume 8, Numbers 1 to 4, and *The Papua and New Guinea Agricultural Journal* from Volume 9, Number 1 onward.