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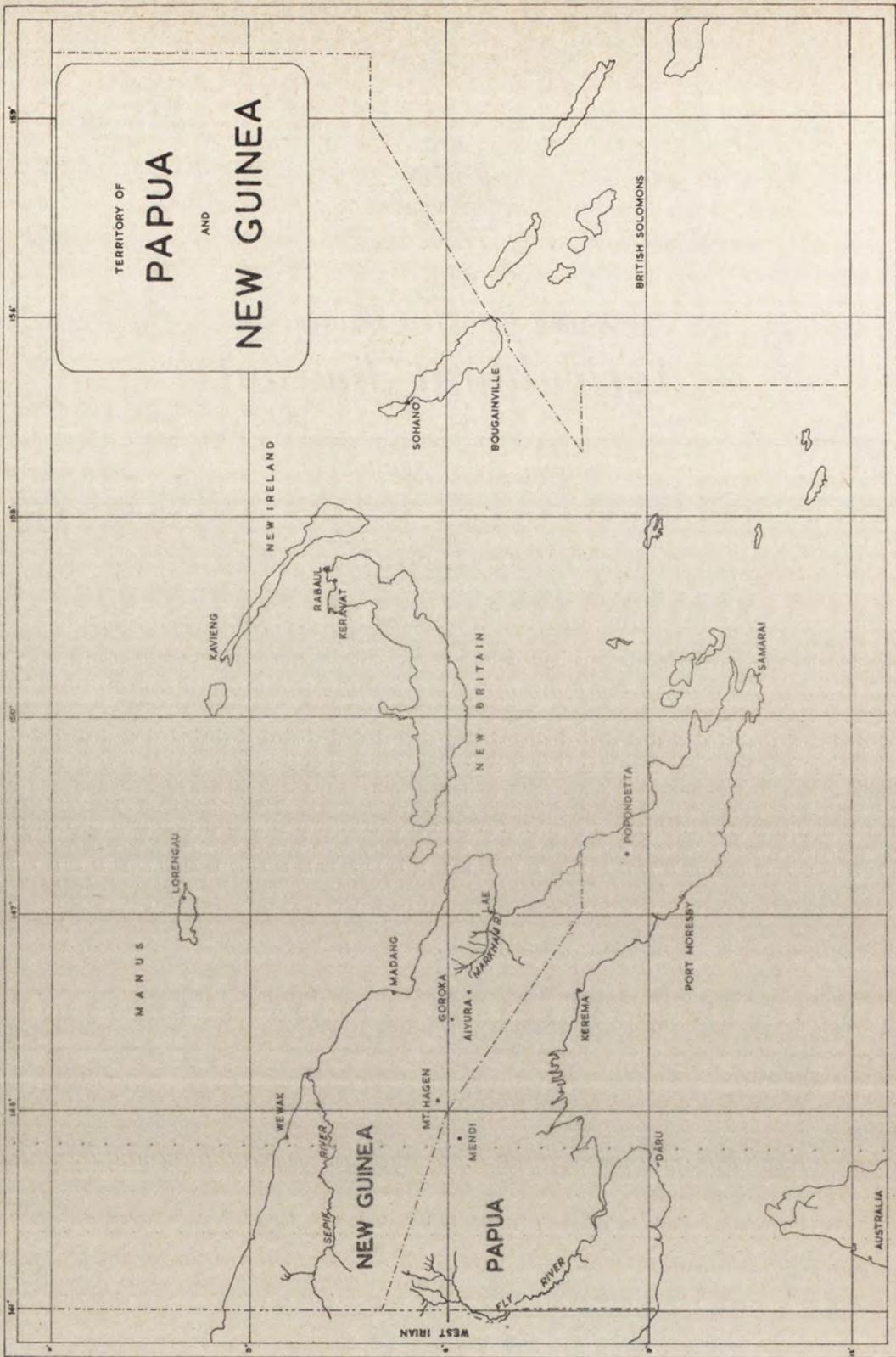
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The Development of Indigenous Agriculture, Land Settlement, and Rural Credit Facilities in Papua and New Guinea

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Development Prior to 1939-45 War.

THE early development of Papua (known as British New Guinea until 1905) was associated mainly with exploration and pacification of the indigenous inhabitants. As the number of people contacted by Europeans increased, and the influence of the colonial government established in 1888 expanded, tribal warfare ceased and steel implements replaced the more primitive traditional tools. The government considered that development of commercial agriculture in the colony was important and encouraged villagers to utilize the surplus labour that these changes created by engaging in cash cropping.¹ However, it lacked the capital and services necessary to carry out a comprehensive development programme. Subsistence farmers on the other hand, were indifferent to cash cropping in villages and invariably diverted their surplus labour into other traditional pursuits such as leisure, hunting and ceremonial activity. The government adopted coercive methods of development, and a series of regulations designed to compel villagers to participate in commercial agriculture was introduced. The first was Regulation No. 2 of 1894 which enabled district magistrates to compel villagers to plant coconuts. The magistrates were empowered to fix the minimum number of coconuts that would be planted each year in a village.

⁽¹⁾ In a post-war study of the Siane people in the New Guinea highlands it was estimated that the introduction of steel axes led to a 30 per cent. reduction in the amount of male labour required to maintain the existing level of subsistence production. Salisbury, R. F., *From Stone to Steel*. Melbourne University Press, Melbourne, 1962. A more detailed theoretical treatment of the concept of surplus labour within the subsistence sector is given by E. K. Fisk in "Planning in a Primitive Economy: Special Problems of Papua-New Guinea", *The Economic Record*, Vol. 38, No. 84, December, 1962, pp. 462-478.

Because of the poor results obtained with these regulations emphasis shifted to developing the colony with European plantation agriculture. Although several Europeans had begun to establish coconut plantations by 1891 the development of plantation agriculture was severely restricted by the lack of internal communications, settlers and capital. In 1899 the government initiated an advertising programme in England and Australia to attract settlers and capital. There was a poor response to early advertisements and by 1907 only 1,467 acres were under development, although some 29,000 acres had been alienated for the purpose. A period of rapid expansion followed and by 1914 there were 42,921 acres under development. During the war the settlement programme stagnated and increased emphasis was placed on the development of indigenous agriculture. Much greater use was made of the planting regulations to force villagers to engage in cash cropping and additional ordinances designed to increase indigenous participation in cash cropping were introduced. They were to supplement the existing regulations. A Native Plantations Ordinance was introduced in 1918 and was followed by a Native Taxation Ordinance in 1919. Every able bodied male villager between the ages of 16 and 36 years was required to complete 60 days labour each year in developing an area with coconuts, coffee, rubber or rice. The only people exempted were government and mission employees and those under contract of service, or who had been under contract within the preceding three months. Crown land could be declared a native reserve for the purpose of establishing a plantation, or village land could be used. In practice most plantations were established on village land that was resumed for the purpose. Two months work entitled the villager to a

remission of the whole of his tax. The government supplied seeds and tools and supervised the planting and maintenance. Profits from the sale of produce were divided equally between the villagers and the government, with each villager being paid according to the number of days worked. The government's share could only be spent on projects concerning native welfare. Penalties were provided for those who did not comply with the regulations, which remained in use until the 1939-45 War.

Before the German government annexed New Guinea in 1884 several Europeans had established coconut plantations in the Bismarck Archipelago. After annexation and formation of the German New Guinea Company there was a further expansion in plantation agriculture. Villagers were compelled to grow food crops and coconuts for sale under the Planting Ordinance of 1887, and until the 1914-18 War a large proportion of the copra exported from the German colony was produced by village farmers harvesting nuts in excess of subsistence needs. By 1909 some 45,000 acres of land had been developed under the plantation system. After 1910 the area under plantation agriculture expanded rapidly. This trend continued during the 1914-18 war when the colony was occupied by the Australian military forces, and by 1919 there were 145,000 acres under development on plantations. When the Australian government began administering New Guinea in 1921 plantations were sold to Australian ex-servicemen. Plantation agriculture continued to expand until 1939 but at a much slower rate. Indigenous commercial agriculture was developed in many parts of New Guinea by the continued use of the planting regulations used in Papua.

Although substantial areas of coconuts, and smaller areas of coffee, rubber and rice were established prior to the 1939-45 War the attempt to develop indigenous commercial agriculture was generally considered to be unsuccessful. There are a number of reasons why cash cropping was not a success. The planting regulations could only be used effectively in areas that were close to established government stations. Villagers preferred traditional activities to cash cropping and were opposed to the government's use of

compulsion to develop commercial agriculture. Other important factors were the lack of qualified agricultural officers, the inadequate processing and marketing facilities that were provided by the government, the practice of distributing profits from native plantations among villagers only once a year, and the meagre returns received by villagers because of low prices obtained for the produce on overseas markets.²

In 1938-39 the value of the principal agricultural exports from Papua was £221,000 and from New Guinea £799,000.³ Paucity of statistical data precludes any attempt to accurately determine what proportion was produced by village farmers, but it was probably no more than a quarter of total exports by value.

Post-War Development of Indigenous Agriculture.

Following the 1939-45 War the element of official compulsion was removed from indigenous agriculture and a more liberal policy of raising levels of living within the rural population was evolved. The aim of the policy was to raise output of village farmers by improving land use and labour efficiency. Emphasis was placed on expanding commercial agriculture within the framework of traditional tenure systems. The development programme that was drawn up involved an expansion of the area cultivated with export crops such as coconuts, cocoa, coffee and rubber; cultivation of import replacing crops such as rice; and development of local food markets with fruit and vegetables.

After the war, farmers were encouraged to jointly develop a single area of cash crop in their village in preference to numerous individual family plantings. Although the composition of a group developing an area of cash crop was related to traditional social groups within the village, the members were

(2) For a more detailed discussion, see J. Miles, "Native Commercial Agriculture in Papua", *South Pacific*, Vol. 9, No. 2, September-October, 1956, pp. 318-327.

(3) Shand, R. T., "The Development of Cash Cropping in Papua and New Guinea", being a paper given at the Annual Conference, Australian Agricultural Economics Society, Sydney, February, 1963, Tables 1 and 3.

not necessarily accustomed to interacting for any long term economic activity. As the government did not apply constraints to those villagers not interested in continued participation in a project, there was a need for leaders of the group concerned to develop appropriate sanctions. The existing legislation, however, did not provide for the exercise of such sanctions by village leaders. In addition, problems of land tenure were created when people of one sub-group were obliged to cultivate perennial tree crops on land held by another sub-group in the village. As the apparent disadvantages of this system of planting cash crops became known, emphasis shifted to encouraging each family to cultivate an area of cash crop separately. This policy was clearly established by 1956. Farming has been carried on by nuclear families in some cases and extended families in others, and income from sales has been shared among members. Some families draw on the labour of kinsmen to help with certain seasonal tasks; payment is sometimes made in cash or kind but more often in reciprocal assistance at a later date.

It is likely that the main avenue for future indigenous agricultural development will continue to be family farming. The Minister for Territories, Mr. Hasluck, has stated that "... the big majority of the present population are likely to find their advancement in changing from village subsistence to cash cropping, forming a native peasantry that ... will not be a major employer of wage earning labour."⁴

Social accounts prepared by Swan and White indicate that substantial progress has been made in raising indigenous farm income. They have shown that the total income received by indigenous farmers rose from £700,000 in 1950-51 to £4,000,000 in 1959-60.⁵ This increase has mainly been the result of an expansion in the area cultivated with perennial tree crops for export markets. Within the rural population the variation in the degree of contact with the money economy,

and participation in commercial agriculture, has led to marked differences in income per capita. It was estimated that the employable male population in 1959-60 was 600,000 and of these 250,000 were partly or fully self-employed in agriculture.⁶ Epstein estimated that in 1959-60 Tolai income from cash cropping was £30 per capita.⁷ Shand calculated that indigenous farmers other than Tolais received £9 10s. per capita from cash cropping in the same year.⁸ However, these data may underestimate per capita incomes because many farmers also engage in wage employment.

A limited amount of attention has also been given to improving traditional systems of agriculture, most of which are based on some form of bush fallow rotation. Attempts have been made to raise the level of nutrition within the rural population by introducing new or higher yielding cultivars of food crops. Crops that can be stored after harvest have also been introduced to supplement the more perishable traditional foods. Although there has been no attempt to make radical changes to traditional systems of subsistence agriculture it is apparent that in some areas the population may soon reach the critical density that can be supported by the systems at existing levels of subsistence. To safeguard the level of living of the people concerned it may be necessary for the government to undertake re-settlement programmes to relieve population pressures, or to modify traditional methods of food production. Alternate systems of production may include more efficient rotations that increase output per acre of the land under cultivation and permit a greater area of land to be cultivated at any one time. Research to devise more efficient rotations (in Papua and New Guinea, and overseas) has largely evolved about the use of green manure and leguminous crops to replace the natural bush fallow. This research has not yet produced

(4) Hasluck, P., "Employment Policy in Papua and New Guinea", being a statement in the House of Representatives, Canberra, 15th August, 1961, p. 13.

(5) Bettison, D. G., *et. al.*, *The Independence of Papua-New Guinea*. Angus and Robertson, Sydney, 1962, pp. 27-28.

(6) Hasluck, P., "The Economic Development of Papua and New Guinea", being an address to the Economic Society of Australia and New Zealand (New South Wales Branch), Sydney, 20th October, 1961, pp. 7-8.

(7) Epstein, T. S., "European Contact and Tolai Economic Development: A Model of Economic Growth". Australian National University (Mimeo), 1961, p. 11.

(8) Shand, *op. cit.*, p. 24.

systems that are suited for subsistence farmers with low per capita incomes, and that are significantly more efficient than the existing traditional ones. The success of any large scale re-settlement programme may be largely determined by the extent to which the schemes are planned to meet the needs of the people concerned. Though there may be a tendency to establish schemes in which farmers would be expected to increase output per head considerably above their existing level of subsistence output, some groups in need of resettlement may be opposed to the significant changes in time patterns that would be expected of them. They may prefer a lower level of living in their existing habitat to re-settlement in a scheme in which conditions are considerably different from those to which they are accustomed.

The rapid expansion in indigenous cash cropping in the post-war period has focused attention on the suitability of the existing agrarian structure as a long-term base for the development of commercial agriculture. Particular attention has been given to traditional systems of land tenure in which the presence of rights of different types, held by related persons and social groups, has often caused difficulty in defining the rights of individuals. A Native Lands Commission was established in 1952 to settle land disputes and to define and register indigenous land ownership. The aim was to record existing rights rather than to change tenure systems, and in practice it was found that rights were usually held by social groups rather than by individuals. The traditional systems were widely criticised for their inability to support advanced agricultural development, and the government decided that a tenure system of universal application, based on individual title to land, should be introduced. In 1960 it was announced that the long-term objective of policy was "to introduce a single system of land holding regulated by the Administration and providing for individual titles along the pattern of the Australian freehold system."⁹ Legislation to provide for implementation of this policy has been tabled and is being debated by the Legislative Council.

⁽⁹⁾ Anon., "Land Tenure in Papua and New Guinea", *Australian Territories*, Vol. 1, No. 1, December, 1960, p. 15.

Given that the traditional tenure systems in many ways impede agricultural development, the extent to which a system of tenure based on individual titles will overcome these impediments has yet to be determined. Individual tenure may permit farmers to make greater use of credit facilities. Credit institutions have placed severe limitations on provision of capital to those not farming land under freehold or leasehold title, partly because of the absence of a recognised land market and the complexity of ownership within traditional systems. Most indigenous farmers have few if any assets other than land held under a traditional system which could be offered as security for a loan. It is frequently said that by replacing the traditional systems of tenure with a system of individual titles, the present problem of multiplicity of right-holders in land would be removed, thus providing individual farmers with a greater incentive to expand their production of crops. Individual title will not remove the possibility of fragmentation of land holdings which is usually associated with congestion of rural population and the operation of laws of inheritance that prescribe division of property among surviving relatives according to fixed rules. The existence of the right of the land holder to freely transfer and alienate his rights in the land, particularly the right to subdivide or add to the existing holdings, greatly facilitates progressive fragmentation of holdings.

Development of a Land Settlement Programme.

The extent to which output per head has been raised in the post-war period has been determined largely by the rate at which the rural population has accepted the technical, economic and institutional innovations that have been introduced. Villagers may be assumed to act in the most advantageous and least costly manner apparent to them, in terms of the values they themselves hold, even though the range of their perception may be extremely limited. The government has recognized that acceptance of these innovations depends largely on a successful demonstration of the advantages that result from their adoption, and has attempted to demonstrate these in a series of land development schemes.

The first scheme was started in 1952 when the Administration provided the Rabaul Local Government Council with a 99 year agricultural lease over 1,000 acres of land in the Keravat area. It was the first experiment in providing individual title for villagers wishing to re-settle and engage in cash cropping. An area of 500 acres was reserved for subsistence gardening and any resident in the Council area could cultivate there. In 1954 the remaining 500 acres were subdivided into 96 blocks, each of 4.9 acres, for sub-lease to individuals for cultivation of cocoa.¹⁰ After an encouraging start enthusiasm began to wane, particularly when it was found that the water table rose substantially as bush was cleared. By 1956 it was evident that many blocks were unsuitable for cocoa because of severe waterlogging. There was little prospect of drainage. When the scheme was reappraised in 1959 it was found that 19 blocks were totally suitable for cocoa, 23 were partly suitable for cocoa, and 19 were partly suitable for subsistence gardening. An additional area of land was made available to the Council and the total area re-surveyed in 1960. Where possible the size of each block was increased to eight to ten acres. Thirteen of the original blocks remained intact, 16 were set aside for leasing to people of the Vunadadir Council area, and 34 were held for applicants from other areas in the Gazelle Peninsula. All blocks are now being developed with cocoa.

In 1956 a cocoa planting project was launched by the Ambenob Local Government Council in the Madang area. As well as demonstrating the advantages of individual title to land it was intended that with adequate technical guidance the scheme would be a suitable means of demonstrating the correct techniques of cocoa cultivation. People from a number of villages in the Council area agreed to sell land to the Administration. The 11 blocks of land purchased were located in various parts of the Council area. They varied in size from 18 to 129 acres. A total area of approximately 800 acres was purchased. The land was leased from the Administration to the Ambenob Council and subdivided into 276 blocks, each of three acres. The blocks

were allotted to individuals by ballot, with preference being given to the original land owners. Each block was to be developed by a family. It was intended that village farmers who sub-leased blocks would continue to reside in their villages and would cultivate subsistence gardens on land held under the traditional tenure system. Although cocoa planting commenced in 1959 the rate of development has been variable. Some blocks have been fully planted, while on others there has been no work at all.

In 1957 the Vunamami Local Government Council obtained a 99 year agricultural lease over 390 acres of land in the Warangoi Valley. The area was subdivided into 34 blocks of 10 to 12 acres each. In allocating blocks the Council decided that two be leased to two persons from each of the 17 villages in the Council area. A total of 33 blocks was allocated. One was retained as a reserve for lessees to reside on. Some blocks were cleared with wage labour paid by the Council and others were cleared by voluntary workers from whom the lessees were later drawn. It was intended that the majority of blocks be developed with cocoa and coconuts, but most planting carried out to date has been with cocoa.

There has not been a detailed analysis of these local government council schemes to determine what factors contributed to their limited success. Observers have suggested that the lack of adequate advisory services and credit facilities may have been important. Other possibilities are that the lessees had some misconceptions about the nature of the rights associated with a leasehold title, and that they often had access to ample supplies of land within their traditional tenure systems. As the blocks were primarily considered to be for commercial agriculture there was a tendency to divorce cash cropping from subsistence. In a number of cases settlers in the Rabaul and Vunamami Council schemes continued to cultivate subsistence crops some distance from their cash crops, on land held under traditional tenure systems.

On several occasions councillors rejected an Administration suggestion that blocks be at least ten acres in area in favour of much smaller blocks. The councillors' view that a

(10) The number of sub-leases was later reduced to 72 when it was found that some were encroaching on an adjoining lease.

two or three acre block was quite adequate for cash cropping probably reflected a similar widely held view among village farmers. The Administration believed that a village farmer, using the labour available in his nuclear family, could cultivate more than two or three acres of cash crop given adequate extension services, capital and other resources. In 1958 it planned the introduction of another series of settlement schemes in which settlers would be able to cultivate both cash and subsistence crops on their blocks.

The Land Development Board devised the concept of a minimum economic area that could be farmed by a nuclear family.¹¹ A minimum economic area for any given system of land use was defined as that area on which subsistence crops could be cultivated in the traditional manner and cash crops, sufficient to provide a gross farm income of £600 a year, could be cultivated. The farm size for each system of land use was determined by making a series of value judgments concerning the mean size of a nuclear family, the labour inputs required to develop a given area of the cash crop being grown, the labour

requirements for other activities such as housing and subsistence gardening, and trends in factor product prices. In 1958 it was expected that a gross farm income of £600 a year would be obtained from six acres of cocoa or coffee, or five acres of coconuts interplanted with either cocoa or coffee, or 20 acres of coconuts in areas not suited for cocoa or coffee, or four acres of rubber. In areas suited for cocoa, coffee, rubber, or interplanted coconuts the blocks were subdivided so as to contain at least .15 acres of land suitable for cultivation.¹² In those areas suitable for coconuts only blocks with up to 30 acres of cultivable land were subdivided. In each block more land was included than was necessary to develop a minimum economic area of cash and subsistence crops. The additional land was intended to provide settlers with the opportunity to expand their plantings beyond the minimum economic area, if they had sufficient labour and capital resources.

Land available for leasing was advertised throughout Papua and New Guinea, and the Land Board interviewed applicants at various centres in order to assess their ability to fulfil

Table 1.

Blocks under 60 acres made available from September, 1959, to March, 1963.

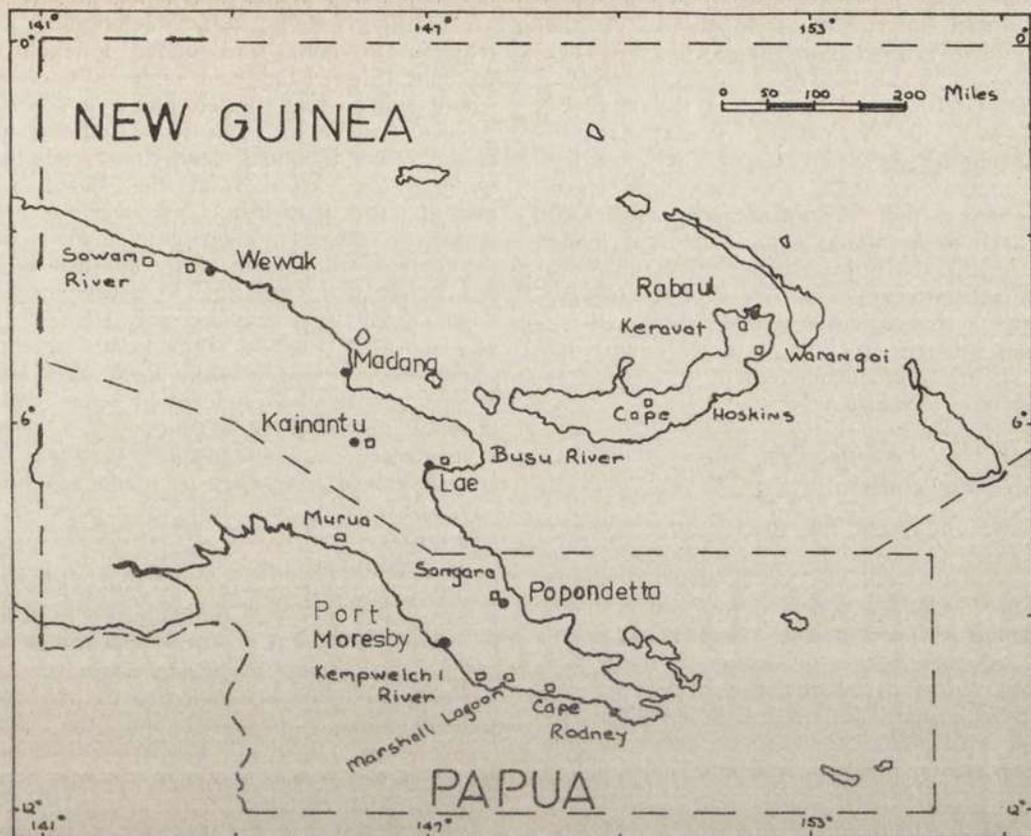
Locality	Year Made Available					Total No. Leases Made Available
	1959	1960	1961	1962	1963	
Warangoi	33	.....	50	.....	.....	83
Sangara	87	19	83	35	224
Kempwelch River	22	.....	.....	.....	22
Cape Rodney	6	53	47	45	151
Cape Hoskins	45*	.....	45
Busu River	30	.....	30
Sowam River	15	.....	15
Murua	45	.....	45
Kainantu	1	.....	1
Wewak	1	.....	1
Keravat	15	15
Marshall Lagoon	2	2
Total	33	115	122	267	97	634

*.57 blocks were advertised but 12 were later cancelled.

(11) The Land Development Board advises the Administration on matters concerning land development, settlement and patterns of land use. The Assistant Administrator is the Chairman of the Board. The other members are the Directors of the Departments of Lands, Surveys and Mines; Native Affairs;

Agriculture, Stock and Fisheries; Public Works; and the Executive Officer (Policy and Planning).

(12) It is now general practice to include at least 20 acres of cultivable land in each block. However, blocks of up to 60 acres have been subdivided because of the presence of areas of grassland considered unsuitable for development.



Locations of Land Settlement Schemes.

development conditions of the lease.¹³ The assessment made by the Board is based on the applicant's previous experience in agriculture and other employment, education, capital resources and his presentation before the Board. After hearings are completed the Board allocates blocks to successful applicants, subject to the Administrator's approval. A lessee receives a 99 year leasehold title to his block. The first blocks were advertised in September, 1959, and by March 1963, a total of 634 had been made

(13) The Land Board is a statutory body empowered to consider applications for the leasing of land and related matters. Its three members are appointed by the Administrator, who may also appoint additional members to act in relation to certain localities for a specified period.

available for development.¹⁴ These are detailed in Table I. Location of the various settlement schemes is shown on the accompanying map.

Although the government expected that the majority of settlers would use no labour beyond their own nuclear families to develop their land, they could not be prevented from drawing on other members of their extended families for assistance. Those who had sufficient resources could engage wage labour. They are required to carry out

(14) Under the current five year plan, it is proposed to subdivide 7,500 blocks by 1967. Hasluck, P., "The Five Year Plan—a reprint", *Journal of the Public Service of the Territory of Papua and New Guinea*, Vol. 3, No. 4, December, 1961, p. 101.

agricultural improvements to 1/5th of the area suitable for cultivation in the first five years, 2/5ths in the first ten years and $\frac{3}{4}$ in the first 20 years. In addition, the improved area must be maintained at a standard acceptable to the Land Board.¹⁵ Given the satisfactory operation of the settlement programme the Administration anticipated that each settler would enjoy a level of living considerably above that enjoyed by the majority of village farmers. This was expected to give rise to a demonstration effect among village farmers, thereby creating favourable attitudes towards the introduction of a tenure system based on individual titles.

Rural Credit Facilities For Indigenous Farmers.

It was necessary for special loan agencies to provide settlers with credit because of their lack of assets suitable for developing blocks and the prolonged period during which there would be no farm income. Commercial banks did not regard the financing of individual farmers in the settlement schemes as an attractive proposition because it involved so many small units, and because most of the settlers had no previous experience in handling credit.

In May, 1958, the Australian government announced that it would make capital available to finance agricultural development by Australian, Papuan and New Guinean ex-servicemen. An Ex-servicemen's Credit Board was established to be responsible for the distribution of loan capital.¹⁶ Those eligible to apply for a loan were ex-servicemen of the Second World War who had lived in Papua or New Guinea for at least five years since discharge and who had knowledge and experience in tropical agriculture. The Board required that land being developed be offered

as security for a loan. Applicants were required to hold land under leasehold or freehold title. Land held under a traditional tenure system was not acceptable as security. As very few Papuans or New Guineans held freehold or leasehold land, most of those wishing to borrow from the Board were obliged to participate in one of the settlement schemes. Those granted loans were required to reside permanently on their blocks and devote their full time to development of them. Credit was provided only if the Board was satisfied that an agricultural enterprise could be developed or maintained to a home maintenance standard and would be no greater than was necessary for that purpose. A "home maintenance area" was defined as being "an area developed to a stage of production based on suitable land use, which on average yields and prices, would in the opinion of the Board, in each particular case be sufficient to provide a reasonable living for a borrower after meeting such financial commitments as would be incurred by a person possessing no capital."¹⁷ A home maintenance area for each system of land use was taken as the minimum economic area prescribed by the Land Development Board. Farmers developing blocks in the various local government council schemes were excluded from obtaining credit as their blocks were too small to be developed to a home maintenance standard.

The Credit Board considered cocoa, coffee and coconuts to be the most suitable crops for settlers to cultivate. Those growing cocoa or coffee were required to establish six acres during the first two years of development. Although settlers growing coconuts were not required to interplant with cocoa or coffee the Board expected that in those areas which were suitable, most settlers would do so after the coconuts were five years old. Settlers were expected to establish 20 acres of coconuts by planting five acres a year for four years. The Board drew up a budgeted development programme for settlers to follow in order to reach a home maintenance standard. It was decided that those growing cocoa would receive a loan of £750 in which there would be a maximum cash expenditure of £600 over a four-year period. Those growing coconuts would

(15) *Land Ordinance 1911-1960*, Section 30.

(16) The Ex-servicemen's Credit Board was established under the Ex-servicemen's Credit Ordinance which became effective on 6th November, 1958. It was intended to operate for three years but was extended for another year in 1961. The Board is responsible for granting of loans to eligible ex-servicemen and for the supervision of development carried out by grantees. Its members are the Treasurer and Director of Finance, the Director of the Department of Lands, Surveys and Mines, and the Director of the Department of Agriculture, Stock and Fisheries.

(17) *Ex-servicemen's Credit Ordinance 1958-1961*, Section 4.

receive a loan of £1,200, of which a maximum of £1,050 could be spent over a seven-year period. With each loan granted £150 was held by the Board as a reserve to meet contingencies. The most likely contingency was extension of the period during which there would be no income, because of unfavourable weather or attacks by pests and diseases in the development period. When the ordinance was promulgated it was intended that the Board would provide a non-repayable living allowance to each cocoa or coffee grower in the fifth year, and each coconut grower in the eighth year of development. During this year (referred to as the "assistance year") settlers would not be required to make any repayment of principal or interest. A recent change in the legislation permits the Board to determine the "assistance year" at its discretion. Principal and interest must be repaid within 25 years from the date the loan was granted. Interest was at the rate of $3\frac{3}{4}$ per cent. per annum.

Loans provided for controlled expenditure on hand tools and equipment, building materials, agricultural supplies such as seeds and insecticides, rent, conveyance fees, and where necessary, cost of travel to blocks at the commencement of settlement. These items represented about one-third of the total amount of loan money granted. The remainder was consumption credit provided as living expenses to compensate for the absence of a cash income in the initial years of development. Rations and a small cash allowance were provided during the first six months of settlement before food gardens came into bearing. After gardens matured, rations were dispensed with in favour of a higher cash allowance. The amount paid to a family each month was calculated on a sliding scale related to the number of dependants who must be supported; the maximum monthly payment was £8. The cash allowance enabled settlers to purchase a variety of imported foodstuffs and other consumer goods such as clothing, soap and kerosene. The first loans to Papuans and New Guineans were granted in the latter part of 1960. When the scheme closed in November, 1962, 136 loans had been granted.

It was clear from the outset that the Ex-servicemen's Credit Scheme would only play a limited role in providing indigenous

farmers with capital for agricultural development. There was an obvious need for a permanent loan agency, able to make capital available to indigenous farmers as required.

In November, 1958, the Chairman of the Native Loans Board announced that the Board would make loans available to individuals.¹⁸ Previously it had been restricted to providing loans of money or goods to co-operatives, societies, councils or other groups or associations of Papuans or New Guineans for economic or welfare purposes. In March, 1960, the Board announced that loan applications from people who were not eligible ex-servicemen, and who were interested in taking up leases in the government settlement schemes would be considered.

In 1959 credit was granted to settlers who were developing blocks made available in the Warangoi area. Each applicant was granted a maximum loan of £144 payable at £12 a month over a period of 12 months. The purpose of the loan was to enable settlers to employ wage labour to develop their blocks. They were then expected to maintain plantings with family labour supplies. If, after four and eight months, development was not satisfactory it was proposed to discontinue payments. In a number of cases the rate of development was found to be unsatisfactory. Credit was also granted to settlers in the Rabaul and Vunamami Local Government Council schemes. The amount of credit each settler received depended on the development he had carried out. Those who had almost fully developed their blocks did not require as much capital as those who were still in the early stages of development. Monthly cash payments were made to settlers to employ labour and to purchase food and equipment.

When providing credit to farmers in other settlement schemes the Board adopted an approach similar to that followed by the Ex-servicemen's Credit Board. Settlers who were developing blocks with cocoa received loans of £600, budgeted over a four-year period. Those growing coconuts received

(18) The Native Loans Board was established under the *Native Loans Fund Ordinance 1955*. The Board consisted of three members until 1960, when a fourth was appointed. The Chairman is the Treasurer and Director of Finance.

£1,050 budgeted over a seven-year period. Allowances for various items in the budget were similar to those granted by the Ex-servicemen's Credit Board. There was no contingency reserve nor was there an "assistance year." Although no specific development conditions were laid down, the Native Loans Board expected a rate of development similar to that required of settlers with finance from the Ex-servicemen's Credit Board. No specific rates of repayment of principal and interest were required by the Board. Interest was at the rate of $4\frac{3}{4}$ per cent. per annum. Settlers were expected to reside on their farms and devote their full time to development of them.

In July, 1962, it was announced that the role of the Native Loans Fund would be altered. Emphasis was placed on economic development rather than welfare, with the Fund being used to fill more effectively the gap between existing commercial sources of credit and the needs of the indigenous people. An applicant can now apply to the Board for any amount of credit he wishes and may request such terms of payment of loan money and repayment of principal as he feels inclined. In contrast to its previous policy the Board now examines each applicant's assets when considering loans. Where an applicant possesses some capital the amount of credit made available may be restricted and the applicant required to make use of his own capital. Interest is at the rate of $4\frac{3}{4}$ per cent. per annum. The Board is empowered to postpone the repayment of any principal and or interest for up to five years on such terms as it thinks fit. Although there is no statutory limit to the amount of capital that can be borrowed, it is expected that the majority of applications will come from farmers who have no capital resources and who are interested in developing farms with family labour. As the Board requires security over the land being developed, and does not consider land held under a traditional tenure system to be an acceptable security, most farmers interested in borrowing capital must participate in one of the government settlement schemes at present.

Development budgets were drawn up for farmers wishing to grow cocoa, rubber and coconuts on the assumption that an applicant would be developing an unimproved farm

with family labour supplies.¹⁹ The data relating to labour inputs, yields and factor product prices previously used by the Land Development Board and Credit Boards were revised. The budgets include an allowance for tools, pest and disease control, seed supplies, building materials, processing and marketing equipment and share capital for establishing central processing facilities where required. Rations are provided until subsistence gardens are in production, and a cash allowance of £4 a month is paid during the loan period.

A number of loans of £673, budgeted over a six-year period, have been granted to farmers wishing to grow cocoa in the various government settlement schemes. They are required to establish ten acres of cocoa in the first six years. It is expected that they will sell wet cocoa beans to a central processing organization. If they receive four pence a pound for wet beans sold to a fermentary (equivalent to £100 a ton for dry beans) they could expect an income of £370 a year. For farmers wishing to cultivate rubber a loan of £704, budgeted over a five-year period, will be made available by the Board. They will be required to establish six acres of rubber in the first two years of development. Most probably farmers will coagulate latex in trays and carry out milling with central processing facilities. The loan includes an allowance for a £20 share in a co-operative processing unit. It is expected that farmers would have an income of £375 a year from six acres of mature rubber if they receive the equivalent of 15 pence a pound for dry rubber from the central factory. The Board proposes to make available to farmers wishing to cultivate coconuts a loan of £720 budgeted over eight years. They are expected to establish 15 acres of coconuts in the first seven years, and to produce hot-air dried copra on the farm for sale to the Copra Marketing Board.²⁰ They could expect an income of

(19) Budgets for robusta and arabica coffee have not yet been completed.

(20) The Copra Marketing Board is a statutory body set up under the *Papua and New Guinea Copra Marketing Board Ordinance 1952-1957* to purchase and sell copra on behalf of producers. The Board consists of a Chairman and five members. There are two representatives of the copra producers of New Guinea, one representative of the copra producers of Papua, the Director of the Department of Agriculture, Stock and Fisheries, and another member.

£300 a year if a price of £50 a ton for copra was received from the Marketing Board. Each of the above income figures refers to income received by the farmer at the point where he disposes of his produce.

The considerable differences between the 1958 and 1963 data for returns per acre for the various crops is due to the use of more conservative yield data in the 1963 figures, and the deliberate use of price data more conservative than present market prices which, for some crops, have declined since 1958. In the case of cocoa the annual return per acre using 1958 data was expected to be about £100, and using 1963 data about £37. Although the decline in the product prices has been overstated, the past instability of the market for these crops suggests that there may be considerable variations in farm income. Farmers may have very little insurance against a fluctuating farm income in the absence of any price stabilization measures, or diversification in the farming systems being developed.

Conclusions.

In the development of indigenous agriculture in Papua and New Guinea a system of small scale family farming has gradually been evolved within the framework of the traditional tenure systems. This type of farming contrasts sharply with plantation agriculture (the other important system of agriculture in the economy) which has remained almost entirely under the control of expatriate groups. A widespread belief that indigenous farmers lack the necessary skills and managerial ability to operate large organizations has been an important factor in influencing the development of family farming.

The present indigenous land settlement programme, in which settlers are expected to develop small scale farms with family labour supplies, has not expanded very rapidly and in the first nine months of the current five-year plan only 243 of the 7,500 blocks to be made available for leasing have been subdivided and advertised. The imbalance between the geographic distribution of resources and population suggests that a much greater rate of re-settlement may soon be required. The existing programme may not be sufficiently flexible to meet all the resettlement needs of

the economy, particularly if the communities concerned do not have the propensity to change time patterns to the extent required in the present scheme.

The value of the settlement programme as a demonstration scheme will depend largely on the extent to which settlers are able to increase output per labour unit above that of the majority of village farmers, and the extent to which the various innovations used by the settlers can be introduced into village farming. The ability of a village farmer to emulate the settlers will be determined by the amount of land available to him for cultivation, the extent to which he is able to adjust time patterns to increase output of produce, and the amount of resources he has to cultivate the increased area of land. If he has to depend on credit he must be able to obtain either freehold or leasehold title to the land he proposes to cultivate. The multiplicity of rightholders that exist in most traditional systems of tenure means that the farmer must obtain the consent of the other rightholders to register the land under individual title. This implies that the other rightholders are prepared to forgo their rights to that piece of land.

It is widely believed that the rate of tenure conversion will not be very rapid, and that the most significant expansion in indigenous agriculture will continue to come from those farming within traditional tenure systems. Continued improvements in marketing and credit facilities, advisory services, and communications, will be required to ensure that it is profitable for villagers to increase output by expanding the area under cultivation, by cultivating crops with a higher value per acre, and by adopting improved agricultural practices. The present practice of restricting credit for land development to those farmers with a freehold or leasehold title may not be justified. Much more flexible credit facilities may be required to allow villagers to make better use of available innovations. A farmer's ability to repay may be a better criterion on which to provide loan capital than the present notion of "credit worthiness" in the sense of adequate tangible farm assets.

The increased output in indigenous agriculture in the post-war period has largely been a function of the extent to which villagers

have adopted innovations and have substituted cash cropping for traditional activities such as social obligations, leisure and hunting. In many communities some farmers have exhibited a desire to change their time patterns more rapidly than the majority of the people in their community, but they have found that opportunities to increase output have been limited by a need to conform with accepted patterns of activity in the village. In some cases they have preferred to leave their village to obtain employment in other fields. The present land settlement programme has an important role to play in providing such people with the opportunity to engage in

farming under conditions that permit substantial increases in output. The scheme also provides farmers who have insufficient land in the village with an opportunity to engage in commercial agriculture.

However, the present rigidity in farm size and land use systems, and the absence of a land market in the economy will restrict some settlers who fully develop their farms and who wish to expand further. In an economy in which lack of skills and managerial ability is as great an obstacle to development as the lack of capital, the present land settlement programme may be unnecessarily restrictive if it cannot meet the needs of these settlers.

Diseases of Cacao in Papua and New Guinea

DOROTHY E. SHAW.

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CACAO in Papua and New Guinea is free from several of the serious diseases which in countries overseas, cause considerable economic loss, such as the virus diseases, and Witches' Broom (caused by the fungus *Marasmius perniciosus*). The rigorous quarantine which has been enforced in the Territory has without doubt been mainly responsible for this state of affairs.

Following are brief notes on the diseases and other conditions which have been recorded on Territory cacao. If any planter is in doubt as to the cause of a condition in his cacao, it is recommended that he contact the local agricultural officer, who, if the condition is not one of the common diseases, will request that specimens be forwarded to Port Moresby for examination. If such specimens are sent, information on the symptoms present, and the extent and duration of the condition will be of the utmost assistance to the pathologists, especially as specimens often deteriorate during transit to the laboratory.

Specimens of leaves and small twigs should be forwarded in a plastic bag if delivery can take place within 24 hours, otherwise they should be put between newspaper and wrapped in brown paper. Pods should be forwarded in a cardboard box—if they are sent in a tin with a tightly fitting lid the resulting high humidity encourages the growth of saprophytic fungi whose spores might be lying dormant on the surface of the pods or which have already invaded the moribund tissue.

The co-operation of every planter is enlisted to report any unusual condition immediately so that steps can be taken to determine the cause with as little delay as possible.

BLACK POD caused by *Phytophthora palmivora*.

Black Pod disease occurs in all the cacao growing countries of the world, but, although

figures for reputed losses are available for many countries, precise methods for assessing loss of crop have not been worked out and it is uncertain if the figures for percentage loss reported by some workers overseas can be directly compared.

Symptoms.

Brown lesions appear on pods 3-4 days after infection has occurred, and production of fungal spores generally begins on the night following the second day of visible symptoms. The spores are produced in large numbers on the surface of infected pods and these are distributed in rain splash droplets.

Pods of all ages can be attacked, but usually the susceptibility of pods increases with age. In some areas the fungus causing Black Pod also contributes to wilt of cherelles, although in many cases Cherelle Wilt is primarily a physiological condition.

Lesions can occur at either end of the pod or in the centre, but usually occur at the place where moisture has been retained, i.e., where drops persist at the tip of pods, or where moisture is retained around the stalk.

The lesions enlarge rapidly and the whole pod becomes brown, and later black (after about 10 days. (Plate I.) At this stage secondary fungi have usually suppressed the primary fungus. During this period, crops of spores are continually produced, and often white powdery spore masses can be seen on the pods. (It should be noted, however, that all white spore masses on diseased pods need not be the *Phytophthora*—they could well be secondary fungi.) The fungus spreads in the pod shell tissue extensively but does not immediately penetrate the beans.



Plate I.—Lesions of *Phytophthora palmivora* on cacao pods.

Organism.

The causal organism is the fungus *Phytophthora palmivora* (Butler) Butler. This species has been recorded on many other plants, but the isolates from cacao were formerly regarded as a biologically distinct strain. It now appears, however, that the cacao strain can attack other plants, e.g., rubber, but further study is needed on the full host range.

The most recent work on the cacao isolates themselves has revealed the existence of distinct strains which differ in lesion development on pods, spore size, and in geographical distribution. This study was done in West Africa and included isolates from many countries, including one from New Guinea.

The spores of the fungus are water-borne and only germinate in water or if relative humidity is over 95 per cent. (Dispersal in air has also been shown to occur, but at present is regarded as being insignificant as far as dissemination of the fungus is concerned.) Spores can also be carried by insects, by hands, and on knives. A few workers are now investigating whether the fungus can survive at all in the soil or

in old pods on the ground, and if so, whether this has any importance in the life cycle of the fungus.

Environment.

Work in many countries has shown that Black Pod incidence increases with greater rainfall and some workers have claimed that atmospheric humidity is important. Infection does not necessarily occur only in a period of heavy rain, but after the infection stage, the disease is generally stimulated by prolonged rains and, as mentioned above, water is usually necessary for the germination of the spores. It has also been claimed that lower temperature might lead to higher incidence of the disease.

It has been shown that the larger the number of pods per tree, the greater the percentage infection, although this tends not to apply at very high levels of infection.

Control.

The most obvious method of control is by the removal of diseased pods from the trees. This immediately reduces the sources of infection and helps to cut down cushion infection. The removal of diseased pods

has been shown to reduce the disease greatly, especially for low yielding trees. For the best results, the pods should be removed as soon as the lesions become evident or, failing that, every week if possible.

The above method of control not only has an immediate effect, but is thought to also have a cumulative effect by reducing cushion infection and soil infection, although more research is needed on the latter before its importance can be assessed.

Chemical Control.

Good control has been reported from some countries with Carbide Bordeaux, particularly on high yielding trees, and by high volume spraying with Bordeaux and other copper compounds, and by low volume mist blowers, particularly with cuprous oxide. In general, organic fungicides have not given good results.

Claims for increases in yields resulting from chemical spraying differ from country to country. The reasons for the varying results are not known, but two factors which might influence the efficiency of the spraying are perhaps whether the infections are mainly distal or proximal on the pod and which strain or strains of the fungus are present (as previously mentioned the strains have slightly different growth rates.)

Resistance.

This would be the most desirable method of control but to date none of the varieties in commercial use shows any degree of resistance. Some reports of resistance have been shown to be merely disease escapes, but the search for resistant lines is continuing. There have been several suggestions that green pods are more resistant than red pods. One of the major problems in assessing resistance is to find a reliable standard method of testing. One of the complicating factors in assessing "resistance" in the field is that infections on low yielding trees are lower than on high yielding trees.

Assessment of Loss.

Losses caused by the Black Pod disease are not as obvious, for instance, as the death of a cacao tree by a root rot fungus, and the losses are sometimes discounted as

unimportant or not worthy of special attention by the Pest and Disease team on the plantation. Only a little thought is needed, however, to calculate the loss of yield per annum if only one pod per tree per month is diseased, and from observation the loss, on some plantations, is far greater than that. It is recommended that a record of the number of diseased pods be kept for two or three rounds of the Pest and Disease team so that the loss of yield per annum, caused by this disease can be assessed on a plantation.

*CANKER caused by *Phytophthora palmivora*.*

At one time this was one of the most widely spread cacao diseases in the world, but since the predominance of other types over Criollo, it has disappeared in most countries.

Symptoms.

Canker is usually first detected in the field when an exudate or drip mark is noticed on the bark or sometimes on the main branches. The liquid can be traced to a small longitudinal crack in the bark, often only half an inch long, which would be unnoticeable without the drip mark. If the bark is cut away in thin slices, with a scalpel, the underlying tissue will be obviously discoloured, usually light brown but often assuming a deep red colour when exposed for a little time. The edge of the canker is distinctly delimited from the unaffected tissue surrounding it. If further underlying slices of bark are removed, the canker will usually be found to penetrate to the wood, but rarely further; only occasionally is the wood also attacked. (Plate II.)

Trees can have one canker, or if severely attacked, many cankers. If very severe the tree can be killed, the foliage becoming gradually thinner over many months.

Organism.

The causal organism is the fungus *Phytophthora palmivora*, but it should be noted that high black pod incidence need not be, and usually is not, correlated with high canker incidence. To illustrate this further, canker rarely occurs in Ghana, where types of cacao other than Criollo are now grown, whereas incidence of black pod is still very high.

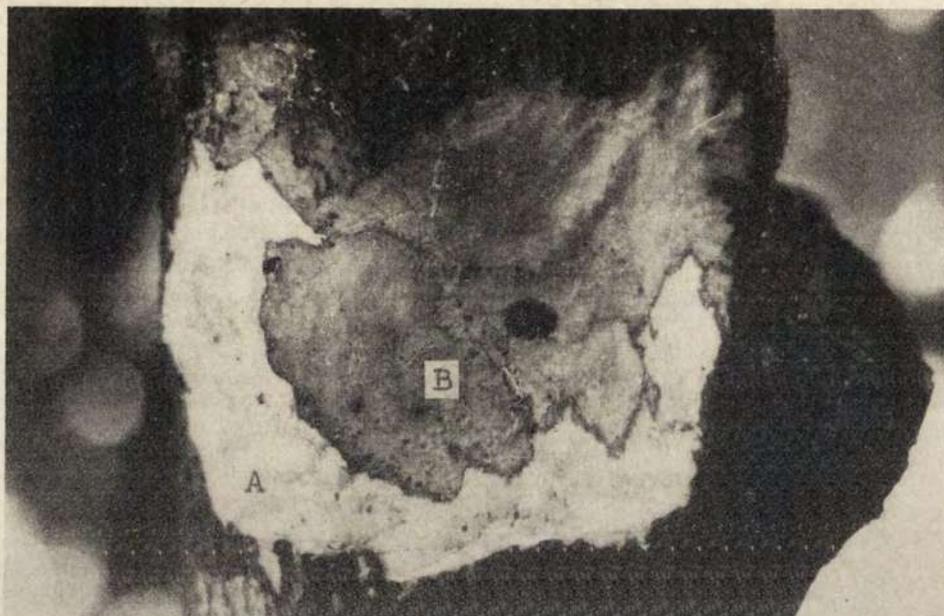


Plate II.—Canker caused by *Phytophthora palmivora* on cacao trunk just below jorquette. The surface of the bark has been cut away, showing unaffected tissue at A and affected tissue at B.

It is not known at present whether the canker-causing strain or strains of *P. palmivora* are the same or different from the Black Pod strains.

Control.

Very often the trees recover from canker as the dry season progresses. If cankers are examined at this stage, a small callus will be noted surrounding the lesion (under the bark). In very dry weather, the whole lesion can dry up, and sometimes separates completely from the healthy wood by a layer of wound cork. Very wet conditions and moist soil, of course, favour the fungus.

The direct treatment of the trees by excising the affected parts has great drawbacks; the trees generally suffer considerably and the remedy is not completely effective. This treatment is therefore not recommended. Shaving off the bark superficially to enable the spot to dry out, so that the fungus dies, has been tried in some places, and painting the shaved lesion with Bordeaux Paste has also been used overseas. However, it is now considered that it is better to prevent infection by strict plantation hygiene, than to cut the trees in

an attempt to excise cankers, as exposed wood and tissues can become sites for secondary fungi and insect attack.

CHUPON WILT caused by *Phytophthora palmivora*.

Occasionally chupons are also attacked, and these then die back. The point of attack is usually in the axil of a leaf, the affected area first becoming darkened in colour, and then sunken. The infection spreads upwards, downwards and around the stem, which then dies.

DIE-BACK OF CACAO.

Ordinary die-back of cacao twigs and branches can be caused by many factors, e.g., attack by various insects, deficiency and toxicity diseases, over-exposure, drought, water-logging, etc. In these cases, one or more lateral buds are stimulated to develop (following the death of the terminal) and normal growth is resumed if and when the causative factor is corrected.

If a branch with ordinary die-back is split longitudinally, the dead wood will be seen to stop abruptly, with normal, unmarked wood directly below.

Die-back of cacao in West Africa has usually been associated with capsid damage or periodic drought, although the factors of soil fertility, thrip damage, and invasion of the fungus *Calonectria rigidiuscula* following capsid attack have also been important. Cacao trees in Ghana infected with virus die back more rapidly when infected with *C. rigidiuscula*.

Botryodiplodia die-back occurs when the fungus enters through damage, wounds or weakness, as listed in paragraph 1, usually at the tip of the branches or twigs (both terminal and lateral). (Plate III.)

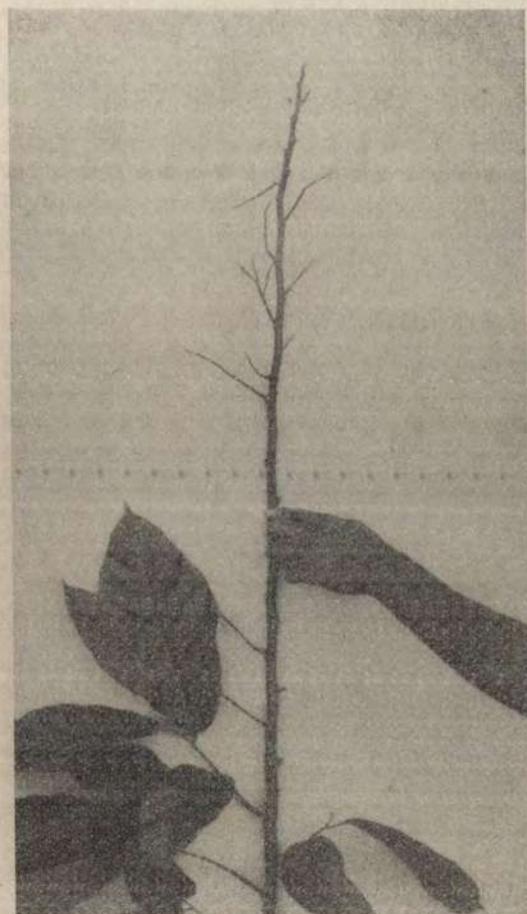


Plate III.—Terminal die-back of cacao.

Botryodiplodia die-back has been recorded in many cacao-growing countries of the world, particularly in Ceylon, Trinidad and North Borneo, and is in fact one of the oldest known diseases. It has been present in New Guinea for many years and in 1938 it was recorded as being widespread in the Gazelle Peninsula. Little was heard of it during the early post-war years although undoubtedly it did occur.

Symptoms.

The main symptom is death of the extremity of the twig (either lateral or terminal) or branch. Below the dead area (i.e., proximal to the trunk) the bark is apparently healthy but when the twig or branch is split longitudinally, light brown streaks are found to occur in the wood for some distance, until they imperceptibly fade away, and apparently unaffected wood is reached.

From research work which has been carried out in the Territory during the last few years, it is now known that the fungus can be isolated from the dead areas, from the area with streaks, and even from the apparently healthy wood below the streaked wood, the distance varying with size of twigs and branches, vigour of the tree, etc.

Once the fungus gains entry into the wood of the tree it will continue growing, especially if the tree is not in the most vigorous health (through root rots, repeated insect attacks, over-exposure or water-logging, etc.), and unless action is taken to prevent it, succeeding branches and eventually the whole tree will die.

Often associated with the die-back are the following:—sponginess of bark, increase in thickness of bark, enlargement of lenticels (giving a rough bark) and prolific production of lateral buds (which, however, often wither quickly). Some at least of these symptoms, however, can occur even when this fungus is not involved, e.g., enlargement of lenticels with disturbed physiology.

Organism.

The fungus isolated from affected tissue is *Botryodiplodia theobromae* Pat. This fungus is pan-tropical and occurs on the moribund parts of many plants, including old cacao

Pods, where spores are produced in abundance. There is no evidence that it can attack healthy undamaged cacao wood, or that there has been any change in its virulence in recent years. Once it gains entry the fungus can proceed down the inside of the branch in the wood without difficulty.

The pycnidia or spore bodies of the fungus do not readily form on die-back branches, although occasionally they are found. Once the bark dies, secondary fungi (many of which have now been recorded) invade the dead tissues and sporulate on the surface, especially on the lenticels.

Control.

The first requirement is to prevent, if possible, any factor which damages the tips or weakens the cacao (such as insect attack) or to adjust other factors (such as over-exposure or soil deficiencies) which reduce the vigour of the trees.

Trees should be kept under close observation by the manager, and any die-back should be immediately reported by the Pest and Disease team. As soon as it is noticed, the dead twig and the streaked wood below and at least one foot-two feet of good wood below that should be removed. If this is done as soon as the condition is reported, not much damage will have occurred.

If the condition has been allowed to progress unchecked, then more severe pruning will be necessary. The ability of the tree to overcome any mycelium or fungus threads left in the branch after pruning, depends on the amount of fungus left in the tree and the vigour of the tree. Therefore, any practice which promotes the health and vigour of the tree will assist it to recover; judicious fertilising has been particularly successful on some plantations, and an insecticide programme might need to be considered. After pruning, the trees should be kept under close observation and any branches with a profusion of lateral twigs which are not vigorous should be especially examined, and removed if fungus is still present.

If a young seedling is attacked, remove the branch at the jorquette; if streaking occurs below the jorquette, stub the tree back to

about three inches above ground level; if streaking is still present at three inches above soil level, replace the seedling.

If die-back does occur, prompt action before the fungus progresses far in the seedling or tree is imperative in order to prevent greater losses. It is emphasised, however, that the best insurance against the disease is the preventive measures designed to keep and maintain the trees in an undamaged condition and in vigorous health at all times.

BOTRYODIPLODIA POD DISEASE.

Occasionally, in areas of low rainfall or in the dry season, a pod rot occurs from which *Phytophthora palmivora* cannot be isolated, but from which *Botryodiplodia theobromae* is obtained. The first symptom is a brown spot which becomes enlarged until the whole pod is black. On the mainland, loss of pods in this way is very rare. On the Gazelle Peninsula it seems that pod loss caused by *P. palmivora* might decrease to some extent and pod loss by *B. theobromae* rise slightly during the dry season.

ROOT ROTS.

Root rots of cacao occur to some extent in all the cacao growing areas of the world. Some of the fungi causing root rots on rubber are identical with those affecting cacao, and most of the research work which has been carried out on these species has been done by workers at the Rubber Research Institutes at Kuala Lumpur (Malaya) and Ceylon.

Symptoms.

The first sign of root rot is usually a slight yellowing of the leaves followed by death of the tree, often in a week or so. The dead leaves usually remain hanging on the tree for some time, as the quickness of the last stages does not allow the formation of an abscission layer at the base of the petiole.

It must be noted that, although final death occurs quickly, the first penetration of the fungus would have occurred months previously, and the fungus would have been permeating the tissues since that time.

On the outside of the affected tap root and laterals, strands of mycelium or fungal threads can sometimes be noted; some fungi, however, form a sheath rather than strands. In all cases the colour of the mycelium seen is a diagnostic character, and it should be noted whether it is stranded, sheathing or patchy and whether it is black, white, brown, purplish or some other colour.

Note should also be made as to whether soil is adhering to the outside of the tap root or not—some species of root rotting fungi secrete a substance which cements the soil particles to the bark, and these particles still adhere even when vigorously rubbed. (Plate IV.)



Plate IV.—Cacao infected with root rot. Note soil encrusting the tap root.

The fungus usually runs along the laterals until the collar is reached just below soil level, and it is in that region that the main penetration occurs.

One common form of one of the fungi on cacao (and on *Leucaena glauca*) is as a velvety to hard brown crust encircling the collar and lower trunk, sometimes up to one foot above soil level; this is clearly visible to the naked eye.

In order to be quite certain, however, that the death of a tree has indeed been caused by root rot, the trunk should be severed about three feet above soil level and then the collar and tap root split longitudinally and the newly exposed faces of each half examined. (Plate V.)



Plate V.—Same tap root as in Plate IV, split longitudinally to show discoloured interior.

Note first the undiseased wood at the uppermost part of the collar, particularly its colour and texture. Then note the wood about the region of soil level—if a root rot fungus is present, the wood will be a different colour, often lightish brown (but quite hard) and the discolouration will extend up the trunk for some distance and often down into the taproot and some at least of the laterals. Often the wood about soil level or just below has reached the last stages of rot—it loses its light brown colour and looks bleached, with a texture so soft that pieces can be broken off with the finger nail. Some of the root rotting fungi can also form "black lines" in the affected wood.

This examination should be carried out as soon after the leaves have wilted as possible; if the examination is delayed, difficulty will be experienced in distinguishing the unaffected wood from the diseased wood.

Organisms.

The main root rotting fungus recorded on cacao in the Territory to date is *Fomes noxius* Corner. The other fungi which can be concerned are *Fomes lignosus* and species of *Ganoderma*.

The identification of the fungi is made from brackets, but it should be noted that it is quite uncommon for brackets to occur on cacao; usually the tree dies and is removed before brackets can form. It must also be remembered that brackets which occur on old cacao wood could be those of secondary Basidiomycetes which help to break down moribund tissue.

The positive identification of any root rot fungus cannot be made unless the brackets are present, but a *probable* identification can be made from an examination of the symptoms, the type and colour of mycelium and rot produced, adherence of soil, presence of black lines, etc.

Source of Inoculum.

It is generally considered that the primary source of inoculum occurs from infected roots of forest trees which were allowed to remain

in the ground. Please note that *all* forest tree roots would not, of course, be infective, but only those which were carrying the disease originally. (This is mentioned because it is a point which is often misunderstood.)

If diseased cacao trees are removed as soon as they are observed, the inoculum from the primary forest will be used up in about five-10 years. However, if diseased cacao roots are not removed, a further build-up of inoculum will occur and new cacao trees will be infected from the old diseased cacao roots.

It is generally considered, though it is not finally proved, that there is very little, if any, spread of these types of root disease by spores borne on the brackets of fruiting bodies.

Control.

As will be apparent from the above, the diseased taproot and laterals must be removed and burnt.

It is important to note that the ability of the fungus to infect is correlated with the size of the infective piece, and any piece of root with a volume of more than a few cubic inches is regarded as dangerous. While smaller pieces are considered unlikely to support the successful infection, they are still regarded as possible sources of infection.

Overseas experiments have been carried out for many years in an endeavour to detect and treat root rots at an early stage. These experiments, however, (which were carried out on rubber), entail careful freeing of the base of each tree from the soil, inspecting the collar and laterals near the collar, scraping off fungal rhizomorphs or strands, if present, and painting with fungicides (originally copper compounds and more lately organic mercurials such as "Tillex"). However, the interpretation of the results of these experiments is still under discussion and at present these treatments are not recommended. It will be apparent, anyway, that the cost involved of examining much of the root system

of every cacao tree even once in six months would be quite out of the question. It is also thought that the damage done to the roots during the inspections might do more harm than any odd attack of root rot. The above is only mentioned here in case some reference from outside the Department is made to these experiments.

Some planters like to dig a trench around the infected site, at a sufficient distance to encompass all the laterals, the trench being about one foot wide x one foot deep. If soil is sandy and labour available, this can be done, but it is preferable to devote the time and labour to removing all the laterals.

If all the inoculum or infected root pieces are removed from any one site, it is theoretically possible to replant immediately. If it has not been removed, then replants are exposed to infection—whether they become diseased or not depends on the number, size and position of the infective pieces.

Assessing Loss.

It is strongly recommended that records be kept on the plantation as to the number and position of root rots. The Pest and Disease team can be trained to report immediately the death of trees; these should be split longitudinally and checked by the manager or staff for the presence of root rot and if so, the appropriate control measures carried out. A record should be kept of the position of the tree, and the neighbouring trees kept under observation.

It is important that the number of trees lost by root rot be noted. On the other hand, undue attention is sometimes paid to root rot losses, because dead trees are obvious, whereas less spectacular loss (such as continual loss of pods throughout the year by *P. palmivora*) is often overlooked. Against this however, the cumulative effects of root rot over the years, if adequate control measures are not carried out, should not be discounted. If records on the number and position of trees lost by root rot are available each year, a true assessment of the importance of this disease on a plantation will be available.

OTHER ROOT AND COLLAR DISEASES.

Other root and collar diseases caused by fungi such as species of *Rosellinia* and *Armillaria mellea* and *Ustulina deusta*, have been reported on cacao (and other crops) in various parts of the world, but only a few have been reported occurring on cacao in New Guinea.

If any of these are suspected, it is recommended that specimens be forwarded for examination.

PINK DISEASE caused by *Corticium salmonicolor*.

Pink Disease is caused by the fungus *Corticium salmonicolor* Berk. & Br. which attacks many arborescent plants in the tropics, including cacao, coffee, rubber and citrus, as well as many leguminous shade crops.

The fungus occurs first as fine silver-white threads on branches, and at this stage is often overlooked. Later the cobwebby threads transform into the well-known, easily recognized pink-white crust, like kalsomine. The crust which usually forms on the under-surface of the branch, is at first continuous but later a fine network of cracks, mainly at right angles to each other, divides the surface.

The sexual spores of the fungus can form on the pink crust, but they are not visible to the naked eye. They can be windblown and therefore constitute a source of inoculum at a distance. The crust, however, is often sterile. The asexual or vegetative spore form (once thought to be another fungus called *Necator decretus*) has only been recorded to date in the Territory on coffee over 4,500 feet. The spores form as bright orange pustules about the size of a pin's head, on the upper surface of the branch (i.e., on the opposite side to the crust), protruding through the bark. These spores are water-borne.

Some of the fungal threads in the region of the crust penetrate the bark and may enter the wood, killing the upper part of the branch.

Pink disease does not occur often on cacao in the Territory and rarely causes any damage. Infected branches can be removed and burnt. Care should also be taken to see that other host plants which commonly occur in or near plantations, such as citrus, *Crotalaria anagyroides*, pigeon pea (*Cajanus cajan*), *Tephrosia candida*, and *Eriobotrya japonica* (loquat) are not infected or providing inoculum for adjacent cacao.

WHITE THREAD BLIGHT.

White Thread Blights occur occasionally on cacao in the Territory, especially in regions of high rainfall, but are seldom of economic importance.

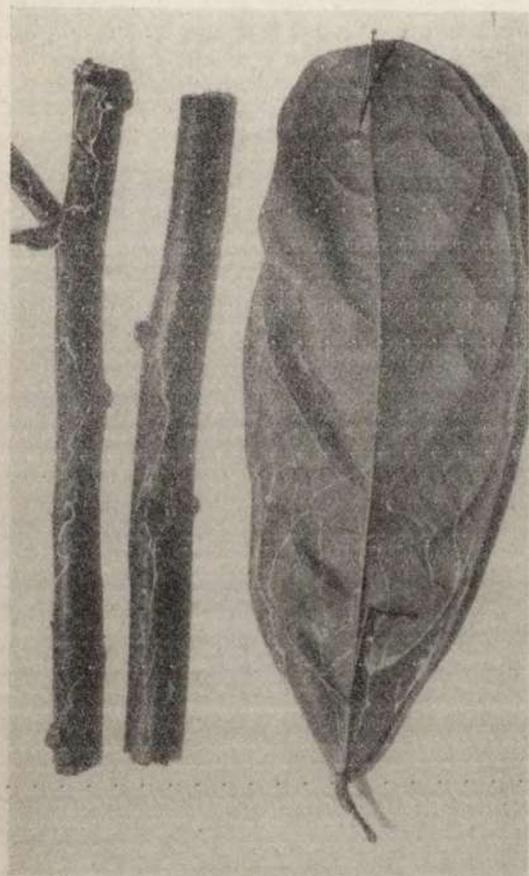


Plate VI.—White thread blight on undersurface of cacao leaf and on stems.

The fungi causing White Thread Blights are probably species of *Marasmius*, *Marasmiellus* or *Corticium* but, as they usually occur as fungal threads only, without producing spores, the specific identification usually cannot be given. One collection from Bougainville with spore-bodies present has been identified as *Marasmius cyphella* Dennis and Reid while another from New Britain proved to be *Marasmiellus* sp.

The White Thread Blight fungi occur on the under-surface of the leaves, having spread along the petiole and up and down the branches. (Plate VI.) The leaves die prematurely and the petiole or leaf stalk breaks off at the junction with the stem. The leaves remain attached to the branch, however, by the fungal threads, but can be easily detected as they are brown and papery and hang vertically. As far as is known, the disease is spread by contact (e.g., piece of fungal thread carried by birds, insects, on pruning shears, etc.).

The spore-bodies are small white plaques of fungal material about quarter inch wide, appressed to the leaves, something like a tiny flattened mushroom without a stalk. We are anxious to receive any collection of White Thread Blight showing these fruiting or spore-bodies.

The blights can be easily controlled by removing infected branches and burning, at the same time checking shade and thinning if it is too dense.

HORSE HAIR BLIGHT.

Horse hair blights, caused by species of *Marasmius*, occur on cacao occasionally, but do little damage. (Plate VII.) The fungi cannot be identified from the black "horse hair" strands alone; the fruiting bodies, which are like small fragile mushrooms on slender stems, have to be present. Any collection with the fruiting body should be forwarded to Port Moresby for identification.

SOOTY MOULDS.

The sooty moulds include many different species of fungi, all black to the naked eye, which live on leaf and stem surfaces, and are particularly abundant in the tropics.



Plate VII.—Horse hair blight on cacao. Note dead leaves still attached by the black threads to the stem.

Many of these fungi are quite superficial and do not penetrate the leaf surface at all, mainly subsisting on insect honey dew or excretions from aphids and scales. If the "soot" or fungal material is carefully scraped with the finger nail, match or knife, the underlying leaf tissue will be seen to be quite undamaged.

Another group of these fungi is also superficial on the leaf surface, but they may attach themselves to the leaf by means of pegs or holdfasts. Others may adhere to the

epidermal cells of the leaf so intimately as to absorb their food, while others may send feeding organs or haustoria into the host tissues.

The sooty moulds are of no economic importance.

ALGAL SPOT.

This spot is caused by an alga, *Cephaleuros virescens* Kunze, which grows mainly epiphytically on the leaf surface, causing very little damage to the underlying tissue. With a hand lens the colony will be seen to consist of reddish filaments, topped by reddish spherical bodies which are the spore cases. The spot is rare on cacao in the Territory, but is abundant on many other trees, e.g., guava, citrus, coffee, etc.

Occasionally a fine fur, or short reddish down, can be seen on young cacao tips in some areas, if examined with a hand lens, although it would probably not be noticed with the naked eye. This fur consists of the filaments of the alga *Cephaleuros minimus* Karsten.

LICHENS.

Cacao leaves bearing colonies of lichens suspected of causing disease are sometimes received for identification. However, they are quite superficial and cause no damage whatsoever.

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

A lichen colony consists of a fungus and an alga (many different species of both) 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.

ENTOMOGENOUS FUNGI ON CACAO LEAVES.

Different sorts of fungi can parasitise live insects, or grow on dead insects. Occasionally the insects die on the leaf surface, and the fungal threads extending out from the invaded insects might be mistaken for fungi attacking the leaf. However, the fungal colony and the remains of the insect can be lifted off and the underlying plant tissue will be seen to be intact. (Plate VIII.)

DISEASES CAUSED BY SOIL DEFICIENCIES.

Various abnormalities of cacao in the Territory are caused by soil deficiencies, (e.g., zinc) or toxicities (e.g., salt spray on leaves), but these diseases are not featured in this article.



Plate VIII.—Fungus growing on insect on surface of cacao leaf. The fungus does not affect the leaf in any way.

Cattle Tick (*Boophilus microplus*)—Its occurrence and attempted eradication in the Territory of Papua and New Guinea

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Introduction.

THE Territory of Papua and New Guinea, which is made up of the Australian Territory of Papua and the United Nations Trust Territory of New Guinea, includes the eastern part of the island of New Guinea and the large islands of New Britain, New Ireland and Bougainville, together with many smaller islands adjacent to them. The map (Figure 1) shows the division of the Territory into its districts and the centres of administration of these districts. The whole Territory is administered by Australia with headquarters at Port Moresby. The districts will be mentioned later in locating the eradication programmes. The Territory lies wholly within the inner tropics and is typical of the wet humid tropics. Most places in the Territory experience an annual rainfall in excess of 80 inches. The central mountain ranges reach heights of over 15,000 feet in many places and include some of the world's most rugged country.

Cattle Tick (*Boophilus microplus*) was probably brought into the Territory with the original introductions of Zebu type cattle from the then Dutch East Indies, prior to World War I. Cattle from this source were brought to Southern Papua and to many parts of New Guinea when it was a German colony. Following the establishment of the Australian Mandate over New Guinea in 1918, importations of cattle were made from Queensland. These importations added to the cattle tick infestation because there was little or no control over them. The parasite was recorded as a serious pest of cattle in the Rabaul area just prior to the hostilities of World War II. Hutchinson (1942) and early residents can recall infestation in almost all parts of Papua and New Guinea where cattle were grazed.

Most of these pre-war cattle were on the coastal plantations. During the Japanese occupation the herds were driven away from their normal grazing areas and the cattle tick was distributed with them. Cattle on the north coast of New Guinea (Madang District) were driven inland across ranges of mountains to the Central Highlands where the Japanese advance did not penetrate. Several small groups were left behind along the route of the drove when they could not keep up with the main herd, and became wild. The influence of the Zebu types from these groups can still be seen in some parts of the Highlands. All of the groups have since been absorbed into herds under control or have been slaughtered. Cattle tick was distributed by this movement over the area which has the greatest potential for cattle raising in Papua and New Guinea.

The population of cattle immediately pre-war was given as 20,494 in the Territory of New Guinea and 5,994 in Papua—a total of 26,488 for what is now the Territory of Papua and New Guinea. The cattle population in both Territories immediately post-war was estimated at 2,500, so that the majority of the Territory's cattle had been destroyed and the cattle industry was forced to recommence from almost nothing. Cattle that did remain provided the reservoir of cattle tick which reinfested the cattle imported post-war to build up the Territory herds.

The first survey of Animal Health in the Territory was carried out in 1946 by 1. Australian Mobile Veterinary Survey Unit of the Australian Army. The report of this survey shows a distribution of cattle tick which parallels the reported distribution pre-war, except that in several areas cattle were not sighted because they had been driven into the bush by the hostilities. Cattle tick were

recorded from cattle in the Central and Milne Bay Districts of Papua, and in the Morobe, Eastern Highlands and Western Highlands Districts of New Guinea. The report also recorded that ticks were first introduced into the Eastern Highlands District with mission owned cattle in 1933, and in 1937 to the Western Highlands District, although more ticks undoubtedly came into the area with the cattle evacuated from Madang.

Cattle tick were recorded by Hutchinson (1942) on cattle on the Gazelle Peninsula, but there were no hosts available at the time of the Army Survey. Similarly, no hosts were available for inspection in the Madang and Sepik Districts.

Blood smears were taken from cattle in many areas where cattle ticks were recorded, but in no case was evidence found of the protozoan diseases collectively known as tick fever. In five cases from the Milne Bay District *Theileria mutans* was recorded but it is of no pathological significance.

Post-war Developments.

Veterinary Services were established within the Department of Agriculture, Stock and Fisheries following the resumption of normal civil administration. The first Chief of the Division of Animal Industry, Mr. W. Granger, recognized the value of having a cattle industry without cattle ticks and cattle tick fever, and his early efforts were directed towards the confinement of infested cattle, together with the importation of tick free cattle to areas which were not infested.

During the period 1947-1950 surveys of cattle tick and cattle tick fever were carried out by officers of the Division of Animal Industry. Clinical diagnoses of cattle tick fever were made at Aiyura, Western Highlands District in November, 1947, Port Moresby, Central District in January, 1948, Goroka, Eastern Highlands District in February, 1948, Mount Hagen, Western Highlands District in August, 1949, Abau, Central District in September, 1949, and Kainantu, Eastern Highlands District in April, 1950. The outbreaks at Port Moresby, Goroka and Mount Hagen were confirmed by blood examination and the identification of *Babesia bigemina*.

Cattle tick were found to have spread considerably since the Army survey, and could be found at all places in the Eastern and Western Highlands where cattle were grazed; in the Morobe District, in the Lae, Boana, Wau, Zenag and Finschhafen areas; in the Madang District near Madang, Bogia, Saidor and on Kar Kar Island. They were found on wild cattle on the Gazelle Peninsula and on Southern New Ireland, and moved into newly imported cattle in the Kokopo and Rabaul areas. They were also noted on the few remaining animals in the Bougainville District.

Measures to control the infestations were instituted on all Administration stations, and other owners of cattle were advised on control measures. Movement of cattle and horses was restricted, and animals were subjected to spraying treatments. Legislation for the control of animal movement did not exist at this time, and this, together with the lack of veterinary and stock inspection staff, mitigated against successful restriction of the spread of cattle tick.

With the precedent of the United States eradication programme and the advent of newer, less toxic acaricides, the progressive eradication of cattle tick from the Territory was proposed by Granger, and a scheme of voluntary eradication was formulated by the Parasitologist of the Division of Animal Industry, Miss O. Macpherson, in 1950. The voluntary eradication agreement was to be drawn up along the following lines:—

The Department of Agriculture, Stock and Fisheries would make available the services of an experienced officer and the necessary equipment for the purpose of eradicating cattle tick on selected properties or in certain areas, provided that the owners of stock on these properties or in these areas agree to carry out any measures considered necessary by the Department for the eradication of tick in accordance with the instructions and under the supervision of an officer of the Department.

Any equipment, including tickicides, will remain at all times the property of the Department.

The owner may be required to keep such records relating to the eradication work

being carried out on his property as may be deemed necessary by the Department.

The decision as to when eradication is complete and when spraying may be discontinued will rest with the Department.

The Department reserves the right to discontinue the free provision of equipment and the services of its officers at any time.

Approval for the implementation of the scheme was given by the Administrator of the Territory on 18th April, 1950, provided that it was made clear to the owners of cattle that the voluntary scheme did not replace a compulsory scheme under Ordinance at a later date, which was considered necessary for complete eradication.

Such a scheme, however, did serve a very useful purpose as a trial for the future compulsory eradication. Field observations were made on the comparative efficiency and suitability of newer insecticides under tropical conditions, and several observations carried out during some of the voluntary eradications influenced future policy decisions with regard to the compulsory scheme.

The voluntary scheme was commenced in the Morobe District on Lutheran Mission, Malahang, Lutheran Mission, Boana, and in the Western and Eastern Highlands, at various mission stations and Government livestock stations, as well as on two properties in Papua.

The following is a short description of a programme which was successful at the Lutheran Mission, Boana. Boana is a small mission station about 20 minutes flight from Lae. It is about 3,000 feet about sea level on the southern slopes of the Saruwaged Mountains. Most of the cattle were descendants of pre-war cattle which had been husbanded by the natives during hostilities. The animals involved were seven station cattle and twelve native-owned cattle. During the eradication all the native-owned cattle were concentrated at the Mission.

October, 1950—Cattle found to be tick infested.

December, 1950—All cattle were concentrated at Mission, and spraying with Rucide* at 0.5 per cent. D.D.T. at 14-day intervals commenced.

4th May, 1951—Inspection showed a few mature ticks. Spraying interval was reduced to 12 days and spray strength increased to 1.0 per cent. D.D.T.

15th May, 1951—Inspection was carried out and no ticks were seen.

March, 1952—Spraying reverted to 14-day intervals. No ticks had been seen since inspection 4th May, 1951.

August, 1952—Spraying was discontinued.

October, 1952—Inspection was made and no ticks were found.

November, 1952—Native cattle were moved back to the villages following two sprayings at 10 day intervals. The movement began immediately after second spraying. The pastures at villages had been unstocked for 23 months.

Cattle ticks have not been recovered from any animals in this area since the treatment was completed.

This programme showed that eradication was possible under certain conditions, and demonstrated the following points:—

1. Treatment with Rucide at 0.5 per cent. D.D.T. at fortnightly intervals did not remove infestation in six months.
2. Treatment with Rucide at 1.0 per cent. D.D.T. removed all ticks in one treatment.
3. Treatment with Rucide at 1.0 per cent. D.D.T. at intervals of 12 days kept animals free of cattle tick.
4. Eradication is possible using power operated hand spraying to treat animals.
5. Treatment for 16 months after the sighting of the last tick is successful in eradicating tick.
6. Eradication can be carried out by leaving pastures unstocked for 23 months.

All these points were used in planning the methods to be used in the compulsory eradication which was carried out later.

* Rucide (Taubman's) D.D.T. suspension.

A visit by Dr. John Legg, the Director, Animal Research Institute, Yeerongpilly, Queensland, to Papua and New Guinea in October and November, 1950, had a profound effect on the future of the proposed cattle tick eradication plan. His report (Legg, 1951) recommended that—

"A campaign of tick eradication should be commenced along the lines recommended in this report. It is believed that ticks can gradually be eradicated by making use of newer insecticides."

He observed that cattle in the Territory were in small groups which were effectively isolated from one another by great distances and difficult country. Tick infested herds did not show the massive infestations observed in Queensland, although there were exceptions, and he suggested as reasons the Zebu blood in the animals and the low population density of cattle. The conclusion reached was that eradication had every chance of success, and should be carried out while the population was low, and the Territory then kept tick free by strict control of imported animals.

The recommendations for the eradication of cattle tick were set out as follows:—

1. All stock movement to be controlled and based upon a permit system so that new centres of infestation are not created.
2. Eradication can be commenced in certain defined areas on a compulsory basis, e.g., those offering the best prospects of immediate success, such as Lae (Morobe District), the Central Highlands, etc.
3. All cattle in the area under eradication to be treated on a fortnightly basis with a synthetic insecticide applied by means of a power spray.
4. Missions to be obliged to concentrate cattle in an area under compulsory eradication to facilitate treatment.
5. Only clean cattle go to a freshly opened centre.
6. Owners of stock in districts outside the area under compulsory eradication to be encouraged to eradicate on a voluntary basis, leaving a smaller number of animals to be dealt with under a compulsory scheme.

7. Fortnightly treatments to be continued for 15 months.

8. Where cattle have taken to the bush and are not under control, attempts should be made to yard and paddock them. If this is not feasible they should be destroyed, preferably by shooting.

These recommendations are merely general ones. There are no doubt places where eradication could be immediate, e.g., by cleaning the animals, removing them to clean pasture some miles away, and allowing no entry of cattle to the infested pasture for 15 months.

As can be seen from the description of the Boana eradication, these recommendations with few modifications were successful in eradicating cattle tick.

The compulsory eradication programme could not be carried out without the backing of adequate legislation, so, until the appropriate Ordinance was brought into force, voluntary eradication was the only means available to progress towards the ultimate aim of complete eradication.

The Animal Disease and Control Ordinance (1952) was passed by the Legislative body and was assented to in January, 1953. It was not until January, 1955, however, that Regulations under this Ordinance were gazetted and enabled the compulsory scheme to be put into full effect. This delay of over four years (from Dr. Legg's visit to the stage where compulsory eradication could commence) allowed a more widespread distribution of cattle tick together with a considerable increase in the Territory cattle population making the task of eradication more difficult. During this period control over the movement was impossible, and many of the tick free areas of 1950 and 1951 became tick infested with the constant danger of infection with tick fever. It was fortunate indeed that cases of tick fever were limited to Zenag (Morobe District), Mount Hagen (Western Highlands District), Madang, and Kikori (Gulf District). The total losses from the disease did not exceed 150 head.

There were some exceptions to this general picture of spread of cattle tick where owners strictly followed Departmental

recommendations and carried out successful eradication. These owners reaped the benefit later when compulsory eradication was begun. The recommendations in operation for voluntary eradication at this time were:—

1. The treatment of all cattle and horses with an approved insecticide.
2. The first three sprayings at weekly intervals with B.H.C. 0.05 per cent. gamma isomer or Dieldrin 0.05 per cent.
3. The next five sprayings at 10 day intervals with D.D.T. 1.0 per cent. para para isomer.
4. Remainder of sprayings at fortnightly intervals with D.D.T. 1.0 per cent. para para isomer.
5. Inspect cattle at each spraying and reduce interval between sprayings to 10 days if engorged ticks found.
6. Continue spraying for 15 months from sighting of last tick.
7. Treatment to be carried out with power operated hand sprays.*

A second visit was made to Papua and New Guinea by Dr. John Legg in August and September, 1953, and his report of this visit (Legg, 1953), provides information on the occurrence of tick infestation at that time. He states that the Territory requirement for the importation of cattle from tick infested areas in Australia, which was formulated following his 1950 visit had been successful in preventing the further introduction of cattle tick into the Territory. A considerable number of cattle which had come from heavily tick infested areas of Queensland, were seen by him in clean areas in the Territory, and there was no reason to believe that ticks were brought with them. Some of these animals were closely examined, and although there was evidence that some at least had been at some previous period, heavily infested—as shown by the numerous tick marks—no ticks were seen. No ticks had been sighted on the cattle since their arrival in the Territory.

The requirements stated that cattle from tick infested areas of Australia must be treated with an approved acaricide at least three times

at intervals between 5 to 10 days, the last two treatments to be clean treatments (free of cattle tick on individual examination) and the animals moved onto the vessel within 24 hours of the last treatment. The treatments were to be carried out under the supervision of a responsible officer (Veterinary Officer or Stock Inspector). Cattle entering the Territory were given further treatments on arrival. There were at least three treatments and the animals were kept under close surveillance for some considerable time. This requirement still forms the basis of the restriction on the importation of cattle from the tick infested areas of Australia, and also on the restriction on the movement of cattle within the Territory from tick infested areas to clean areas.

Legg's general impression of the situation after inspecting cattle in the main centres in 1953, and comparing them with the findings of 1950, was that in spite of staff shortages and other difficulties the prospects of eradicating ticks from Papua and New Guinea were quite good. It was true that ticks had appeared in some places that were previously clean, but on the other hand there were districts where large numbers of cattle were clean. To keep stock movements under the strictest control was all that was necessary to prevent infestation of new areas. He had observed that although voluntary eradication had been attempted in many instances, successful eradication had not always followed. It was noticeable that this non-success tended to occur where official supervision was not available, and it stressed the need for supervision by a Stock Inspector at all times.

It was as a result of this second visit by Dr. Legg, and the recommendations included in his report, that action was taken to recruit further veterinary and stock inspection staff for the Division of Animal Industry, so that eradication of cattle tick could be commenced on a sound basis of compulsory treatment under supervision. Veterinary staff included laboratory personnel recruited in 1953, and field officers, one recruited in 1955 posted to Morobe District, two in January, 1956, posted to Central District and New Britain District. Two Stock Inspectors were operating in the Morobe District at the time of Dr. Legg's visit, and three other officers commenced

* "Marino" firefighting spray unit.

duties in the Central District, Eastern and Western Highlands Districts and New Britain District in 1954. An officer was stationed in the Madang District late in 1956. Attempts at tick eradication have been carried out in these five districts.

Local control and implementation of the spraying programmes was vested in the stock inspector in the District and the programmes were begun in 1954 under the following conditions. The conditions were laid down by Mr. J. M. Marley, who was Chief of Division of Animal Industry from 1955 to 1958, and was acting in the position at the commencement of the operation.

1. The eradication to be carried out on an area basis, i.e., all cattle and horses in a fixed area, usually one with natural boundaries of distance or difficult country to prevent unauthorized stock movements, to be treated, and all stock movements into these areas strictly controlled.
2. The spraying of all cattle and horses at weekly intervals for a period of 18 months.
3. The treatments to be made with D.D.T. * 1.0 per cent. para para isomer.
4. The cattle to be treated in a crush with a power operated hand directed sprayer.
5. Stock Inspectors to supervise each treatment of properties and submit spraying reports for them.
6. The Administration to supply all acaricide, spraying plants and operators.
7. The cattle owner to be responsible for complete musters of all his cattle and horses, the provision of adequate yards and crush, and the presence of himself or his agent together with labour to work the animals in the yard.

In July, 1956, two further acaricides were included in those approved for use in the eradication programme. These were Dieldrin and Diazinon. D.D.T. was continued at 1.0 per cent. para para isomer, and Dieldrin introduced at 0.075 per cent. active principle and Diazinon at 0.06 per cent. active principle. These three acaricides were alternated on a two

monthly basis in the following manner:— D.D.T. Diazinon, Dieldrin, Diazinon, D.D.T., etc., i.e., each acaricide was used for a period of two months and Diazinon alternated after each two month period of D.D.T. and Dieldrin. The percentages of Dieldrin and Diazinon were determined from trials carried out at the Central Veterinary Laboratory, Port Moresby.

This alternate use of different acaricides was facilitated by the method of treatment using power operated hand sprays. The mixture used at each property was made up just prior to use and the concentration of the active principle was accurately known at all times. With the machines in use there was no return of mixture for re-use and the small amounts remaining after treatment of the herd were discarded. This was wasteful of acaricide and it was calculated that about 1½ gallons of mixture was used for each animal with about half of this being lost on the ground. It did have the advantage of accurate knowledge of concentration of the acaricide, the need to mix only sufficient for the animals being treated and the treatment of all animals in small groups on the owner's property with minimum disturbance of normal routine.

To attempt to recover some of the waste acaricide, investigations were carried out into the use of mechanical spray races * where a long draining race enabled the return of part of the mixture carried out on each beast, into the reservoir via a filtering system, and its re-use in the spraying chamber. These spray races facilitate treatment especially where numbers in excess of 200 are to be treated. Cattle and horses move through the spraying chamber in a continuous stream taking out with them slightly less than three-quarters of a gallon of the mixture. The spray races have the following advantages over plunge dips for Territory conditions:—

1. They are cheaper to install.
2. They are less likely to be affected by earth tremors regularly experienced in Papua and New Guinea.
3. They require a charge of mixture sufficient for the animals being treated with a small reserve.

* Formulations included Rucide (Taubmans) and 25 per cent. D.D.T. Emulsion (Shell).

* Cooper "Afgate" and "Waterwall" spray race.

4. They can be used with different acaricides in accordance with the eradication programme.
5. The small quantity of mixture can be made up freshly at each use and so eliminate the risk of using acaricides at reduced concentration.
6. After the first one or two treatments cattle move through the spraying chamber without baulking and are thoroughly wetted by the spraying mixture under high pressure. The race can handle up to 600 cattle per hour and spraying is therefore much faster than dipping.

They have proved most successful in eradication programmes and have been installed on most Government stations, on stock routes, and on several private properties.

The spraying programme was varied in 1958 and reduced the number of sprayings to which animals were subjected. The variation resulted from discussions with officers of the New South Wales Tick Control Board and from a small scale investigation into the life cycle of the cattle tick at the Central Veterinary Laboratory. After the discussion Dieldrin was removed from use in the eradication programme both because of its toxicity and because of experience in other countries of the rapid development of insect resistance to it, and also the concentration of D.D.T. was reduced to 0.5 per cent. para para isomer. The investigation into the life cycle of the cattle tick showed no significant change in the length of the parasitic stage of the cycle from that recorded in Australia. It is this period which is critical in determining the interval between treatments which will not allow ticks to mature. The majority of the ticks detached at 22 days and none detached earlier than the 20th day. This means that treatment at 14-day intervals should adequately cover this parasitic stage of the life cycle. It was felt however that the massive infestations of cattle tick which are experienced in this Territory would be rapidly reduced by the treatment at weekly intervals at the opening of the spraying programme. More frequent spraying would also assist in more rapidly reducing pasture infestation to very low levels by using the

sprayed animals as sweepers over the infested pasture. The spraying programme was laid down as follows:—

1. The spraying of all livestock at seven day intervals for the first three months.
2. Thereafter increase the interval between sprayings to 14 days. The spraying to continue until 18 months have elapsed from the last sighting of cattle tick.
3. If cattle tick are sighted at any time during the programme then the three months spraying at seven day intervals recommences before the 14 day sprayings begin again.
4. Initial treatment to be carried out with Diazinon and to be followed by alternate two monthly periods of D.D.T. and Diazinon.

This spraying programme is the one in use at present, with the addition of a new organic phosphate acaricide, Asuntol, into the sequence. Asuntol is used at a concentration of 0.05 per cent. active principle. The concentration of Diazinon was also reduced to 0.05 per cent. active principle from the level of 0.06 per cent. used previously.

Properties which become infested within the clean areas are placed in quarantine under the *Animal Disease and Control Ordinance* 1952-1958, and the spraying programme is begun. When spraying finishes the property remains in quarantine for a further 12 months. During the total quarantine period, which is a minimum of 30 months from the outbreak, the property is treated as tick infested and any movements off the property are strictly controlled and treated according to the requirements mentioned above. The extension of the tick free areas similarly involves this procedure of quarantine, treatment and inspection.

Eradication Results.

The eradication of cattle tick has been successfully carried out under all the spraying programmes, and the history of the attempts is given by Districts.

Central District, Papua.

The cattle raising areas of this District were not invaded by the Japanese during World War II, and cattle remained in reasonable numbers through the War. The

1 Australian Army Mobile Veterinary Survey Unit (1946) reported cattle tick throughout the District, the heaviest infestations being seen in the Port Moresby area. Army horses became infested and needed occasional treatment. In 1952 cattle tick were collected from a deer, many of which run wild in the forested areas near Port Moresby. Numerous records of cattle tick from cattle and horses in the Port Moresby and Sogeri areas were made until eradication commenced under the supervision of a Stock Inspector in the Sogeri area early in 1954. (The Sogeri area is an upland plateau, averaging about 1,500 feet above sea level, about 30 miles from Port Moresby. It is the valley of the Upper Laloki River). Voluntary eradication had been undertaken by one cattle owner prior to this date and no cattle ticks were sighted on his property although he adjoined two infested properties. His property was also included in the compulsory scheme.

The compulsory scheme commenced in January, 1954, and involved 358 cattle and 78 horses on eight properties. The last spraying was carried out in June, 1955, when 497 cattle and 95 horses were held on the eight properties. This eradication was carried out using 1.0 per cent. para para isomer D.D.T. at weekly intervals for 18 months. The Sogeri area has remained free of cattle tick until an unexplained outbreak occurred on one property in May, 1962. This property is now in quarantine and under an eradication spraying programme. The Sogeri area has been maintained a free area because of the strict control of movements into it, even though the lower Laloki Valley remained a tick infested area. Control was facilitated because of the single road access to the area.

With the completion of the eradication programme in the Sogeri area a start was made on cattle properties in the lower Laloki Valley. This programme was begun in January, 1957, with the treatment of 1,074 cattle and 52 horses on eight properties. The last spraying took place on December, 1958, when there were 1,778 cattle and 78 horses on the properties. In March, 1959 re-infestations were discovered on two properties. Eradication programmes were recommenced early, in the hope that only one or two properties would be involved, but when most properties were

reinfested a control programme of spraying at 21-day intervals was introduced. This control programme has been continued to date. This eradication attempt was carried out using weekly treatments of D.D.T., Diazinon, and Dieldrin alternated at two monthly intervals as outlined earlier. The reasons for the breakdown in this attempt have not been accurately determined, but several possibilities showed up in the investigation of it. It is the only attempt in the Territory which has broken down completely. The possible reasons are as follows:—

1. Failure of cattle owners to provide full musters at each spraying date. This became particularly noticeable as cattle numbers on the properties increased. Because spraying was being carried out at weekly intervals, there was no follow up of incomplete musters immediately after treatment, under the supposition that the missing stock would most likely be presented on the next spraying date, and this would still give 14 days between sprayings. In all probability, however, the same animals would be absent from each treatment.
2. The occurrence of wild horses over the fringes of the cattle properties. These animals are known hosts of the cattle tick, and could have maintained it outside the grazing areas.
3. The presence of deer within the grazing areas and outside them. During the eradication spraying programme many deer were shot, but cattle tick was not recorded from them. When the breakdown of the eradication occurred and the cattle carried a heavy infestation of cattle tick for a short period two deer which were shot both carried cattle tick. Studies on captive deer as hosts for cattle tick showed a 0.4 per cent. survival rate of 100,000 larvae applied, when attachment of the larvae was protected by hessian coats. Earlier application of 20,000 larvae without the protection of hessian coats were unsuccessful, there being no engorged adult ticks recovered from the test animals. (Department of Agriculture, Stock and Fisheries, 1961.) In the trials

it was obvious from the severe allergic reaction of the deer and the low survival rate of ticks that the deer are not a favoured host.

4. One property was mechanically infested from one of those in which early breakdown occurred. Pasture planting material was taken from the infested property and planted on the second one. Two months later when the pasture was established and cattle were allowed to graze it an outbreak of cattle tick occurred on the small group of cattle grazing this new pasture. Cattle on other parts of the property were free but the whole property was included in the control programme.

The control programme which was commenced in April, 1959, was designed to reduce the pasture infestation of cattle tick in an attempt to eliminate deer as an effective host of the cattle tick. This is based on an unconfirmed assumption that only while pasture infestation is high do deer carry cattle tick. During the control programme the opportunity has been taken to capture or kill the wild horses, and to shoot out the deer in the grazing areas, and drive them further into the forest areas. There have been no recordings of cattle tick from deer shot since the control programme commenced. It is planned to re-introduce an eradication spraying programme about January, 1964.

Extension of eradication programmes to other areas of the Central District has not been undertaken. It is planned to initiate spraying in the Kairuku and Goilala Subdistricts north-west of Port Moresby as the next stage of the Central District programme. There are several properties along the south coast of the District which have not been included in any eradication attempt, because they are sufficiently isolated by distance and difficult country from the main cattle raising areas, and there is no movement of cattle from them to other parts of the Territory. These isolated properties will be some of the last to be tackled in the eradication programme.

Milne Bay District, Papua.

Cattle populations in this District are in the same category as the isolated properties along

the south coast of the Central District. No eradication attempts have been made and the extension of eradication to the District will await success in other Districts where the cattle population is larger. There are 570 cattle in the District of which only a small number on isolated islands is tick free.

Northern District, Papua.

All cattle introduced to this District were tick free on arrival and the District has remained a clean area. There are 997 cattle in the District.

Gulf District, Papua.

There is only a small number of cattle in the District. One voluntary eradication programme on 10 head was undertaken and was successful. The remainder of the District's cattle is infested. Further voluntary schemes may be of importance and are under investigation.

Western District, Papua.

Only three small herds are present in the District. One of these is tick infested while the others are tick free having been new areas stocked with clean cattle. The protection of free areas in this District may be complicated by the presence of deer, and their migration to and from the Merauke area of West New Guinea, which is tick infested. There are 99 cattle in the District of which 12 are tick free.

Morobe District, New Guinea.

The only cattle remaining in this District after the war were the remnants of the drove of cattle from Madang, and a few mission owned cattle which were herded by the native people and hidden from the troops. All these cattle were tick infested. The Morobe District contains the areas of the Territory which have the greatest potential for cattle development. Several large properties have been taken up for grazing purposes by expatriate settlers and the number of cattle owned by native villagers is the largest by far of any district in the Territory. The district carries almost 40 per cent. of the Territory cattle population at the moment.

The potential of the District was recognised early, and the voluntary eradication schemes were first introduced there. The Boana programme mentioned earlier was successful in eliminating cattle tick from the area in which the establishment of cattle in the village economy has taken place. A second voluntary scheme removed the cattle tick from the small number of cattle on the coast adjacent to Lae. Two schemes were successful in the Wau Valley and one was unsuccessful. A second scheme was also unsuccessful in an upland area closer to Lae. The cattle in these unsuccessful attempts were later cleansed in compulsory schemes controlled by the Department.

At the time of the completion of the compulsory schemes in early 1957 all cattle in the District were tick free. New properties were being developed and stocked with clean cattle. The majority of these cattle were imported from Queensland, and had been subjected to acaricide treatments according to the requirements, i.e., three treatments at five to ten-day intervals, the last two treatments to be clean treatments as determined by individual inspection. They were again treated on arrival in the Territory in most cases for a further three treatments at five to ten-day intervals. Following one introduction of cattle from North Queensland in 1957 an outbreak of cattle tick was discovered on the quarantine station, but it had already spread to two other properties in the district. The properties, involving 1,171 cattle, were placed under eradication spraying programmes in February, 1958. The spraying programme on one of these properties was satisfactorily completed in 18 months and the quarantine was lifted in a further twelve months (August 1960). On the other two properties reinfestations were seen in January, 1959, and the spraying programme was extended for a further 18 months. Spraying was completed in May, 1960, and the quarantine was lifted in September, 1961. Since this date there have been no further outbreaks. At the same time as these outbreaks were under eradication a voluntary eradication was undertaken in the Finschhafen area. This attempt was successful even though it was not carried out strictly according to the programme. Its successful completion eliminated the last

pocket of cattle tick in the District, which now has a population of 8,675 cattle which are tick free.

Eastern Highlands District and Western Highlands District.

These two districts will be dealt with as one since the eradication in both was carried out simultaneously, and was under the supervision of the Stock Inspector stationed at Banz in the Western Highlands.

The first treatments of cattle in the Districts began early in 1953. By March, 1954, 17 properties were under treatment involving 593 cattle and 204 horses and donkeys. The last spraying treatment was carried out in September 1955, with the exception of two isolated mission properties that began their spraying later than March, 1954. Inspections then showed that the programme was successful. The districts remained tick free until an outbreak occurred near Goroka in December 1958, on two properties involving 20 cattle and four horses. Three cattle had been introduced from the Madang District under the supervision of a Stock Inspector, and had received the prescribed three sprayings at five to ten-day intervals. They had been inspected at each spraying and no ticks were seen. The animals were moved by air in September, 1958 and the outbreak discovered in December, 1958. Quarantine was imposed on the properties in January, 1959 and sprayings ceased in June, 1960. The quarantine was lifted in August, 1961. There has been no reinfestation of the Districts, which now carry 3,982 tick-free cattle.

Southern Highlands District.

This District was stocked with tick-free cattle from herds in the Western Highlands District and ticks have never been recorded in the District. There are 59 cattle in the District.

Madang District.

Some cattle remained in this District from stock held on the plantations prior to the War. Numbers of these were recovered from the bush to help re-stock plantations. These were tick infested and also carried the organisms of

tick fever. Further cattle were imported (many from tick free areas of Australia), and because no attempt was made to control the cattle tick, losses were experienced in the imported cattle from tick fever. Cattle tick eradication began in the District in 1958, after some preliminary work in organizing suitable handling facilities on properties, and determining the numbers of cattle to be included in the eradication attempt. Six properties were included in 1958, and these carried 374 cattle. By the end of 1959 eight further properties carrying 531 cattle and 60 horses had been added to the eradication programme. The only additions to the programme later than this was one property carrying 16 water buffalo and a group of native owned cattle, 12 head, which were in an area inaccessible by road from Madang. This last herd was left in strict isolation until the Stock Inspector completed spraying on some of the other properties in the eradication area, and could spare the time for the two day journey to treat this small herd.

Eleven of the 16 properties completed their spraying programmes in the minimum period of 18 months. Two properties took 20 months, one took 21 months and two properties were under spraying for 30 months. These delays were due to the observation of cattle tick on animals in the herds. The two properties under treatment for 30 months were involved in the outbreak on the water buffalo. The buffalo proved almost impossible to muster and treat. Some of the most intractable animals were slaughtered before the group was finally brought under control.

Cattle tick have not been sighted within the eradication area of the Madang District since October 1960, but the twelve month period of inspection on some properties has not yet elapsed so the quarantine on the area has not been lifted. The eradication area extends from Madang northwards, a distance of approximately 60 miles. Action has been taken to extend the area southwards towards the Morobe District border, there being only one small pocket of tick infested cattle in this direction.

Difficult country separates the northern boundary of the eradication area from further tick infested cattle to the north. These are

found around Bogia near the mouth of the Ramu River. About 550 head of cattle are involved but the position is complicated by the presence of an unknown number of wild cattle and water buffalo in close proximity to plantation cattle. It is intended to leave the Bogia area until other areas are completed and action can be taken to control or slaughter out the wild cattle and water buffalo.

Other areas of the Madang District particularly in the upper reaches of the Ramu River, have been stocked with tick-free cattle via the port of Lae. The natural outlet for this area is via the Markham Valley to Lae.

Sepik District.

No formal eradication programme has been undertaken in this District. Cattle tick remained on wild cattle which were recaptured after the War. A voluntary eradication programme at Aitape was successful prior to stocking with cattle imported from Australia, and the herd has remained tick free since then. A second eradication near Wewak was carried out by treatment and movement to fresh pastures, the original area being left unstocked for the cattle tick to die of starvation. This attempt was successful, but almost three years later reinfestation occurred when carcasses of beef from the Bogia area were introduced to Wewak. The beef was poorly slaughtered and pieces of skin remained on the carcass. It was transported direct to Wewak wrapped partly in the hide and in leaves. This outbreak was in two herds and has been treated in two ways. One was sprayed weekly for six weeks and moved to new pasture. It has remained tick free for over 12 months. The second herd was sprayed under a voluntary scheme but reinfestation occurred followed by an outbreak of tick fever. The spraying has since been carried out under Departmental supervision and over half the herd has been transferred to new pastures.

The situation in the Sepik District is uncertain at the moment, but it is the District into which the eradication programme moves next. Of a District cattle population of about 550 head, 250 in two herds are known to be tick infested.

Manus District.

The cattle population in this District is small. All herds are on isolated islands and in the main are tick free. The actual status of some of the cattle is uncertain.

New Ireland District.

Eradication has not been undertaken in this District although large areas of the main island have been stocked with clean cattle. Tick infested cattle are present on plantations in Southern New Ireland, but distance and difficult country separate these plantations from the tick free area. Islands to the north of Kavieng also have herds of cattle, and one island in particular has a large herd of water buffalo. The cattle tick status of these herds has not been investigated because their insular isolation prevents any possible reinfestations of controlled cattle herds. Islands to the east of New Ireland also have tick infested herds on them. It is intended to begin voluntary eradication schemes on these herds in the near future.

New Britain District.

The first attempts to eradicate cattle tick in this District followed the posting of a Stock Inspector to the District late in 1953. Only two properties were infested. These carried a total of 553 cattle and 12 horses. Because the cattle were owned by a company which had several other properties in the area, the number of cattle under treatment was progressively reduced by movement to clean properties. Three horses and 369 cattle still remained under treatment when the spraying programme ended in December, 1955. Reinfestation occurred on one of these properties in July, 1956. Weekly spraying treatments were carried out until December, 1956, when all cattle were removed to another property. An outbreak occurred on this second property and there was no doubt that this infestation arose from the transfer of ticks from the original property. The source of the infestation on the original property was thought to be from the presence of deer and a small focus of infested wild cattle near to the property. There were 408 cattle involved in

the spraying programme which was carried out until July, 1958. No reinfestation of the property has been recorded to date.

A second reinfestation occurred on a different property in the same area in May, 1960. This property has not been infested since the completion of eradication spraying in March, 1955. This outbreak involved 131 cattle. Spraying was completed in December, 1961 and no reinfestation has been observed. A third reinfestation occurred in March, 1961 on a property close to that involved in the second reinfestation. This outbreak involved only seven head of cattle.

This succession of reinfestations on properties in this area of the New Britain District would indicate the presence of a source of infestation outside the present grazing areas. There is rumoured to be still present near to the area a number of wild cattle and deer which roam through the plantations and jungle of the area. The increase in population has tended to drive the deer from the grazing areas, but occasional ones are still seen. The area is becoming of less importance in the Territory cattle industry because of the increase in plantings of cacao in coconut plantations. Cacao plantings are taking over previous grazing areas.

In order to protect the cleansed areas of the District the programme must be extended to eliminate the pockets of infestation of wild cattle and deer close to them

Bougainville District.

There was only a small number of animals remaining in this District after the war. No formal eradication programme has been undertaken although a number of small herds in the District are tick free. The main infestation is in herds in the Kieta Subdistrict. The isolation of the District has not warranted its inclusion in the formal eradication programme to date.

To summarise the present status of cattle in the various Districts the following table has been compiled based on population figures at 30th June, 1962.

Table I.

Cattle Population—Territory Papua and New Guinea
Cattle Tick Status 30th June, 1962.

District	Total Cattle	Tick-Free Cattle	Cattle Under Treatment	Tick Infested or Unknown
<i>Papua</i>				
Central	4,602	1,590	2,345	667
Gulf	120	10	....	110
Milne Bay	570	....	....	570
Northern	997	997	....	....
Southern Highlands	59	59	....	....
Western	99	12	....	87
<i>New Guinea</i>				
Bougainville	124	....	....	124
Eastern Highlands	1,863	1,863	....	....
Madang	2,340	1,699	20	621
Manus	165	....	....	165
Morobe	8,675	8,675	....	....
New Britain	1,403	1,067	11	325
New Ireland	643	225	....	418
Sepik	559	300	....	259
Western Highlands	2,117	2,117	....	....
TOTALS	24,336	18,614	2,376	3,346

SUMMARY.

A short history of the progress in the eradication of cattle tick (*Boophilus microplus*) from the Territory of Papua and New Guinea is given together with the materials and the methods used in the eradication attempts. In general the eradication attempts have been successful with only one area showing a complete

breakdown in the attempt. Cattle ticks have been eliminated from a large area of the Territory, particularly from the Districts where the greatest potential exists for the future development of a large cattle industry. Of a total Territory cattle population of 24,336 head, 18,614 head are tick free, 2,376 are under eradication or control treatment and the remainder are either tick infested or their status unknown. If future progress in eradication attempts can be measured from past successes then the goal of complete eradication is within reach, and it will rest with efficient quarantine services to maintain the tick free status.

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Observations of the Biology and Control of the Armyworm *Tiracola Plagiata* Walk. (Lepidoptera : Noctuidae)

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SERIOUS damage to agricultural crops by the armyworm caterpillar *Tiracola plagiata* Walk. is described by Corbett and Gater (1926), Weddell (1930), Kalshoven (1950) and Catley (1962). In each instance the pattern of attack is similar and it appears to be typical for this species. The caterpillars breed up very quickly in enormous numbers on weeds and other secondary growth plants, from which they migrate to cultivated plants and cause considerable damage. Despite the widespread distribution of this pest in tropical and subtropical countries, little has been published regarding its biology. Temperley (1930) made a preliminary study of the life history in association with Weddell's investigations in Queensland in 1927, but no studies have been undertaken in tropical areas. From Malaya, W. P. Panton advised (in litt. June 1962) that all that is known about the species there is that the pupal stage is from 16 to 18 days. The lack of knowledge of the biology of *T. plagiata* can be ascribed to a major degree to its relative unimportance as a pest in tropical countries, where it is usually controlled in a very short time by naturally occurring parasites and predators.

Recently, however, it has assumed the status of a major pest of cacao at Popondetta in the Northern District of Papua (Catley, 1962). During the course of investigations into this sustained outbreak some observations on the biology of the species in the field and in the laboratory were made and are herewith recorded.

Eggs.—The eggs are laid at night in batches of from 200 to 1,200 on the leaves of the host plants. The favoured site is on the undersides of the youngest leaves, and on cacao the new flush leaves are selected, although eggs are also found on older leaves. It appears that some trees are more attractive egg-laying sites than others and frequently a tree will have up to eight batches of eggs whereas adjacent trees will be completely free of them.

In Queensland, Weddell (1930) found eggs were generally laid singly in the field and these were on the upper and lower surfaces of inkweed leaves which was the commonest weed species involved in the Queensland outbreak.

The colour of the eggs is white with a faint green tinge. (Plate I.) Shortly before hatching, they become progressively darker until they are almost black. This is due to the dark colour of the head capsule and prothorax of the caterpillar becoming visible through the shell of the egg

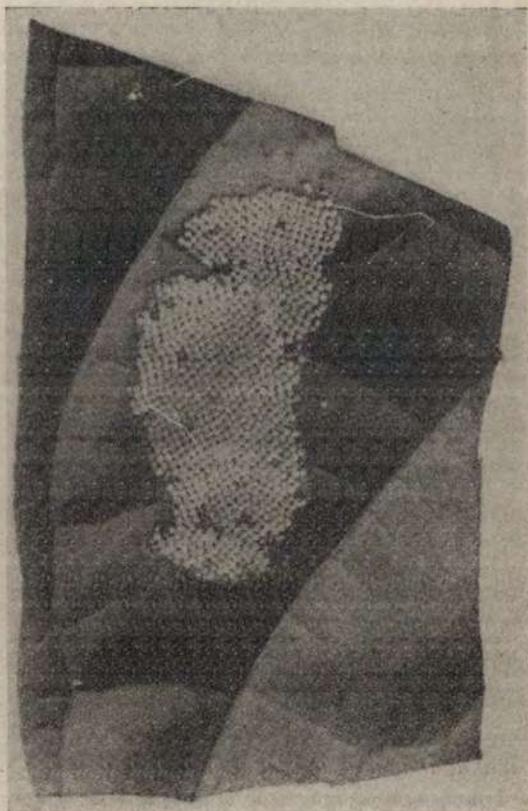


Plate I.—Egg batch of *Tiracola plagiata* on underside of cacao leaf.

[Photo : A. Catley]

which retains its colour. (Plate II.) They are globular in shape and about 0.7 to 0.8 mm. diameter. The surface is ornately patterned with longitudinal striations radiating down the egg from the top to the bottom with smaller lateral striae in between. Under field conditions at Popondetta, the incubation period is three and one-half to four days.

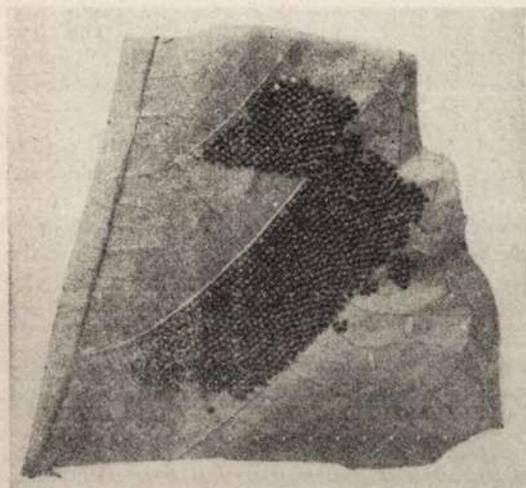


Plate II.—Egg batch of *Tiracola plagiata* prior to hatching.

[Photo: A. Catley]

Larvae.—The larva emerges from the egg by chewing around the topmost side which is then pushed back on itself to enable the larva to crawl out. Eggs of a particular batch hatch within minutes of one another and feeding commences immediately—generally the shell of its own and neighbouring eggs is first devoured and unhatched eggs may also be attacked. Provided the host plant is acceptable, the larvae are able to rapidly skeletonize the leaves by feeding between the veins, which are too hard for the mandibles to penetrate.

The young larvae are positively phototropic and in the laboratory they congregate on the lighter side of breeding jars.

Shortly after hatching, the larvae begin to wander away from their fellows and silken threads are produced from labial glands. These threads give the caterpillars much greater powers of dispersal and they can drop and swing from

them and even ascend them by rolling the threads into compact balls between their thoracic legs. By the time the larva gets to the fourth instar the silk thread is no longer used as a medium for dispersal, possibly because the insect is too heavy for the thread at this stage.

Six larval instars have been observed for *T. plagiata*. In the first two instars the body is straw coloured with rows of dark tubercles along the dorsal and lateral sides of the body, giving an overall appearance of black stripes on a grey background. The colour of the third, fourth, fifth and sixth instars is similar—the head is reddish brown and the body smoky black with a prominent cream to yellow coloured band along both sides of the abdomen. On the dorsal surface of the first abdominal segment are two irregular white spots either side of the mid-line. There is also a diffuse white area at the tip of the abdomen on the dorsal surface. (Plate III.)

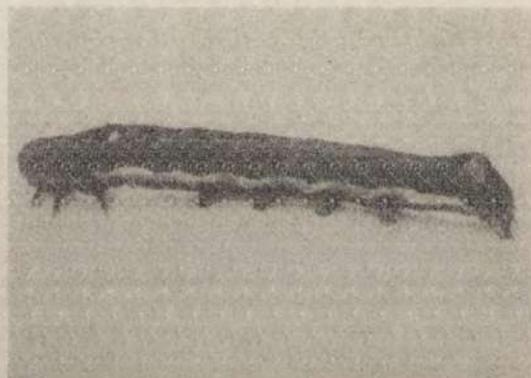


Plate III.—Sixth instar larva of *Tiracola plagiata*.

[Photo: A. Catley]

The larvae are very easily disturbed and in the early stages they will drop on their threads at the slightest pretext. The older larvae will drop to the ground and curl up upon themselves with the head withdrawn into the body. Another defensive reaction when approached is the expulsion of a green fluid from an eversible gland which opens on the ventral surface of the body immediately behind the head. This reaction is often accompanied by the caterpillar rearing up on its abdominal prolegs in a threatening attitude.

After from fifteen to seventeen days under field conditions at Popondetta, the larva is fully grown and about two and one-half inches long. At this stage the body colour often lightens somewhat to a pale smoky brown colour with almost white lateral stripes.

Prepupa.—At the completion of feeding, the larva becomes sluggish and either walks or falls to the ground where it excavates a cell in the earth and enters the prepupal stage. The body shrinks considerably and after about four days the skin splits longitudinally and the pupa wriggles free into the earthen cell.

Pupa.—During the pupal period which lasts about twelve days, with a range of ten to fifteen days, the tissues of the larva are broken down and reconstituted to form the substance of the adult moth.

The pupa is a reddish-brown colour and about 2 cms. long (range 1.9 to 2.3 cms.). The last four segments of the abdomen are capable of movement and when handled the pupa wriggles considerably. At the rear of the pupa are two spines surmounting four stouter ones.

Adult.—Emergence of moths always occurs at dusk or during the night. They are strictly nocturnal creatures and only very rarely are they seen in plantations during the day, although a few have been seen resting on the undersides

of cacao leaves and on the trunks of *Leucaena glauca* shade trees with which they blend very well. They are not attracted by white light.

The moths are about 2.8 cms. long with a 4.7 cm. wing span. The colour is grey to pinkish-fawn with a distinct dark brown to black V-shaped mark on the fore margin of the fore wings. The lateral margins are somewhat darker than the rest of the wing. The hind wings are smoky grey with lighter fore and lateral margins. The dorsal surface of the abdomen is smoky grey and darker than the sides and underside. (Plate IV.)

Moths have not been induced to mate or oviposit in the laboratory but field observations indicate there is a preoviposition period of about four days after emergence from the pupae.

Total duration of the life cycle from egg to egg occupies about thirty-five to forty days in the field but experimental lengthening of the larval period has been obtained by withholding food so it seems probable that under adverse conditions of poor nutrition the length of the life cycle could be extended considerably but this is not considered to be applicable to the plague outbreaks at Popondetta where there is an abundance of food.

In Queensland where rearing experiments have been undertaken by Temperley (1930), the length of the life cycle averaged 91.9 days under laboratory conditions with each stage

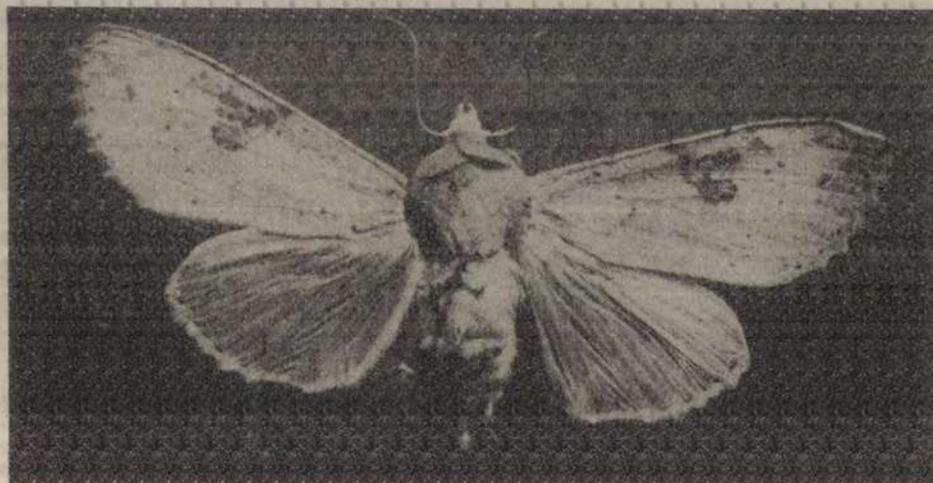


Plate IV.—Adult moth of *Tiracola plagiata*.

[Photo : N. Moderate]

occupying a greater period than that observed at Popondetta. The main cause of these differences can be attributed to differences in climatic conditions since not only feeding stages but also the morphogenetic ones were lengthened considerably. (See Table I.)

Control.

Investigations into the nature of the outbreak at Popondetta revealed many natural controlling factors acting against *Tiracola plagiata* but none of these was in sufficient numbers to exert a satisfactory degree of control. (Catley, 1962.) Accordingly, trials were undertaken to determine the most satisfactory insecticide which could be employed against the pest.

Since only the cacao flush growth was being seriously damaged, it was decided to concentrate on the protection of this as each wave of caterpillars appeared, at five to six-week intervals. The rhythmic cycle of attack made control much easier since outbreaks could be predicted with a fair degree of certainty and the spray could be applied at the most opportune time. With *T. plagiata* this is when the insect has just hatched from the egg. A spray applied to the tops and undersides of the flush leaves, particularly at the latter site, can kill many hundreds of caterpillars since they are then clustered together and they are very susceptible to the action of the insecticides.

In the Territory of Papua and New Guinea, the choice of insecticides is very much restricted because of the difficulty experienced in getting plantation workers to wear protective clothing, consequently the more toxic materials are not generally used. For the purposes of the Popondetta trials, D.D.T., Sevin, Dieldrin and Endrin were selected.

Two-acre trial blocks were selected and tops and undersides of flush cacao leaves were sprayed with high volume apparatus (knapsack or pneumatic type sprayers) when the eggs and young larvae appeared.

Results.

The concentrations selected for the trials were 0.25 per cent. D.D.T., 0.15 per cent. D.D.T., 0.2 per cent. Sevin, 0.15 per cent. Dieldrin, 0.025 per cent. Endrin and 0.05 per cent. Endrin.

Of these materials, Dieldrin was found to be markedly inferior to the others and this appears to be generally the case with Dieldrin when used against noctuid caterpillars in Papua and New Guinea.

Endrin, D.D.T. and Sevin all gave satisfactory control of the caterpillars, but the residual effect of Endrin even at 0.05 per cent. concentration was only about three days as against six days for D.D.T. at 0.25 per cent. concentration and Sevin at 0.2 per cent.

Although 0.15 per cent. D.D.T. was effective in controlling the caterpillars, the residual effect lasted for only about three days and this was insufficient to protect the flush growth until it had hardened and become resistant to attack.

Sevin at 0.2 per cent. did not give any better results than 0.25 per cent. D.D.T. and in view of its greater cost and its wettable powder formulation, it was decided to make 0.25 per cent. D.D.T., applied with high volume apparatus, the standard control recommendation.

The effect of insecticide applied to the egg batches on the leaves was also studied and it was found that Endrin, D.D.T. and Sevin at all concentrations killed the eggs if applied before the "dark stage" shortly before hatching. However, even though larvae still emerged from the eggs, they were invariably killed by contact with insecticide deposits about the eggs.

High volume sprayers are quite satisfactory for use on young cacao trees where only about eight to twelve gallons of spray are required per acre, but once the trees have ramified, considerably more spray is required to cover the flush leaves and cartage of water can be a real problem.

In view of this, low volume spraying trials were undertaken using 2.5 per cent. D.D.T. in water and applied with portable motor driven spraying machines. Satisfactory control was obtained although there was some difficulty in controlling the direction of the spray and it was rather wasteful. Another factor which mitigates against the use of low volume apparatus is the necessity for skilled operators, and these are difficult to obtain in plantation labour lines.

Another material tested against *T. plagiata* at Popondetta, although not generally considered as an insecticide, was a commercial preparation of the insect pathogen *Bacillus thuringiensis*

Berliner. This was obtained from the United States of America where it is marketed under the name of "Thuricide." The preparation tested was a wettable powder formulation containing 30×10^9 viable bacterial spores per gram of material. Larvae of all stages were fed on leaves dipped into a heavy suspension of the spores in water but no abnormal symptoms

developed after ten days of feeding. The only effect observed was an initial distaste for treated leaves but this was probably due only to the gritty texture of the carrier material. Normally susceptible caterpillars begin to show symptoms of infection within twenty-four hours of feeding and death occurs after three or four days.

Table I.

Duration of Developmental Stages of *Tiracola plagiata* in Queensland* and at Popondetta**

Locality	Length of each stage in days					Total length of life cycle
	Egg	Larva	Prepupa	Pupa	Pre-oviposition	
Queensland (laboratory averages)	8.2	45.7	8.3	29.7	—	91.9
Popondetta (laboratory and field observations)	4	16	4	12	4	40

* Based on Temperley (1930)

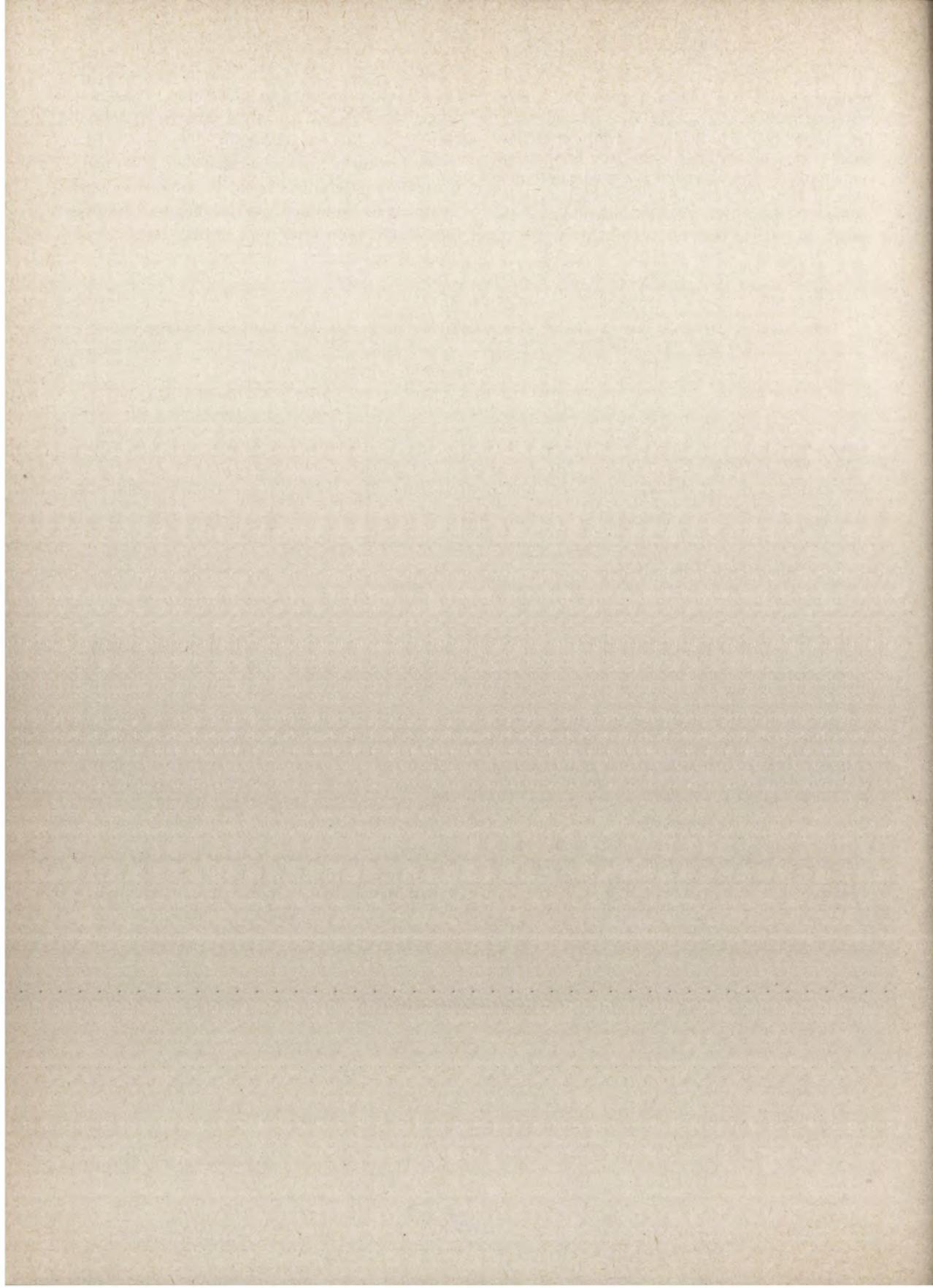
** Estimates based on field and laboratory observations at Popondetta

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The Rationalization of Peasant Agriculture

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AN efficient agricultural system is an essential prerequisite for a country's economic development. It should be productive and at the same time conservative of land and soil. The system should be flexible and should contain within it adequate provision for the extension of short and long term credit at reasonable rates of interest. The reform of a country's agriculture is difficult, and often at first unpopular, but there are many countries, especially those of the tropics, where it has become necessary.

The peasant agriculture of most tropical, and some European countries is characterized by the inefficient farming of small fragmented holdings of land. Brown (1957) gives two examples from Kenya: One landowner's aggregate holding was nine acres divided up into 29 small plots, the furthest of which was 14 miles from his house; another had eight acres divided into 43 separate plots. Papua and New Guinea contains numberless similar examples. Besides being fragmented, many holdings are held only on tenuous traditional claims which are subject to considerable litigation. Swynnerton (n.d.) states that prior to the Mau Mau Emergency the cost of land litigation amongst the Kikuyu of the Kiambu district of the Central Province of Kenya ran at a rate of £10,000 stg. per annum, bribes apart. Beckett (1943) reports that a survey village of 1,100 inhabitants in the Ashanti region of Ghana had outstanding debts of £2,000 due to lawsuits concerning disputed land boundaries.

Land is often held on a communal basis in Africa as well as Papua and New Guinea. Under this system, individuals have rights to land by virtue of their membership of the land-holding community which may be a tribe, village, kindred group, family, or other social group. The normal unit of land ownership is generally the extended family. The most common method of land use under this system of ownership is shifting cultivation or "bush fallow" and this requires a relatively plentiful

supply of land—as the population density increases there must be a corresponding increase in the intensity of cultivation. This eventually leads to a deterioration in fertility and an increase in soil erosion.

Gourou (1958) states that "To raise the standard of living of tropical peoples the first step is to abolish the . . . system of shifting cultivation . . . since it is incompatible with a high standard of living."

Shifting agriculture in Africa has been found incapable of withstanding the economic pressures arising from the increasing invasion of the subsistence economy by an economy based on exchange. To be satisfactory, any new system must lead to economic development without in the long run destroying much of the land for agricultural production, or resulting in abuses detrimental to the social and economic welfare of the community.

Thus the ultimate aim of the re-organization of a country's agriculture should be the improvement of the standard of living of the nation as a whole and the farming community in particular. Due consideration must, however, be given to various social factors including ownership of land and size of holdings. These will depend upon the cropping programme envisaged. For several reasons the family farm is often considered to be the model unit on which to establish an agricultural system but some crops, such as sugar, are said to be most efficiently produced on an estate scale. Whether this is so, will, of course, depend upon the crop and the size of the holdings—the optimum size will permit the best use of all agricultural resources—capital, and labour, as well as land. Farms can be too small or too large and the optimum size will be subject to continuous changes as the economy develops and more intensive land use becomes possible.

Gourou (1958) believes that if small-scale native holdings replace large-scale European plantations the yield and the quality of the

produce, and the prime costs, will be detrimentally affected. He also doubts that it is a good step to direct tropical farming towards a system of peasant proprietorship, and suggests that a system of co-operative or collective farming would be more efficient. This is not, however, necessarily so. For example small scale production of coffee in Kenya has proved completely competitive when compared with European production. However, to be efficient, small scale farms must be of a minimum economic size, and credit facilities must be available for the farmers.

Land can be held under three forms of tenure—tenancy, owner-occupancy and group tenure. Generally owner-occupiers are more efficient farmers than tenants as they are less likely to "mine" the land, but tenants may be as efficient if they are provided with security of tenure and are not burdened with excessively high rentals. One particular advantage of tenancies is that they can be made subject to the tenant's satisfactory farming of the land. This is virtually impossible with freehold land. The group-ownership of land at present applying in Africa has already broken down in many areas. In parts of Ghana and Uganda, for example, the traditional system has changed in response to the desire to exploit land for commercial purposes, to one of individual private holdings (United Nations 1951). Similar changes can be expected to take place in Papua and New Guinea.

Various efforts have been made to rationalize peasant agriculture in Africa and elsewhere and these may be classified under the following headings:—

1. Consolidation schemes;
2. Resettlement schemes; and
3. Co-operative or Partnership schemes.

CONSOLIDATION SCHEMES.

Consolidation schemes aim at the elimination of fragmentation of farms by the creation of larger contiguous units. According to Jacoby (1959) they may consist of:

- (a) Re-allocation of scattered plots without expanding the size of the individual farms ("equivalent exchanges");

(b) Enlargement of individual farms (without re-allocation); or

(c) Consolidation in the wider sense, re-allocation of plots into larger contiguous units combined with the expansion of individual farms.

Consolidation by itself cannot lead to an increase in productivity. To do so it must be accompanied by an improved land use system. Once such a system has been determined it will become apparent that holdings below a certain size are sub-economic, and some measure must be decided upon to deal with them. This may entail re-settlement to other agricultural or industrial areas, or increasing the size of the sub-economic holdings through a local re-distribution of land.

The main problems associated with consolidation are social rather than technical. Unless it is entered into voluntarily, consolidation is unlikely to be successful and so its advantages should be pointed out to the people over a preparatory period. The decision to consolidate must apply to the entire area and it is best if complete support for it can be obtained. There should be at least 75 per cent. of the farmers in favour before any steps are taken, and then attempts should be made to persuade the remaining farmers of the advantages of the scheme. Whether to proceed with less than 100 per cent. support from the participating farmers must be an administrative decision. It is probably best to wait until complete support is forthcoming.

One of the best ways of obtaining support for consolidation is through example, and herein lies the great challenge to the early schemes. They must succeed if other areas are to be won over to consolidation. Thus the first areas selected should be chosen only after careful and detailed preliminary survey work. A proven and improved land use system must be available and the absolute support of the participating farmers must be ensured. If the scheme is to succeed, technical and extension assistance must continue after consolidation to prevent any relapse to the previous inefficient farming methods.

The technical problems of consolidation are mainly related to pre and post-consolidation

survey. There must be an accurate and detailed survey of all fragmented holdings and a similar survey of the consolidated blocks. Each new holding should have access to road and water and they should be so designed as to be capable of incorporating a more intensive farming system.

One of the greatest difficulties following consolidation is to ensure that there is no reversion to fragmentation through the subdivision of the consolidated farms. This cannot be solved simply by legislative action, as private arrangements may be made between joint heirs to farm their inheritance separately although making no legal agreement to do so. Thus discrepancies can arise between land records and the actual situation in the field.

The problem is possibly best tackled through extension and education and in the first generation through the obvious example of the favourable effects of consolidation. This example is lost, however, to the next generation, and to overcome this Sweden makes a distinction between holdings which are legally sub-divided and those sub-divided by private agreement. The latter can be mortgaged only with difficulty and are excluded from Government grants for purchase and improvement purposes. (Jacoby 1959.)

It must be emphasised that at all stages of consolidation competent technicians must be available but "technical competence alone is not enough, as consolidation demands at least three parts of psychology and diplomacy for one part of technique." (Jacoby 1959.)

Land Consolidation and Farm Planning in Kenya.

In Kenya over 1,200,000 acres of peasant land in the Central Province alone, has been consolidated into individual holdings. The process has differed from tribe to tribe depending on land tenure customs. That adopted in the case of the Kikuyu, who farmed land owned under a form of individual ownership, was as follows:—(Kolbe and Fouche 1959.)

1. The people of a clan were persuaded by various propaganda means to adopt consolidation voluntarily.
2. A survey of all the clan-land in the particular sub-location was made. Within

this area the boundaries of all individual fragments were measured and recorded.

3. A committee of clan elders, and all district representatives of departments met to determine what areas should be set aside for public purposes (i.e., roads, churches, schools, hospitals, townships, etc.) These recommendations were then put to the clan elders for their approval. The area so approved was then calculated as a percentage of the total area and all members of the clan were required to contribute an equal percentage of the total area of their holdings for public purposes.
4. A committee of elders of the clan was set up to hear and settle disputes or complaints arising from the preliminary survey. Thirty days were allowed for such appeals.
5. The land remaining after that set aside for public purposes was re-allocated in consolidated holdings to farmers according to the size of their previous holdings. These new holdings were sited according to size—those which were defined as "sub-economic" (in this case less than four acres) were sited close to the village area, whilst larger holdings were sited, if possible, so as to incorporate any perennial crops previously planted by the farmer. Each new holding had an access road and access to water. In the case of farms incorporating tree crops planted by someone other than the new owner, then arrangements to the mutual satisfaction of both parties were made by private treaty.
6. The boundaries of the newly demarcated holdings were trenched by paid labour gangs preliminary to more permanent fences or hedges being established.
7. Any further disputes arising were settled and the holdings were then registered by the Government (a charge of 10s. per acre being made) and owners were given a registration certificate.

In the case of the neighbouring Embu and Meru people who owned land on a communal basis, the process was similar but disputes as to land ownership were settled at sub-clan level and the size of holdings allotted to individuals was determined by the sub-clan elders after consultation with the people.

The people of other tribes—especially the Kipsigis, Nandi, and Elgeyo—are primarily pastoral people but since the war they have become more interested in agriculture. These people have, of their own volition, enclosed much of their former communal lands into individual holdings. (Huxley 1960.)

Once individual ownership was established it became relatively simple to improve the standard of farming through more intensive planning, with the aim of supplying the farmer's subsistence needs and a minimum cash profit of £100 per annum. (Brown 1957.) With security of tenure smallholders were able to offer security for developmental loans.

Farm planning is most advanced in the Nyeri-Embu area and has been along the following lines:—(Brown 1957.)

1. The farm is laid out to provide five basic necessities.
 - (a) Homestead area;
 - (b) An area of permanent or semi-permanent cash crops and famine crops;
 - (c) An area of arable land adequate for the family's needs and some surplus to set aside against poor years;
 - (d) An area of temporary and permanent grass equal to or greater than the arable, which provides for keeping stock and for alternate husbandry; and
 - (e) A tree plot.
2. The layout of the farm is designed to suit possible future mechanical cultivation and to provide for soil conservation measures. Arable areas are divided into fields of equal size to enable a satisfactory cropping rotation to be practised. The decision as to the proportion of land to be apportioned to cash cropping is made by the farmer, but this is usually between one fifth and one quarter of the total farm area. Monoculture is discouraged because it is considered to be a dangerous practice on a small farm. (Kolbe and Fouche 1959.)
3. The outer perimeter of the farm is planted with a hedge and internal boundaries are planted with thatching grass or a hedge or are wired.

4. Once the farm is fully fenced into fields and all necessary soil erosion measures have been taken, provision is made for rotating the grass and cultivated areas and all the farmer's stock is kept on the holding.

5. When the farmer becomes self-sufficient in food and is using improved methods of cropping (e.g., application of manure, better spacing, etc.) then he becomes eligible for a loan for a specific purpose such as permanent fencing, dairy-shed, etc.
6. A cash crop is not introduced until the farmer has shown that he can farm his land and that his family is self-supporting. The cash crop—usually coffee but possibly tea or pyrethrum—is planted under carefully supervised conditions.
7. The farmer is encouraged to repay his loan as soon as possible out of the farm income. The maximum time for repayment is five years, and it is paid in yearly instalments plus interest.

The coffee produced by the planned farms has been of high quality, 60 per cent. being in the top three classes in 1959-60. (Clayton 1961.) This is no doubt due to the strict control kept by the pulper management committees (all African) which refuse to accept coffee from poorly managed blocks. Yields have been 8-12 cwt./acre with some to 15 cwt. Farmers are receiving a return of 8s. to 10s. stg. per tree per year (i.e., a minimum of £200 stg. per acre of coffee per year) and all farms in the coffee and tea areas should be able to produce a net profit of £35 to £50 stg. per acre of their farm per annum. (Kolbe and Fouche 1959.) Individual farmers are receiving a net income of £600 to £1,000 stg. per annum.

In 1960 difficulty was being encountered in the enforcement of loan repayment despite the obvious ability of farmers to repay. This was due to the prevailing political confusion at the time. There was a considerable lack of understanding of the meaning of the anticipated

"independence" of Kenya which many farmers thought would be accompanied by a revocation of all outstanding debts. Difficulty in obtaining repayment emphasises the cost of loan finance—it is estimated that there are 600,000 farms in Central Province which could readily and beneficially use a loan of £200. (Swynnerton n.d.) The initial injection of capital required to start off satisfactory development is considered by Kolbe and Fouche (1959) to be a minimum of £10 stg. per acre.

The productivity of the native breeds of livestock has been unsatisfactory and better stock are required. Improved Zebu types are being introduced below 5,000 ft. and selected local breeds to Jersey through artificial insemination above that altitude. Unless the productivity of livestock is improved they become a burden upon the farm which would be far more productive if planted entirely to crops.

There is no assurance that the consolidated holdings will not be re-fragmented. Legally it is impossible to subdivide holdings of less than eight acres but as yet this has not been tested. The enforcement of this law will lead to an increase in the present landless class.

This problem was first faced after the initial consolidation when a landless class—previously not known to exist—emerged. These people had been tenants on other people's land. They were settled on large re-settlement schemes designed especially for them. However, such schemes cannot be continually established and it will become necessary to educate Kenyas to change their traditional belief that without land a man is nothing, and to realise that in a cash economy there is room for a landless class which need be neither poor nor depressed. Consolidation has been followed by an intensification of agriculture, and most farms, especially those of more than 6 acres, require additional labour. (Clayton 1960, Brown 1957.) Thus there is developing a considerable need for paid agricultural labour, which should increase with increasing intensification of land use.

Land re-allocation in Southern Rhodesia.

In Southern Rhodesia until 1962 the land was apportioned so that natives farmed approximately 40 per cent. of the total land.

Native land was subdivided into Native Purchase Areas where farmers could purchase farm land, and Native Reserves where farming was carried out under traditional land tenure systems. Land in the reserves has become badly eroded as a result of overstocking and poor cultural techniques and with the population increasing at about two per cent. per annum the position is deteriorating annually. Following the success of farm planning of European farms from aerial photographs the technique has been introduced to native areas.

The procedure is as follows:—

1. Aerial photographs are obtained of the area and from these the land is divided into eight classes. (Classes I-IV being arable, V arable but wet, and the remainder suitable for grazing only.)
2. Within the reserves the land is re-allocated to individuals. This re-allotment is on the basis of available land rather than previously farmed portions, and arable and non-arable rights are given. The arable rights may be units of 8 to 12 acres, depending on the available clan land. Chiefs receive three units whilst other people receive one. The arable blocks are laid out along the contour and delimited by stone cairns.

The re-allocation of African owned land has not led to an increase in productivity, but it has slowed down, and possibly halted, deterioration through overgrazing. It has shown that simple re-organization of land tenure cannot, in itself, lead to economic development. To attain a real improvement in the African agriculture it will be necessary to devise better systems of agriculture. This should not be difficult, as alongside the African owned land there are European farmers obtaining 24 bags of maize per acre compared to the African's two to six bags. The secret is higher plant densities (15,000 plants per acre instead of 2,000) and the application of fertilizer (100 lb. N. per acre.) (Rowland 1959.) The poverty of the Africans prevents them from adopting such simple measures—to be able to do so they require credit facilities.

SETTLEMENT SCHEMES.

Settlement schemes may be used for several purposes:

1. to develop previously unused areas.
2. To introduce a more intensive agricultural system into an area.
3. To re-settle people from an over-populated area in an area of relatively low population density.
4. To enable progressive farmers to break free from the conservative influences of their traditional society.

If a settlement scheme is to be a success there must first be available accurate information regarding the various factors determining its agricultural potential. Thus a preliminary survey is required to determine the soil fertility and the carrying capacity of the land. A land use system capable of maintaining fertility and providing a satisfactory return to the farmer must be available. The projected individual holdings must be of a size capable of supplying food, and an acceptable, and improving, standard of living for the average farmer. There should also be provision for progressive farmers to expand their holdings and so reserves should be set aside for future allocation.

No full scale settlement scheme should ever be attempted without a successful pilot scheme.

Settlers should be carefully selected and should receive training in the new techniques of agriculture involved in the farming of their holdings. They should be required to live within the settlement from the earliest possible stage of development. They may require financial assistance until their crops are harvested. In addition both long term and short term credit should be available. Settlers should be expected to pay for all direct services they receive and if they cannot do so over a period then the scheme can be considered a failure.

Security of tenure is essential for any satisfactory agricultural development and after serving a probationary period settlers should be given long term leases at economic rentals. Adequate safeguards should be incorporated in the leases to ensure that a satisfactory standard of husbandry is maintained.

Farm Settlements in Western Nigeria.

The Western Nigerian Government has embarked upon an ambitious programme of Farm Settlements. These are located in each district of the Region and are so designed that each settler should be able to receive a net cash income of up to £600 stg. per annum (i.e., considerably more than a Government clerk with eight years schooling). The twin aims of these settlements are to demonstrate that scientific farming, supported by capital investment offers a return at least equal to that of city employment, and to increase the production of Western Nigeria (both on the settlements and through example to other farmers).

The lay-out varies according to the crops. Each settlement is planned to cater for 150 farmers to be settled over a five year period.

ESA-OKA Farm Settlement.

Each individual farm is planned to consist of—

- 15 acres cocoa;
- 5 acres Robusta coffee; and
- 5 acres arable.

The aim is to establish ten acres of cocoa before the farmer takes over the land. Each block will have a well-built house and the farmer will be supplied with the necessary tools and planting materials by the Ministry of Agriculture.

ORIN Farm Settlement.

This is similar to Esa-Oka but instead of Robusta coffee the secondary crop is citrus.

MBIRI Farm Settlement.

This is located in the wetter Benin Delta Area (rainfall 70in.-80in.) and is based on rubber and oil palm. Each farm consists of—

- 20 acres oil palm;
- 10 acres rubber; and
- 1 acre food garden in the settlement village.

The Settlement is so planted that each farm has rubber and oil palm blocks adjacent within the farm and contiguous with those in

the neighbouring farms. Cattle will be owned communally and will graze between the oil palms.

This settlement requires labour in addition to the farmer-owners and this labour will be located in planned villages in the settlement.

Ogbsomosho and Ilora Settlements.

These two settlements are based on maize cultivation and are in the savannah country north of Ibadan where the 70 inch rainfall is divided into two seasons. Each settler will have a holding of 70 acres and this will be cultivated so that 35 acres is under maize at any one time. (The rotation will be maize/maize continuously for three years and then fallow.) The aim is to mechanize the cultivation as much as possible, using contract equipment, and to control weeds with chemicals. Yields are expected to be ten cwt./acre. It is not planned to sell the maize direct but rather to feed it to poultry and pigs which will be farmed in intensive units in decentralised villages on the settlements (four villages/settlement). By doing this it is hoped to maintain a steady £20 per ton for the maize—if it were sold on the open market in Western Nigeria the price would slump to £10 or less per ton.

The cost of each settlement scheme is calculated to be about £1,500 stg. per farm unit (i.e., up to the stage when the unit has permanent housing and is self-supporting). Naturally clearing costs per acre vary with the crops. The maize farms were cleared and contoured, either by hand or heavy equipment, at a cost of £11 per acre whilst the cost of clearing the Mbirri farms was £45 per acre.

The planned programme of establishment of the Farm Settlements was:—

1960.—First batches of settlers were to go straight to the Settlement sites to obtain "on site" practical training and also to work as paid labour. The second and third batches of settlers were to enter one of the five Farm Training Institutes and there receive instruction in all the crops that are to be handled on the settlements (i.e., rubber, cocoa, coffee, oil

palm, vegetables, subsistence crops). There is a strong emphasis on the practical side at the Training Institutes.

1961.—The first batch of settlers were by then to have taken up their own blocks which at this stage were to be self-supporting. The second batch of settlers after one year at the institute were to take up their blocks after assisting in their establishment.

1962-4.—The third and subsequent batches of settlers, after two years at the Farm Institute, were to take up their blocks after assisting in their establishment.

The following are standard requirements for the settlements:—

1. The potential settlers are selected young men from the 18-22 age group who have received education to sixth standard and who have shown a desire and an aptitude for farm work and who live within a 30 mile radius of the settlement.
2. All labour in the developmental stages is paid for—i.e., there is no "voluntary" forced labour.
3. The settlers enter into an agreement with the Ministry of Agriculture to farm their blocks according to direction from its approved agent. Settlers failing to maintain a satisfactory standard of husbandry are to be dispossessed. A probationary period must be undergone before the settler can receive a long term lease.
4. The settler receives a long-term mortgage on the farm and this is to be re-paid in annual instalments.
5. The blocks may be inherited but not sub-divided.

The Farm Institutes, although established primarily for the Settlement scheme, are to be a permanent feature of the Region's Agricultural Education Policy.

It is too early to give an appraisal of the scheme but the farms based on the tree crops appear sound and should be successful. The prospects for the maize farms, however, appear dim. They were established for political reasons and without any prior experience in the large scale cropping of

maize and thus without knowledge of the agronomic problems, such as the build up of insect pests, which will occur. The produce is to be marketed in a roundabout way, which may appear theoretically possible, but will probably be beset with practical difficulties.

Makueni Farm Scheme, Kenya.

The Makueni area is waterless and tsetse infected and has an unreliable rainfall of 20-30 inches. It was in this area that families from the neighbouring crowded Mackakos area were settled. Settlement was under a "crash programme" during the Mau Mau Emergency.

The plan was to settle families onto holdings of 22 to 30 acres with five acres under crop. The Government provided dams and roads and eliminated tsetse by discriminatory clearing of bush. The holdings were prepared for the reception of settlers by clearing and ploughing five acres of land and all necessary soil conservation measures were taken.

Settlers were carefully selected and were rationed during their first year. Holdings were registered and security of tenure ensured, provided that the settler maintained a satisfactory standard of husbandry. No subdivision of blocks was permitted. Strict rules regarding stocking rates were laid down. Settlers were to clear one acre of bush per year and to put one acre of cultivated land out to grass. It was thus intended to clear the blocks completely over a 20-25 year period.

The rules laid down for the bush clearance and cropping programmes could not be enforced and bush encroachment became an extremely costly problem which remains unsolved. By 1958 more than 2,000 families had been settled on the scheme at a cost of more than £200,000 stg. but few of these remained for long. In 1960 the scheme was virtually abandoned pending the introduction of a satisfactory farming system.

Although strict husbandry and sound land tenure rules were made the scheme has been an apparent failure. This was caused by the lack of any proven farming scheme for the area. There was no previous experience of farming the area and no pilot scheme was attempted.

CO-OPERATIVE AND PARTNERSHIP SCHEMES.

These schemes are a modified form of group tenure and aim at the combination of the incentive of ownership with the technical advantages to be gained by large scale agricultural methods. The communal farms of the Communist countries are a particular form of this type of ownership. They are liable to inefficiencies if the incentive for individual enterprise is decreased too greatly.

There is a large variety of this type of scheme combining in differing degrees the principles of individual and joint ownership. In some, ownership and cultivation remain individual, and machinery only is hired or used on a co-operative basis. In others land ownership is merged to a degree and most farm operations are conducted jointly. The communal farms of Eastern Europe are so organized that the members are organized into work "brigades" which are assigned to special tasks. The net proceeds from co-operative farms are divided amongst the members on different principles depending upon the organization of the farm. Generally there is a limit upon the amount of rent paid and most of the proceeds are divided according to the quality and quantity of produce produced by each member.

Partnership schemes are a specialized form of co-operative in which the Government or some other authority provides the capital, technical skills and supervision, and the farmers provide labour and sometimes land. To be successful, partnership schemes require certain pre-requisites.

1. Considerable knowledge as to the proposed land use must be available before the scheme commences full scale operation.
2. The topography of the area chosen must facilitate large scale cultivation and intensive supervision.
3. There must be a low capital development cost per productive area.
4. There must be an active external demand for the crop produced and its marketing should be so controlled by the management that it is able to recoup all its costs, and especially advances made to farmers.
5. Farmers should have security of tenure provided they work efficiently.

The difficulty of obtaining such pre-requisites limits the application of partnership principles but a realisation of their need will assist in planning development projects.

The Gezira Scheme of the Sudan.

Possibly the best known of all partnership schemes is that of the Gezira. (Gaitskell 1959.) There are 1,750,000 acres under cultivation (including 800,000 in the New Managil extension) and the scheme directly supports over 600,000 people as well as being the economic backbone of the Sudan.

Originally the vast Gezira plain between the Blue and White Niles south of Khartoum was farmed by Arab peasants who were semi pastoral. They planted their staple crop of sorghum in fields surrounded by low earth banks which prevented rain-water from running off. When the crop was harvested they left their villages to seek grazing further south. Land was owned by large landlords as well as small farmers. It was inherited under Moslem Law, and this results in the repeated sub-division of land so that the stage is often reached where land owners have so little land that they are unable to support a family on it (Tothill 1948.)

From 1906 to 1910 all native owned land in the Gezira was registered, and rigid land sale laws were enforced to prevent land speculation by foreign interests.

The first cotton grown under irrigation in the Sudan was harvested in 1906 at Zeidab on the main Nile north of Khartoum. This was grown by an English company which was later asked to manage the small experimental irrigated cotton project which the Government established at Tayiba in the Gezira in 1911. This project at first consisted of 600 acres of land rented from the native owners and sub-divided into 30 acre blocks. These were leased to tenants who cultivated the blocks under the supervision of the company's staff. The Tayiba project proved more successful than the Zeidab one and it was expanded, and in 1913 an agreement drawn up to distribute profits in the following proportions:

- 35 per cent. to the Government;
- 25 per cent. to the company (Sudan Plantations Syndicate Ltd.); and
- 40 per cent. to the tenant.

The Government realised that if the scheme were to be expanded it would be necessary to re-organise land tenure in the Gezira. Under the Gezira Land Ordinance of 1921 it leased all land in the area at 2s. per acre per year. (This was the highest ruling rental of unirrigated land at the time.) The land was then to be sub-divided into economic units let by the State to tenants.

In 1919 negotiations were commenced for a new agreement which was eventually finalized in 1926. Under this agreement the profits from the sale of the cotton were divided in the following proportions:—

- Government 40 per cent.;
- Syndicate 20 per cent.; and
- Tenants 40 per cent.

In 1927 a sister company of the Syndicate, the Kassala Cotton Company, was granted a concession of 45,000 acres in the western Gezira. This company received a slightly larger share of the profits than did the Syndicate.

The responsibilities of the parties to the agreement were:—(Tothill 1948.)

Government:—Provision of the land; construction, maintenance, and operation of the Sennar Dam, the Main Canal, and the main canalization; payment of rents for the land.

Concession Companies:—The construction and maintenance of subsidiary canalization; the clearing and levelling of land; the provision and working of ginning factories; the provision and maintenance of buildings, machinery, stores and supplies required to enable the companies to carry out their functions; the general management and supervision of letting of land, the cultivating by the tenants; the collection, storing, and marketing of the cotton crop (including seed); the making of loans to tenants.

Tenant-Cultivators:—The growing of crops under supervision of the Companies, and the provision of the necessary labour.

The original 30 acre tenancies were later expanded to 40 acres. (The new Managil extension has 15 acre tenancies and a slightly different rotation system to the original Gezira.)

After June, 1950, the Syndicate ceased operating and was replaced by the Sudan Gezira Board which continued its activities.

After the formation of the Gezira Board in 1950 the allocation became:—

- Government 42 per cent.;
- Tenants 42 per cent.;
- Gezira Board 10 per cent.;
- Tenants' Reserve Fund 2 per cent.;
- Local Govt. Councils 2 per cent.; and
- Gezira Social Development acc. 2 per cent.

Tenancies are of one year's duration but are renewable provided that the tenant maintains satisfactory cultivation standards.

Original allotments were made to:—

1. Right Holders;
2. Nominees; and
3. Preferential Tenants.

Right Holders were those who originally held 40 acres or more and these had the final claim. The right holder could either cultivate himself or appoint nominees to farm the land; he normally could cultivate only one holding himself, unless the Syndicate representative agreed to more. Sons of right holders were included in this category.

Nominees were pre-scheme cultivators or relatives of the class above. Where there were several claimants to a 40 acre holding, they selected one of their number who thus became a right holder. Right holders and legal nominees were given tenancies unless they had bad cultivation records; in such cases they were persuaded to nominate someone else. In the case of nominees other than heirs, the Syndicate was not compelled to accept those with bad records.

Preferential tenants were those who owned between 20 and 40 acres, and therefore did not qualify as right holders. This class was allotted tenancies in preference to landless men.

After the claims of these three groups had been satisfied further allocations were made to those considered suitable after consultation with the native authorities concerned.

All proceeds realised from the sale of cotton products, lint and seed are credited to the "Joint Cotton Account." From this account are

deducted all costs incurred after delivery of the cotton crop to the collecting stations until its ultimate disposal. These include, amongst others, the costs of ginning, sacks and baling materials, transport, insurance, freight and marketing expenses. All fertilizer and pesticide costs are also deducted from this account. The balance is then divided according to the above formula.

Individual accounts are kept for each tenant and against these are debited any advances made for clearing, cultivation and picking. Payments are made to tenants in two stages:—

1. Initial payments are made on the basis of the quantity and quality of the tenant's cotton.
2. Later payments are made on a flat rate irrespective of grade and paid out when the tenant's needs for cash are most acute.

The Tenants' Reserve Fund has a statutory maximum of £3 million stg. which is financed from the profit distribution and from the "spillover" of the Board receipts (i.e., the excess of receipt over calculated requirements of the Board). If the statutory maximum is present in the Reserve Fund the "spillover" is shared amongst the tenants.

Besides providing a livelihood for the families of its 40,000 tenants the scheme requires about 200,000 pickers from outside the area. (Sudan Gezira Board 1959.) This large seasonal labour requirement is one of the weaknesses of the Gezira scheme and it was in an effort to reduce the dependence of the tenants on outside labour that the Managil Extension was subdivided into tenancies of 15 acres rather than 40 acres. The aim of the smaller holding is to employ fully the tenant's family and at the same time to require little outside labour. It is hoped that this will also increase the productivity per acre.

There have been many efforts to emulate the Gezira scheme but few have been successful, and some have been notable (and costly) failures. (For one see Baldwin 1957.)

Kongwa Farm Settlement Scheme, Tanganyika.

This is a partnership scheme in which tenant farmers and the Tanganyika Agricultural Corporation combine to produce ground nuts and beef at Kongwa, one of the sites of the unsuccessful East African Groundnut Scheme.

In 1960 the scheme involved 110 farms of ten acres under crop and one acre under food and communal grazing sufficient for 20 head of cattle per farmer.

The farms are laid out on suitable soils as compactly as possible and on the contour. Farmers receive an annual leasehold which is renewable provided that satisfactory standards of cultivation are maintained by the farmer.

The following rules apply to all tenants:—

1. The tenant is not permitted to transfer in any way his right to the farm to any other person.
2. The farmer must personally occupy and cultivate the farm.
3. All cultivation must be diligently carried out according to the directions of the Corporation's Manager.
4. The farmer is not permitted to sell or let any grazing on his farm.
5. The farmer must pay for all goods and services rendered to him by the Corporation annually when his crops have been sold. If a farmer is unable to pay his debts to the Corporation from his receipts from the sale of his crops then the Corporation sells sufficient of his cattle to cover its charges.
6. The farmer is not permitted to pledge his crops to persons other than the Corporation.

The Corporation provides the following services:—

1. All services considered necessary to assist the farmer to cultivate and manage the farm efficiently.
2. All mechanical cultivation.
3. Water supplies for stock and domestic purposes.
4. Necessary credit facilities for the farmer's crops. The farmer receives a net return equal to the gross amount received by the Corporation for the farmer's crops, less all charges incurred by or due from the farmer to the Corporation and all amounts due from him in respect of goods and services supplied to him or loans made to him by the Corporation.

In addition to the above regulations which apply to the arable area the farmer must abide by special Animal Husbandry Regulation. These require the routine dipping of cattle and castration of all male calves. (Bulls are provided by the Corporation). No male cattle may be sold to persons other than the Corporation but females may be sold to the farmer's choice of buyer. The Corporation hires to farmers in-calf cows and the calves become the property of the farmer. There is a limit on the number of cattle that a farmer may graze. Cattle are grazed communally in accordance with Corporation requirements to ensure the best possible pasture management.

This scheme has evolved from an earlier one where the emphasis had been on crop production and the holdings were of 20 acres incorporating two different soil types. Heavy fertiliser applications were required but the tenants were not prepared to pay for the fertiliser. The average return on the holdings was £27 per annum plus food. Tenants did not stay long and many were unable to repay their debt to the Corporation. Since the re-organisation of the scheme to give more emphasis on grazing there has been an improvement in the income of the tenants, and the Corporation has been able to ensure that all its loans are repaid. Cattle are the main source of income on the new scheme and the nearby Tanganyika Agricultural Corporation's Cattle ranch provides a ready market for all surplus stock.

CONCLUSION.

From the foregoing it is obvious that for any rationalization of peasant agriculture to be successful it is essential that certain prerequisites be met. These are:—

1. A proven farm system must be available for the area. This system must be more productive than that prevailing under the traditional land usage—i.e., there must be a changeover from extensive to intensive farming.
2. Farmers must be given security of tenure of their holdings. This may be in the form of freehold or leasehold. There should be provision made for forfeit if a satisfactory standard of husbandry is not employed.

3. Financial assistance must be available to farmers so that their standard of farming may be raised.
4. Safeguards must be incorporated in the title to ensure against fragmentation, through inheritance or for other reasons, to sub-economic holdings.

The necessity for pilot programmes and for their slow development emphasises the need to commence such programmes in Papua and New Guinea. Already there are small settlement schemes in the Gazelle Peninsula, Northern and Central Districts, and valuable experience is being gained through these. It is doubtful, however, whether settlement schemes will ever be the main means of rationalizing the agriculture of this country. They are expensive [Hasluck 1962 estimates £5,000 for the development of each block, which may be excessive, but is probably of the right order when all auxiliary services are charged for], and there will be great difficulty in providing the large areas necessary for them from existing areas of Crown Land. The present attitude of most native landowners is that they will not dispose of land to the Crown and this attitude is unlikely to change. It therefore seems necessary to introduce additional schemes and consolidation appears the most suitable. Settlement schemes should probably be reserved for those people who have no land suitable for agriculture but who wish to develop agricultural blocks.

Any pilot consolidation programme should be carefully sited as it will prove to be the key to success or failure of later schemes. It should be located in an area which has all the factors necessary for success.

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The Soils of Bougainville Island—Their Distribution and main Characteristics in Relation to Agricultural Development

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Introduction.

THE nature of the country, the distribution of the soils in relation to landscape, the characteristics of the main soil types and their agricultural potentialities have been surveyed. Only the areas which topographically appear suitable for future development have been examined, while the extensive area of topographically difficult and dissected mountain country has been omitted.

A provisional map shows the approximate areas and locations of the main soil associations with an indication of areas considered suitable for extension of agricultural activity.

Location.

Bougainville Island, principal island of the northern group of the Solomons, extends in a north-west south-east direction from 5 degrees 26 minutes to 6 degrees 52 minutes south latitude and from 154 degrees 39 minutes to 155 degrees 59 minutes east longitude.

The area is about 3,880 square miles. Administratively the island is part of the Trust Territory of New Guinea and has a population estimated at 46,000.

Natural Conditions.

I. TOPOGRAPHY—

Well over 80 per cent. of the island lies 500 feet or more above sea-level. The northern mountain ranges are part of the Emperor Range, with its highest point the active volcano Mount Balbi (9,000 feet.)

The southern section is dominated by the Crown Prince Range, the Deuro Range and Tonolei Harbour Mountains. The volcanic

Mount Takuan-Taroka-Loloru complex constitutes a separate mountain area to the south-west. A number of extinct and dormant volcanoes are present in the Crown Prince Range. The active volcano Mount Bagana (6,560 feet), which is part of the range, is separated from Mount Balbi by a low saddle, which gradually slopes down towards Wakunai on the east coast.

Narrow strips of coastal lowland are present on the west, north and east coast. Owing to the presence of a coastal levee the lowland remains in marshy condition for most of the year. The coastal plain is separated from the rugged mountains by low foothill country, only a few miles wide. An extensive coastal plain has developed along the south-east, south, and south-west coast from Toimanapu Bay to Torokina. It comprises gradually sloping dry lowland country along the Loloru-Taroka-Takuan complex, varying in width from two to six miles, and flat swampy alluvial country several miles wide along the coast.

The eastern portion of the plain, the Lolui river area, is separated from the southern Buin-Siwai plain by the Deuro Range. On the north-west coast, north of the Jaba River towards Torokina, the coastal plain narrows and is in a permanently swampy condition.

The extreme northern part of the island is a raised coral limestone peninsula.

I.2 *Morphology—*

Like New Britain, the island of Bougainville is essentially of continental, rather than of volcanic origin. The mountain core of Emperor and Crown Prince Ranges consists of axial fold ranges, which are composed of metamorphics (altered shales, phyllites, quartzite and silicified

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grit) in association with porphyries (breccias and conglomerates). The basement rock has been covered by Upper Tertiary sediments and volcanic products.

Vulcanism has been intense and of paramount importance in landscape development. During late Miocene or possibly early Pliocene explosive vulcanism occurred along the east coast and a cover of fine volcanic sand was deposited over the older landscapes. The origin of the natural harbours (Raua Bay, Teop Harbour, Tinputz Harbour, Kieta Harbour and Tonolei Harbour) has been connected with this vulcanism.

During the Plio-Pleistocene era volcanic activity along a subsiding coastline gave rise to the deposition of thick strata of grey liparitic coarse sand. This sand underlies the main soils of the southern coastal plain. The grey coarse sandy and gravelly deposits of Mount Balbi, Mount Bagana (and dormant twin volcano Billy Mitchell crater lake) on the east coast between Tenekau and Arakawau are supposedly of the same age.

A layer of fine grey brown sand and gravel, originating from an intermediate magma, is often found superimposed on the grey sands.

The volcanoes of the Takuan-Taroka-Loloru complex consist of yellow-brown andesitic tuff, as do the active volcanoes and foothills.

In the wide environment of active vulcanism, sandflows carrying rock-fragments, besides pumice, are common.

Recent air borne (aeolian) products are found as layers of fine sand, silt and pumice, covering the soils derived from old rock or tuff. There is a definite variation in these deposits, which is mainly related to the age of the eruptions, composition of the magma, distance and direction from the eruption centre, and power of the eruptions. As a result these recent deposits are heterogenous in composition.

1.3 Climate and Hydrology—

The climate at low elevation is warm and humid. Maximum and minimum day temperatures at sea level are in the order of 90 degrees F. and 70 degrees F. respectively. The main rainy period occurs during the north-west monsoon.

The northern coast of the island receives less rainfall than the south-eastern and southern

part, where the south-east trade winds bring a higher precipitation.

Rainfall figures vary from 90 inches at Raua in the north and 90 inches to 120 inches on the central east coast, to 200 inches in the south-east at Toimanapu.

The south coast receives an average annual rainfall of 120 inches, with an increase to the west. An exceptionally high rainfall year has yielded to 250 inches. Soraken on the north-west coast has the lowest average annual rainfall with 75 inches.

Sparse rainfall records indicate the absence of long periods of pronounced drought; a favourable circumstance on the highly permeable soils. However the high rainfall causes heavy leaching and impoverishes plant-nutrients in the sandy soils, as well as impeding drainage in part of the andesitic tuff loams.

Unfortunately the high humidity, particularly in the southern plain, creates optimum conditions for fungal diseases.

Numerous streams with permanent water rise in the forested country. Some of these have sufficient capacity and fall to generate hydro-electric power. A few rivers discharge sulphuric water from areas of active vulcanism and crater lakes; others transport large amounts of sand and volcanic debris, which have been deposited over large tracts of floodplain.

1.4 Vegetation—

The mountain ranges are covered by dense tropical rainforest consisting of several tree storeys and with a reasonable to dense undergrowth of shrubs, weeds and vines. On the lower foothills timber of commercial value is often present in exploitable quantity, but access is a big problem.

In the Buin-Siwai coastal plain good primary forest is scarce, owing to a relatively dense population, and the shifting cultivation system of agriculture. Vast areas are covered with secondary growth, poor in species and of variable age. In the older re-growth, *Pometia* sp. and *Canarium* sp. are common. *Imperata* grasslands are scarce and are mainly confined to the northern coral limestone peninsula and Baniu Hill. Swamp forest is common in extensive areas of the poorly drained coastal plains. Permanent swamps are covered with grass and reed vegetations.

II. SOILS IN RELATION TO LANDSCAPE—

In broad design the soil formation shows a close correlation with the parent material. As a result of strong volcanic activity much of the old landscape has been covered by volcanic ash, and this is reflected in the presence of ash covered soils over large areas. The soil pattern is discussed in following paragraphs in connection with the main physiographic regions, and the main soils are described and discussed in more detail under Soil Profile Descriptions.

II.1 *The northern raised coral limestone peninsula—*

The peninsula is approximately 15 miles long and five miles wide.

It comprises an uplifted coral shelf composed of coral limestone, fringed by a narrow discontinuous strip of flat lower coral shelf of white coral sand. The topography is slightly undulating and dolines (sinkholes) are characteristic.

On the lower coral shelves no soil development is apparent and the soil is merely a dark humic coral sand over fresh white coral sand.

Owing to accretions of volcanic ash, the soils derived from coral-limestone show variations, which are expressed in differences in colour and consistency.

The soils of relatively pure coral-limestone origin are mainly red to red-brown permeable clays (terra rossa), whereas those of mixed ash and limestone derivation are brown-yellow heavy textured clays.

The soils in general are very heterogenous in respect of depth of solum, shallow phases being more common than deep, while rock outcrops appear in many localities.

The natural vegetation is a mediocre forest, interspersed with *Imperata* grasslands.

The coral limestone soils grow healthy and productive coconut palms along the coast.

II.2 *The northern section of the Emperor Range with foothill country, flat to slightly undulating lowland and intermittent narrow coastal plain.*

The red and yellow clay association is only found on the steep mountain ridges, where these soils are severely truncated.

In the northern and eastern foothill country of gentle topography, the original profile has been preserved in ash-covered red and yellow clay soils. The cover-profiles are brown-yellow loamy sands, derived from a grey-brown volcanic fine sand. The sandy ash cover originated from extinct volcanoes in the area and is almost absent on the foothills west of the Emperor Range.

The red and yellow clays on the ranges are of very restricted agricultural importance. Severe limitations on their use are imposed by steep topography, inaccessibility, shallowness, and impermeability of the subsoil.

The presence of a light textured covering layer however, particularly when it reaches a reasonable depth, provides for the ash-covered red and yellow clays favourable characteristics for agriculture. Although the apparent porosity of the cover profile suggests droughtiness for shallow rooting crops during a dry spell, this is not likely to occur, as the upper horizon of the cover profile preserves moisture for the crop. On the other hand, conditions of impeded drainage could occur in shallow cover profiles in flat locations under excessively wet conditions, but these could be prevented easily by correct drainage measures.

The ash-covered red and yellow clays have the potential for growing a variety of foodcrops, besides plantation crops, such as coconuts, cacao, coffee, and rubber.

II.3 *The slope and foothill country of Mount Balbi—*

The steep volcano Mount Balbi consists of andesitic material. The lower flanks are covered with soft andesitic tuff. This material is presumed to be of late Pleistocene and of Recent age and has weathered into juvenile yellow-brown friable sandy loam and silt loam.

Soils derived from older tuffs of Pliocene age show a more advanced stage to maturity. The latter soils have a higher clay content to depth, while the colour varies from red-brown to red. These red-brown clayloams are present under covering ash layers on the lower slope and in the foothills.

The covering layer, which is seldom less than two feet deep, is composed of material of variable particle size and contains much

pumiceous sand. Its solum development is only at an early stage and is restricted to the formation of a thin layer of yellow-brown sandy loam of favourable physical properties. These soils are highly fertile and have a high agricultural potential. Special management however will be required to preserve the fertility.

Annual crops produced in the area include maize, rice, peanuts, indigenous food crops, and tobacco of a good quality.

Plantation crops are mainly coconut and cacao, which are highly productive. Extension of existing agriculture is unfortunately limited by steep topography and dissection, and would not be possible much further than a few miles away from the coast, in the area between Uruai River and Wakunai.

The area on the western slope of Mount Balbi, south of Kiakara is of the same agricultural potential, with possibilities of development. Access to this area is difficult, however, because of an exposed coastline.

II.4 *The saddle between Mount Balbi and Mount Bagana, fanning out into coastal lowland and adjacent lower hill country of Mount Bagana and Mount Billy Mitchell—*

As a result of recurrent eruptions of Mount Bagana, its dormant twin volcano Billy Mitchell (with crater lake) and Mount Balbi, the country is covered with thick deposits of gravelly, sandy, and silty ashes. The coarser material has been transported in sandflows, while the fine sandy and silty ash strata are predominantly aeolian.

The recognition of separate soils is complicated, as the deposits originate from various eruptions and show an irregular stratification of material of variable granular size.

Thin organic layers of destroyed vegetations which have been found in the soils, would enable the ages of successive eruptions to be determined by radio active carbon 14 tests.

A general characteristic of the soils is that profile development is extremely limited; it does not go beyond the formation of a thin layer of sandy loam over the loose volcanic material.

The ash soils are freely permeable and have an apparently low waterholding capacity by virtue of lack of a clay fraction. This applies

in particular to the compact grey coarse sandy and gravelly ash soils, which occupy a large area of the east coast between Tenekau Plantation and Terara. The latter sands are, in addition, somewhat cemented, and consequently water absorption and root penetration are impeded.

Coconut palms on these dry sands show unsatisfactory development and are unproductive. The natural vegetation consists of low primary forest.

Ash soils with strata of coarse sand, alternating with layers of fine sand and silt ash, have improved soil moisture conditions. These soils are of higher agricultural value, in particular for plantation crops, under the conditions of well distributed rainfall. Even in depressed areas, where the groundwater level is normally high, palms grow well, provided that the land is sufficiently drained.

Ash soils composed of fine grey sandy ash or silty ash overlying grey coarse sand and gravel occupy the area from Mount Bagana and Mount Billy Mitchell towards the coast, approximately between Tarara and Arakawau River (Vito Area). Their agricultural value depends mainly upon thickness of the aeolian deposits. The difference in fertility between deep and shallow phases is reflected in the natural vegetation, which ranges from good quality rain forest on the deep, to scanty low forest on the shallower ones. Ash covered andesitic clayloams are found in higher locations around the periphery.

II.5 *The Crown Prince Range and alluvial lowland—*

This landscape consists of rugged mountain country with steep foothills and narrow isolated coastal plains. Soils consist of red and yellow heavy clays of mixed metamorphic-porphyrific origin and of redbrown andesitic clayloams in areas of extinct vulcanism. The soils have been exposed to severe truncation, and barren rock is present in many locations.

Agricultural development is restricted to a strip of foothill country and to the alluvial soils of the narrow coastal plain and valleys. The latter soils are heterogenous and are composed of alternating strata of brown medium clay and heavy clay overlying gravelly clays.

PROVISIONAL SOILS MAP - BOUGAINVILLE



BUKA IS.

SOLOMON ISLANDS

South Pacific Ocean

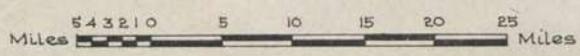
BOUGAINVILLE IS.

ISLANDS

LEGEND.

- Areas suitable for agricultural extension
- ▨ Coral limestone soils.
- ▧ Red brown and yellow brown clays.
- ▩ Fine sand ash covered red brown clays.
- Silt ash covered andesitic tuff loams.
- Silt ash soils.
- ▬ Gravel soils.
- ▭ Pumice ash soils.
- ▮ Brown yellow andesitic tuff loams/clay loams
- ▯ Pumice ash covered andesitic tuff loams.
- ▰ Coarse sand ash covered red yellow brown clays.
- ▱ Coarse sand ash soils.
- ▲ Coarse sand and pumice ash soils.
- △ Silt ash covered coarse sand.
- ▴ Andesitic tuff covered coarse sand.
- Alluvia.

NUMBERS REFER TO DESCRIPTIONS IN ARTICLE.
Solomon Sea.



The alluvial clays are exclusively occupied for copra and cocoa production. Deep drainage and discharge of superficial run off are prerequisite measures for development.

The sedentary red and yellow clays on adjacent steep hill country are less productive than the alluvial soils. Although there are several centres of extinct volcanism in the Range, steep topography has prevented the formation of ash covered soils. Where these soils are found however, as fine ash sands over red-brown andesitic clayloams (Arawa), they are very productive plantation soils.

II.6 *The Mount Takuan-Taroka-Loloru foothill country and coastal plain of south-east and south Bougainville—*

Yellow brown loams and clayloams, derived from fine textured soft andesite tuff deposits and of the same composition as the soils of the Mount Balbi lower slope, cover the slope of this mountain complex and of the Deuro Range. The tuff is present as a thick deposit of yellow-brown soft rock, gradually decreasing in thickness towards the plain, where it covers the stratified fine brown sands, gravel, and grey coarse volcanic sands, originating from older liparitic sand flows. The tuff consists essentially of consolidated aeolian material of volcanic origin and disintegrates easily into fine sand under atmospheric influences. In the wet condition it has a distinctly greasy consistency. Denser layers of cemented sandy ash are often present and these soft "pan" formations commonly cause impeded drainage. Soil formation has only reached a juvenile stage and depth of the solum usually does not exceed two feet.

The soils are mainly friable grey-brown to yellow-brown sandy or silty loams, with red-brown variants of a more clayey texture.

Unfortunately these soils are frequently present as shallow phases, in particular west of the Puriata River in Nagovissi District, and there is a potential danger of waterlogging in these soils in cases where they occupy flat locations. Lateral water movement averts this possibility to a certain extent, but under all circumstances drainage measures are recommended. Growing conditions for tree-crops in particular will be improved considerably by deep drainage and the preparation of planting holes prior to planting.

Volcanic gravel and coarse pumice soils occur in central and east Siwai, between Hongorai and Mivo Rivers. Their agricultural value depends on the depth of the gravel layers below the surface and on the density of this material. The major part is either shallow or even skeletal.

The southern coastal plain has an elevation which ranges from sea level to about 300 feet. The higher elevations have well developed drainage ways, whereas the lower part is liable to periodic flooding and remains in a poorly drained condition throughout the year.

Owing to these adverse hydrological conditions this part of the plain has practically no agricultural value. This applies not only to the alluvia of the southern and south-western plain, but also to the low lying alluvia of the south-eastern Luluai plain.

III. SOIL PROFILE DESCRIPTIONS AND DISCUSSION—

In the following paragraphs more detailed descriptions of representative soils are given and where possible comparison is made with similar soils elsewhere.

III.1 *Coral limestone soils—*

With the exception of a narrow fringe along the coast of friable well drained red-brown to red calcareous clays of variable, but mainly shallow depth (Terra rossa), the soil profiles are typically of the following composition:—

0-12 inches.—Brown granular clay loam, in wet condition sticky and moderately plastic, cracking when dry; some accumulation of organic matter in the surface two inches, gradually grading into

12-24 inches.—Red-brown clay, in dry condition angular blocky and heavily cracking; in wet condition very sticky and very plastic, in this condition impermeable; good waterholding capacity.

24-40 inches.—Brown-red heavy clay, characteristics as for previous layer; internal drainage and water penetration very slow; irregularly grading into

40 inches +.—White compact coral limestone.

These heavy textured soils show a great similarity to the coral limestone soils of New Ireland. An elaborate investigation into the

chemical properties of the latter soils has revealed a close correlation between potassium content and productivity of coconut palms.

No indications of serious decline in productivity of coconuts are known from coral limestone soils of Bougainville or adjacent Buka Island, which is doubtless attributable to a certain potash-enrichment by volcanic ash.

For general agriculture the coral limestone soils are not attractive, being limited by heavy texture and the danger of droughtiness during periods of low rainfall.

III.2 Red-brown and yellow-brown clay soils—

A representative profile of these soils shows the following average composition:—

0-12 inches.—Grey-brown loam to clayloam, crumbly permeable, friable, good water-holding capacity, containing organic matter in the four inch top-layer, where under forest.

12-18 inches.—Reddish-brown clay, weakly cloddy, permeable, good waterholding capacity.

18-36 inches.—Yellow-brown clay, weakly compacted and cloddy, increasingly sticky and plastic in moist condition, containing concretions, reasonably permeable.

36-48 inches.—Greyish-brown and yellow mottled medium clay, compact, sticky and plastic when moist, containing angular blocky aggregates of heavy clay and an increasing amount of soft blue concretions; impeded internal drainage; good water-holding capacity.

48 inches +.—Decomposed, weathered out parent rock.

These soils occupy extensive areas of steep and dissected mountain country in the interior, where the topographic aspect minimizes agriculture to extensive shifting cultivation. Their fertility is mediocre to poor by local standards. On the lower foothills of Regions two and five (ref. II.2 and II.5) these clays are important as part of ash covered profiles.

III.3 Ash-covered profiles—

In general the sequence of horizons in ash covered soils, varies according to the origin of the volcanic deposits, distance from the eruption-centre, and force of the eruptions.

Along the north and adjacent section of the east coast (ref. II.2) the average foothill profile shows the following composition (On map indicated III.3.1):—

0-6 inches.—Brown-yellow loamy fine sand, friable, permeable; organic matter accumulation in the top two inches.

6-16 inches.—Grey-brown loamy fine sand, fine crumbly to loose, very permeable.

16-22 inches.—Reddish-brown clayloam, angular blocky in dry condition, granular to crumbly when moist; permeable, good water holding capacity.

22-36 inches.—Red or yellow-brown clay, compact, cloddy, good waterholding capacity; decreased permeability.

36-56 inches +.—Red or yellow brown mottled heavy clay, compact, sticky and plastic; good waterholding capacity; impeded internal drainage; containing blue stained weathered rock.

The cover layer in this area originates from old extinct volcanoes and has a uniform size sand particle. However, within the sphere of recent vulcanism of Mount Balbi and Mount Bagana, the covering layer shows variability in grain size as indicated in the profile description of a representative soil from the area south of the Aita River. (Ref. II.3 on map indicated III.3.2.):—

0-10 inches.—Grey-brown yellow slightly loamy sand, crumbly to loose, very permeable; accumulation of organic matter in four inches topsoil.

10-18 inches.—Grey coarse pumiceous sand, loose, porous.

18-24 inches.—Light grey-brown fine volcanic sand, loose, porous.

24-36 inches.—Grey-yellow coarse volcanic sand and pumice, loose, porous.

36-48 inches.—Red-brown clayloam, friable, crumb structure with small angular blocky aggregates; permeable; good waterholding

capacity; slightly sticky and weakly plastic in wet condition (representing the top layer of the covered profile).

48-55 inches +.—Red-brown medium clay, cloddy, angular blocky, increasingly sticky and plastic; decreased permeability, good waterholding capacity.

The ash covered profiles, in particular the pumiceous ones, resemble soils of the Warangoi Series of New Britain, described by G. K. Graham.

Judging from the healthy appearance and high production of economic and subsistence crops, the ash covered soils of Bougainville have a satisfactory plant nutrient status.

Previous work on the Warangoi soils by Baseden confirmed a high nutrient status there.

However, it has been anticipated that mechanical stability and sustained fertility most likely will depend upon the maintenance of organic matter in these soils.

III.4 *Brown-yellow juvenile andesite tuff loams or clayloams*—

A representative profile is as follows:—

0-8 inches.—Brown-yellow loam, crumbly, permeable and friable, rich in organic matter in the top 4 inches under forest conditions.

8-16 inches.—Reddish-brown loam to clayloam, crumbly with fine angular blocky aggregates, permeable, slightly sticky and plastic.

16-22 inches.—Brown-yellow clayloam, granular to cloddy; clods easily crumbling under pressure when dry; slightly sticky and moderately plastic when wet; good waterholding capacity.

22-36 inches.—Brown-yellow light clay, granular to cloddy; sticky and slightly plastic in wet condition; permeable; good waterholding capacity; containing some decomposing tuff of sandy clay texture and greasy consistence.

36-44 inches +.—Grey-brown decomposing andesite tuff, in which internal drainage is somewhat impeded.

The above profile is considered to be of favourable depth for general agriculture. In the shallower soils the effect of impeded drainage restricts the agricultural use considerably. "Soft pan," consisting of a compact layer of brown-yellow, partly decomposed tuff within the profile causes less severe impedance, which is easily ameliorated by drainage.

In general the plant nutrient status, except for nitrogen is considered satisfactory for the usual method of indigenous agriculture and for plantation crops. Deficiencies in nitrogen, phosphate and potash are likely to occur, however, under intensified agriculture.

These soils have their counterpart in the soils of the Sangara Crown land near Popondetta and the agricultural experience gained in this area is applicable to large areas of South Bougainville as well.

III.5 *Volcanic ash soils*—

Profile description of a silty ash profile (Vito area ref. II.4).

III.5.1—

0-12 inches.—Brown fine sandy loam; fine crumb structure, friable, permeable, reasonable waterholding capacity.

12-18 inches.—Grey-yellow loamy fine sand, fine crumb structure, permeable.

18-24 inches.—Grey pumice sand, with volcanic silt strata, porous as a layer, but water retaining in the separate pumice particles.

24-40 inches +.—Dark grey coarse volcanic sand, with strata of finer sand, ash and pumice.

The obviously aeolian deposits of sandy ash and pumice in the 24 inch upper layers are far superior in quality to the underlying coarse sand, originating from sand (lahar) flows.

Towards the coast the depth of the aeolian deposits decreases and the coarse sand is present within 14 inches from the surface.

III.5.2 *Gravelly ash profile from east coast near Terava (Bagana, Balbi area)*—

0-4 inches.—Brown fine sandy loam, fine crumbly, permeable, friable.

- 4-12 inches.—Yellow-grey silty ash, good waterholding capacity, permeable, friable.
 12-30 inches +.—Gravelly ash, consisting of a grey coarse volcanic sand, rich in pumiceous gravel, porous.

III.5.3 Gravelly ash profile from South Bougainville (Takuan, Taroka, Loloru complex)—

- 0-4 inches.—Brown humic fine sandy loam, permeable, friable, good waterholding capacity.
 4-18 inches.—Grey-brown fine sandy to silty loam, permeable, friable, good waterholding capacity; rich in pumice gravel.
 18-22 inches.—Grey-brown clayey sand and dense pumice gravel, good waterholding capacity, permeable, friable.
 22-30 inches.—Grey-yellow pumice sand and gravel.
 30 inches +.—Gritty coarse volcanic sand.

III.5.4 Sandy ash profile, from south Bougainville—

- 0-8 inches.—Brown to yellow-brown sandy loam, permeable, friable, good waterholding capacity. Some organic matter in the top two inches.
 8-12 inches.—Grey-brown slightly loamy sand, fine crumbly to loose, permeable.
 12-40 inches +.—Coarse grey volcanic sand and rotten volcanic rock; rusty mottled due to a fluctuating high groundwater table.

III.5.5 Fine sandy ash profile from South Bougainville—

- 0-4 inches.—Brown sandy loam, crumbly, friable, permeable; organic matter restricted to three inches surface.
 4-16 inches.—Brown-yellow sandy loam, crumbly, friable, good waterholding capacity.
 16-28 inches.—Yellow-brown slightly loamy sand, weakly crumbly to loose, permeable, poor waterholding capacity.
 28-36 inches +.—Grey coarse sand, loose, porous, showing rusty mottling, where under influence of a fluctuating groundwater table.

The above brief profile descriptions give an impression of the composition of the various ash soils. It should be borne in mind however, that profile depths are variable and that variations occur over rather short distances.

Adverse physical conditions exclude shallow gravelly ash soils, porous coarse sandy ash soils and compact, cemented sandy ash soils from successful agricultural development.

Generally, ash soils are provided with satisfactory total amounts of plant nutrients, but a high proportion is not readily available.

The weathering of soils from volcanic ash usually leads initially to the formation of very fine "allophane" clay.

This clay has no mechanism for potash retention and supplying power.

Having the availability to absorb organic matter strongly, allophane keeps phosphate out of circulation by slowing down the decomposition of the organic fraction. Phosphate becomes available to plants as the organic matter slowly decomposes.

The benefit of a legume ground cover on soils derived from volcanic ash, the andesite tuff clayloams included, it herewith explained.

Sudden deficiencies in potash and phosphorous are likely to occur with intensified cropping.

It is generally known that ash falls have a rejuvenating effect on the landscape.

III.6 Alluvial soils—

Alluvia are of comparatively minor importance. Coastal flats are narrow, discontinuous and only in the Lualaba River area and along the south and south-west coast are there extensive alluvia. Textures are variable and usually show similarities with textures of surrounding soils. On the narrow coastal flats along the Emperor and Crown Prince Ranges and in the river valleys in these ranges, alluvia are of clayey texture, and gravel is often present as a component of the subsoil. As a result of adverse hydrological conditions most alluvia have a pale grey colour and show rusty mottling features.

The alluvia of the Lualaba area and of the south coast are composed of a wide variety of soils due to deposition of material of different

grain size in thin layers during recurrent floods. The major part of the alluvia are silts or silty loams at the surface, grading into a variety of light textured material to depth. The topography is flat, but in micro relief the country shows a complex pattern of slightly higher ground, separated by faint depressions. The ground-water level is high for long periods, and mottling in the upper horizon is common. Extensive areas remain in a permanent swampy condition.

The heterogenous composition of the soils, the high groundwater table and the possibility of frequent flooding, exclude most of these soils from agricultural development. The same restrictions apply to the alluvia on the south and south-west coast of Bougainville, which consist predominantly of pale grey coarse sands, often gravelly and inter-stratified with layers of clayey sand. The groundwater level is high throughout the year, and rusty mottling close to the surface is usual. Apart from the fact that drainage creates a major problem for these low marshy areas, the soils apparently have a low fertility status, even for paddy rice.

IV. CURRENT LAND USAGE AND AGRICULTURAL POTENTIAL—

The economy of the island is similar to that of the other parts of the Territory and depends mainly on income from the plantation products, copra and cocoa. Indigenous agricultural production of subsistence crops is determined by local demand, but could eventually contribute to the food supply of urban centres in other parts of the Territory.

In postwar years there has been a strong tendency among the population to grow commercial crops, but as a result of the economic position and distance to prospective markets, the specific ability of soil and climate for the production of particular crops has not been fully utilized.

Crops of significance for the indigenous economy are coconuts, cacao, and coffee, besides dryland rice, peanuts, maize, soya beans, and tobacco.

In general coconut palms are healthy and productive along the north-west, north and east coast. Poor soil conditions caused by compacted and cemented volcanic sands and hence

droughtiness, and shallowness of soils and poor drainage in depressed areas are the main contributing factors to unsatisfactory development and production. It appears that the coconut plantations north of Kieta show a higher average production than those south of this town.

There are no coconut plantations along the south and south-west coasts, and attempts to establish plantations on the coarse grey sands with a shallow loamy topsoil have not been encouraging, even where drainage has been introduced.

Village groves are usually closely spaced, which has favoured the spread of *Corticium* disease, and this has caused some unproductivity of the palms.

The production of cocoa ranks second in importance after copra. Cacao growing on plantations, on Mission stations, and by the population, has made steady progress in recent years. The crop shows a vigorous development and satisfactory production on the foothills of the north and east coasts, as well as on well drained alluvia. Occasional borer attacks are a cause of concern.

In south Bougainville this crop thrives well on sandy ash soils, provided that at least two feet of sandy loam, loamy sand and fine sand overlies the coarse sand. The importance of a green manure groundcover for the purpose of increasing the organic matter content of the soils and the need for good shade are often under-estimated. Where these essential measures are omitted, cacao growing is threatened with failure. Serious menaces for the crop are *Corticium* (pink) disease and black pod.

Cacao growing on the coarse grey sands with a very shallow topsoil should be discouraged since these soils have no clay fraction and have a very low exchange capacity. This, combined with the characteristic of high permeability, makes cacao growing hazardous.

Successful growing of cacao on the andesite tuff loams and clayloams depends on effective drainage, preparation of planting holes and establishment of groundcover and shade prior to planting.

The creation of rural societies fosters land use in compact areas contrary to the usual system of gardening in small and often isolated plots. Concentration enables correct management and

protection of crops such as rice, peanuts, maize, and soybeans against pests and diseases. At the same time it opens the possibility for mechanized agriculture in the southern plain and on flat and gently sloping country on the east coast for progressive groups.

Coffee as a cash crop could be a valuable asset for the lower mountainous regions, where the temperature is a limiting factor for cacao growing.

However, most of the mountain country is too steep and dissected to advise its occupation by primitive communities. Coffee has been introduced successfully in the hilly country and valleys of the north-west and east coast.

A good quality cigar tobacco is grown on ash-covered soils and ash soils on the east coast. The product is for local use only, but with proper guidance this crop could become of importance to the local economy. Soils and climate favour a good quality product.

The villagers engage in shifting cultivation and rely on a period of forest fallow to build up organic matter in the soils and so maintain fertility.

The institution of rural societies tends inevitably to stimulate land reform in areas with suitable soils and topography. Unfortunately a big part of the population dwells on steep, dissected country, where development of prosperous rural societies is problematic.

The southern plain has by far the best prospects for agricultural expansion. The agricultural potential is high, the topography favourable, and the area is accessible along a system of roads. A big drawback is the absence of a safe anchorage, a condition that could be corrected at Buin by constructing a breakwater. Development of the at present inaccessible fertile Laluai River area depends entirely on the construction of a road to Tonolei Harbour.

Favourable areas for prospective development have been indicated on the accompanying map.

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The Nomenclature of the Balsa Tree.

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THE recent collection of seed from the two select balsa trees in the Botanic Garden, Lae, has again drawn attention to the involved nomenclature of balsa. This note reviews the names involved and deals with each in turn. A preferred name *Ochroma lagopus* Swartz is recommended with an alternative *Ochroma pyramidalis* (Cav.) Urban.

The balsa tree has long been known as a wild species of the lowlands of tropical central America and northern South America. The utilization of the wood of the balsa trees brought the genus into prominence during the 1914-1918 war. Balsa was extensively used for refrigeration insulation, buoyancy material in life rafts, etc., and in aeroplanes. During 1918 and 1919 W. W. Rowlee and his son were commissioned to investigate the quantity of balsa timber, the quality thereof and the kinds which grew in the Central American countries of Panama, Costa Rica, Nicaragua and Guatemala.

The supposed taxonomic results of this survey were published by Rowlee (1919) who augmented the then recognized names *O. lagopus* and *O. tomentosa* by no fewer than seven new names. The characters used by Rowlee to distinguish his species are:

- (1) geographical distribution;
- (2) supposed discontinuity of flowering periods; and
- (3) degree of "keeling" on the calyx lobes, the shape of the calyx lobes, degree of pubescence on the leaves, leaf shape.

Pierce (1942a) published a short paper on the nomenclature of balsa and a further paper (1942b) in which he evaluated the type material of Rowlee's species. In summary his findings are:—

1. Using the key published by Rowlee (1919), at least one of his types may be identified with any one of nine species; and
2. That the supposed characters of the calyx lobes, leaf shape and pubescence are ontogenetic characters which change with the

maturity of the flowers and the position on the tree from which the flower is taken. Pierce (1942b) also points out that Rowlee is not exact in the use of his terms. In general Rowlee misinterpreted normal variation in the calyx and leaf for specific differences.

Pierce does not discuss Rowlee's segregation of his species on the basis of the month of flowering. On the face of it, this characteristic could be of some taxonomic value. However, there is circumstantial evidence that his observations are incomplete as in Rowlee's works he spent seven months in Panama, Costa Rica, Nicaragua and Guatemala. His field observations would therefore be limited to this period. It is also probable that the onset of maximum flowering in balsa is correlated with the climatic pattern.

Rowlee's species, with their geographic pattern and flowering periods are:—

- O. limonensis* Rowlee. Caribbean coast of Costa Rica and Panama. Flowering May, June, fruiting July and August; lat. 8 degrees—10 degrees north. Limon Balsa.
- O. grandiflora* Rowlee. Ecuador, Pacific coast. Flowering July and August, fruiting September, October; lat. equator—3 degrees South. Ecuador Balsa. (This is the Balsa of the Kon Tiki raft).
- O. velutina* Rowlee. Pacific coast of Costa Rica and Guatemala. Flowering December to February, fruiting February to April. ["That is the dry season where it is found"; Rowlee (1919 p. 165).] Described by Rowlee as a small flowered species at altitudes from sea level to 600 metres. The wood is described as reddish and heavier. (I suggest that the small flowers and denser wood are manifestations of altitude and possibly a dry season which is of longer duration than normal.) Latitude 10 degrees—15 degrees north. Red Pacific Coast Balsa.

O. bicolor Rowlee. Costa Rica at altitudes up to 250 metres. Flowering November to December, fruiting January to March. Rowlee states that this species will grow on the volcanic slopes of Turrialba up to 1,000 metres. Latitude 10 degrees north on the north facing slopes of the cordillera. Guapiles Balsa.

O. boliviana Rowlee. North "eastern" Bolivia, not seen alive by Rowlee. Latitude 16 degrees south, east facing slopes of the cordillera. (Rowlee gives the locality as Mapiro which is north-western Bolivia.) Flowering July and August, fruiting August and September. Bolivian Balsa.

O. obtusa Rowlee. Caribbean coast of Colombia. Not seen alive by Rowlee, altitude "500-2,000 feet"; flowering December and January; fruiting in May, latitude 8 degrees south, low altitude.

O. concolor Rowlee. Gulf of Honduras, Guatemala and British Honduras. Flowering December to January, fruiting February, March; latitude 15 degrees north. Apparently a swamp species. Barrios balsa.

Pierce, after examining all Rowlee's material and considerable additional specimens rejected all Rowlee's names.

There are however, four other names to be considered. *O. tomentosa* Willd. was described from material collected by Humboldt, about 1790, in the upper valley of the Magdalena River, Colombia. The species was then separated from *O. lagopus* by the repand leaves. Since then, further collections have shown that dentate leaves may occur in varying degrees throughout the geographical range of balsa. Consequently, the name *O. tomentosa* Willd. cannot be sustained. *O. peruviana* Johnston was preferred by Macbride to *O. boliviana* Rowlee, and Pierce after further examination of Johnston's material rejected the name as of no specific status.

It is now necessary to discuss the two remaining names which have been published in *Ochroma*, both of which have considerable claim to acceptance as the valid name for balsa.

Of these names, *O. lagopus* O. Swartz is the best known. This name was published in Swartz's Prodrömus, the best estimate of the date of publication being 1788, prior to September of that year. In the same year, Cavanilles (1788)

published the name *Bombax pyramidale* in Lamarck's Encyclopaedia (1788) (pt. 2, p. 552) for the same plant as described by Swartz. The title page of Lamarck's Encyclopaedia is dated 1786 but Woodward (1906) and others who have carefully examined the evidence of publication consider that this volume did not appear until April, 1788. Cavanilles (1788b) also validly published *B. pyramidale*, in June, 1788.

The picture then is that the name *lagopus* was published in 1788 some time prior to September while *pyramidale* appeared twice in April and June, 1788. Urban accepting the title page date of Lamarck's Encyclopaedia as correct, made the combination *Ochroma pyramidale* (Cav.) Urb.

J. H. Pierce considered that as the date of publication of Swartz's Prodrömus will probably never be known with certainty, it is perhaps preferable to accept the most widely used name, viz., *O. lagopus* Swartz and reduce *O. pyramidale* (Cav.) Urban to the synonymy of that species. The reverse arrangement could equally well be used but I follow Pierce in suggesting that common usage of *O. lagopus* O. Swartz should justify acceptance of that name.

The accepted name and synonymy is the *Ochroma lagopus* O. Swartz Prodrömus 98, 1788.

Syn.

O. pyramidalis (Cav.) Urban. *Fed. Rep. Beib.* V.223, 1920.

basonym *Bombax pyramidale* Vac. *Lam. Enc.* 2, 552, 1788.

O. tomentosa Willd. *Enum. Hort. Berol.* 695, 1809.

O. concolor Rowlee *Journ. Wash. Acad. Sci.* 9, 161, 1919.

O. limonensis Rowlee l.c. 163.

O. grandiflora Rowlee l.c. 163.

O. velutina Rowlee l.c. 164.

O. bicolor Rowlee l.c. 165.

O. boliviana Rowlee l.c. 166.

O. obtusa Rowlee l.c. 166.

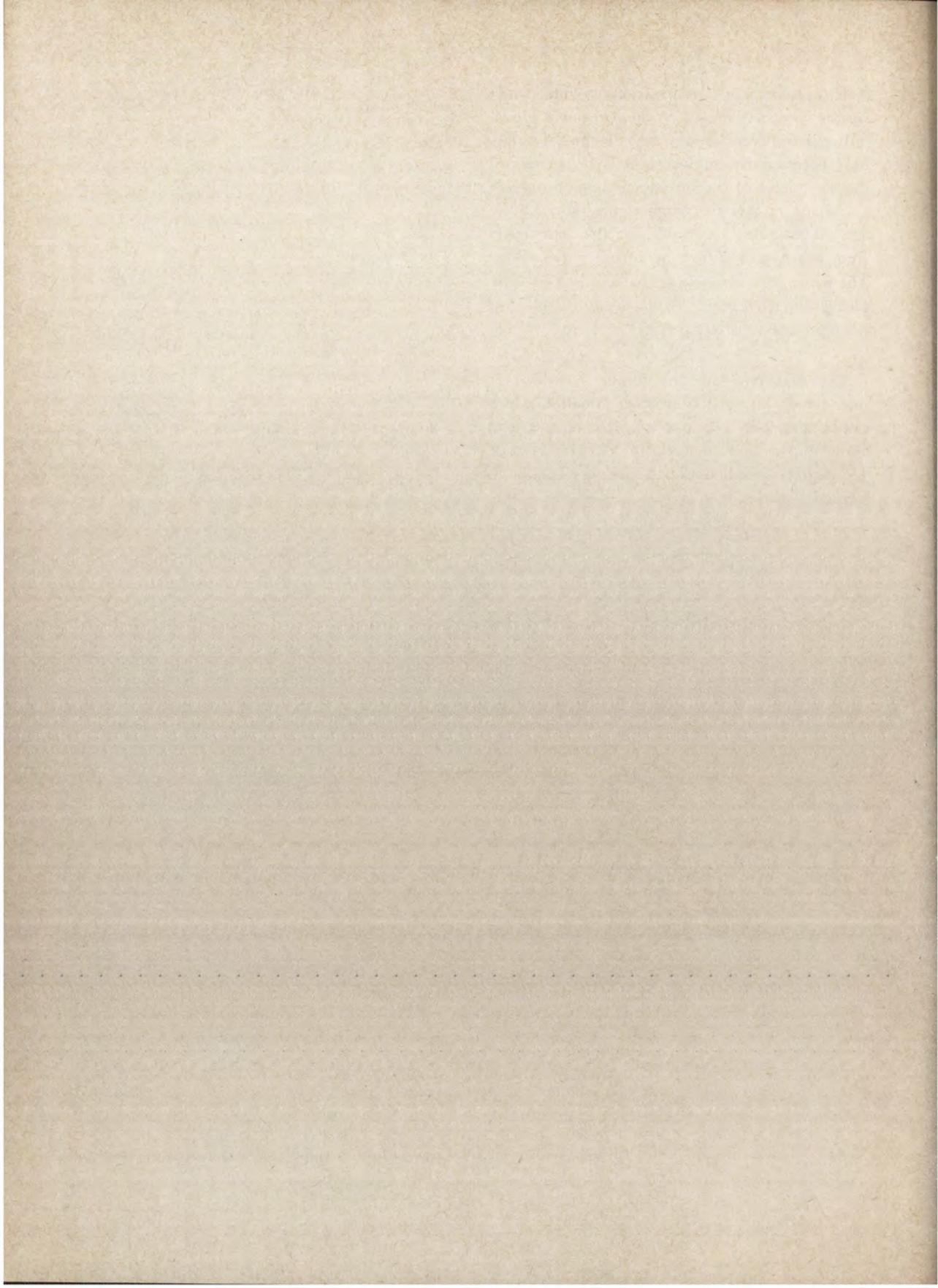
O. peruviana Johnston *Contr. Gray Herb.* n.s. LXXXI, 95, 1928.

The problem now remains to provide names for the several strains of *O. lagopus* being grown in Papua and New Guinea. As no varietal names have been validly published, it is recommended that the source of the introduction could provide a working epithet to recognize the more important strains, e.g., "Sarmi" for the select trees from which seed is now being harvested at Lae. The name *pyramidale* is to be regarded as completely interchangeable with *lagopus* and does not represent a distinct species.

The taxonomy of the genus *Ochroma* is undoubtedly in need of further attention which can be done only if supported by extensive field work in the belt of country between latitude 15 degrees north and 15 degrees south in Central America.

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Notes.

NEW RECORDINGS OF ANIMAL DISEASES.

Animal diseases and parasites, not previously recorded in the Territory are described. All were found in livestock in the Morobe District of New Guinea.

Ascaris Vitulorum—

A specimen of *A. vitulorum* was passed by a zebu calf at Singaua during collection of a faecal sample.

A. vitulorum is a large worm, measuring up to 30 cm. in length with a soft translucent appearance. The life-cycle is migratory, involving stages in the liver and lungs. From the lungs, the larvae migrate up the trachea to the pharynx and pass down the oesophagus to the intestine, where they mature. In a pregnant animal, the foetus may become infested when larvae escape into the general circulation.

Symptoms produced by this parasite include loss of appetite, unthriftiness and diarrhoea. Piperazines are effective in removing *A. vitulorum*.

Avian Encephalomyelitis—

An outbreak of this disease occurred among a batch of chickens imported as day-olds into Lae. There were 500 chickens in this batch and they were three weeks old when the outbreak started. Deaths occurred over a period of one week with a total of 21 (4%) affected. All affected birds either died or were destroyed.

Avian encephalomyelitis is caused by a virus and is generally seen in chickens one to two weeks old. The disease is believed to be transmitted to chickens from infected breeders via the egg. Mosquitoes are thought to transmit the disease among breeders.

Affected chicks first show a dull expression followed by an ataxic gait. The ataxia becomes more pronounced as the disease progresses, the chickens resting on their haunches and showing little control over their gait when disturbed. A tremor of the head and neck may be evident. The ataxia progresses until the chick is unable to move about and death follows.

Avian encephalomyelitis may be confirmed by histopathological examination of the central nervous system. Confirmation of the Lae outbreak was made in this manner.

Avian Thrush—

This disease was diagnosed among a batch of nine weeks old chicks reared on a large poultry farm in the Morobe District. In this outbreak about 25 per cent. of the batch of 150 were affected and about 10 per cent. died or were destroyed. Lesions consist of easily removed necrotic material in the corners of the mouth. Two birds were autopsied but did not show the commonly described crop and proventricular lesions.

The disease is caused by a fungus *Monilia albicans* which was cultured from an affected bird in this outbreak. No effective treatment is known and in this outbreak the birds threw off the disease as they matured.

Enzootic haematuria—

Enzootic haematuria was diagnosed in a native-owned cow in the Wain Census Division. In the past, other cows in this area are said to have died with similar symptoms.

Enzootic haematuria is characterized by the intermittent passages of bloody urine, leading to emaciation, weakness and death due to anaemia. At autopsy, haemorrhages and friable, easily bleeding tumours (haemangiomas) are found in the bladder wall.

The cause of this disease is not known. It occurs as an area problem, usually on poor, neglected or recently opened up land and tends to disappear as soil fertility and land management improves. No effective treatment is known.

Juvenile osteoporosis—

This nutritional disease, characterized by poor bone development, has been commonly seen in cats at Lae.

Generally cats under six months of age are affected. Symptoms usually appear suddenly and include reluctance to move, lameness, posterior weakness progressing to posterior paralysis and obvious deformity of the hind quarters. Affected cats resent handling.

Juvenile osteoporosis of cats is caused by a deficiency of calcium in the diet. Popular cat foods such as muscle meats, heart, liver and kidney are low in calcium and the diet of young

cats should always contain milk to provide the necessary calcium. Cats when young can be taught to eat many foods, though later when eating habits are well established, they may starve rather than change. In these cases, when milk is refused, calcium tablets should be provided.

In the early stages of the disease addition of a calcium supplement to the diet often produces a dramatic cure, however, later in the course of the disease, the condition is incurable.

Trichostrongylus axei—

Some specimens of *T. axei* were found in the stomach of a horse at Lae during a routine post-mortem examination.

The adults of this nematode are very small and slender, measuring up to 8 mm. in length. The same species is found in the abomasum of cattle. The life cycle of *T. axei* in horses is uncertain but is known that the larvae penetrate the mucosa of the stomach.

The worms cause a chronic inflammation of the stomach and can cause a loss of condition in infested horses. Carbon disulphide and phenothiazine have both been recommended for treatment of *T. axei* infestation in the horse.

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THE PREPARATION AND GERMINATION OF BESOEKI COFFEE SEED.

Besoeki strain of Robusta Coffee beans realize premium prices, and consequently the policy of the Department of Agriculture is to supply seed of only this strain to Extension Centres and private growers.

Preparation of Seed—

After harvesting, the berries are pulped mechanically to remove the skin, and the beans are allowed to dry in the shade for a few days, during which time damaged and broken beans are removed. The seed is then mixed with powdered charcoal or woodash to dry off the remaining moisture and to prevent the beans from sticking. Seed is then ready for packing and distribution by air-freight. There are approximately 1,100 Besoeki coffee seeds to the pound.

Germination—

A study has been made on the effect of age on the germination of Besoeki seed. Results have shown that a very poor strike is achieved from seed which has been held for more than two months. It is preferable for the seed to be planted within a month of the date shown on the back of the Certificate of Inspection which accompanies the package. Germination should commence about a month after planting.

A trial was carried out on one month old Besoeki seed to compare depths of planting of one inch and half inch. Results showed that slightly earlier germination resulted from half inch planting, but by forty days after planting, one inch planted seed germinated faster than half inch. By the end of the trial, one inch planting resulted in 70 per cent. germination, against 60 per cent. for the half inch planting.

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Book Reviews.

Agriculture and Land Use in Ghana.

Edited by J. Brian Wills. Oxford University Press, for the Ghana Ministry of Food and Agriculture: London, 1962.

504 pp. (illus.) 102s. Aus.

Senior civil servants, scientific research staff, and University lecturers working in Ghana have combined to produce in this volume an invaluable account of the background, state and problems of agriculture and land use in Ghana.

By presenting a tremendous amount of information of the type which is so often available only by personal contact with agricultural workers at research centres, regional and district agricultural offices, and agricultural stations, the book fulfills a requirement which is common to many tropical territories.

The 26 chapters, all of which have been contributed by workers who are authorities in their field, are divided into two parts. The first deals with the physical and human background to agriculture while the second covers a wide field of forestry, plant, and animal husbandry.

As an introduction to the first part of the book, a short outline is given of the background history and the physical environment. Ghana, with a group of exports consisting mainly of primary products, and a population density of 73 per square mile, is still a relatively under-developed country. However it is claimed that "it enjoys a standard of living very much higher than its neighbours", a fact with which it is difficult to agree in view of the low standard of living and poor development in the Upper and Northern regions of the country. To the south of this area in the forest zone it is true that the integration of cocoa growing into subsistence agriculture, and a natural endowment of exploitable mineral deposits has enabled the rapid development of good communication systems and the completion of a comprehensive range of public works projects.

The introductory outline is followed by a chapter on weather and climate, which explains the development and characteristics of the dry harmattan and moist monsoonal air masses originating to the north and south of the country,

and also the warm, moist equatorial air masses which move slowly and irregularly during the year within the Inter Tropical Convergence Zone. The distribution and inter-relationship of the weather zones which are associated with that Zone, and which determine the climate of the country, are discussed together with an exhaustive tabulation of climatological statistics.

A condensed outline of the general geological structure of the country follows with short descriptions of the principal geological formations which are supported by well tabulated data on the chemical constitution of the associated rocks. For the agriculturalist a pleasing feature of this section is that for the main part only those aspects of geology which are of immediate interest, are presented, e.g., the chemical nature, distribution, and weathering of the rock types immediately below the surface. Detail of rocks and minerals at greater depth have been omitted.

The greater part of Ghana, including all the northern and eastern districts and some coastal areas, suffers a chronic shortage of water, especially water fit for drinking. It is therefore appropriate that the discussion on rural water supplies should include detail of simple methods by which water can be obtained and stored. The types and occurrence of springs, wells and boreholes are mentioned together with an outline of various methods employed for trapping surface water supplies such as ponds, tanks and dams. However the discussion is incomplete, and this section could have been more appropriately coupled with the later chapter on soil erosion and conservation in which details of the programme of work undertaken to conserve water in the land planning areas of Tamme, Bumboga and Zurunga in the north of the country are outlined. There, contouring, road building and dam building schemes have been instituted over large areas in an effort to greatly increase water supplies for agriculture and for human and stock consumption.

Turning to the soils of Ghana the book presents an excellent and authoratively written chapter containing concise descriptions of the major soils of the country. The author has, in addition to descriptions of the physical and

chemical characteristics and profiles of the major soil groups, included a wealth of information on the associations or catenas in which these soils occur. A clear indication is given of their agricultural value, the crops most suited to them and the effects on organic matter, nutrient status and structure of various methods of handling or farming the soils. This information is of great value and application.

The importance of soil chemical properties is again emphasised in relation to the fertility of Ghana's soils, as it is these properties which can be more easily altered than physical characteristics in programmes of fertility improvement. The distinction between total nutrients and available nutrients is outlined. Included also is an interesting section on the availability of nitrate and ammonium nitrogen in forest and savanna soils and the variation between nitrogen levels in wet and dry seasons. The phosphorus cycle is clearly discussed with reference to the mineral and organic forms and the manner in which they contribute to the pool of exchangeable phosphate in the soil solution. Of particular value in the consideration of soil fertility is the account given of the changes which occur in soil nutrient levels during the fallow and cropping periods in the traditional system of agriculture, and the comparative effectiveness of forest and grass fallows. Both authors have done much in the past to obtain the data necessary for a better understanding of systems of subsistence agriculture. The superiority of a natural fallow over any form of planted fallow is indicated, together with pertinent comments on the effectiveness of methods such as mulching, green manuring, grass fallows and forest fallows which may be used to improve the physical condition of the soil.

Part II of *Agriculture and Land Use in Ghana* is concerned with forestry, the agronomy, diseases and pests of cocoa and all other crops, food storage, weeds, grasslands, stock and tsetse flies. It begins with further consideration of the role of the forest fallow in the maintenance of soil fertility for foodcrop farming. The author sets a fifteen year fallow period alternating with a three year cropping period as an essential basis for the farming system and these must be considered very generous limits which could not possibly be maintained in the more densely populated areas. However, whether an eight, ten or fifteen-year fallow is issued, the system remains one which is wasteful of land and

labour, but which is the only practical way of food farming in the absence of proven improved systems or the utilization of animal manures, composts, etc. Consequently the preservation of forest areas is of prime importance. It has been achieved by the demarcation of reserves which in the closed forest zone are used to safeguard water supplies, protect forest and agricultural crops grown either in or near the forest, and secure the supply of forest produce to villagers of the area. In the savanna zone watersheds, shelterbelts and barrier reserves have been set aside, the latter to prevent further conversion of closed forest in savanna woodland. In Ghana, as elsewhere, the continual cutting, cultivating, and cropping of closed forest results in the establishment of grasses under the influence of fire and associated forest destruction. Closed forest is already well to the south of its natural northern climatic limits, and it is emphasised that because there is no part of Ghana in which the dry season is not sufficiently long and intense to dry grass to burning point, forest areas could gradually disappear. Barrier reserves are intended to prevent this and the manner in which these should be managed with regard to burning is outlined.

With regard to the timber industry itself, rapid post-war growth and a tenfold increase in exports between 1945 and 1957 have established Ghana as one of the largest exporters of tropical hardwoods. The industry is now the country's third largest revenue earner. The principal export timbers, and the organization of the timber trade from pit sawyers to million pound companies is described. Also the physical mechanism of the export log trade, handling, shipping, etc. and the problems associated with saw-milling and local production of well seasoned sawn timber.

As might well be expected the greater part of the second section of the book is devoted to cocoa which alone accounts for some 70 per cent. of the value of total domestic exports. Cocoa in Ghana is a peasant crop and is not organized on a plantation basis. Selection and preparation of land for establishment of a peasant cocoa farm, maintenance work and harvesting routines are haphazard. There is some indication that the procedures adopted are based on experience of the farmers, necessity for pest control, economic considerations, weather conditions and so on. Even so there is little doubt

that general management is of a fairly low standard. Valuable information on physiology, pollination, breeding, propagation, soils, manuring and fermentation is presented, with a wealth of detail and excellent references lists. The early introduction and spread of Amelonado cocoa and Trinitario and Criollo types is outlined. Also the performance of more recent introductions, with emphasis on the high performance of Amazonian lines. Introduction of these Amazonian lines has by now been achieved in many of the world's cocoa growing areas and it is well worth noting that these countries, particularly those producing a well recognized standard flavour type cocoa, will have to take care in utilization of Amazonian material. Maintenance of uniformity of flavour and bean size is important, and careful selection necessary so that Amazonian types distributed to growers will not alter this uniformity. These factors are taken into consideration in Ghana's cocoa breeding programme which is essentially based on the production of hybrid seed from crosses between Amelonado, local hybrid types, and Amazonian selections.

Principal soil series of the cocoa belt and the manner in which topographical factors have influenced these series and given rise to catenary sequences, are discussed. In Ghana the productivity of peasant cocoa farms usually declines after some years because of pest and disease infestation and unfavourable soil conditions. New areas are then established in high forest because of the extremely poor growth of cocoa when replanted in secondary forest on old farm areas. The reasons for this poor growth are not clear. Capsid attack and a "fertility problem" are mentioned, together with the possibilities of an unsuitable microclimate under secondary forest, competition against a different group of lower storey species and a shade density effect. However, nothing conclusive arises out of this and it is apparent that a problem exists which will have to be solved to enable successful utilization of such areas.

Almost half the chapter on diseases and pests of cocoa is devoted to an extremely thorough and detailed review of the virus diseases, their symptoms, effects on growth and yields, transmission, alternative hosts, control measures and so on, with excellent plates and references. Likewise, the review of the current knowledge on capsids is a thorough and invaluable one and

includes several plates and a list of references. The nature of capsid damage and description of the field symptoms of "Blast", "Stag-headed cocoa" and "Capsid pockets" are discussed with a section on capsid control. Of particular interest is the association between capsid damage and the infection of lesions by the fungi *Calonectria rigidiuscula* and *Botryodiplodia theobromae*. Attention is drawn to the fact that capsid lesions are better sites for fungal infection than mechanical wounds and that the pathogen *Calonectria rigidiuscula* may either remain dormant or spread through the wood depending on environmental conditions. In fact it is claimed that infection can be followed, after a lapse of up to ten years and under certain conditions, by rapid spread of the fungus and severe die-back. How this has been proven is not clear. *Calonectria rigidiuscula* is most frequently found in its imperfect stage *Fusarium decemcellulare*, the spores of which do not appear to be air borne but which under laboratory conditions have been readily spread by water splash or run-off and under field conditions have been found on the legs or bodies of capsids. Conversely, with black pod, the evidence suggests that dispersal of the fungus from tree to tree by insects is not an important factor and that dispersion by wind and air currents is probably more significant. Within the tree, contact and drip infections assume importance. For the control of black pod, regular and frequent harvesting of infected material will reduce the direct loss of crop and removal of shade trees may lower air humidities to levels unfavourable for growth and development of the pathogen. Weekly harvesting has been found better than monthly harvesting but it is hardly a procedure to be recommended when harvesting costs can be as high as eighty per cent. of the total cost of harvesting, processing and bagging. Effective chemical control by spraying is likewise generally uneconomic.

There is little doubt that cocoa growing in Ghana is at a fairly low level of efficiency. Farmers harvest their trees only three to four times each year and as a consequence losses from black pod and rodents are high. These losses coupled with the debilitating effects of the capsid, die-back and swollen shoot complex combine to depress yields to a very low level. That yields can be improved is well demonstrated by the fact that regular fortnightly harvesting, capsid control, spraying against pod disease and

reduction of overhead shade can more than double yields. Losses from pod diseases over a four year period were reduced from 41.2 per cent. to 2.3 per cent. A further example comes from the West African Cocoa Research Institute where yields for three years running from a shade fertilizer trial have been 3,091, 3,088 and 3,474 lb./acre.

By comparison with the chapters on cocoa, the discussion on other crops is relatively brief. Coconuts, coffee and rubber are mentioned as crops of potential economic importance and it is obvious that they can be grown successfully. This also applies to the oil palm, which in Ghana occurs as a carefully preserved palm throughout the farmed areas in the forest zone. Palms are protected from destruction when land is farmed although they are usually damaged by fire when the forest is burnt or severely pruned during clearing operations. However a large number of oil palms are cut down each year for palm wine, and this destruction is particularly severe in some areas. In terms of the country's primary industries the oil palm fills a very minor role, there being less than 5,000 acres of plantation palms. Average annual exports of palm kernels between 1950 and 1959 was 6,748 tons. No palm oil has been exported since 1954. By comparison Nigeria exports some 200,000 tons of palm oil and 450,000 tons of kernels. The fact that the oil palm in Ghana is primarily a foodcrop and production is mainly dependent on wild palms causes a basic weakness in the industry. However if the crop was put on an organized basis with the development of plantations and utilization of improved planting material and production methods, Ghana could add a significantly valuable commodity to its list of exports.

The latter part of this book is concerned with grasslands, pastures and fodder production, animal husbandry and diseases and pests of stock. Two main grassland areas exist, the interior savanna and coastal savanna; each of which is described together with the relationship between the distribution of human and stock populations and the soils of the area, systems of stock husbandry and other local conditions. A programme for future work on pastures and fodder production is suggested and the present state of knowledge reviewed. The author considers that enclosure of livestock and rotational

grazing would be too difficult to introduce, and fencing too expensive to install. However this is an aspect which requires serious consideration and effort if any attempt is to be made to rationalize the relatively inefficient management systems in current use. Ghana has some 430,000 head of cattle which supply about one-third of the carcass beef consumed in the country. Over 60,000 head are imported each year from territories to the north together with 250,000 sheep and goats, and cattle consumption is limited by the association of high prices with a supply considerably smaller than potential demand. The industry is depressed by diseases, unskilled husbandry and poor grazing and water supplies. To improve this situation there is a tremendous task ahead.

This well produced demy-quarto volume concludes with a first class bibliography, indexes and maps—geological, administrative, great soil groups and vegetation zones. The text, which is in double columns on each page, is relatively free from misprints, and the photographs, drawings and diagrams are of a high standard. *Agriculture and Land Use in Ghana* is a monument to the exacting task which its preparation must have been. Similar in concept to *Agriculture in Uganda* and *Agriculture in the Sudan* by J. D. Tothill, it will become and remain for many years a standard reference work on Ghanaian agriculture.

K. Newton.

Economic Development of Latin America.

(Proceedings of a Conference held by the International Economic Association.)

Edited by Howard S. Ellis and
Henry C. Wallich.

Macmillan and Co. Ltd., London, 1961. 479 pp.
45s. Stg.

It is unfortunate that the title of this publication is misleading, as its main emphasis is not towards the problems of economic development in Latin America. From several papers read at this Conference one gained the impression that reference to various Latin American countries was made out of deference to the location of the Meeting, Rio de Janeiro.

Nevertheless this book of the Proceedings is of considerable interest to students of economic development and growth. No new concepts emerged as the general theme of the papers was problem-raising rather than solution. One of the main interests to economists with limited knowledge of foreign languages is that such gatherings give some insight into the thoughts of leading authorities in other countries.

The publication can be roughly divided into four groups of papers. The first covers the general theoretical concepts of economic development and growth. The second relates to the supply of capital and the role of financial institutions in the mechanism of economic development. The third examines international trade theory and its place in economic development. The fourth, of three papers, is a mixed bag dealing with investment priorities, agricultural versus industrial development and the use of exchange controls in economic growth.

The third section is the most interesting and contains papers by Professors Nurske, Haberler, Schultz and Wallich. The paper presented by Nurske is perhaps the most challenging as it attempts to strike some balance between the classical theory of international trade with its resultant specialization and the notion of balanced growth. Nurske maintains that "expansion cannot be relied upon through international trade" but it still should not be overlooked as one method of economic development. He sees a programme of balanced growth as the principal weapon in economic advancement.

Professor Haberler's paper has a defensive note as he contends that there is no clear evidence of a secular downward movement in the terms of trade for primary products. The general lack of confidence in international trade as an "engine of growth" in this century is most apparent in the policies of the underdeveloped nations. From the discussions of Haberler's paper it would appear that he represents a minority group at this Meeting. His comments on international commodity agreements must be quoted simply because they come from no less than one of the world's leading authorities on international trades. Speaking of underdeveloped nations he said, "Instead of learning to live with a certain amount of instability, making the economy flexible, and evolving methods to offset some of the consequences of the fluctuations in international

demand and export proceeds, administratively and politically, if not economically, *hopelessly* (my italics) unworkable schemes of price stabilization are being proposed and discussed" (p. 296). Such statements from Haberler must cause one to pause and think.

Professor Schultz's paper is somewhat at variance with Haberler's as he sees no real improvement in the terms of trade for primary products. However, some cold comfort can be taken by the underdeveloped nations in his statement "the price indices of farm products, minerals, and even fuels may well recede somewhat but probably will not fall enough to change substantially the price picture now before us" (p. 324). This picture is anything but bright.

Unfortunately none of the papers deals with the implications of agricultural and commercial policies of the industrialized nations, particularly the United States of America, on the developmental programmes of the underdeveloped countries. The informal discussions of the papers in this third section of the Proceedings clearly showed the wide gap between economists working full time in underdeveloped nations and those in developed countries. The latter can look at the problems in an impartial manner. For this reason the informal discussion is of the most interest.

The editors of the book, Professors Ellis and Wallich, are to be congratulated on the presentation of the Proceedings. In each case, the informal discussions are split into the main themes and then brief comments on each are included.

G. R. Spinks.

Meat Handling in Underdeveloped Countries.

I. MANN.

F.A.O. Rome, 1960. Price unknown.

The Food and Agricultural Organization of the United Nations has given a great deal of attention to animal production, because of the urgent need to increase supplies of protein for human consumption throughout the world. While aspects of animal production such as nutrition, disease control, and animal breeding are of fundamental importance, it is essential that the end products be so handled that all possible waste is prevented.

This publication represents the first part of a two part treatise on the handling of these end products. The second part, published in 1962 by F.A.O. is titled "The Utilization of Meat By-products". The author, Dr. I. Mann, is employed in the Department of Veterinary Services, Ministry of Agriculture, Animal Husbandry and Water Resources, Kenya, and consequently this publication is based mostly on experiences in Africa.

The Author's aim is to provide a guide to those interested in meat and meat by-products in the less developed regions and to assist the man on the spot in the choice of equipment and methods best suited to the environment in which he has to work. Chapters deal with the following subjects: Simple slaughter facilities, Basic factors in abattoir design, Designs of different types of slaughterhouses, Poultry slaughtering, Field abattoirs, Environmental sanitation, Post abattoir handling of meat, Preservation of meat, Fats and oils. Finally there is a series of plans of buildings, some equipment for meat handling, and a selected bibliography.

In the Territory of Papua and New Guinea at the present time most slaughtering is carried out in small slaughterhouses located on European owned cattle raising properties. Construction of the central abattoir at Lae will completely alter this situation in the Morobe District, which is the Territory's greatest stock raising District. Many of the subjects discussed by Dr. Mann could find application in these small slaughterhouses. For example Chapter VIII, "Environmental Sanitation" deals with Water Supply, Disposal of Effluents, Extermination of Rodents, Insect Control, etc. Cattle slaughtering in the Territory, although carried out in widely dispersed locations is at present on a small scale. Slaughterhouses are under close Government control and usually a Meat Inspector is present at slaughtering. The cattle dealt with in these slaughterhouses are of a very high quality and because of the Territory's relatively disease free state are seldom diseased. Hence some of the dangers described by Dr. Mann are non-existent in Papua and New Guinea.

The Chapter dealing with Preservation of Meat is interesting reading. The four general processes which are widely used are described, i.e. drying (including smoking), curing, refrigeration, heat sterilization (canning). Some

mention is made of the use of microbial inhibitors and of radiation. Some of the methods of drying and curing could conceivably be used by natives in this country for the preservation of pig meats and ultimately beef. However, native cattle projects when established will probably be considered as a "cash" rather than a subsistence crop.

In conclusion, parts of this book dealing with simple slaughtering facilities, slaughterhouse operations, slaughterhouse hygiene and post abattoir handling of meats would provide valuable reading for those concerned with meat handling in New Guinea. Most of the other parts of this book have no real application to this Territory. Nevertheless the book as a whole provides interesting reading and has good general knowledge value for anyone in this Territory directly concerned with livestock.

T. L. Rothwell.

The Economics of Agricultural Land Tenure.

GRAHAM HALLETT.

Land Books Limited, London, 1960. 206 pp. 25s. Stg.

One would expect a publication with the above title to present an economic examination of various land tenure systems. However, the book discusses nothing but the farm tenancy system in the United Kingdom.

Few would disagree with the author's main argument that farm rents in the United Kingdom are too low and this situation can have serious economic and social effects on agriculture in that country. It is maintained that the determination of rents must be left, or if set by statute must be based, on economic factors as far as possible. The theoretical framework behind this pricing system is carefully examined and is presented in a manner which can be understood by the layman. This is perhaps the most interesting section of the book for readers not acquainted with the land tenure system in the United Kingdom.

The Agriculture Acts of 1948 and 1958 are compared and discussed in light of their effects on present farm rental levels. The latter Act attempted to use some economic arguments in rent determination.

The remainder of the book covers a wide range of topics directly related to land tenure in the United Kingdom. A brief history of the various economic and philosophical arguments behind land tenure in that country is presented with passing reference to the influence of the theories of David Ricardo and Henry George on agricultural land ownership. A number of practical matters relating to estate management are discussed, including cover methods of rent determination, suggested system of keeping estate accounts, the influence of the British taxation system on estate management, and a consideration of rent as a return on capital. A chapter is devoted to land nationalization and the change in the reasons for this action over the last century in Great Britain is mentioned. This section is concluded with a suggested agricultural policy for the British Labour Party.

The author sums up his thesis with the statement "the book has argued the economic advantages of tenancy" but in fact it has failed to do just this. No comparative study of farm tenancy and owner-occupancy is presented. But nevertheless, generalizations such as the following are made, "if letting of agricultural land is not allowed to be profitable, land will eventually cease to be let and this, it has been argued, would be a grave blow to British agriculture". Why this should be the case is not shown by the author. Perhaps it may be in the interests of British agriculture to keep rents low so that "land will cease to be let". This action could allow a new class of owner-occupants to emerge.

The smallness of many British farms is a major economic and social problem and under the present system of tenancy, which accounts for more than half the agricultural land, consolidation as a solution is not occurring. However, in the U.S.A. and Australia where owner-occupancy is the dominant land tenure system, farms are increasing in area. This is taking place because of normal economic forces.

The unfortunate title of this publication directs criticism and the author's defence of farm tenancy is considerably weakened by the absence of any comparative study of tenancy and owner-occupancy. The book is of little interest to anyone outside of the United Kingdom.

G. R. Spinks.

Report on an Economic Study of Small Farming in Jamaica.

DAVID EDWARDS.

Institute of Social and Economic Research, University College of the West Indies, Jamaica, 1961. 370 pp. 28s. Stg.

The book is based upon results of a study of small farms in Jamaica carried out by Mr. Edwards in 1954 and 1955, and is similar to a thesis approved for the degree of Doctor of Philosophy in the University of London. The text, well supplemented with statistical data and illustrations, is of four parts dealing respectively with the background of the study, resource use and returns, possibilities of change, and conclusions.

As first conceived by the Colonial Economic Research Committee the purpose of the investigation was to secure "... as full as possible an understanding of all the determinants in Jamaica of ... the economics of farming and of farm families." (p. 7). Edwards has chosen to study intensively a small number of carefully selected farms hoping "... to get beyond the level of understanding possible in the more extensive study." (p. 25). He first describes economic conditions on the small farms studied, and then discusses the technical improvements needed, together with the possible reaction of farmers to proposed changes. He concludes that "... the small farming studied was technically bad, but economically ... a reasonable response to the conditions under which farming is practised ...", whilst to improve the level of technique he says that "... the farmer's entrepreneurship will have to be changed in appropriate ways so that it becomes obvious to the farmers that their ends can be achieved by introducing the technically more desirable practices." (p. 282). However, Edwards neither defines clearly what he means by the term "farmer's entrepreneurship", nor attempts to substantiate methods that would bring about the desired change.

For those not familiar or concerned with conditions in Jamaica the broader issues are of interest. In recent years, with more attention being focused upon the development of suitable farming systems in many of the underdeveloped countries the great need has been for basic information describing the systems being evolved

by independent farm communities. In most cases the amount and accuracy of agricultural statistics is limited; thus pilot studies of this kind are of great value. Moreover, as well as defining those improvements that are technically or economically more desirable, there is a need to understand what is acceptable to farmers, and the factors important in influencing acceptance or rejection of improvements. In this regard the study is valuable for its contribution towards understanding the way in which Jamaican farmers react to obstacles that confront them, and the effect this has upon the adoption of improved farm practices.

R. J. Cheetham.

Migrants and Proletarians—

Urban labour in the economic development of Uganda.

WALTER ELKAN.

Oxford University Press, London. 145 pp. 39s. 3d. Stg.

ONE of the many reasons delaying the development of a general theory of economic growth for under-developed nations of the world is the defensive position into which economics has been forced by some of the other social sciences, particularly anthropology and sociology. Behaviour is often explained in non-economic terms, when in fact, closer examination would reveal that economic reasons are the major motivating force. Furthermore, policy is sometimes made on assumptions that economic factors play little, if any part, in the behaviour patterns of individuals. Nowhere is this more the case than in the field of labour policy in the under-developed nations.

The author of this publication has attempted to rehabilitate the place of economics in explaining the motivating force behind urban labour in Uganda. Although many of the conclusions are tentative, and require further research, they are sufficiently provocative to raise some doubts about the acceptance of non-economic factors in explaining behaviour of urban labour. It is this that makes the book worthy of study.

The plan of the book follows the traditional pattern of labour economics, and covers supply, demand, wages levels, degree of skill, labour relations between the different types of employers—government, European, Asian and African—

and general government policy. In each case these are considered against the background of the migratory nature of the labour force. The author sees this as a permanent feature of urban labour in Uganda.

Although a class of proletariat is emerging in the urban centres of Uganda, the larger section of the labour force consists of the migrant. The findings of the study indicate that economic factors are the major motivating force for migration but close ties with home villages remain. Migration is only a temporary phase and is considered as a means of accumulating capital. Many of the labourers set themselves up as minor entrepreneurs on return to their home villages.

The transient nature of the labour force creates problems for employers and although government policy is directed towards the establishment of a stable supply, the author suggests that this is unlikely to occur. Private employers have adapted labour management to the migratory nature of the labour force.

The fundamental issue of labour in the under-developed nations of Africa is closely connected with the role of the welfare state and the economic growth of these countries. Although this is not specifically raised in this publication, it is a problem of which the author is well aware. This attitude is most apparent in the section on labour relations.

G. R. Spinks.

The State of Food and Agriculture, 1962.

F.A.O. Rome, 1962. 198 pp.

There is no doubt that this annual report is the most important of all the F.A.O. publications. The introduction of special articles since the 1956 issue has improved greatly its value for those interested in world economic events. Within this report the two articles deal with the role of forest and livestock industries in the less developed countries. The former is of particular value and covers a number of little known aspects of forest industries. The latter covers familiar ground.

The general theme of the survey of world food and agricultural production during the year under review continues to show that the

pressing problem of raising living standards in the less developed nations is no nearer solution. World agricultural production has maintained a steady growth, apart from a check in 1957-58, but this increase has come mainly from the developed nations. In the less developed countries, population growth continues at a faster rate than agricultural production. Despite some reservations by the underdeveloped nations, international trade is of great importance to their economic growth. Here again the survey presents a dismal picture. For the seventh successive year, the terms of trade for agricultural exports has declined. In fact, in 1961 the terms of trade were "24 per cent. less than in 1952-53". This fall in the year under review resulted from increased exportable surpluses of agricultural products facing a world import demand which was increasing at a much slower rate. At the same time, world average prices for manufactured goods, which are essential for economic growth, rose by about 2 per cent from 1960 to 1961.

The world demand for agricultural raw materials also suffered from the general slowing down of economic activity in the industrialized nations. In the first half of the year, the level of activity in North America failed to reach the heights expected, while in western Europe and Japan economic expansion did not maintain the rate of the previous years.

On top of these problems, the report has some strong words to say about the commercial policies of the industrialized nations. In particular, the agricultural and trade policies of the European Economic Community have caused considerable uncertainty to many of the less developed nations.

There is a growing faith in world stabilization schemes for the major agricultural products entering world trade, but this will only be a temporary solution to the inherent problem of the economies of the underdeveloped countries. Some measure of instability is and will remain a feature of world trade and all countries must be prepared to live with it. It is up to the underdeveloped countries to make their economies more flexible. They cannot do this alone and the developed countries must assist. Much of this can be done simply by the "have" nations being more aware of the implications of their agricultural and commercial policies.

The chapter, "The Role of Forest Industries in the Attack on Economic Underdevelopment", is refreshingly down-to-earth in its appraisal of the forestry sector in developing nations. Warning is given against grandiose plans incompatible with the socio-economic background where both skilled labour and capital are commonly scarce resources. The latter aspect is given special emphasis in the excellent subsection "Making Capital Go Further".

Very useful data on production, consumption and trade trends of various categories of forest products are presented in some of the ten tables incorporated in the text. Comparisons between the advanced and underdeveloped nations are freely drawn. The latter bloc, while generally favourably endowed with natural hardwood forest reserves and having very low levels of consumption of forest produce, nevertheless experience a net trading deficit in value but not in volume terms. The developing nations are exporters of low unit value sawlogs but larger net importers of the higher valued products processed from wood. The significance of this need hardly be stressed where there are foreign exchange difficulties.

The implications of the importance of forest industry development are carried further by an interesting evaluation of capital requirements by the "have-nots" to 1970 to satisfy increasing consumption while maintaining the present volume of net trade. The capital cost of expanding productive capacity over that period of time would appear to be little greater than that of importing the required additional quantity of product in one year. In addition, the propulsive nature of investment in the forestry sector is given strong emphasis. For quantitative support indices of the degree of indirectness and of interdependence with other sectors are derived.

Foresters in particular will find the suggestions for profitable avenues of applied research of considerable practical interest. Perhaps the most important is the great need for research into the scaling down of the economic production of pulp within the known processes.

In the humid tropical areas there still remains a formidable volume of testing to be carried out on the complex range of "secondary" species which do not normally enter the trade. Attention

might have been given to the problems associated with sorting and grading, and the sale of those species which occur infrequently in the forests of this climatic region. It is gratifying to note however that research into low-cost and low-capitalized extraction and logging road construction is suggested. There is no doubt that the opening up of forest tracts in countries or localities not endowed with natural forests of high productivity, must follow these lines.

In a broad appraisal such as this is, readers should not expect to discover a neat answer to the particular problems of their own countries. Forest resources, and conditions and the availability of production factors are widely variable throughout the developing bloc. A detailed path of development cannot be located without sound knowledge of the underlying economic and social structure. But generalities and broad principles have their place, and for this reason the chapter is an excellent contribution to the fairly sparse literature in this field of forest economics.

E. C. G. Gray.

G. R. Spinks.

Rural Settlement and Land Use.

An Essay in Location.

MICHAEL CHISHOLM.

Hutchinson & Co., Ltd. (London), 1962. 207 pp.
12s. 6d. 5tg.

There are many factors which influence location patterns. In this book the author has attempted to provide a systematic account of the way in which distance affects rural settlement and land use. The use of theory is minimized, and for the most part descriptive data and research results, drawn from a wide variety of sources, are used to illustrate the impact of distance on patterns of land use. Consequently, most of the ideas and arguments presented in the book will be familiar to students of location. The author suggests that the book may fill a gap between location studies that examine all the factors important in determining the location of an individual firm, and studies that attempt

to develop a general theory embracing all the main features of spatial distributions (notably those of Losch and Isard). However, any gap that the book may fill is only in terms of a collection of somewhat unrelated descriptive material demonstrating the importance of distance in determining patterns of land use and settlement.

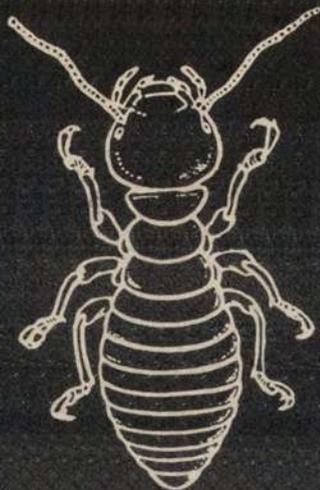
After an introductory chapter the elementary theory of location developed by von Thünen and Weber is described, together with their methods of partial equilibrium analysis. It is assumed that the location of a settlement, or major concentration of population, is given and fixed. Thus, the aerial distribution of crops and livestock as determined by the competition between products and farming systems for the use of any particular piece of land, is examined at the individual farm and village level and then at the regional and world levels. The way in which distance affects land use patterns about settlements is examined, with particular attention given to the effects of fragmentation and consolidation on the pattern and level of production. There follows a chapter dealing with the impact of distance on marketing arrangements and zoning on a regional and world basis. The analysis is then inverted so that patterns of land use are predetermined by natural conditions and the location of settlements is variable. An attempt is made to measure some of the economic costs attributable to different degrees of nucleation of rural settlement, and the location of lines of communication with respect to rural and urban needs or potential needs is examined. In the final chapter, dealing with the impact of technical change on patterns of location, it is suggested that there is a tendency towards an increasing degree of agglomeration at all scales of operation in land use.

The book is valuable in that it does provide interesting background material for those who wish to become acquainted with the role of distance in determining patterns of rural settlement and land use without becoming involved in an abstract theoretical treatment of the subject.

R. J. Cheetham.

Port Moresby: V. P. Bloink, Government Printer.—10816/10.63.

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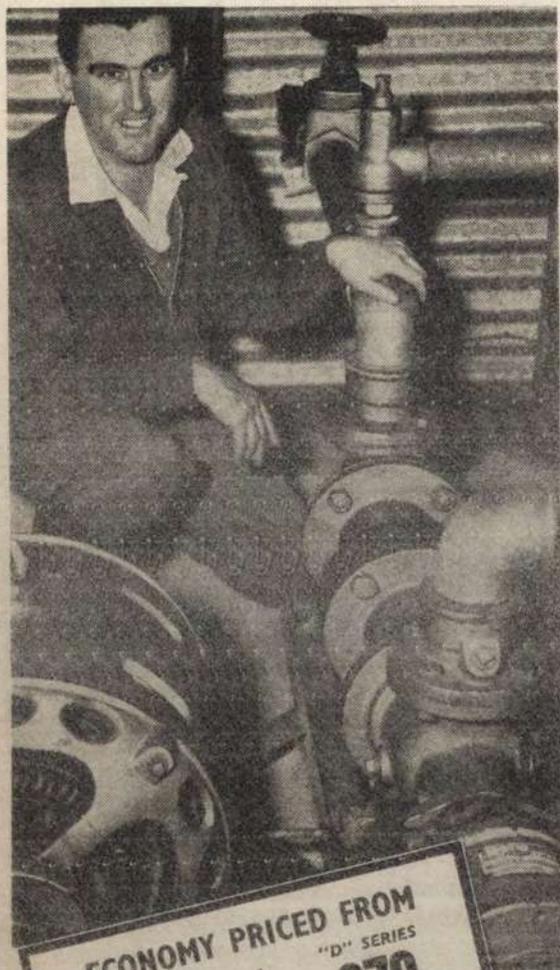
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