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

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CONTENTS

The Development of a Cattle Industry in the Territory of Papua and New Guinea

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Chief of Division of Animal Industry, D.A.S.F., Port Moresby.

An address given to the Australian and New Zealand Association for the Advancement of Science, Brisbane, May, 1961.

Introduction.

IN common with Australia, the Territory of Papua and New Guinea had no indigenous cattle. The first importations of cattle were made prior to World War I, when the Territory of New Guinea was under German Administration. The early importations into German New Guinea were mostly of the Jersey and Guernsey breeds, and the influence of these breeds was seen in New Guinea cattle prior to World War II. (Hutchinson 1941.) Following the Australian mandate over this part of the Territory, several other breeds were imported including some with Zebu blood. In 1909 there were fewer than 1,000 cattle in New Guinea while in 1939 the figure was in excess of 21,000 (T.N.G. Admin. 1939).

Most of these cattle were associated with the coconut plantations around the coastline of the islands. They were used on the plantations to keep down the growth of grass and herbage under the coconut palms and were most effective in reducing the cost of this operation. They provided the plantations with a supply of fresh meat and a small number of the cows were milked. There was, in effect, no cattle industry prior to World War II. The raising of cattle was a subsidiary interest of copra producers. The majority of these animals were killed during World War II, although small numbers of them did survive hostilities.

In post-war times the cattle industry has developed along slightly different lines although the use of cattle as grass cutters in coconut plantations is important in some areas. Large areas of land have now been made available as pastoral leases and these have been taken up for the grazing of beef cattle. A census of cattle in the Territory of Papua and New Guinea taken at 30th June, 1960, showed the presence of 17,478 head.

The Administration of the Territory of Papua and New Guinea has an active policy of encouragement of a cattle industry. The ultimate aim is a cattle industry which will enable the Territory to be self-sufficient in beef and beef products. To this end the Administration provides free veterinary and advisory services, operates a freight subsidy scheme on the importation of approved breeding cattle and runs livestock stations where experiments in cattle breeding and management and pasture improvement are carried out.

The present land tenure system in the Territory of Papua and New Guinea will restrict a rapid expatriate development of a pastoral industry. All land in the Territory is native-owned until it is purchased by the Administration at which time it becomes Crown Land. This Crown Land is then leased by public application. Purchase of land depends upon the willingness of the present native owners to sell the land as well as their ability to sell based upon their estimated future needs. As a result, the large areas for pastoral pursuits can be obtained only in areas of low native population. Expansion of the pastoral industry in areas of high population density will depend on the development of a native cattle industry. At the present time in the Markham Valley, the area of the greatest potential, approximately 86,000 acres are under pastoral lease and approximately 20,000 acres are under mixed farming lease. These areas developed to the full would carry in excess of the present Territory cattle population.

Environment.

The Territory of Papua and New Guinea lies within the zones of super humid and humid tropics. The temperatures are moderately high and humidities very high. Climatic stress on domestic livestock is therefore considerable and tends to favour small breeds of animals and small individuals of other breeds. This poses a challenge to the development of high producing cattle.

There are two completely separate environments in Papua and New Guinea :—

(*a*) *Lowland Environment.*

It was in this environment that all pre-war cattle development took place. The environment is typical of the humid and super-humid

tropics. In many areas plantation and pastoral lands must be wrested from tropical rain forest but several large areas of natural grassland occur along the valleys of the larger rivers. It is in these large grassland valleys that present development is concentrated. Foremost among these valleys is the Markham-Ramu river system which cuts right across the island of New Guinea from the Huon Gulf (Lae) to the mouth of the Ramu and Sepik Rivers between Wewak and Madang.

In this lowland environment European breeds of cattle show poor productivity and although much can be done in the development of improved pastures providing a better nutritional level, the immediate answer seems to lie in the development of types of cattle which are fitted to economic performance in the environment.

Climatic details of Port Moresby are given in graphical form in Figure 1.

(*b*) *Highland Environment.*

Several upland valleys exist in the highland areas of the jsland. Chief among these are the Wahgi and Asaro systems where a large proportion (approximately 40 per cent.) of the native population of New Guinea is found. As a result of the high population density in these highland valleys there is little land available for pastoral development. Most of these valleys are between 4,000 and 6,000 feet above sea level and this altitude modifies the climate sufficiently to produce an environment to which European breeds of cattle are adapted.

A climograph of Goroka, the chief centre in the Asaro valley, is included in Figure 1 and coincides closely with climographs of a typical temperate climate, and also of tropical areas into which European breeds have been successfully introduced (Kenya Highlands and Ceylon Highlands).

It is in this highland environment, which is suited to European breeds of cattle, that the introduction of cattle to the native village economy has been attempted.

Pastures.

In both the lowland and highland pastoral areas the dominating natural pasture is one of Kangaroo grass (*Themeda* spp). and Kunai (*Imperata* spp). The vine type legumes *Centrosema, Pueraria, Calopogonium* and *Clitoria* were introduced as cover crops for plantation management and have become firmly established throughout the island. Where rain forest has been cleared for plantations these legumes combine with *Paspalum conjugatum* to provide a nutritious pasture which forms a significant portion of the coastal pastoral land of the Territory.

The natural kangaroo grass and kunai pastures are not very productive and the introduction of better type grasses plays an important part in the development of the Territory cattle industry. This can be attributed to several factors among which are :—

1. The relative scarcity of alienated pastoral land encouraging lessees of the available land to develop the maximum carrying capacity of the areas leased.
2. The need for an intensive system of animal husbandry because of husbandry and disease problems peculiar to the Territory.
3. The need for most breeders of cattle to fatten their own bullocks.

The grasses which have shown most promise are Guinea grass (*Panicum maximum*), Elephant grass (*Pennisetum purpureum*), Buffel grass (*Cenchrus ciliaris*), Para grass (*Brachiaria mutica*) and Molasses grass (*Melinis minutiflora*). Of these Buffel and Molasses grasses provide little problem in establishment as viability of locally produced seed is high, however, the other grasses must be established by cuttings. The vine type legumes mentioned above are used in conjunction with these grasses and provide a good mixed pasture. Townsville lucerne (*Stylosanthes sundaica*) and Brazilian lucerne (*Stylosanthes gracilis*) have also proved of benefit in some areas. The leguminous tree *Leucaena glauca* is used extensively in coastal areas as a shade tree for plantation crops of cacao and coffee, and volunteer growth in pastoral areas is readily eaten by cattle. It has not been used to any degree on any of the pastoral leases.

Animals.

On animal health grounds the importation of cattle into the Territory of Papua and New Guinea is limited to animals originating from Australia. As a result, we are placed in the position of importing cattle bred in temperate and sub-tropical areas into a purely tropical country. Although Zebu and Zebu crossbred cattle are available in Australia, they are not available in any large numbers to develop rapidly the Territory industry.

Immediately post-war, cattle herds were built up by introduction of large numbers of breeders of the European breeds. These cattle, together

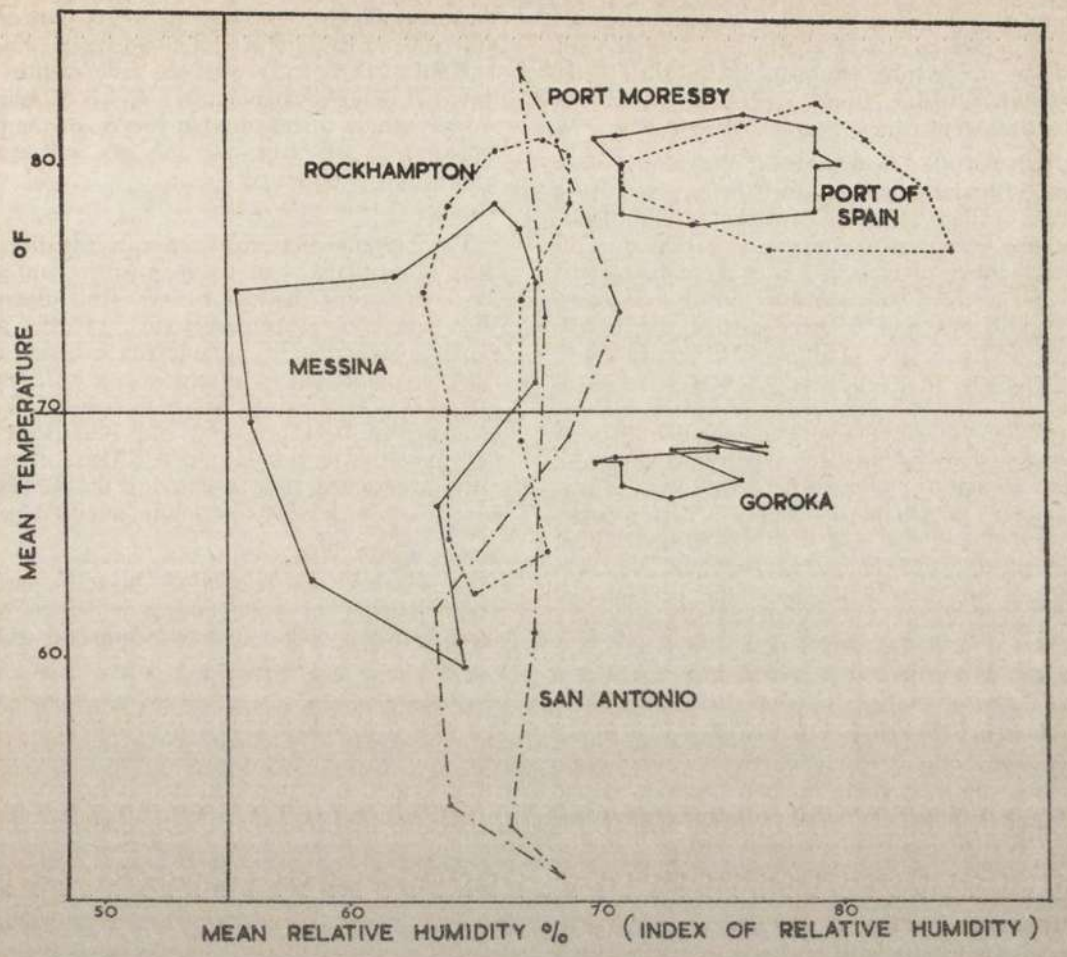


Figure 1.

with the more recent importations must form the basis of the development of types of cattle which produce well under Territory conditions. The tendency in later importations has been to purchase cattle from properties in the north of Australia especially where the animals are destined for properties in the lowland environment.

It has been found that the introduction of European breeds of cattle into the Territory is accompanied by a failure of adaptation to the new environment in a varying percentage of the animals imported. The percentage depends upon the type of environment into which the animals are taken and is lower in the highland environment than in the lowland environment. This can be shown particularly with dairy cows imported from the one herd. Some cows after importation produced close to their Australian herd average while others produced considerably less. Visual estimations on beef breeders seem to indicate the same tendency. This type of phenomenon was shown by Payne & Hancock (1957) in the experiment with identical twin calves one of each pair being in Fiji and the other in New Zealand.

European breeds thrive quite well in the highland environment. The main breeds encountered are Shorthorn and Angus. These animals produce well, particularly where pasture improvement has been undertaken. Two trial shipments of steer beef air-freighted from the Department's Western Highlands Livestock Sta-

tion, Baiyer River, to Port Moresby, showed that Shorthorns would produce carcases dressing out at an average of 610 lb. at 2-2½ years. Figures available from a private producer at Kokoda show similar carcase weights.

In 1954 the Department of Agriculture, Stock and Fisheries imported three heifers and three bulls of the American Brahman breed. These animals provided an important nucleus for the development of crossbred animals more adapted to the lowland environment. Small scale cross-breeding experiments were carried out in the Port Moresby area and in 1959 an intensive programme of cross-breeding was commenced on the Papuan Lowlands Livestock Station, Moitaka. In this programme Brahman blood is being introduced into an Aberdeen-Angus herd with an aim to produce a herd with varying percentages of Brahman blood. Performances within this mixed herd will be compared under the existing environment. The final aim will depend on observations upon the performance of animals within the varying percentage groups. Selection is to be carried out towards the type which shows optimum performance under the local environment. (Anderson 1961.)

A subsidiary programme of grading up to the Brahman breed is also under way to increase the number of high grade Brahman animals in the Territory. Bulls from this programme are available for sale to Territory cattle owners.

More recently other importations of Brahman and Brahman crossbred cattle have been made by private interests and the Department has introduced Afrikander bulls obtained from C.S.I.R.O. National Cattle Breeding Station, "Belmont", via Rockhampton. The successful development of a cattle industry in the lowlands of Papua and New Guinea will depend largely on the use of these tropical breeds of cattle.

This may be illustrated by the results of a preliminary weight gain trial in progress on the Papuan Lowlands Livestock Station, Moitaka. Five Angus heifers and five F^1 Brahman-Angus heifers are the test animals. They were weaned onto the natural kangaroo grass pasture and have been maintained on this pasture throughout.

Average weights just after weaning (12 months) were for the Angus group 331 lb. and for the Brahman-Angus group 407 lb. At 21 months the weights were 466 lb. for the Angus group and 670 lb. for the Brahman-Angus group. A graph of the weights against age is shown at Figure 2. The almost 100 per cent. difference in gain between the two types (Angus 135 lb. to B.A. 263) over the nine months of this trial is highly significant. The B.A. heifers are now ready for mating but the Angus heifers although of the same age are not sufficiently well grown to be mated.

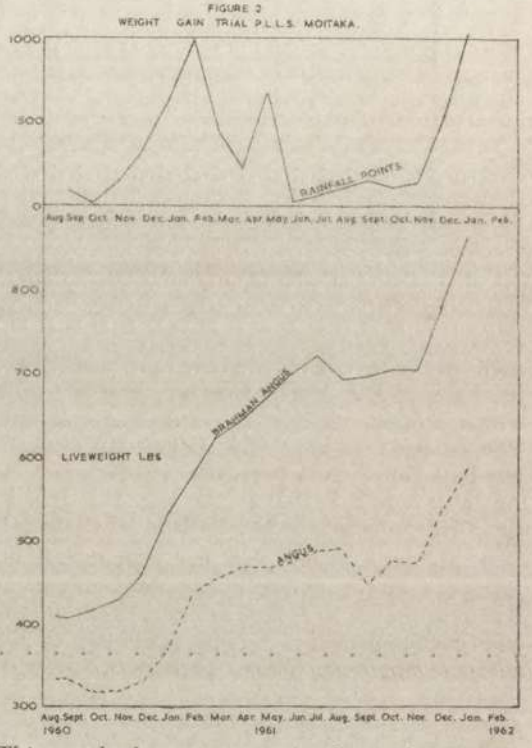
Disease.

The Territory is freer of serious cattle diseases than is Australia. In common with Australia we have none of the major exotic virus diseases. We have no pleuropneumonia. Cattle tick exists as a legacy of pre-war cattle herds and has been eradicated from some major cattle raising areas. Tuberculosis has been reduced to an incidence of 0.44 per cent. and Brucellosis to 0.95 per cent. of animals tested. These diseases can be prevented from re-entering the Territory by quarantine service controlling importations.

Screw Worm Fly.

One disease not present in Australia has a major bearing on cattle raising in Papua and New Guinea. This is screw worm fly strike.

FIGURE 2
WEIGHT GAIN TRIAL P.L.L.S. MOITAKA.



This graph shows progress in the trial 8 months beyond the stage mentioned in the text.

The fly incriminated in this disease is *Chrysomyia bezziana* the common old world screw worm fly. This fly is a common species widespread in Africa and the Orient. In the South-East Asian area it occurs in India, Ceylon, Indo-China, Malaya and eastwards to the Philippines and New Britain. It does not appear to be known from Australia or the South Pacific area east of New Britain (Crosskey 1961 in litt.).

The fly is present throughout the Territory of Papua and New Guinea with the exception of the Islands of Bougainville and Buka. It is not a severe problem at altitudes of 5,000 feet above sea level. Its presence necessitates regular (4-6 weeks) prophylactic insecticidal treatment of all animals and the inspection of the animals at least every two days. Routine procedures such as branding and castration must be carried out at times when the incidence of fly is low or has been reduced by spraying at more frequent intervals. The treated animals must be kept under close supervision until the wounds have healed to the stage where they are no longer attractive to the fly. It is important also that each new born calf be treated to prevent navel strike. If calving proceeds during the wet season, the period of highest fly activity, it is not unusual to have 100 per cent. of new born calves struck by the fly within 24 hours of birth.

From this short explanation of the effects of the screw worm fly it is evident that cattle raising must be carried out on a more intensive scale than is usual in much of Australia. This fact was mentioned earlier in discussing the reasons for an emphasis on pasture improvement in the Territory. If cattle are not constantly inspected then losses will occur from screw fly strike. Figures available from one property where an extensive method of husbandry is practised show that an average of 13 per cent. of the cattle are permanently under treatment for screw fly strike, while on properties where cattle are more intensively and carefully managed, less than 0.5 per cent. are permanently under treatment.

It is because of screw worm fly that polled breeds of cattle are recommended for the Territory. The characters of the skin of Brahman and Brahman crossbred cattle and their great skin mobility may also have a bearing on the susceptibility to fly strike. It is unusual to find these animals struck while European breeds running under the same conditions may suffer severely.

Thus, screw worm fly strike is the disease which has the greatest single bearing on the establishment of a Territory cattle industry. It increases basic establishment costs because of the greater sub-division necessary for adequate control of the cattle. It greatly increases running costs because of the constant inspection, prophylactic spraying, and treatment of any affected animals.

Cattle Tick.

The cattle tick (*Boophilus microplus*) was introduced into the Territory with pre-war importations of cattle. With the low cattle population early post-war, a programme of progressive eradication was laid down.

Eradication has been successful in two areas :—

1. *Eastern, Western and Southern Highlands, Territory of New Guinea.*

   This is an area which can be completely isolated. There is only one road entry, all other movement being by aircraft. Spraying treatments were completed in 1955 and the areas have remained clean since. One reinfestation occurred on two herds in the area from introduced cattle even though these cattle had been subjected to three spraying treatments, the last two of which were reported to be clean. The reinfestation was immediately treated and no further outbreaks have occurred.

2. *Sogeri Subdistrict of Central District, Papua.*

   This again is an isolated highland area with only one road access. The area has remained clean despite constant cattle movements in and out since 1954.

Eradication has been undertaken in four other areas :—

1. *Morobe District.*

   This area was cleansed in 1956 and remained clean until 1958 when an outbreak occurred on three properties. Retreatment was introduced on these properties and they have now been clean for over twelve months. I might venture to suggest that the programme appears to have been successful in this District.

2. *Rabaul Area.*

   Eradication spraying treatments were completed in 1955. Reinfestation occurred on one property in mid-1956 and again on a second property in late 1956 to which

animals from the first reinfected property had been moved in order to attempt eradication by destocking.

These sprayings were completed in mid-1958 and eradication appeared to be successful until an outbreak occurred in 1961 on two adjoining properties. These properties are being retreated. The focus of infection may possibly be the presence of feral cattle and water buffalo in reasonably close proximity to the cattle areas and the passage of deer from this focus to the cleansed areas. One anomaly in this supposition is that the cleansed cattle closest to the focus have remained clear whilst reinfestations have occurred in cattle much further from the possible source of infection.

3. *Port Moresby Subdistrict of Central District.*

Eradication was attempted but reinfestation occurred on all properties involved. The causes for the complete failure are threefold :—

(*a*) Incomplete musters were obtained on at least two properties ;

(*b*) Deer are present in the area ; and

(*c*) Wild horses are present in the area.

The area is now under a control spraying programme in an attempt to considerably lower pasture infestation while efforts are made to kill or capture the horses and drive the deer from the cattle areas.

4. *Madang Area.*

Eradication spraying programmes have been completed but the surveillance stage has not been completed. To date no reinfestations have been observed.

Some preliminary studies on the suitability of the deer as a host for *Boophilus microplus* were carried out.

In the first experiment two deer were infected with 10,000 larvae hatched from an engorged female tick recovered from a heifer. No engorged female ticks were collected from this infestation. A severe reaction to attacking larvae was observed in both animals.

In the second experiment 10,000 larvae were placed on one deer and the larvae were protected by a hessian coat. 224 engorged female ticks were recovered.

In a third experiment larvae hatched from an engorged female tick collected from a deer which had been killed in a hunt readily infected an experimental heifer.

The second experiment was designed to determine whether repeated generations of cattle tick could be maintained solely on deer. Technical difficulties however, prevented the experiment proceeding beyond the stage reported above.

This point is of importance if pasture infestation can be maintained at a very low level by control treatments of all cattle. The tick may not be able to maintain itself on deer alone, and future eradication programmes may have some chance of success.

Tuberculosis and Brucellosis.

These two diseases are subject to eradication programmes. All cattle over six months of age in the main areas are subjected to the intradermal test for Tuberculosis annually. The incidence of the disease has been reduced considerably to a figure in 1959-60 of 0.44 per cent. of animals tested.

A test and slaughter programme for Brucellosis was introduced in 1957 using the serum agglutination test. Eradication has been successful in New Britain District and Highlands Districts and the incidence in the Central District and Morobe District has been reduced to such an extent that eradication seems imminent.

Other Diseases.

Surveys into other infectious diseases will be introduced although the absence of any major infectious disease problems in Territory cattle reduces the urgency of such surveys.

Deficiency diseases are suspected in some areas especially where heavy rainfall conditions produce highly leached soils. In most cases the cattle are such a recent introduction that deficiencies shown in soil and pasture analyses have not manifested themselves in the grazing animal.

The problem of infertility in European breeds of cattle when run in the lowland environment is one of considerable concern. The Brucellosis eradication campaign has removed one possible cause of this infertility and surveys of the presence of Vibriosis and Trichomoniasis will be carried out. A small number of phosphorus estimations have been made with inconclusive results. The problem could be directly related to the non-adaptability of these animals to the

tropical environment. Differential figures of calving percentages from Angus cows and F^1 Brahman-Angus and Brahman-Shorthorn cows mated to the same bulls have been extracted from records of the Department's cross-breeding programme. The figures show a 24 per cent. (23/97) calving in Angus cows and 100 per cent. (16/16) calving in cross-bred cows. The number of crossbred cows in this group was small compared with the number of Angus cows. Fully comparative figures of calving percentage of these two types of animals in the one age group are difficult to obtain because of the poor growth rate of European breeds of cattle under the local conditions and the need to hold heifers of these breeds for an extra year so that they have grown sufficiently for mating. The different growth rates of these animals are shown in Figure 2 and illustrate this point.

Within the Angus group the calving percentage on an age basis has also been extracted. Imported cows, nine years of age and over, gave a calving of 26 per cent. (16/62) while locally bred cows, three to six years of age, gave a calving of 20 per cent. (7/35), the overall figure being 24 per cent. mentioned earlier.

It is commonly observed that bulls of European breeds refuse to work in the local environment. Bulls of Zebu breeds are much more vigorous and can be used at a lower mating percentage than bulls of European breeds. In part of the programme mentioned above, two breeding groups, one mated to Brahman bulls and the other mated to Angus bulls, were used. The Brahman bulls were mated at two per cent. while the Aberdeen-Angus bulls were mated at eight per cent. The number of calves born per Brahman bull was 32.3 and the number of calves per Aberdeen-Angus bull was 10.4.

These figures only serve to confirm the value of the Zebu and Zebu crossbred animals over the European breeds in the lowland environment.

Present position.

With the present Territory population of 17,000 head of cattle there should be a theoretical annual turnoff of 1,700 head. The total population figure, however, is biased towards breeding cattle, because of the infancy of the industry and the steady importation of breeding stock. Actual turnoff for 1959-60, excluding animals killed for private consumption, was 698 head.

Territory imports of fresh chilled or frozen beef for the year 1959-60 totalled 1,234,712 lb. which at 600 lb. per carcase would represent approximately 2,100 head. Thus, the total Territory consumption for that year was 2,800 head. As a result, approximately 30,000 can be taken as an immediate target figure for the Territory cattle population from which the Territory will produce its present consumption. This figure will increase considerably with the increase in consumption of beef by the native population as a result of the rise in living standards. This figure does not take into account the large amount of tinned meat imported into this Territory in 1959-60, which exceeded 8¼-million pounds weight. The partial replacement of this by local fresh meat will also increase the consumption figure.

Freight Subsidy.

The Administration subsidises the importation of approved breeding stock into the Territory. The subsidy covers the cost of freight exclusive of fodder and attendants' fees for the shipment of approved cattle to Papua and New Guinea. To date over £70,000 has been spent for the shipment of 2,128 cattle on behalf of fifteen importers. The lack of suitable shipping has seriously affected the operation of the scheme at times but the position has been relieved by the introduction of a modern vessel to the run over the last few months.

In 1960 it was announced that the scheme would continue until a further 8,000 breeders have been imported or until 1965 whichever is the sooner. The effect of the scheme will then be reviewed.

The scheme provides a strong incentive for the establishment and stocking of pastoral properties in the Territory and will materially assist in the attainment of the target of a cattle population of 30,000 head.

Abattoir Construction.

Full development of a cattle industry in the Territory is seriously hampered by the lack of slaughtering facilities. At present beef producers must provide their own small slaughter floor if they are to market their beef. This procedure is unsatisfactory for several obvious reasons.

1. It is a time consuming and onerous job for the producer himself.
2. It is wasteful of by-products and offals.

3. The installation of the facilities for slaughter and storage of the beef on the property is expensive.
4. Transport of beef to market in the tropical environment poses problems.
5. Departmental supervision of slaughtering and inspection of carcases is difficult if not impossible.

A plan has been prepared for the establishment of central killing works where the disadvantages mentioned above are eliminated. In the first instance, the works will be operated by the Department and a reasonable killing fee will be raised. All producers can avail themselves of the facilities and freezer and chiller storage space will be available.

The establishment of these works should supplement the subsidy scheme in encouraging the development of the Territory industry. As in all developing industries the Territory cattle industry is at a stage where present production is too small to support a processing works but the potential will not develop unless producers can see a readily available market for their produce.

Concentration of slaughter cattle upon the works and the distribution of the beef to the consumer also provide problems to be overcome. The establishment of a works in Lae where cattle can be concentrated by land from a vast area of country including the Highlands Districts will be the first step in the scheme. Distribution of local beef can be carried out in the same way as imported beef is now distributed although this will necessitate the freezing of much of the beef.

The ready availability of such works will encourage the small producer to increase his herds, and as a result the native producer will find a ready cash market for his animals.

Zebu cross-breeding.

The Administration's programme of Zebu cross-breeding has been mentioned above. This programme will provide basic adapted stock to improve Territory herds. Beef production in the hot lowland environment will, therefore, be placed on a firmer footing.

Native Cattle Industry.

The introduction of cattle to the native village economy presents an entirely new concept to the native mind. The Papuan and New Guinean has had no previous experience with animals as large as cattle and he must be taught methods of handling them until he has some confidence in his ability. The natives who have been introduced to this work have readily absorbed the teaching and have no trouble in managing the animals.

Cattle under native ownership now total 288 head all of which are European breeds of cattle which are run at altitudes over 3,000 feet. Natives in these areas have been selected for the initial projects because of the ready availability of European breeds of cattle and the disease-free status of the areas in which they live. Husbandry in these native units is based upon a system of daytime herding with a securely fenced paddock to hold the cattle at night. The fencing and handling facilities are provided on a co-operative basis between individual cattle owners.

The scheme is still in its early stages and interest from natives outside the present pilot projects is high. The further introduction of cattle into the native economy will help to utilize large grassland areas where population densities are too high to permit alienation of areas sufficiently large for expatriate settlement. If interest remains at its present high level native owned cattle will constitute an increasing proportion of cattle marketed for Territory consumption.

The control of the problems discussed together with the application of the functions of the Administration which are mentioned should enable the Territory to approach rapidly the aim of self sufficiency in beef and beef products. Beyond this aim is a possible export market for beef products which can be produced under the conditions of an almost disease free tropical environment.

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Shark Attacks in New Guinea Waters

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Chief of Division of Fisheries, D.A.S.F., Port Moresby.

An address given to the Tenth Pacific Science Congress, Hawaii, August, 1961.

Introduction.

INFORMATION concerning the prevalence of sharks in New Guinea waters was obtained in inshore netting tests close to Port Moresby in Bootless Inlet in the dry season (May to November) of 1954. These experiments showed that shoals of small sharks up to 3 ft. 6 in. total length entered these waters which have a salinity up to 4.1 parts salt per 1,000. The estuaries become stable environments in the south-east season without any influence from fresh water, and ocean fish species enter the inshore waters sometimes in large numbers. The sharks come to prey on these fish.

Small sharks do considerable damage to mesh nets so that it is not practicable to leave nets untended, and even nets watched continuously are often damaged by the small sharks which are not caught in the standard type of mesh net used (about 3-in. mesh), but are able to bite their way through, causing considerable damage to the net. These shoals of small sharks seriously disrupt the normal inshore shoaling of small fish with the result that few big catches of the normal inshore species are made.

In inshore water near Port Moresby lines on the surface, buoyed so that each hook was only two feet below the surface, were tested in fishing for larger species—Trevally, etc.—which at times appeared in great shoals. The only species caught were sharks up to eight feet long. In similar tests inside the barrier, again sharks were captured, although considerable numbers of surface fish were in the vicinity at the time the tests were made. In further tests outside the reef, eight miles offshore, long lines set about 25-30 fathoms below the surface again produced sharks, although quite small baits set for other species of fish were used. It is perhaps significant that two mud crabs (*Scylla*) were captured and it is possible that crabs had formed the baits for the nine and ten foot sharks (*Carcharinus* sp.) which were captured.

Sharks are most abundant in the open sea which is their normal habitat: they feed on ocean species and they appear to follow the tuna shoals and other migrating species.

Long line fishing carried out in New Guinea has been largely uneconomic because sharks took a considerable portion of the catch, and tuna weighing 80-120 pounds have been consumed in about six bites of about 15-20 pounds each, leaving the head, backbone and the fibrous fins. Localities where sharks were dominant are off the south-east of Papua and to the North of Louisiade Archipelago.

This dominance of the open sea has also been seen at Eastern Fields Reef south of the Gulf of Papua where vertical lines in depths of 60 fathoms have produced only sharks. At Jomard Entrance in 100 fathoms only sharks were caught, and at Hankow Reef to the north-east of Madang sharks on many occasions have completely dominated the fishing which has been largely uneconomic because of their attacks. *Carcharinus, Hypoprion* and *Galeocerdo* are probably the most important. *Galeocerdo* is believed to be responsible for most fatal attacks.

Localities where shark attacks have occurred.

Although sharks are the greatest menace as potential attackers in shallow, discoloured water, they also occur at times in perfectly clear water and can sometimes be seen in large shoals. In Buka Passage and south of Woodlark Island, shoals of long snouted sharks following skipjack tuna and reef snapper respectively, were observed.

Chart No. 1 shows a considerable preponderance of attacks in the Central Papuan southern coast. In this region there has been much fishing activity and at least six attacks have been associated with skin diving for fish in the years 1954-56, the shark attacking initially to take the fish. Only one of the attacks was fatal and it is probable that the swimming skill of the fishermen was partly the means of avoiding more serious injury. Several fishermen have

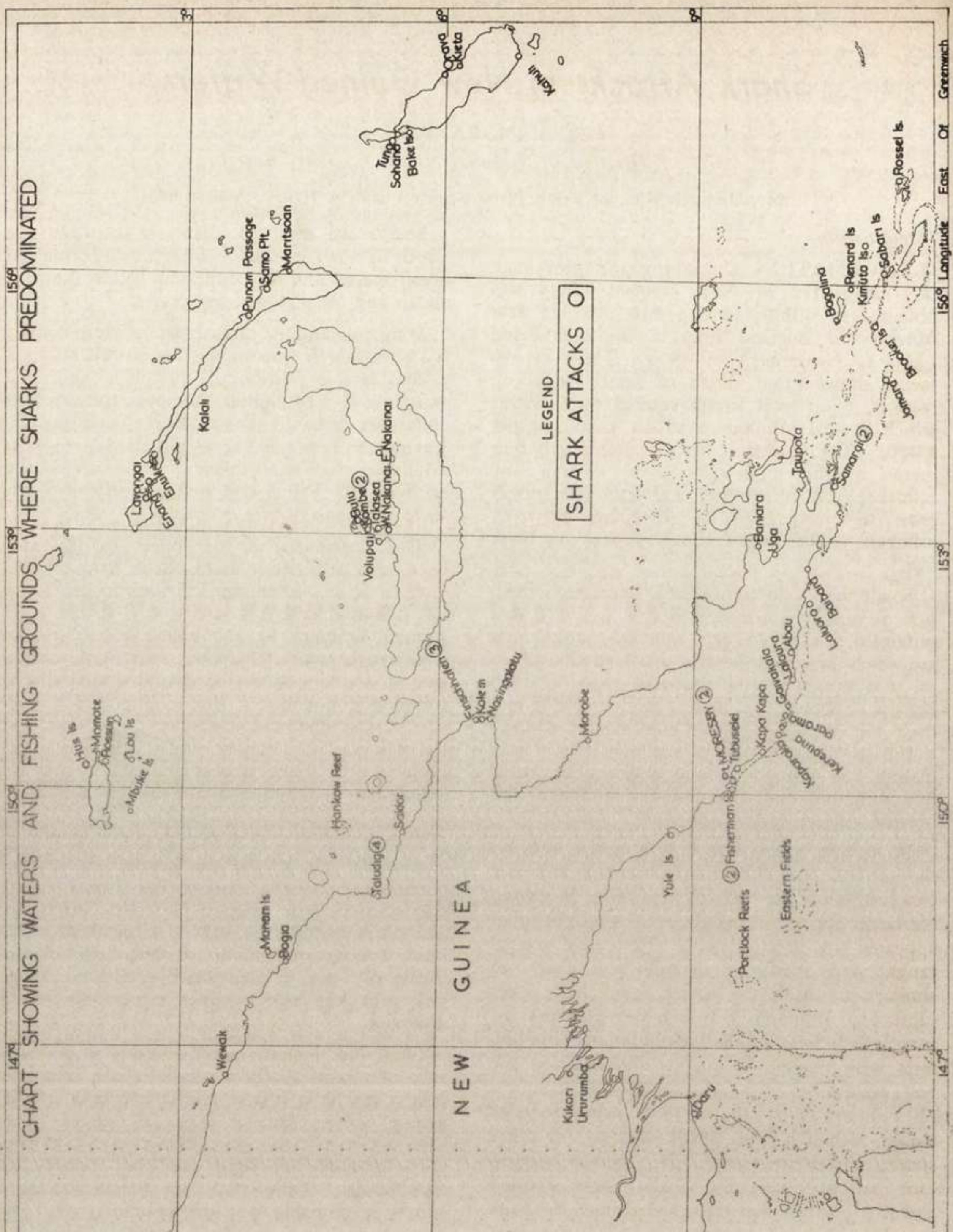
CHART SHOWING WATERS AND FISHING GROUNDS WHERE SHARKS PREDOMINATED
LEGEND
SHARK ATTACKS
NEW GUINEA
Wewak
Manam Is
Bogia
Talasea
Hankow Reef
Saidor
Morobe
Kikori
Urumba
Daru
Yule Is
Portlock Reefs
Eastern Fields
Fisherman Is
Pt MORESBY
Tubuseia
Kapa Kapa
Gavuvaita
Paramana
Kerepuna
Laloura
Abau
Baibara
Baniara
Uga
Taupota
Samarai
Bogalina
Renard Is
Kimuta Is
Sabari Is
Brooker Is
Rossel Is
Jomard Is
Volupai
Talasea
Kalai
Punam Passage
Samo Pt.
Mantsoan
Tung
Sohano
Buka Is
Kieta
Kahuli
Mus Is
Momote
Lou Is
Mbuke Is
Kolem
Nasingalatu
147°
150°
153°
156°
Longitude East Of Greenwich

stated that they know the dangerous ocean sharks which they avoid, but it is apparent that ocean sharks may attack from unseen positions and that small reef sharks sometimes attack.

Attacks have occurred over a wide area, some as at Baibara in 1955 in inshore shallow water, others on offshore reefs.

Places where shark attacks have not been reported.

No attacks have been reported from the following places :—Lae, Tufi, Karkar, and Ela Beach swimming area, Port Moresby. These areas are of interest as they are centres of considerable populations and there is a greater amount of swimming than in many other places where attacks have occurred. The Ela Beach area, Port Moresby, is relatively shallow and at high tide seldom more than 1½ fathoms deep. The shoal reef area extends seawards about 100 yards beyond the normal bathing area and is protected at the outside margin by a broad zone, mainly of staghorn coral. The area is not productive of fish and inshore shoals of small fish are rare. At Tufi, although there are no reported attacks by sharks, two deaths have occurred through crocodile attacks.

Attacks on humans and animals.

Unfortunately, the first shark attack in any area is not easily explained and an examination of the data in Appendix II indicates that in many cases the victim was taken completely unawares.

Although brushing attacks as described by Coppleson do not appear to occur in Territory records, some of the attacks are possibly related to this type of testing where sharks have taken hold of a victim and then actually released him on his retaliating by blows or vigorous struggling. One of the most interesting attacks of this type occurred at Baibara where an eight-year old boy fought with bare hands a shark which he succeeded in driving off. It is this type of retaliatory attack which appears to put human beings, in their attacks by sharks, generally into a different category from other animals, as most fish species attacked appear to become paralysed and more readily submit to their fate.

These brushing or testing attacks are evidently not uncommon and G. P. Whitely in his book "Sharks" gives a photograph of a victim of such an attack in which the shark tried to take the victim's head.

By far the greatest number of attacks are on limbs and it is probable that these offer the parts most easily obtained by sharks, although such method of feeding is contrary to that found where sharks feed on other fishes, when they leave any hard parts or even fibrous fins until last. Sharks in this respect may quickly form habits and increased efforts to catch sharks, both with the aim of preventing attacks and using the meat for food, are recommended.

It is not possible to predict where shark attacks will occur, but in discoloured waters, even a few feet deep, care should be taken. After one attack, there is good reason to believe a second will follow within a short period. Shark attacks may develop as a habit unless entirely prevented. The taking of a dog three months before a young boy was taken at Kaparoka in 1959 is an example of this.

A suggested method by which this habit is developed is remembrance of the mammal smell and after attack the remembrance of the smell of mammal blood. There is some doubt if rogue sharks as described do exist but it is worth recording here that a similar type of characteristic is developed in crocodiles which are even more cunning than sharks, and in New Guinea waters also attack canoes, seeming to know when there are no weapons aboard.

At Taludig near Madang on the north coast of New Guinea, three shark attacks occurred (believed to be a rogue shark). Only after the third attack was any publicity given and the Division was made aware of the situation. The attacks took place in shallow water only two or three feet deep, close to steeply shelving bottom descending rapidly to some fathoms. Sharks which were plentiful lay in wait in deep water. It was believed that these attacks were related to the brushing attacks described by Coppleson. However, the victims were always bitten and although the first three attacks were not severe, after the capture of one large shark and the withdrawal of the fishing team to another area, a subsequent fatal attack occurred. Intensified fishing by the local people caught more than thirty big sharks, suggesting that the "rogue" shark may in fact be a number of sharks.

Three other fatalities in Papua should be mentioned. A young boy died swimming under his house at Kaparoka near Hula, and two school boys, one returned from Australia, lost their lives in one week in December, 1956, swimming

close to the Kwato Mission near Samarai. It is probable that large sharks were responsible although subsequent newspaper reports stated that a shark about seven feet long captured after the second attack contained clothing belonging to one of the youths. Later evidence has shown that this is not likely to have been the shark responsible for the deaths. The details given above are recorded to show the difficulty in analysing the results of these surveys. After these deaths, the Division of Fisheries took more active interest in shark fishing.

It is appropriate to state here that at the Chatham Islands to the east of New Zealand, fishermen do not normally venture out in vessels less than 35-40 feet in length. Even vessels of this size are attacked by sharks which apparently consider the vessel is an invader of the shark's own private territory. Only at the Chatham Islands have I heard of a prepared plan to attack sharks by spearing behind the pectoral fin. From the way sharks attack, this method of defence is not likely to be possible on many occasions. Needless to say, behind and below the pectoral fin the shark skin is relatively soft and a good lance could penetrate the skin with a moderately strong thrust.

At Abau in 1955 a shark took a string of fish from a fisherman and then attacked the canoe, while in 1961 at Rossun, Manus, a shark which had been speared overbalanced a canoe, threw one of the occupants into the sea, bit him and, after the victim had regained the boat, bit the canoe. These are the only records of sharks attacking boats although there are numerous reports of sharks swimming in shoals near small canoes to the considerable anxiety of the canoeists.

Analysis of data on attacks.

Appendices I and II give details of attacks. The provoked attacks are not discussed as they in part are caused by carelessness or lack of fishing experience. The records of unprovoked attacks do not include deaths of two Europeans and several New Guineans whose bodies have never been recovered. One New Guinean and one European were almost certainly victims of shark attacks. The second European is suspected of being taken by a crocodile and the fate of a second native is not known as it may have been a shark or a crocodile that attacked.

Prior to 1950 only nine attacks are recorded of which six were fatal. There were no attacks in 1950 and only one attack in 1951. Fifty-four attacks occurred from 1951 to June, 1961, and of these twenty were fatal. There were four fatal attacks in 1956, four in 1958 and three in 1960. In 1955 there were no fatal attacks.

Table I gives an analysis of the attacks into fatal and non-fatal categories. Head, body and multiple injuries comprise the greater part of the fatalities and if the records for which no details are available are added (probably body injuries) the total is about 85 per cent. In the non-fatal attacks, head, body and multiple injuries comprise only about 20 per cent.

Of the fatal attacks about 40 per cent. were fishermen and of the non-fatal attacks 60 per cent.—50 per cent. of all attacks were on fishermen.

In a number of cases in which sharks attacked the body from the back, including shoulders and buttocks, the shark released its grip and the victim escaped. This was not the case when the shark attacked from underneath. Many of the attacks on the upper thighs were also fatal but some remarkable escapes are recorded.

How to avoid shark attacks.

Although most shark attacks appear to have been avoidable, in many instances the methods by which sharks attack show that certain standard precautions should always be followed. Example may be quoted of the fisherman who dived into the sea at Wewak in 1954 (Appendix II) during fish cleaning operations and received a fatal injury. The example emphasises the type of act which should never be attempted.

The following suggestions are made on the basis that many of the attacks would have been avoided with a few simple precautions. To-day young children crossing the road look to right and left, and the evidence of shark attacks indicates that, for fishermen at least, the possibility of a serious attack in New Guinea waters is not negligible and is of the same order as the risk of becoming involved in a serious motor accident. The following precautions should be taken :—

A. *Fishermen.*

(1) Fish in groups, keeping a watch for sharks. Even small sharks, apparently not able to do much harm, can inflict serious and even fatal wounds.

SHARK ATTACKS.—1948-1960. (1)

Table 1.

	FATAL.						NON-FATAL.						
Year.	Head and Body.	Multiple Injuries.	Legs or Thighs.	Hands Arms or Shoulders.	No Details (2).	Total Fatal Attacks.	Head and Body.	Multiple Injuries.	Legs or Thighs.	Hands Arms or Shoulders.	No details	Total Non-Fatal Attacks.	GRAND TOTAL.
1948	....	....	....	....	....	....	....	....	....	1(F)	....	1(1F)	1(1F)
1949	2(1F)	1	....	....	1	4(1F)	....	....	1	2	....	3	7(1F)
1950	....	....	....	....	....	....	....	....	....	....	....	....	....
1951	....	....	....	....	....	....	....	....	....	....	1	1	1
1952	1(F)	1(F)(4)	....	....	....	2(2F)	....	....	1(F)	....	....	1(F)	3(3F)
1953	1	....	....	....	....	1	....	1(5)	....	....	....	1	2
1954	2(F)(1)(6)	....	....	....	....	2(2F)	....	2	....	....	....	2	4(2F)
1955	....	....	....	....	....	....	1	....	2(1F)	3(F)	....	6(4F)	6(4F)
1956	....	1	1(F)	....	2	4(1F)	....	....	4(3F)	1(F)	1	6(4F)	10(5F)
1957	....	2(F)	....	....	....	2(F)	....	....	1(F)	....	....	1(F)	3(3F)
1958	2(F)	....	....	1	1	4(2F)	1	....	2	4(F)	....	7(4F)	11(6F)
1959	....	1	....	....	1	2	....	....	2	....	2(F)	4(2F)	6(2F)
1960	1	....	1	....	1	3	2(1F)	....	2(1F)	....	....	4(2F)	7(2F)
1961	....	....	....	....	....	....	....	....	....	2(F)	....	2(2F)	2(2F)
TOTALS	9(6F)	6(3F)	2(1F)	1	6	24(10F)	4(1F)	3	15(7F)	13(11F)	4(2F)	39(21F)	63(31F)

(1) Only records prior to 1948—2 fatal attacks, 1939 and 1940. (2) No details sometimes includes no remains found. (F) Fisherman.
(4) Attacked by several sharks—no remains. (5) Arm and leg bitten off. (6) Head.

(2) Do not hold fish in the water and particularly keep fish away from the body as far as possible.
(3) Return to the canoe trailing fish with a cord attached to the spear in preference to holding the fish or spear in the hand. Allow someone in the boat to take the fish aboard, away from your body.
(4) Do not dive deeply into deep water; go down feet first preferably in small groups looking all around.
(5) When fish are being gutted at sea, do not enter the blooded water.
(6) Even sharks out of water, apparently dead, can inflict serious injury. Treat them with caution.
(7) The shark when attacked by a fisherman will often turn on the fisherman and attack him. Be sure fishing gear and vessel are suitable to stand an attack when fishing for sharks.
(8) Other methods of fishing may be more efficient than spear-fishing—handlining, netting, trapping are all efficient methods—and with a small capital expenditure may produce a greater income for a smaller effort than is required in spear-fishing.
(9) If animals are taken, keep a closer watch and set lines for some months after the attack. The setting of lines with good baits will attract sharks so that added precautions should be taken when the lines are set and for some time after, even if no sharks are caught.
(10) As large sharks usually do not feed for some days after attacking, set lines after a few days. Often there are a number of sharks in a shoal, so do not stop shark fishing after one shark has been caught.

B. *Bathers.*

(1) Bathe in groups, keeping a close watch especially to seaward or to deep water. Do not bathe near deeply shelving bottom. Sharks and other large predaceous fish are often close inshore in these places.
(2) Avoid muddy water or discoloured water as far as possible, particularly blooded water.

Actions which have been successful in fighting attacks.

An analysis of the successful fights with sharks shows that, except in cases where large sharks deal fatal first attacks, the chance of escape is high. So much has been written by spear-fishermen and shark fishermen on encounters with sharks that it is difficult to give advice concerning the preliminary nosing attacks which some large sharks make, but it appears that sudden panicking, splashing movements would only increase the likelihood of the shark attacking immediately. Keep the shark in front and, if any weapon is at hand, use it to point and thrust at the shark. Try to protect the body as much as possible with hands or legs. The number of attacks which have been repelled with bare hands show that no effort should be spared in attacking the shark in some way, all the time endeavouring to get to a canoe or to the beach. It should be remembered that a shark, only four feet long, can inflict a fatal wound in one bite.

The following methods have been successfully used in escaping after an attack by a shark :—

(1) When an attack occurs in shallow waters, wade or swim quickly to the victim's assistance. Sharks are at a disadvantage in shallow water and are often scared off. The victim may also need assistance to get ashore. In five per cent. of cases sharks have attacked the rescuer. (Leonard P. Schulz, Smithsonian Institution, Washington, D.C. U.S.A.—Personal communication.)
(2) If in deep water, go quickly in a boat or canoe to help the victim. If he fights the shark off he may also need urgent assistance.
(3) Remember mouth-to-mouth artificial respiration in case victim of attack needs this type of help also.

Shark fishing as a means of preventing attacks.

It is unlikely that shark fishing in itself will prevent attacks. However, this method of combating sharks will essentially reduce the risk if carried out systematically. Shark meat is good food and fishing is often profitable. A market exists for shark skins prepared as for crocodile skins.

Certain principles should be followed if fishing is to be carried out on a large scale :—

(1) Fish with good gear so that if a shark is hooked it has little chance of escape. Shark-meat smoked or made into dried meal will keep for months.

(2) Fishing should be done some distance from villages or habitations where people normally bathe or of necessity travel in small boats.

(3) Red meat is good bait but blood or chum material should not be used where current may take the scent near inhabited places.

(4) Vessels used for shark fishing must be of suitable size to permit large sharks to be easily handled.

(5) Crews must be well trained.

The large number of sharks caught at Daru and saw sharks in Lake Murray suggests that with the correct fishing gear shark fishing would at certain seasons be economic close inshore, and further survey work might extend the range of shark fishing and also locate stocks of better fish.

Conclusions.

The large number of accidents, 22 fatal (two unconfirmed) and 34 non-fatal, caused by sharks which have occurred in the last ten years in New Guinea indicate that considerable effort could profitably be undertaken to give training in shark attack prevention, as suggested. Particular reference to shark fishing should be made, primarily as a source of food, but also as a means of preventing attacks.

Sharks are the dominant group of fish in tropical waters and feed by taking their prey unawares. Even very active predators are caught in this way. For this reason few sick or injured fish are ever found.

ACKNOWLEDGEMENTS.

Officers of the Department of Public Health have supplied many details of shark attacks, not otherwise available. Miss J. Herbert has made the tabulations and checked the manuscript.

DETAILS OF SHARK ATTACKS IN NEW GUINEA WATERS—1948-1961.

Appendix I.—PROVOKED ATTACKS.

Year.	Month.	Locality.	Remarks.
1948	March	Punam Passage	Fisherman. Grey shark speared in shallow water. Bites and lacerations to leg.
1948	....	Tung Island	Fisherman. Taking shark off spear, was bitten on face.
1959	February	Ururumba, mouth of Kikori River	Fisherman. Savaged on arm by 12-ft. shark which he thought was dead.
1959	November	Rapindik Beach, Rabaul	Fisherman. Companion speared shark. Helping to land it, both hands bitten.
1959	....	Morobe	Fisherman. Bitten on penis when trying to kill shark he had speared and dragged to beach.
1960	November	Toro Passage (Western District)	Fisheries trainee. 4-ft. 6-in. black tip taken from net alive and put in bottom of dinghy. Pushed aside by trainee—shark snapped at his left wrist and jaws had to be prised open to release it.
1961	June	Rossun, Manus	Fisherman. 9-ft. shark speared, attacked canoe and man overbalanced into water. Bitten severely on thigh. Regained canoe, then shark attacked canoe, breaking teeth on side.
1961	August	Vanimo	Fisherman. On Musu side of Wutong anchorage—two large sharks passed. Speared one and it savaged him on left thigh, causing deep jagged laceration.

DETAILS OF SHARK ATTACKS IN NEW GUINEA WATERS—1939-1961.

Appendix II.—UNPROVOKED ATTACKS.

Year.	Month.	Locality.	Remarks.
*1939	....	Gaivakala, Aroma	Fatal. Man swimming to anchored boat. Injuries to lower abdomen.
*1940	....	Bagalina, North coast Misima Island	Fatal. Small girl. No other details.
* 1948	....	Finschhafen	Fisherman. Right hand holding fish bitten.
*1949	....	Kerpuna, Abau	Fatal. Two men swimming near the village close to the bank when they were attacked. One victim's stomach torn out, second received severe multiple injuries.
1949	....	Sohano, Buka Passage	Man swimming close to wharf. Right hand torn off.
*1949	....	Orava, near Kieta, Bougainville	Fatal. Spearfisherman—youth 18 years old. Practically bitten in two through loin. Attacking shark not seen.
1949	....	Enang, Kavieng	Hand and shoulder bitten. Recovered. (Kavieng Hospital.)
1949	....	Kulengei, (South-east of Kilili) Kavieng	Leg amputated. (Kavieng Hospital.)
*1949	....	Sabara Island, Calvados Chain	Fatal. No details. (Misima Hospital.)
1951	....	Manam Island	No details. (Bogia Hospital.)
*1952	....	Samo Plantation, East coast New Ireland	Fatal. Spearfisherman. One bite, lower abdomen bitten out. Shark not seen.
*1952	....	Momote, Manus Island	Fatal. Fisherman. Underwater fishing, a number of sharks attacked. No remains.
1952	.... October	Lalaura, Abau	Fisherman. Near reef, bitten on right thigh but managed to fight off shark.
*1953	....	Kahuli, Buka Island	Fatal. Man washing, shark took piece out of side.
1953	.... March	Rossel Island	Fisherman. Arm and leg bitten off. Tiger shark then smashed at body with tail.
1954	....	Volupai, Talasea	12 years old boy swimming. Lacerations to leg and abdomen.
1954	.... January	Saidor	Bitten on back and thighs (a circle of teeth marks). Released when victim struggled.
*1954	.... May	Wewak	Fatal. Fisherman cleaning fish, dived into water to retrieve a lost fish. Head bitten off.
*1954	.... December	Port Moresby, Kila Beach	Fatal. Fisherman swimming near canoe in shallow channel of water 200 yards offshore. Shark bit pieces from stomach and thigh. Four others with him did not see shark.
1955	.... March	Kabiman, West coast New Ireland	Fisherman. Youth putting speared fish into canoe, bitten on leg by small brown shark.
1955	.... ..	Lavongai, Kavieng	Back bitten. (Kavieng Hospital.)
1955	.... April	Port Moresby	Fisherman. Bitten on shoulder. Shark released grip when struck by victim.
1955	.... April	Abau	Fisherman. Took string of fish from him, then attacked canoe.
1955	.... November	Low Island, Manus	Fisherman. Right arm almost torn off, while spear fishing.
1955	.... November	Baibara	Eight year old boy fought off shark with hands in shallow water. Badly bitten on thigh.

DETAILS OF SHARK ATTACKS IN NEW GUINEA WATERS.—1939-1961—*continued.*

Appendix II.—Unprovoked Attacks—*continued.*

Year.	Month.	Locality.	Remarks.
1956	June	Port Moresby (Fisherman Island)	Fisherman from Hula. Badly mauled during underwater fight with 7-ft. shark. Had speared two fish when attacked. Deep gashes 6 in. long in foot and leg.
1956	August	Yule Island	Fisherman from Tsira attacked when fishing on reef. Leg torn off.
1956	August ...	Port Moresby (Paga Point)	Fisherman. Badly lacerated down leg.
*1956	August ...	Port Moresby (Fisherman Island)	Fatal. Fisherman from Hula. 14-ft. shark seized him by upper thigh. Other fishermen had not seen shark until attack.
1956	October	Kapakapa	Fisherman from Rigo. Badly mauled on left arm which held a 5-ft. fish just speared (12-ft. shark).
*1956	December	Samarai	Fatal. Youth on leave from school in Australia, swimming. No remains.
*1956	December	Samarai	Fatal. Boy from Wedau, swimming. No remains. About two days after previous attack.
1956	....	Kimuta, Renard Island	No details—not fatal. (Misima Hospital.)
1956	....	Hus Island, Manus	Man bitten on right calf. Friends held victim and fought off shark.
*1956	....	Enuk Island, Kavieng	Fatal. Bitten on leg and neck. (Kavieng Hospital.)
*1957	....	Duke of York Island	Fisherman severely mauled while dynamiting fish and died in water.
*1957	....	Laluoro, Abau	Fatal. Fisherman fishing near reef. Severe multiple injuries.
1957	....	Kieta, Bougainville ...	Fisherman. School boy attacked while fishing. Leg bitten off. Shark disappeared.
*1958	....	Brooker Island, Calvados Chain	Fatal. No details. (Misima Hospital.)
(3) 1958	....	Korem, Finschhafen	Fisherman. Three attacks similar to previous attacks in which hand of victim bitten while holding fish.
*1958	July	Maritzoan, Namatanai (South of East Cape, New Ireland)	Fatal. Arm bitten off, while swimming. Shark escaped.
*1958	....	Bulu, Talasea	Fatal. Spearfisherman, injuries to back and buttocks.
*1958	....	Kombe, Talasea	Fatal. Spearfisherman, several sharks attacked. Severe abdominal injuries.
1958	April	Nasigilatu (near Malasanga), Finschhafen	Fisherman. Left hand bitten holding fish. Forearm amputated.
1958	October	East Nakanai, Talasea	Man collecting shells. Injuries to leg and foot.
1958	November	M'Buke Island, Manus	Spearfishing, boy lost leg.
1958	December	Taludig, Madang	Hip bitten in shallow water bordering deep water.
1959	January	Uga, Baniara, Milne Bay	Shark 4½ ft. long in 2 ft. 6 in. water, made two bites—first took lower left calf, second the muscle right thigh (front inside). Shark chased away by man's brother. Recovered.

DETAILS OF SHARK ATTACKS IN NEW GUINEA WATERS.—1939-1961—*continued.*

Appendix II.—Unprovoked Attacks—*continued.*

Year.	Month.	Locality.	Remarks.
1959	October	Taludig, Madang	Thigh bitten in shallow water bordering deep water.
*1959	December	Kaparoka, Hula	Fatal. 13-year old boy swimming under house in village. Dog taken three months previously.
*1959	....	Enuk Island, Kavieng	Fatal. Abdomen and leg bitten.
1959	....	Poi, Kombe, Talasea	Spearfisherman. Minor injuries.
1959	....	Kalapiai, Kombe, Talasea	Fisherman. Minor injuries.
1960	January	Taludig, Madang	Lower left leg bitten, later amputated. 11-ft. 6-in. shark captured. Third in series of attacks.
*1960	February	Tupuselei, Port Moresby	Fatal. Lower part of body bitten. 11-ft. tiger shark captured.
*1960	May	Taludig, Madang	Fatal. Fourth in series of attacks. 39 sharks subsequently captured in effort to rid the area of sharks.
1960	July	Bimat, Bogia	Fisherman. Aid post orderly fishing in sea, right buttock deeply slashed.
1960	August	Taupota, Milne Bay	Serious injuries to back and chest.
*1960	November	Paramana, Abau	Fatal. Fisherman attacked on reef, severe mutilation of genitals and upper legs.
1960	....	West Nakanai, Talasea	Fisherman. Slight lacerations to leg.
1961	May	Kokopo	Man collecting dynamited fish when thumb and two fingers bitten off.
1961	June	Rabaul	Spearfisherman. Shark struck causing minor lacerations to arm.

* Shows fatal attacks.

Observations on the Influence of Frogs on the Ecology of Coffee Plantations in the Western Highlands of New Guinea.

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Introduction.

IN the course of a field survey of the frog fauna inhabiting the Wahgi Valley in the Western Highlands of New Guinea in 1960, many specimens were found to occur in coffee plantations. As it is well known that frogs are insectiverous animals, an attempt was made to establish the role played by these creatures in controlling insect pests of coffee.

Diet of Frogs and Toads.

There is a certain amount of controversy as to whether frogs and toads are selective feeders, accepting certain kinds of potential food items and rejecting others, or indiscriminate, accepting any small moving object. A frog in the latter category will ingest insects which are likely to be injurious to it (e.g., stinging bees), and have even been known to accept inanimate material such as stones.

The range of prey ingested by frogs and toads has been determined by direct observations in the field and examination of their stomach contents, supplemented by palatability trials conducted under artificial conditions in the laboratory, revealing that almost all orders of insects are eaten. There is an indication that availability of prey is the all important criterion in some species, so that their diet indicates the relative abundance of insects sharing the same environment.

Frogs and toads have long been regarded as beneficial to the horticulturalist, and in 1936 the American toad *Bufo marinus* was introduced into Queensland in an attempt to control insect pests of sugar cane. The introduction was opposed by local apiarists on the grounds that the toads would be just as likely to consume their bees. The value of this attempt at biological control is not easily assessed, and the population of the predators has now reached almost plague proportions in some areas.

New Guinea Frog Fauna.

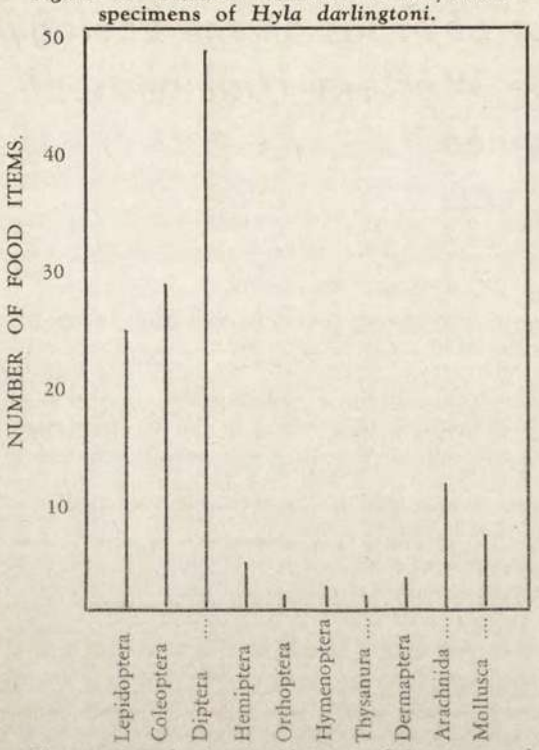
Approximately one hundred and twenty-five species of frogs occur in New Guinea, representing the families Hylidae, Microhylidae, Ranidae and Leptodactylidae. Members of the first three families have been found in the Western Highlands but, as the Microhylidae are confined to moss forest, it is only the Hylidae and Ranidae which are likely to inhabit coffee plantations.

The Hylidae are commonly known as tree frogs. The majority are well adapted to an arboreal life by possessing large circular discs at the tips of their fingers and toes, which enable them to gain a purchase upon smooth vertical surfaces.

The only hylid reported to inhabit coffee plantations is *Hyla darlingtoni* (Tyler, in press). This species has a maximum length of approximately two inches, and may be distinguished from other members of the same genus found in this region by its colour in life: upper surface brown with a thin mid-dorsal stripe situated on the skin covering the vertebrae, and black patches on the back of the thighs which are spotted with bright orange.

The Ranidae are known as grass frogs, and are commonly found in damp situations such as beneath long grass on the banks of streams and ditches. *Rana grisea* is the only ranid found in the Western Highlands (Forcart, 1953). It shares with the majority of the members of this genus a pointed head, strong muscular limbs and extensively webbed toes. The back is a golden brown colour and there are several black bands across the thighs. The undersurface of the body is white or cream in adults (yellow in juveniles) mottled with dark chocolate brown. Specimens were found in two plantations beneath decomposing vegetation used for mulching.

Figure 1.—Stomach contents of fifty-three specimens of *Hyla darlingtoni*.



The totals of the Lepidoptera, Coleoptera and Diptera include 19, 2 and 36 larvae respectively. The frogs upon which this point frequency diagram is based were collected in the Wahgi Valley during the period 22.1.60-28.3.60.

The native vernacular names used in the Wahgi Valley are "Wasip" and "Nagungar", for *H. darlingtoni* and "Gemboogal," for *R. grisea*. Although very little is known of their breeding habits, they both appear to select either static or slowly moving water for the deposition of spawn. The form of their spawn masses is unknown, but ova dissected from gravid females of the two species have been found to have a black upper hemisphere, and an unpigmented lower hemisphere.

Diet.

(*a*) *Hyla darlingtoni.*

The stomach contents of 53 specimens were examined, and 132 food items recovered (see Figure 1).

Approximately 10 per cent. of this total can be regarded as pests of coffee, 10 per cent. (mosquitoes, etc.) as harmful to man, and 5 per cent. (spiders and insect parasites) creatures which could be beneficial.

(*b*) *Rana grisea.*

This species, being of larger size, showed a marked tendency to ingest food items of greater bulk than those selected by *H. darlingtoni*. Amongst the few stomach contents examined, large grasshoppers and snails were frequently included, but there were also lepidopterous larvae, weevils and other beetles of the families Carabidae and Elateridae.

Discussion.

In a discussion of the pests and diseases of Highlands coffee Barrie (1956) states that two genera of weevils (*Cryptorrhyncus** and *Oribius*) are amongst the most important insect pests. It is therefore of interest to find that five of the Coleoptera ingested were members of the latter genus. *Oribius destructor* and *O. hostis* are defoliating weevils, the adults causing severe damage to coffee leaves.

Hyla darlingtoni is however likely to devour the Coccinellidae which are reported by Barrie to be predators of harmful scale insects and, in such a case, the presence of the tree frog could be regarded as disadvantageous if it failed to control the scale insects as effectively as the Coccinellids had done. Since there is an indication that *H. darlingtoni* may undertake the destruction of some of the more important pests of growing coffee, the possibility that this frog could be introduced into well established plantations for this purpose needs further investigation.

ACKNOWLEDGEMENTS.

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Thanks are also due to Dr. F. Lippay of the Department of Human Physiology and Pharmacology, The University of Adelaide, for reading the manuscript.

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Cowpea Mosaic, a Virus Disease of Vigna Sinensis in New Guinea.

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(Manuscript received 3.1.1962.)

SUMMARY.

A *STUDY has been made of a mosaic virus disease of* Vigna sinensis (*Linn.*) *Savi ex Hassk. located on the Gazelle Peninsula of New Britain in the Territory of Papua and New Guinea. Field observations on its occurrence and symptoms, together with experimental data on host range, mechanical, insect and other modes of transmission are recorded.*

The virus was found naturally in the field on V. sinensis *and* V. sesquipedalis *Fruwith. The host range is restricted mainly to the Leguminosae, although* Nicotiana rustica *L. and* Sesbania speciosa *Taub, ex Engl. were artificially infected.*

The virus is mechanically transmissible, has a thermal inactivation point between 60 *and* 62 *degrees C. for an exposure of ten minutes, a dilution end point of* 1 : 400 *and a longevity* in vitro *of less than* 84 *hours. Cowpea mosaic virus is transmitted by* Aphis gossypii (*Glover*) *and* Myzus persicae (*Sulzer*) *in a non-persistent manner, but not by* Toxoptera aurantii (*B.D.F.*), A. craccivora *Koch.*, Halticus tibialis *Reut. nor* Planococcus citri (*Risso*). *It is not seed transmitted. Although no serological investigations were carried out, the virus appears to be related to other mosaic viruses of cowpea investigated by McLean* (1941), *Snyder* (1942) *and Yu* (1946).

Introduction.

Virus infected cowpea, var. "De Groite" plants were first observed by Mr. C. Brooks at the educational centre at Raval on the Gazelle Peninsula in November, 1960. Nearby *V. sesquipedalis* F. plants were also found with mosaic symptoms. This disease was investigated at the Lowlands Agricultural Experiment Station, Keravat, New Britain, to determine the identity of the virus and its host range.

Mosaic viruses of cowpeas have been recorded in U.S.A. (McLean 1941, Anderson 1955b, Warid and Plakidas 1952), Trinidad (Dale 1949), Nigeria (Chant 1959), South Africa (Klesser 1960), and China (Yu 1946).

Cucumber mosaic (Klesser 1960, Anderson 1955a) and tobacco mosaic (Chant 1959), viruses also readily infect *V. sinensis* (Linn.) Savi ex. Hassk.

EXPERIMENTAL RESULTS.

Mechanical Transmission.

The virus is mechanically transmissible with ease and in host range tests and the determination of physical properties, sap was obtained from artificially infected plants of *V. sinensis* var. "De Groite".

Host Range.

Experiments were carried out to determine the host range of the virus. Infective sap was obtained from infected *V. sinensis* var. "De Groite" and plants were inoculated in the glass house with the sap with the aid of 500 grit carborundum. The plants were maintained for 28 days and then ground up with a mortar and pestle. *V. sinensis* var. "De Groite" seedlings were inoculated and maintained for a further 28 days. The results of the host range tests are given in Appendix I. The host range appears to be mainly restricted to Leguminosae, although *Nicotiana rustica* L. was found to be a symptomless carrier and *Sesbania speciosa* Taub ex. Engl. was also infected.

Symptoms produced on susceptible hosts.

Vigna sinensis var. "De Groite"—

Mosaic symptoms appeared on inoculated plants 5-7 days after inoculation and were persistent. The first trifoliate leaves were normal

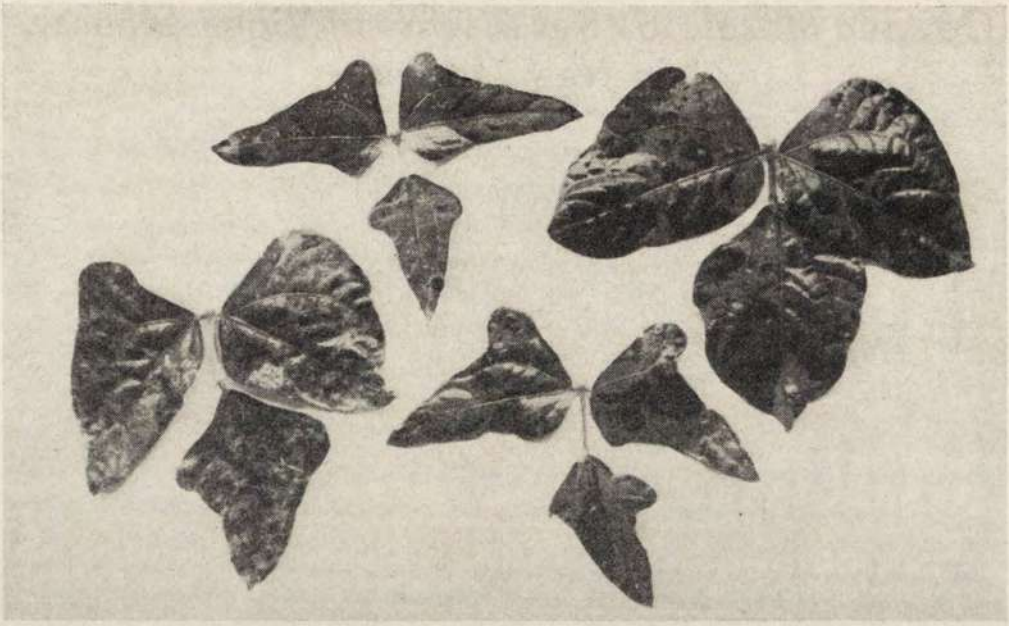

Plate I.—Mosaic and leaf distortion on *Vigna sinensis* variety " De Groite ". (x 1/3)

apart from vein banding and mosaic symptoms. Subsequent leaves had severe mosaic symptoms and were severely blistered and puckered and were greatly reduced in size (Plate I). There was a marked reduction in yield and severe stunting of the diseased mature plant.

Vigna sinesis varieties—

Cowpea varieties " Poona Pea ", " Black Eye", " Xape ", " Witzenberg Upright ", " Newera Gray ", " Training White " and " Dr. Saunder's Upright " all exhibited mosaic symptoms 5-7 days after the inoculation of the first two leaves. The symptoms were persistent, but the infections produced no reduction in yield or vigour.

Phaseolus vulgaris L. var. " Pinto Bean "—

Mosaic symptoms appeared on the first set of trifoliate leaves which emerged 7-10 days after the inoculation of the first two leaves. Subsequent leaves all bore mosaic symptoms with severe leaf curling, and distortion (Plate II). The plants were reduced in size compared with healthy plants. The symptoms were persistent.

Phaseolus mungo L.—

Mosaic symptoms and leaf distortion appeared on the first set of trifoliate leaves which emerged 8-10 days after the inoculation of the first two leaves. The symptoms were persistent and the vigour of the plant was reduced. The infected leaves were reduced in size.

Phaseolus aureus Roxb.—

Severe mosaic symptoms with vein banding appeared on the first set of trifoliate leaves developed after the inoculation of the first true leaves. The leaves were not reduced, but the plants were stunted. The symptoms were persistent.

Phaseolus calcaratus Roxb.—

Small discrete pale green swellings appeared on the upper surface of the inoculated leaves 2-3 days after inoculation (Plate III). Subsequent leaves bore typical mosaic symptoms which were persistent. The plants were not reduced in vigour.

Vigna sesquipedalis Fruwith—

Typical mosaic symptoms appeared 7-10 days after inoculation, and were persistent. The plants were not reduced in vigour.

Mucuna deerigianum Small—

Pale chlorotic circular spots appeared on the first set of trifoliate leaves which emerged after inoculation. Subsequent leaves also showed dis-

Plate II.—Mosaic and leaf distortion pattern on *Phaseolus vulgaris* variety " Pinto Bean " following inoculation with cowpea mosaic virus. (x 1/3)

crete circular spots, but there were fewer than on the first leaves. Large chlorotic areas appeared on subsequent leaves and when near the leaf margin they caused leaf distortion (Plate IV). Subsequent leaves showed chlorotic spotting and severe leaf distortion. The diseased plants were greatly reduced in yield and vigour. The symtoms were persistent.

Canavalia ensiformis DC.—

The leaves which emerged after inoculation exhibited a dark green mosaic pattern with some leaf distortion. The leaves became rolled at the margin and were often misshapen. The mosaic and leaf distortion were systemic, but as the leaves matured, the symptoms became indistinct.

Nicotiana rustica L.—

This host was a symptomless carrier.

Sesbania speciosa Taub ex Engl.—

Discrete pale green swellings appeared on the first true leaf 2 days after inoculation. The pinnate leaves exhibited mosaic symptoms and small circular pale green swellings on the upper leaf surface. On the fourth and subsequent pinnate leaves only mosaic symptoms were observed. The mosaic symptoms were persistent (Plate III).

Physical Properties.

The resistance of the virus to exposure at various temperatures for 10 minutes, to ageing *in vitro* at 1 degree C. and to dilution were studied. *Vigna sinensis* var. " De Groite " was used for the test plant. The virus was active after an exposure to 60 degrees C. for 10 minutes, but inactive after an exposure of 62 degrees (Table I). It was inactive after an exposure of 84 hours at 1 degree C. (Table II), and was inactivated when diluted to 1:400 but active at a dilution of 1:300 when diluted with distilled water (Table III).

Insect Transmission.

Klesser (1960) recorded *Aphis craccivora* Koch. capable of transmitting cowpea mosaic virus A and cowpea mosaic virus cucumber

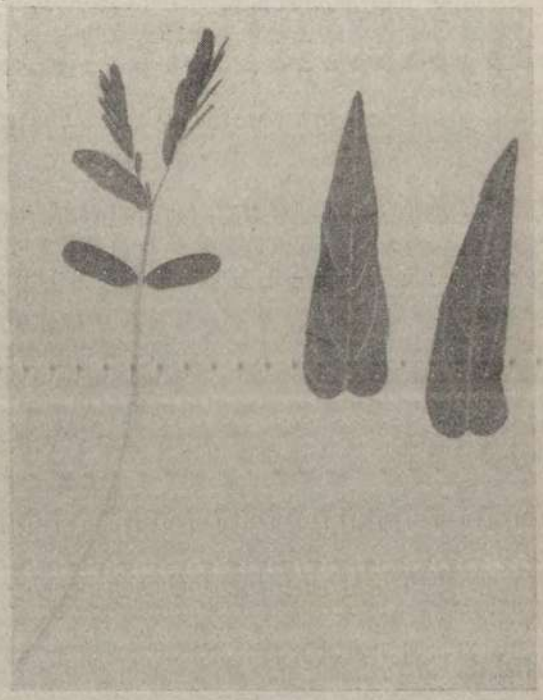

Plate III.—On right side of photograph, two leaves of *Phaseolus calcaratus* showing small discrete swellings following inoculation. On the left, *Sesbania speciosa*, showing swellings on the first true leaf two days after inoculation with cowpea mosaic virus. (x 1/3)

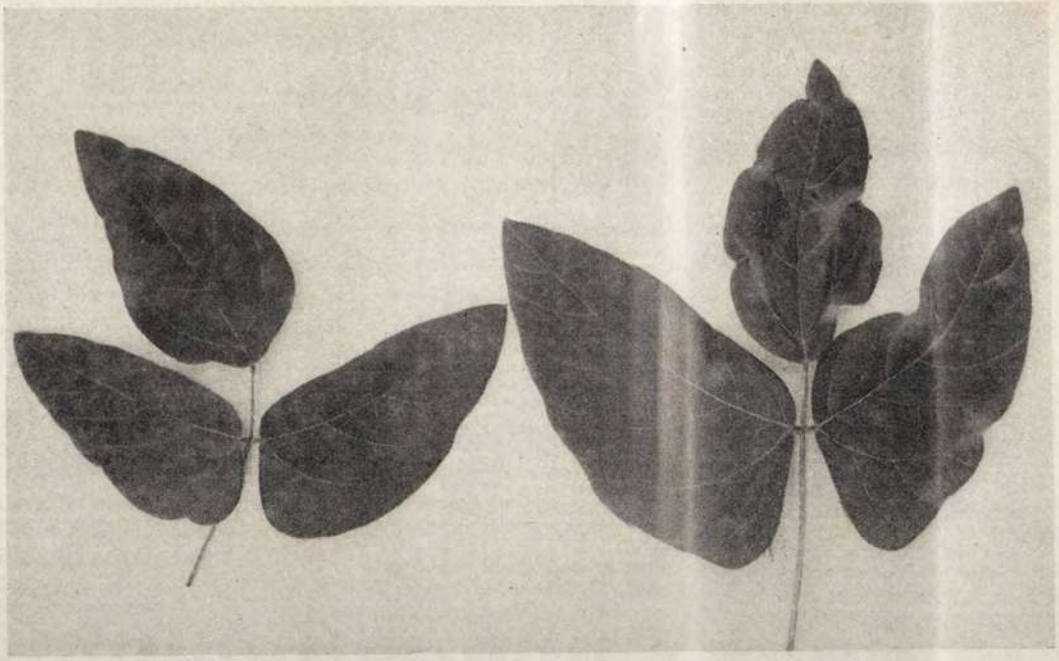

Plate IV.—Chlorotic spotting on *mucuna deeringianum* following inoculation with cowpea mosaic virus. Leaf distortion on the leaflet on the right hand side. (x ½)

strain. *A. gossypii* (Glover) and *Macrosiphum solanifolii* Ashm. were recorded by Anderson (1955b) and McLean (1941) to be capable of transmitting cowpea mosaic virus. McLean (1941) also recorded *Macrosiphum hisi* Kalt. capable of transmitting cowpea mosaic virus. In Trinidad, Dale (1953) was able to transmit cowpea mosaic by a beetle *Ceratoma ruficornis* (Oliv), and Chant (1959) recorded a beetle *Ootheca mutabilis* Sahlb. in Ghana capable of transmitting cowpea mosaic.

At Raval, the aphid *A. craccivora,* shield bugs (identity not known) and *Planococcus citri* (Risso) were the only insects found feeding on *Vigna sinensis* in the field. In the glass house, tests were carried out to determine the insect vectors using the above insects. *A. gossypii, Toxoptera aurantii* (B.d.F.) and *Myzus persicae* were also included in the test. The insects were starved for two hours, allowed an access feed for two hours and test fed until the end of 28 days or until they died. The results are given in Table IV. Only *A. gossypii* and *Myzus persicae* were found capable of transmitting the virus. Further attempts were made with *A. craccivora* in an endeavour to transmit the virus with access feeding times ranging from two minutes to 24 hours, and test feeds from two hours to six days. However no transmission was obtained.

Persistency of virus in Aphis gossypii *and* Myzus persicae.—

Fourth instar nymphs of *A. gossypii* were collected from stock colonies maintained on *Citrullus vulgare* Schrad. in the glass house. The aphids were starved for two hours and then fed diseased cowpea leaves for 15 minutes. The nymphs were then transferred by brush to healthy seedlings of *Vigna sinensis* one per plant, for a test feed of 24 hours. Every 24 hours, the aphids were shifted to correspondingly numbered fresh seedlings. The aphids were maintained for ten days or until they died. After 28 days the results were recorded (Table V). Of the 20 aphids tested, 12 were able to transmit the virus to *V. sinensis* within the first 24 hours of feeding, but none transmitted the virus after this period. Thus the virus appears to be transmitted by *A. gossypii* in a non-persistent manner.

A similar experiment was carried out using *M. persicae*. Fourteen aphids transmitted the virus within the first 24 hours of the test feed, but no transmission was recorded in subsequent 24 hourly test feed periods. Thus *M. persicae* transmits the virus in a non-persistent manner.

Effect of starvation on efficiency of transmission by Aphis gossypii *and* Myzus persicae.

Fourth instar nymphs of *A. gossypii* and *M. persicae* were collected from stock colonies and divided into two lots. One lot was starved for two hours, then allowed an access test feed of two hours and then transferred to test seedlings for a test feed of 24 hours : only one nymph per plant. The plants were maintained for 28 days and the results are recorded in Table VI.

It is evident that pre-access feed starvation increases the efficiency of transmission by *A. gossypii* and *M. persicae*.

The effect of access feeding period on transmission.

Fourth instar nymphs of *A. gossypii* and *M. persicae* were collected from stock colonies and starved for two hours. Lots of twenty nymphs were allowed access feeds of 30 seconds, five minutes, and 15 minutes and two hours. The aphids were then transferred to test plants of *Vigna sinensis* for a test feed of 24 hours. After 28 days, the results were recorded (Table VII).

It is evident that *A. gossypii* and *M. persicae* are capable of transmitting the virus after an access feeding period of 30 seconds. This supports the previous evidence that the virus is transmitted in a non-persistent manner by *A. gossypii* and *M. persicae*.

Attempted Seed Transmission.

Seed was collected from artficially and field infected plants of *Vigna sinensis*, planted in the glass house and allowed to grow to maturity. A thousand seeds were collected from each of these and a thousand from healthy plants : 941 plants were established from seed from artificially inoculated plants, 929 from field infected plants and 931 from healthy plants. At maturity all the plants under observation were healthy. Five hundred seeds were collected from artificially infected *Vigna sesquipedalis* and 463 were established. At maturity, all plants were healthy. Thus it is evident that the virus is not transmitted by seed.

DISCUSSION AND CONCLUSION.

In Appendix II all available references of cowpea mosaic viruses have been collected for comparison with the virus investigated. Since no serological investigations could be conducted the main criteria for identification are the host range and mode for transmission. The Kerevat cowpea mosaic virus differs widely in host range to cowpea mosaic viruses A and B and cucumber mosaic viruses investigated by Chant (1959), Dale (1954) and Anderson (1955a). Also the virus is not transmitted by *Aphis craccivora*.

The virus investigated has similar host range, physical properties and host symptoms to the cowpea mosaic viruses investigated by Snyder (1942), McLean (1941) and Yu (1946). However the virus is not seed borne in asparagus-bean or cowpea var. " De Groite ", whereas the above three viruses are all seed transmitted.

The virus is transmitted in a non-persistent manner by *Aphis gossypii* which was also found to transmit cowpea mosaic virus (McLean 1941 ; Yu 1946).

Since the symptoms and the properties of the virus *in vitro* vary due to climatic conditions, different reactions in host varieties etc., it is reasonable to consider the virus is related to the viruses investigated by Snyder (1942) McLean (1941) and Yu (1946). Thus the virus is considered to be a strain of cowpea mosaic virus.

In the literature cited there is no mention of the mode of transmission of cowpea mosaic virus by its aphid vectors. The virus investigated is readily transmitted by *Aphis gossypii* and *Myzus persicae*, but in all tests carried out, *A. craccivora* and *Toxoptera aurantii* failed to transmit the virus. Nymphs of *A. gossypii* and *M. persicae* were able to transmit cowpea mosaic virus after an access feeding time of 30 seconds and within the first 24 hours of test feeding. No transmission was obtained with test feeding periods greater than 24 hours. Pre-access feeding starvation increased the efficiency of transmission in both *A. gossypii* and *M. persicae*.

Thus it is concluded that the Kerevat strain of cowpea mosaic virus is transmitted in a non-persistent manner by the aphids *Aphis gossypii* and *Myzus persicae*.

ACKNOWLEDGEMENTS.

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legume species by the Division of Botany, Department of Forests, Lae, and the supply of pea and bean varieties by the Institute voor Plantenziektenkundig Onderzoek, Wageningen.

The photographs were taken by Mr. A. E. Charles.

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Table I.

The thermal inactivation of cowpea mosaic virus using *Vigna sinensis* var. " De Groite " as the test plant.

Temperature in degrees Centigrade.	Proportion of Infected Plants.
29	20/20
40	18/20
48	18/20
50	15/20
55	12/20
58	4/20
60	1/20
62	0/20
64	0/20
65	0/20

Table II.

Longevity *in vitro* at 1 degree C. of cowpea mosaic virus using *Vigna Sinensis* var. " De Groite " as the test plant.

Time in hours of Exposure.	Proportion of Plants Infected.
0	20/20
24	16/20
48	10/20
60	8/20
72	3/20
84	0/20
96	0/20
144	0/20

Table III.

Dilution end point of cowpea mosaic virus using *Vigna sinensis* var. " De Groite " as the test plant.

Dilution.	Proportion of Plants Infected.
Undiluted	20/20
1 : 10	20/20
1 : 100	3/20
1 : 200	2/20
1 : 300	1/20
1 : 400	0/20
1 : 500	0/20
1 : 1,000	0/20

Table IV.

Transmission of cowpea mosaic virus by insects found infesting *Vigna sinensis* in the field.

Insect Species.	No. Insects/ plants.	Proportion of Plants Infected.
Aphis craccivora *	10	0/20
A. gossypii *	10	14/20
Planococcus citri *	10	0/20
Halticus tibalis *	10	0/20
Shield bugs	10	0/20
x *Toxoptera aurantii* *	10	0/20
x Sweet Potato aphid	10	15/20

* identified by Dr. V. F. Eastop of the Commonwealth Institute of Entomology.

x not found on *Vigna sinensis* in the field.

Table V.

The longevity of cowpea mosaic virus in apterous forms of *Aphis gossypii*, using *Vigna sinensis* var. "De Groite" as the test plant.

Days	1	2	3	4	5	6	7	8
Aphid Number								
2	x	—	—	—	—	—	—	—
3	x	—	—	—	—	—	D	....
4	—	—	—	D	....	....	....	....
5	x	—	—	—	—	—	—	—
6	x	—	—	—	D	....	....	....
7	x	—	—	—	—	D	....	....
8	—	—	—	—	—	—	—	—
9	—	—	—	—	D	....	....	....
10	x	—	—	D	....	....	....	....

x Virus transmitted.
— Virus not transmitted.
D Aphid died.

Table VI.

The effect of pre-access starvation on the efficiency of transmission of cowpea mosaic virus by *Aphis gossypii* to *Vigna sinensis* var. "De Groite".

Treatment.	Proportion of Plants Infected.
Starved	12/20
Non-starved	4/20

Table VII.

The effect of variations in access feeding periods on the transmission of cowpea mosaic virus by *Aphis gossypii* to *Vigna sinensis* var. "De Groite".

Access Feeding Period.	Proportion of Plants Infected.
30 seconds	5/20
5 minutes	8/20
15 minutes	16/20
2 hours	12/20

Appendix I.

The Host Range of Cowpea Mosaic Virus.

Host.	Reaction.	Proportion of Plants Infected.
Vigna sinensis var.—		
"De Groite"	Mosaic	20/20
"Poona Pea"	Mosaic	12/20
"Black Eye"	Mosaic	13/20
"Xape"	Mosaic	4/20
"Witzenberg Upright"	Mosaic	10/20
"Newera Gray"	Mosaic	12/20
"Training White"	Mosaic	19/20
"Dr. Saunder's Upright"	Mosaic	16/20
V. sesquipedalis Fruwith	Mosaic	2/20
Canavalia ensiformis DC.	Mosaic	12/20
Phaseolus mungo L.	Mosaic distortion	14/20
P. aureus Roxb.	Mosaic vein-banding	16/20
P. calcaratus Roxb.	Swelling mosaic	20/20
Mucuna deeringiana (Small)	Chlorotic spotting	18/20
Sesbania speciosa	Swellings mosaic	20/20
Nicotiana rustica L.	Symptomless	3/20
Phaseolus vulgaris L. var.—		
"Pinto Bean"	Mosaic	12/20
"Brown Beauty"	....	....
"Top Crop"	....	0/20
"Bountiful"	....	0/20
"Genfer"	....	0/20
"Saxa"	....	0/20
"Beka"	....	0/20

Appendix I.—*continued.*

The Host Range of Cowpea Mosaic Virus—*continued.*

Host.	Reaction.	Proportion of Plants Infected.
Pisum sativum L. var.	....	....
" Earlicrop "	....	0/20
" Pluck Market "	....	0/20
" Wisconsin "	....	0/20
" Dippes Foli "	....	0/20
" Perfection "	....	0/20
Crotalaria anagyroides H.B. et K.	....	0/20
C. juncea L.	....	0/20
C. spectabilis Roth.	....	0/20
C. mucronata Desv.	....	0/20
Dolichos lablab L.	....	0/20
Medicago sativa L.	....	0/20
M. orbicularis	....	0/20
Trifolium pratense L.	....	0/20
T. repens L.	....	0/20
T. hybridum L.	....	0/20
T. incarnatum L.	....	0/20
Melilotus alba Desv.	....	0/20
Lupinus albus L.	....	0/20
Cajanus cajan Millsp.	....	0/20
Calapogonium mucunoides	....	0/20
Flemingia congesta	....	0/20
Vicia faba L.	....	0/20
V. villosa Roth.	....	0/20
Glycine max Mer.	....	0/20
Cassia tora L.	....	0/20
C. occidentalis L.	....	0/20
Leucaena glauca	....	0/20
Lathyrus odoratus L.	....	0/20
Arachis hypogaea L.	....	0/20
Zinnia elegans Jacq.	....	0/20
Lycopersicum esculentum Mill var. " Grosse Lisse "	....	0/20
Datura stramonium L.	....	0/20
Chenopodium amaranticolor Coste et Reyn.	....	0/20
Petunia hybrida Vilm. var.— " Rosy Morn "	....	0/20
Physalis floridana	....	0/20
Cucumis cativus L. var.— " Palmetto "	....	0/20
Nicotiana tabacum L. var.— " White Burley "	....	0/20
N. glutinosa L.	....	0/20

Appendix II.

Comparison of host range, physical properties and aphid vectors of cowpea mosaic viruses reported in literature.

—	Keravat cowpea mosaic virus.	Cowpea mosaic Yu (1946).	Cowpea mosaic Snyder (1942).	Cowpea mosaic McLean (1941).	Cowpea mosaic A Kiesser (1960).	Cowpea mosaic B Kiesser (1960).	Cucumber mosaic strain Kiesser (1960).	Cowpea Tobacco mosaic STR. Chant (1959).	Cowpea yellow mosaic Chant (1959).	Cowpea mosaic Dale (1949).	Cowpea mosaic Anderson (1955b).	Cowpea mosaic cucumber Anderson (1955a).
Vigna sinensis	x	x	x	x	x	x	x	x	x	x	x	x
V. Sesquepedalis	x	....	x	....	x	x	x	....	....	....	....	....
Phaseolus vulgaris	x	—	....	—	x	x	x	x	x	—	—	x
P. mungo	x	....	....	....	x	x	x	....	....	x	....	....
P. calcaratus	x	....	....	....	....	....	....	....	....	....	....	....
P. aureus	x	....	....	....	....	....	....	....	....	x	....	....
Sesbania speciosa	x	....	....	....	....	....	....	....	....	x	....	....
Mucuna sp.	x	....	....	....	....	....	....	x	x	....	....	....
Vicia faba	—	—	....	—	x	x	x	....	....	....	x	x
Arachis hypogaea	—	—	....	....	x	—	x	....	—	....	....	....
Pisum sativum	—	—	—	—	x	x	—	....	....	....	....	x
Nicotiana tabacum	—	—	....	—	—	—	x	x	—	—	....	x
N. rustica	x	....	....	....	....	....	....	....	....	....	....	....
N. glutinosa	—	....	—	—	—	—	x	—	—	—	....	x
Cucumis sativus	—	—	....	—	—	—	x	—	—	—	—	x
Zinnia elegas	—	—	....	—	—	—	x	—	—	....	....	x
Lycopersicum esculentum	—	—	....	—	....	....	....	....	—	—	....	x
Petunia hybrida	—	—	....	—	....	....	....	....	....	....	....	....
Chenopodium amaranticolor	—	....	....	....	....	....	....	....	....	....	....	....
Datura stramonium	—	—	....	—	....	....	....	....	....	....	....	....
Crotalaria juncea	—	....	....	....	x	x	x	x	—	x	....	....
C. spectabilis	—	....	....	....	x	x	x	....	....	....	x	—
Dolichos lablab	—	—	....	x	x	x	x	x	—	x	x	x
Glycine max.	—	—	—	....	x	x	x	....	....	x	x	—
Lathyrus odoratus	—	—	—	—	x	x	—	....	....	....	....	....
Lupinus albus	—	—	....	....	x	x	x	....	....	....	....	....
Medicago sativa	—	—	....	....	x	—	x	....	....	....	....	....
Trifolium repens	—	—	—	....	x	—	—	....	....	....	....	....
T. pratense	—	—	—	....	x	x	x	....	....	....	....	....
T. hybridum	—	....	....	....	x	—	x	....	....	....	....	....
T. incarnatum	—	....	....	....	x	x	x	....	....	....	....	....
Centrosema sp.	—	....	....	....	....	....	....	x	—	....	....	—
Canavalia ensiformis	x	x	—	x	....	....	....	....	....	....	....	....
Aphis gossypii	x	x	—	x	....	....	....	....	....	....	....	....
A. craccivora	—	....	....	....	x	?	x	....	....	....	....	....
Dilution end pt.	1:400											
Thermal In. Pt. (°C)												
Longevity (days)	3-4	3-4	9-15	2-3	2-4	2-3	4-5	4-6	....	20	1-2	....

x susceptible. — resistant .... no results given.

Achaea Janata *L.—A Noctuid Defoliating the flush of* Theobroma Cacao.

L. SMEE.

Entomologist, Lowlands Agricultural Experiment Station, Kerevat.

Achaea janata L. (Plate I) is a moth in the family Noctuidae, which has a very wide distribution, and also a wide range of host plants. It has been recorded from Africa, Asia, Australia and many islands in the Pacific Area, and its hosts include rubber (*Hevea brasiliensis*), *Albizzia* spp., castor bean (*Ricinus communis*), Crotons (*Codiaeum variegatum*), peanuts (*Arachis hypogaea*), and cacao (*Theobroma cacao*) (Szent-Ivany 1961).

In the Gazelle Peninsula (New Britain) along with several Geometrids, it has caused extensive damage to the young flush on cocoa (Plate II), which is often sufficient to kill the growing point of the shoot, causing excessive branching. Work on the biology of *A. janata* in the laboratory at Keravat, using *Ricinus communis* as the host plant, gave a life cycle agreeing fairly closely with that of Kalshoven 1950.

Table 1.

Stage	Length of Stage
Eggs	3 days
Larvae	11-17 days
Pupa	9-14 days
Prepupae	1 - 2 days
Adults	10-20 days
Adults (pre-oviposition)	4-10 days
Egg—Egg	32-38 days

The adults live approximately three weeks, though females exhausted by egg laying seem to live only about 10 days. In a test with two females, rate of egg laying was found to be about 600 in five days (though Kalshoven quotes a mean of 1,000 with a maximum of 2,380, for 10 species of *Achaea*). The females were caged singly, and fed on a honey/water mixture.

Eggs are laid overnight, over both surfaces of the leaves, but mainly on the upper surface. Both females died on the fifth day of oviposition.

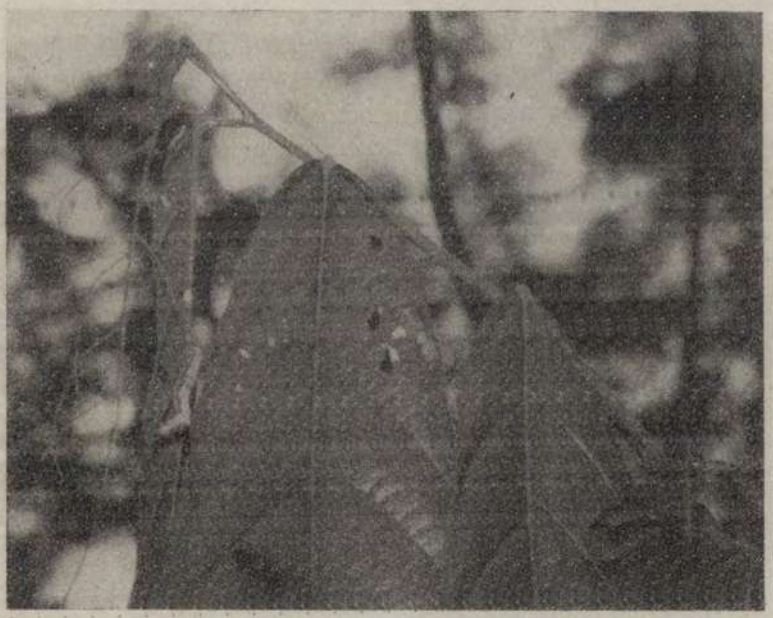

Plate I.—Cocoa flush damaged by *Achaea*, one leaf of which has been reduced to the midrib.

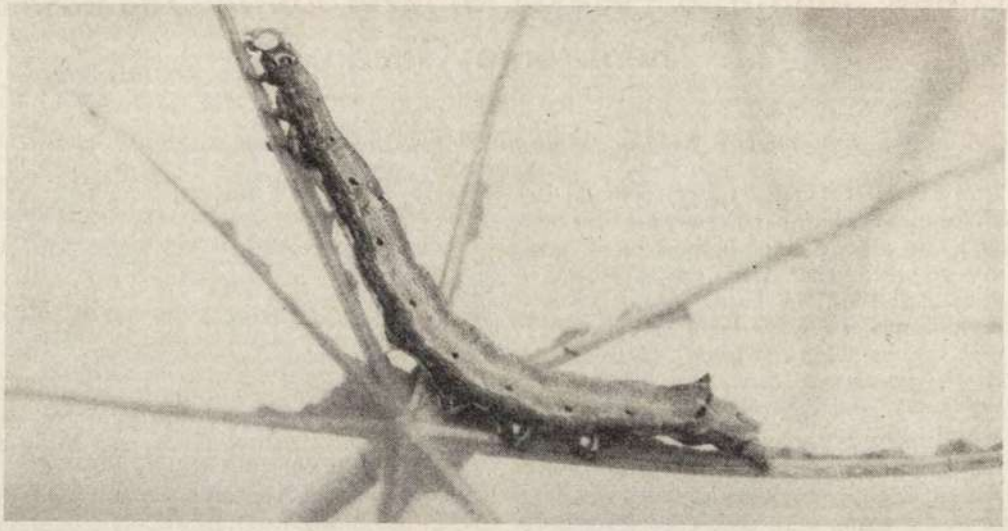

Plate II.—Larva of *Achaea* on *Ricinus communis*. This is a final instar.

Plate III.—Cocoa flush eaten by Achaea.

Table II.

Dates of Oviposition (Eggs/day).

	1	2	3	4	5	total
Female 1	252	172	77	30	60	676
Female 2	177	185	62	107	71	617

The young caterpillars for the first few days attack only the epidermis of the leaf, but soon commence eating large holes in the leaves, till eventually only the mid-rib and main veins remain (Plates I, II and III). Under conditions of extreme over-population such as when the attack is severe, the late instar caterpillars will extensively damage the epidermis of the growing point, causing its death. The young caterpillars are a pale grey colour, later a darker grey/brown colour with black markings and two prominent red protuberances on the eighth abdominal segment.

The caterpillars usually pupate in the leaves, sewing them together with a silk-like substance (Plates IV and V). It was noticed, however, that the caterpillars often pupated on the surface of the soil or in convenient corners, where they wove a silk cocoon which was covered on the exterior with grains of soil, small pieces of vegetable matter or other similar material.

The adult is a moth of about 2¼ inches wingspan. The forewings are brown with black markings, while the hindwings are prominently marked with black and white (Plate VI). This

Plate IV.—Pupa still within leaves.

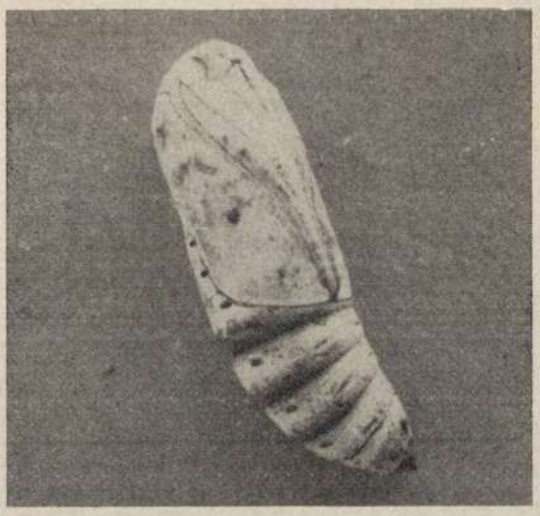

Plate V.—Pupa removed from leaves. It has a light grey appearance.

moth is a strong flier and can travel long distances, even over the sea (Kalshoven 1950).

Work on the control of these caterpillars is proceeding.

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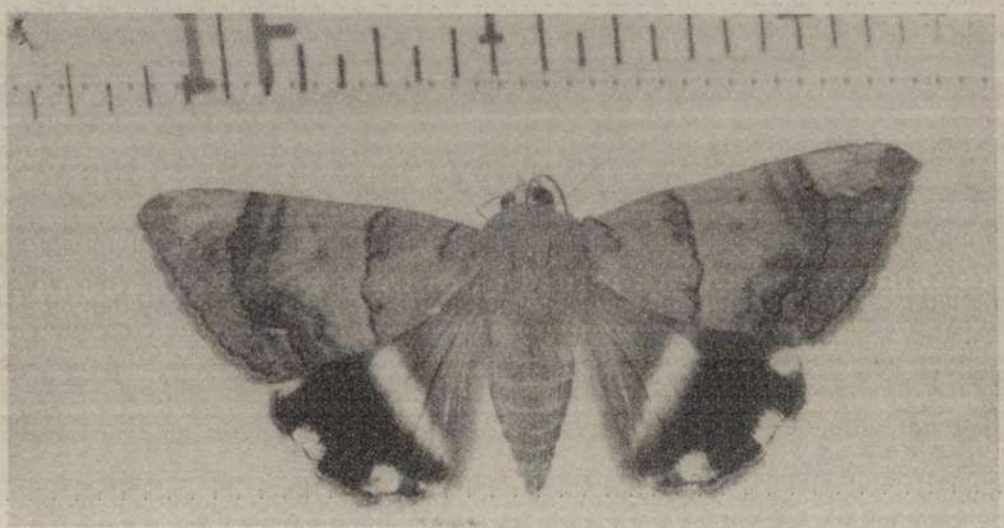

Plate VI.—Adult of *Achaea janata.*

Dugout Canoes of Papua and New Guinea.

A. W. JEFFORD.

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

Introduction.

SINCE the conclusion of the last world war the native people living in the coastal villages of Papua and New Guinea have become increasingly aware of the advantages of modern methods of boat building and mechanical means of boat propulsion.

The principal type of vessel is still the dug-out canoe, and although there are differences in construction between canoes built on the west coast of Papua and those built, say in New Ireland, the basic materials and methods of construction are the same—namely hollowed logs fitted with planks to give additional free board, bindings of vine, and round timbers for other supporting materials.

The building of these vessels was originally the work of those people living in coastal areas with access to the necessary raw materials, and who had the initiative and energy required to undertake such a task. Canoes were built as items of trade and were sailed along the coast and bartered for by coastal dwellers who lacked the raw materials and the skill to provide craft for themselves. To-day in the more settled areas the hollowed hulls only are traded and the building of the craft is undertaken by natives who have a sea-going background, and have also a knowledge of boat design and construction. They may also possess a knowledge of ship's carpentry and the use of modern hand and shop tools. To-day, whilst the native still clings to the use of hollowed logs to form the basic

Plate I.—Single canoe.

Plate II.—Single hull with outrigger.

part of a canoe he seeks modern refinements in construction and design which allow him to enjoy the comforts of civilization to which he is becoming rapidly accustomed. The advances made in canoe construction are quite striking but it is well to bear in mind the economic factors involved.

Early types of canoes.

Canoes range in size and length from ten feet to over 60 feet in length. The smallest, which are usually single hulled outrigger canoes as shown in Plate I may be used to ferry passengers and cargo from the shore to outlying canoes or in villages built over the water for transport to shore. Construction is simple and the materials primitive. The hull is open and with the exception of the outrigger has no other fittings. Propulsion is by means of a pole or paddle. Single canoes slightly larger in size carry a single sail and are steered by a steering oar. Such canoes also have a series of hatch covers over the dugout canoe and the crew and cargo is carried on the outrigger frame. These canoes are found in all coastal villages and also far inland up the principal rivers and estuaries. Although of primitive construction they last for many years without any protection by paint or other form of preservative.

A single-hulled outrigger canoe is shown in Plate II. It is from the village of Maiwa, north of Yule Island on the central coast of Papua, and recently sailed nearly 100 miles along the coast to Port Moresby. The main hull measures 55 feet overall with an outrigger log 27 feet long and outrigger support poles 17 feet long. The deck of the craft upon which several people may live for lengthy periods is confined to the area above the hull. The roughly shaped timbers and methods of fastening are a common feature of this type of canoe.

The most common type of dugout canoe is that with two hulls, usually referred to as a *lakatoi*, although in the Motu language this signifies three hulls. Whilst the single hulled outrigger canoes were designed as vessels of war the multiple hulled vessels were evolved for the carriage of trade goods such as sago and pottery.

The twin hulls provide the basis for a stable platform upon which the native fisherman can build a shelter for his family, install a cooking fire or galley and have sufficient room for his nets and catch. The vessel is seaworthy, manoeuvrable, suitable for either shallow or deep water operations and may be conveniently beached without damage to the hulls. The twin hulled type of canoe lends itself to improvement by the use of modern methods of propulsion such as large canvas sails or outboard motors.

Finally, there are the three and four hulled canoes which in days gone by were the cargo ships of the Papuan coastal traders. The really large types are now rare but the three hulled vessel shown in Plate IV was seen recently at Port Moresby. Here again bush materials are used even to the decorative decks and rigging using palm fronds. The deck house is built by using the palm bark for the walls and thatching the roof with kunai grass and the rolled up door is of palm fronds. The mid-section of the craft is occupied by the cooking and eating facilities. To the right of the table are the fishing nets hanging from the canvas sail support. On such a craft the owner and his family spend a large part of their lives. Fishing and the carriage of passengers and cargo provide their livelihood.

Canoes of this size may use one or two sails and since the craft have no established fore or aft the alterations required to change sailing direction may be carried out simply by reversing the set of the sails and steering from the opposite end of the vessel. It is from such multi-hulled canoes that the double hulled vessels of to-day have developed and become widely used as native fishing boats.

An average sized double canoe requires two logs, some sixty feet in length and four feet in diameter. These must be dragged to the beach and set up for shaping and hollowing.

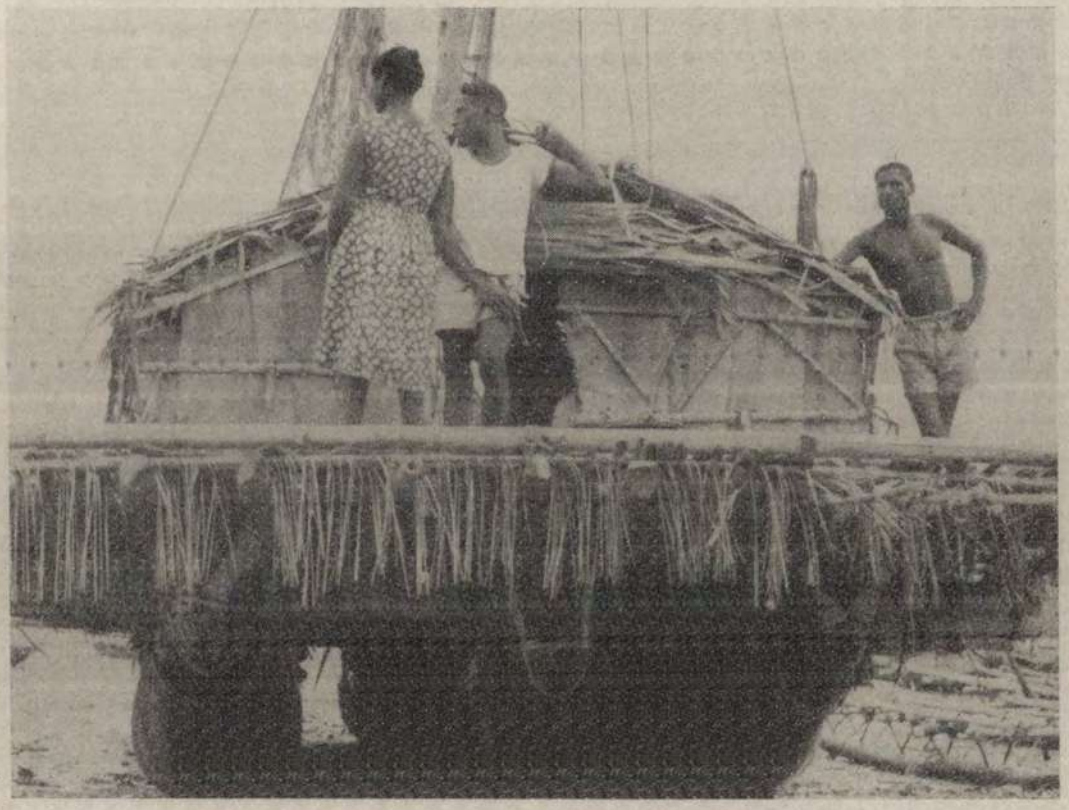

Plate III.—Three-hulled canoe showing hulls and deck house.

Plate IV.—Three-hulled canoe showing galley, fish nets, etc.

The deck and hull timbers must be obtained, and curved or bent roots or limbs rudely fashioned and fastened into position. Fronds of the Nipa Palm are used to render the deck side above the hull watertight and the whole structure is lashed together with vines or canes. Whilst methods and materials are of a primitive nature, a very seaworthy craft is produced. The cane lashings, for instance, shown in Plate VI, are extremely tough and durable and allow sufficient movement of the component parts of the canoe to work in a rough sea without giving way.

The fact that European clothing, cooking methods and appliances, and sanitation are becoming the rule, the training in modern methods of fishing, the construction of nets and use of nylon cords and lines have all contributed to improvements in canoe design. Study of the two canoes in Plate V shows that the hulls are basically the same but the layout and neat construction of the powered canoe indicate the advances made in canoe design by the native people.

Structural Modifications.

Improvements in design bring with them a host of problems which have to be overcome and foremost among these is the need to effect improvements which add to the safety of the vessel and its crew. Initially the craft had a sound hull but rather flimsy fastenings. It was made from crude materials, but was light, manoeuvrable and seaworthy. The flexibility of construction was an asset; frequent bailing kept the craft above the water even in moderate seas. From this has evolved a fairly rigid flush-decked craft with well designed hatch covers to exclude sea water from pouring into the open hulls and a coaming around the deck. The vessel may be propelled by one or more outboard engines and steered by hand tiller and thus now has a fore and aft and must be guided from the one position. The location of the engine or engines is approximately a third of the length of the craft from the stern and situated between the two hulls. The trim of the craft must be tail heavy to keep the bows from diving below the swell of a wave. Should the craft be for

passengers and cargo, the weight should be kept toward the stern whilst a fishing boat requires plenty of room aft to allow for trolling and netting operations.

Much of the passenger cargo and food may be stored in the hull compartments. Here also are stored spare drums of fuel. The cooking fire must be considered, although generally it is placed to suit the convenience of the people on board and the prevailing weather conditions. A danger of fire always exists, but very few cases of damage by fire have been known. Fire extinguishers are carried on very few canoes and life belts are only seen on registered passenger carrying canoes. Plates III and VII show the dangers that exist with petrol operated engines when used under primitive conditions. Note also the hatch cover removed from the left hand hull in Plate VII. Daily running requires the use of the petrol container in the foreground whilst reserve supplies are held in the 44-gallon drum. To the rear of the drum may be seen the deck aperture in which the tiller is hung. Plate VIII shows two outboard engines in position but tilted forward. The decking of this canoe leaves much to be desired. Plate IX shows a very neat well in which is fitted a 40 h.p. outboard engine. It will be noticed that in each case the engine is either at deck level or below. This is necessary to put the propeller well down below the surface of the water and also the deck joist provides a convenient member on which to secure the engine.

The design of dugout canoes imposes several obstacles to the fitting of inboard engines and propeller shafts. As may be seen from the illustrations the fitting of such engines would involve major modification to the design of the hull to provide a suitable bed for the engine and supports for the propeller shaft and bearings. The working of a canoe in a heavy swell could impose strain upon the propeller shaft and the engine. Several engine and propeller shaft arrangements have been suggested to power dugout canoes and the use of universal drive shaft connections has been offered both as a means of overcoming the excessive shaft angle and also to raise or lower the propeller as

Plate V.—Old and new double canoes.

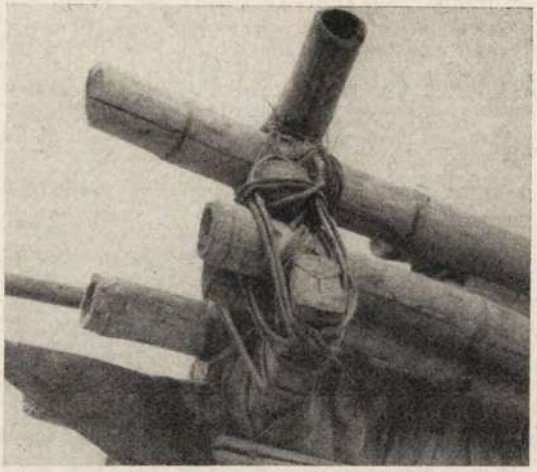

Plate VI.—Construction detail.

required. Such installations may require the fitting of two or more universal joints and the submersion of such joints in seawater would not be a desirable feature. Another suggestion involves the fitting of a standard marine diesel engine and gearbox from which a universal jointed drive shaft extended to a series of vee pulleys set on an angle from the vertical. Immediately below the pulleys are the secondary pulleys attached to the propeller shaft which is set to place the propeller below the engine and forward of the gear box. The propeller in this instance cannot be raised or lowered. Variations of these ideas have been attemped by several amateur canoe builders but the installation of mounting brackets to support the propeller and shaft raises many problems with a craft such as is described. Such difficulties do not arise when fitting an outboard engine. These units are compact, easily installed and relatively simple to operate. Their objectionable features as far as the native owner is concerned are the high initial cost, the local maintenance difficulties and the high cost of operation. Also, being petrol fuelled, they have a low safety factor.

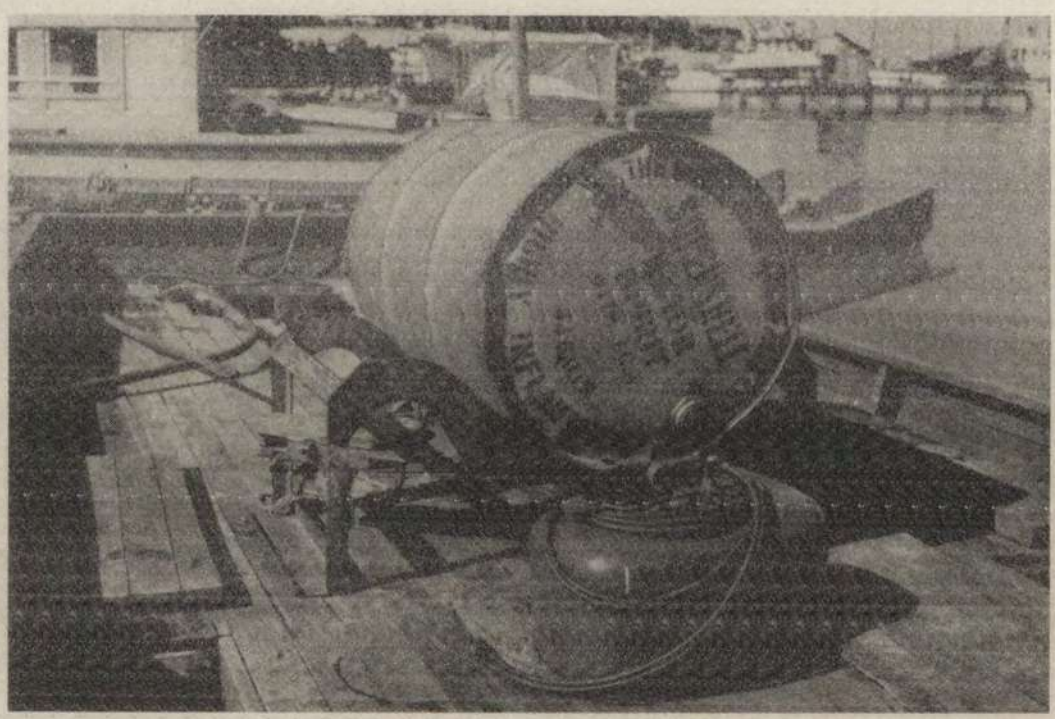

Plate VII.—Benzine, etc.

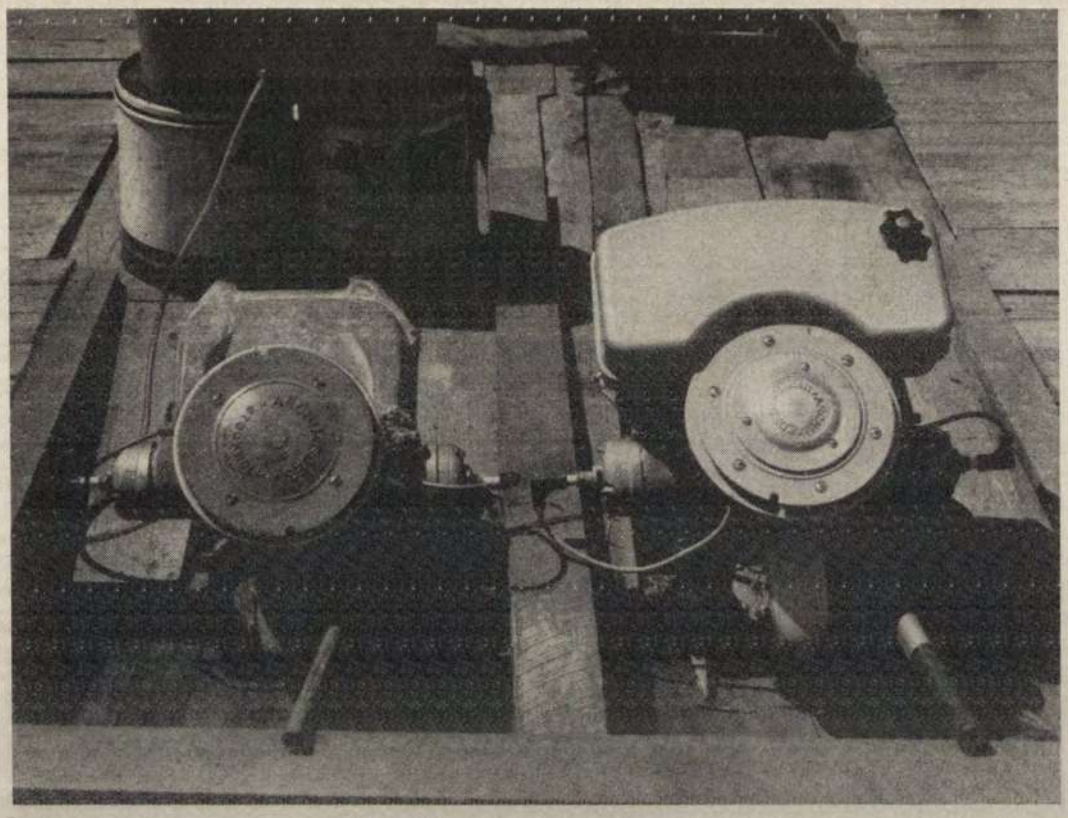

Plate VIII.—Twin engines.

Power Driven Canoe.

A good example of native workmanship may be seen in the double hulled power driven canoe known as the "Logohu" or "Bird of Paradise", shown in Plate X. This vessel has an overall length of 53 feet and a beam of 9 feet. The hulls have an average diameter of 4 feet and the depth inside the hull is 2 feet 11 inches. The power unit, a 40 h.p. engine, is shown in Plate IX. The speed of the craft is about 8 knots with a crew of three and twenty-five passengers or 3½ tons of cargo. The position of the engine is 17 feet from the stern and in this position the propeller is always in deep water irrespective of the angle at which the canoe may ride. The tiller is plainly visible and the bow extension of the deck is an interesting feature. As usual, cargo, stores and fuel are stowed in the hull compartments. Some protection from the weather is provided for passengers and crew by canvas awnings. This vessel carries fire extinguishers and sufficient life jackets for passengers and crew.

While the design of the "Logohu" bears little resemblance to the traditional native canoe, it is interesting to note that the lines of the vessel follow the pattern introduced by the artisans from the Gulf of Papua. The lines are severe and angles quite sharply defined. The "chine" type of construction has been developed for ease of construction above the water level.

Canoes built east of Hood Point, towards Samarai, have more graceful and sweeping lines. The curve of the bows and stern is very pleasing to the eye and the moulding of the coamings heightens this effect. The "Nepuvai", Plate XI, has an overall length of 49 feet and a beam of 10 feet. The mast carries a single sail. Two 12 h.p. outboard engines are installed.

The appearance of the canoe indicates that the native builder can produce vessels possessing seaworthy qualities and pleasing appearance. This canoe is used to carry fish for sale at the local market (visible in the background). These examples of the improvements that are possible by using the dugout hulls clearly show the adaptability of the native shipwright. The use of machine tools and dressed, selected timbers properly prepared and fitted, display the advantages shown in Plate V.

Whilst improvements in the design of the canoes show satisfactory progress, one of the main features to receive little investigation is the mechanical propulsion of such craft. Of the outboard engines there is a very limited choice in the Territory. What are available are high speed units designed principally for craft used for aquatic sports and game fishing. As such, they are a luxury item imposed by necessity upon the owners of native-built canoes. No one has yet determined the horse-power requirements and the most economic speed at which the average sized double canoe should be operated. Recent inquiries by the Fisheries Division of the Administration indicate a speed of eight to ten knots. This figure is doubtful, as these vessels are capable of much higher speeds under sail only.

Future Investigations.

It is intended that while further modifications to canoe construction will be followed, investigations will also be conducted to ascertain the power requirements of such craft. To this end a 40 ft. double-hulled canoe is to be fitted with one (or, if necessary, two) 8 h.p. industrial model diesel engines which will drive by individual vee belts and pulleys, an outboard type shaft and propeller. Each will have forward and reverse gearing, and the engine operating at 1,600 r.p.m. will drive a propeller of 330 mm. diameter and 304 mm. pitch at 750 r.p.m. It is proposed to load the canoe to pre-determined

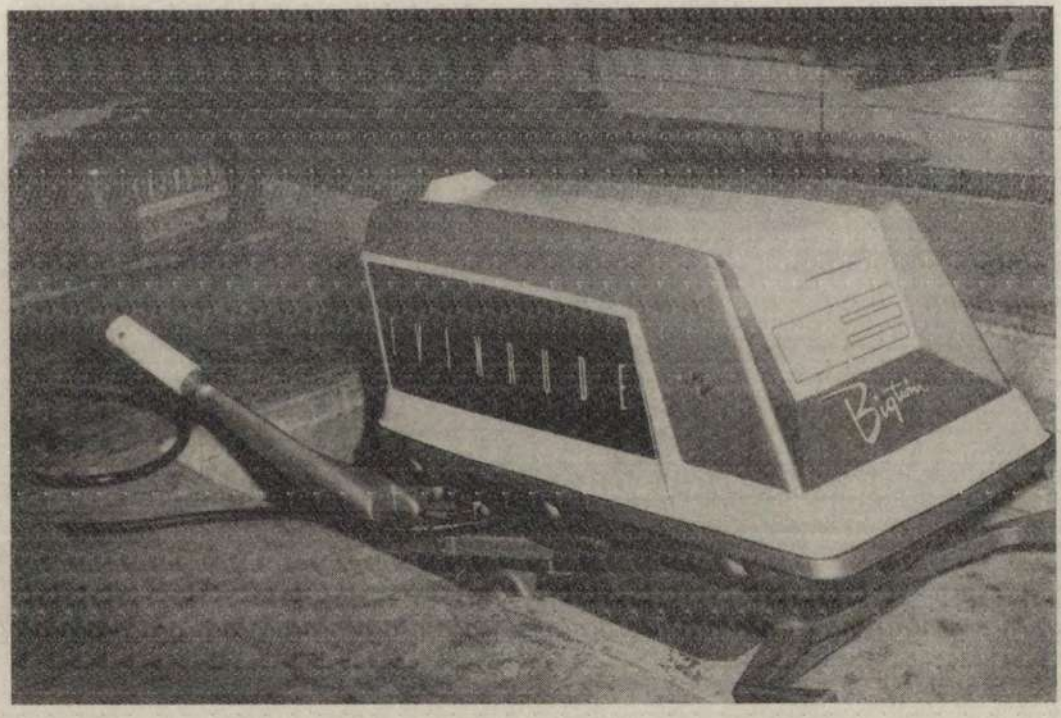

Plate IX.—Neat well, fitted with 40 h.p. outboard engine.

Plate X.—" Logohu ".

specifications and with the use of different pulley and propeller sizes and combinations, carry out sea trials. By so doing, it is anticipated that some idea of the speed requirements of the canoe may be determined. The initial cost of the unit is very low in comparison with the petrol motors now in use and the operating and maintenance costs will also be of economic interest. The engine may, of course, be used for other purposes whilst the canoe is idle, and could also run a small generator to provide electric light if required.

Conclusion.

It appears that future improvements must be made to construction of the hull. At the moment such logs as are required for a double canoe are worth between £10 and £15 at the stump. These logs could contain over 2,000 super feet of milled timber worth £120. It may be possible to build a similar hull by using plywood, or laminated construction using 46-inch sheets and marine glue. The use of fibreglass or other modern coverings may also have applications. However, the economics of such developments require careful investigation and the cost of material for two hulls 45 feet long would be about £150. The training of native artisans in the use of these materials would be important.

There are many catamaran types of craft available today, the plans of which might well be taken into account. Should such developments take place, they may again lead to changes in the coastal natives' mode of living as such craft would in the first instance not have the size to accommodate the families who normally live on board.

Further improvements must be made to develop better rudder control and to accommodate the power unit. Training of qualified engineers is also required on a large scale to

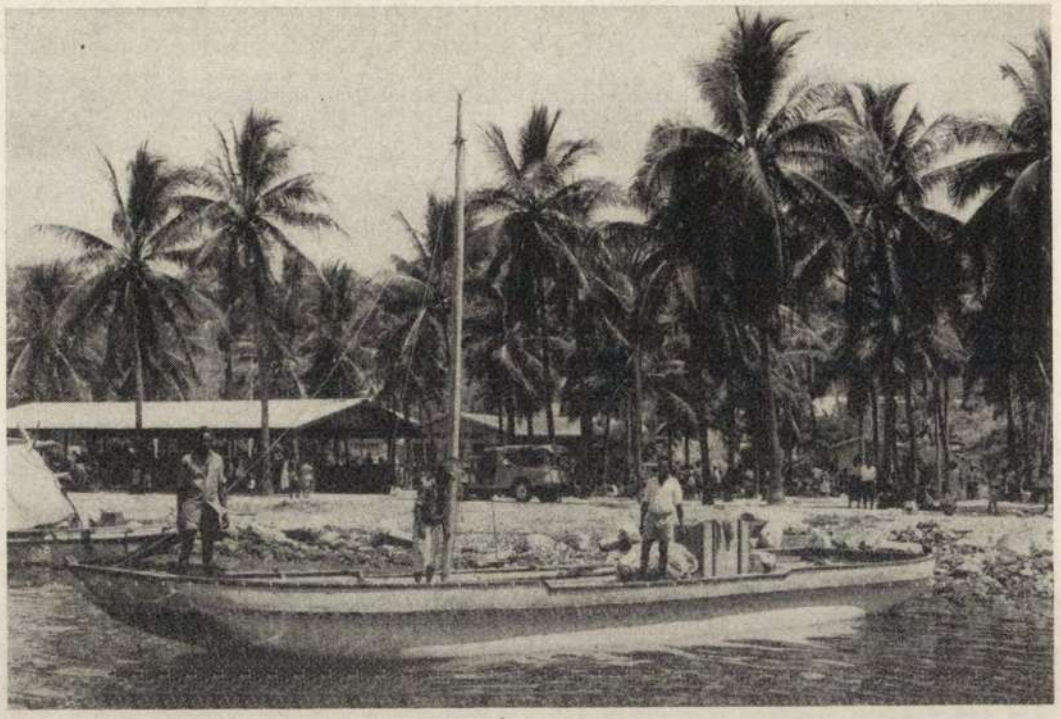

Plate XI.—" Nepuvai ".

deal with engine maintenance and repair. But whatever improvements are made, the important fact is that the craft is, and will be for a long time to come, the means of livelihood for a big proportion of the coastal dwellers of Papua and New Guinea.

ACKNOWLEDGEMENTS.

The author wishes to thank Dr. Rapson and officers of the Fisheries Division, Mr. B. Morris of the Division of Information and Extension Services, and Mr. Q. Anthony of the Department of Native Affairs for the assistance given in the preparation of this article.

The World Coffee Situation.

G. R. SPINKS.

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ALTHOUGH the coffee tree is indigenous to the forests of Africa the use of the beans as a beverage was first adopted by the Arabians and Persians. The stimulating qualities of coffee as a drink became known to Europeans through the Venetian traders and the Moslem conquests of parts of Southern Europe.

The Dutch were the first Europeans to cultivate coffee on a commercial basis and from Ceylon its culture was spread throughout the islands of the former Netherlands East Indies. Both the French and the Dutch introduced coffee into their colonies in the Western Hemisphere.

It is generally agreed that coffee was first sown in Brazil in 1727 and by the end of the century its culture had spread as far south as Rio de Janeiro. The commercial growing of coffee in Africa did not really commence until after World War I.

The outbreak of leaf rust, *Hemileia vastatrix*, which appeared in Ceylon, India and Java in the middle and latter part of the nineteenth century caused the abandonment of arabica coffee as a crop in all infected areas. Leaf rust later spread to Africa and there restricted the growth of arabica coffee to the areas above 4,000 feet. The disease is not known in the Americas. Robusta coffee is not susceptible to rust and since 1900 it has been extensively planted in those countries previously growing arabica coffee but now infected with the disease.

PRODUCTION.

Almost all countries with suitable geographic conditions grow coffee but not all enter international trade. Unfortunately, accurate statistics on acreage, number and age of trees and production are difficult to obtain as much of the world's coffee is grown on very small holdings in underdeveloped countries. However, enough reliable figures are available from the main producing countries to trace trends in world production.

Although there are a number of species of coffee, only four have any major economic significance and of these, only two are of importance in world trade, *Coffea arabica* and *C. canephora* (robusta).

Any discussion of world coffee situation must be influenced by events in Brazil. An examination of Appendix I and Figure 1 shows the dominance of that country in total world production of coffee. In some years, Brazil has supplied over 70 per cent. of the total world output. Over the past four years for which figures are available, Brazil's percentage of world production has varied from 44 to 58 per cent.

Colombia, the second largest producer, has over the years increased its proportion of world production. However, the most marked increases have occurred in the countries of Africa, particularly Uganda, the Ivory Coast, the Congo (ex Belgian) and Angola.

World production has steadily increased since the mid 1950's and reached 4.6 million metric tons in 1959. The following year showed a decline of about 17 per cent. in production. However demand has not kept pace with supply and since 1958 large unsold stocks have commenced to accumulate; of these Brazil has about 85 per cent. (Appendix I.) In 1960, stocks were in excess of world exports. (Compare Appendices I and II.) A smaller but greatly significant build-up of stocks has occurred for the first time since the end of the war in Uganda, the Ivory Coast and Angola. (Appendix I.)

PRINCIPAL PRODUCING COUNTRIES.

Brazil.

In common with many of the other producing countries, coffee plays a dominant part in the export earnings of Brazil. (Appendix I.) In 1958, earnings from coffee exports accounted for approximately 45 per cent. of export income and despite considerable diversification of the Brazilian economy over the past decade, coffee earnings in 1958 accounted for about 40 per cent. of total export income. (Appendix III.)

As a result of Brazil's dominant position in total world production, fluctuations in output have, over the years, had serious repercussions within the world coffee situation. Furthermore the main producing areas within the country are fairly localised so that unusual events in a small geographic region have implications on the world

coffee situation. Because of its dominant position the Government of Brazil has attempted to control world price fluctuations ; the first attempt being made in 1906 by withholding supplies. Such schemes which were originally meant to be of a temporary nature were very successful, particularly when Brazil supplied approximately 70 per cent. of world output. The schemes, known as valourisation, were the answer to temporary excess supplies caused by a biennial bearing ; the tendency for trees to have a high yield followed by a low yield. This " cycle " is further complicated by periodic favourable weather.

When world coffee prices fell in the early 1920's, the valourisation scheme which had been successful in the past seemed the answer. With falling prices, growers and the government were anxious to re-introduce these temporary schemes as a permanent feature of the coffee industry. The plan kept world coffee prices at an artificially high level throughout the 1920's, but had serious long term effects on the Brazilian industry. World consumption of coffee decreased and new plantings were encouraged in both Brazil and other countries. At the same time Brazil's relative importance among world coffee producers tended to decline.

The 1930's were a period of severe overproduction of Brazilian coffee and unlike previous periods, this arose not because of the cyclical pattern of coffee production or extremely favourable weather, but as a result of the coming into production of a large number of trees planted in the period of artificially high prices in the 1920's. Thus, this situation of oversupply had more lasting effects. In order to cope with the situation, supplies were held off the world market with a view to a price rise. Between 1931 and 1934, a total of 78 million bags of coffee had to be destroyed ; enough to supply world needs at that time for three years. Large yields continued throughout most of the 1930's and in 1937 alone about 17.2 million bags[1] were burned. Despite the destruction of stocks, the situation did not improve. Brazil was slowly losing her relative position in the world coffee economy, growers were becoming restive and foreign exchange reserves were falling. Attempts at some type of agreement among the Central and South American producers had also failed, mainly because it was felt that the excess production was largely of Brazil's own making. Finally, towards the end of 1937, the scheme was abandoned.

This abrupt change in policy reacted against the competitors of Brazil most of whom were producers of better quality mild coffees, as they were forced, in turn, to lower their prices through reductions in export levies and relaxations of foreign exchange regulations. However, as soon as the intitial effects of the Brazilian impact on world prices had subsided, the better quality milds recovered and the recognized price differential between Brazil and mild coffees re-appeared.

By 1940 some degree of normal trading in the world coffee market was restored but the outbreak of World War II interrupted trade and Western Europe, a most profitable outlet for Brazilian coffee, was closed. In the immediate post-war period, the dominance of Brazil in the world coffee situation was again demonstrated when Brazilian coffee speculators successfully " engineered " coffee prices to high levels in the United States in 1949. The outbreak of the Korean war also assisted coffee prices to remain at these levels. Since the mid 1950's, production has steadily increased, except for a temporary check in 1956/57, and by 1957 small unsold stocks of coffee began to re-appear in Brazil.

The Future of Coffee in Brazil.

The re-appearance of unsold stocks of coffee poses new problems for the Brazilian coffee industry and it is unlikely that the mistakes of the 1920's and 1930's will be made again. This raises two main issues, firstly the role of international collaboration in the world coffee economy, and secondly measures to improve the overall quality of Brazilian coffee. International co-operation is being attempted through the International Coffee Agreement which is discussed later. In the past, the question of quality improvement policies has been raised many times and it has been contended that Brazil's competitors, particularly those producing the higher quality mild coffees, have catered to the most important market, whilst Brazil has not. There is some truth in this, but any overall attempt to improve quality in the past has been hindered by the very nature of the Brazilian coffee industry. Until recently, coffee in Brazil has acted as a " frontier " crop in that as the

(1) One bag equals 132 lb. or 60 kilo.

older coffee areas were exhausted it was more economical to move to new areas than to regenerate the old. Thus coffee was used to open up new areas. Such a system had a sound economic basis when there was an abundance of good coffee land but under it it was virtually impossible to put into operation any scheme for overall quality improvement. However, as land has become scarce, the industry has been forced to be more permanent in its location and therefore, plans for quality improvement now have a much greater chance of success.

If this occurs in Brazil, there will be repercussions throughout the world coffee market. Brazilian coffee will be able to compete more actively with that of Colombia and the other producers of higher quality milds so that the prices of the latter are likely to fall.

Colombia.

Colombia is the second largest coffee producing country in the world and the most important for the marketing and production of "mild" coffee. Production has increased rapidly (Appendix I) but the proportion entering world trade has shown little change over the past five years for which figures are available; averaging about 14 per cent. (Appendix II.) Mild coffees from Colombia, the best trade types are known as Manizales and Medellin, command a premium over Brazilian coffee on world markets.

In common with many of the main coffee producing countries, export earnings from the product constitute the largest proportion of total export income. In 1938 coffee exports accounted for about 54 per cent. of total export earnings, while 1954, the percentage had risen to approximately 84 per cent. However, over the latest two years for which figures are available, the percentage has declined to about 77 per cent. (Appendix III.) Because of the importance of foreign exchange from the sale of coffee for the development of the country, attempts have been made to eliminate the effects of price fluctuations on world markets by systems of market control and the use of differential exchange rates.

Unsold stocks of coffee have been accumulating in Colombia since 1958. (Appendix I.)

Africa.

As mentioned previously, coffee production in Africa is relatively new as large scale commercial production only commenced after World War I. Considerable expansion occurred during the Brazilian restrictions in the 1930s' but even then production for the five years (1934-38) amounted to only 4.5 per cent. of total world output. (Appendix I.) However, by 1960, this figure had risen to approximately 19 per cent.

Much of this accelerated expansion after World War II was due to high world prices and also to the efforts of European colonial powers in encouraging coffee production during the post-war dollar shortages. Imports of coffee from colonies were given special concessions by means of import duty remissions.

Arabica coffees account for about 25 per cent. of total African production. Therefore in all Western European countries except West Germany, the percentage of robusta in ordinary coffee blends has gradually increased; in September, 1957, the following percentages were listed, Portugal 98; France 71; Italy 41; Holland 49; Belgium 36; United Kingdom 33; Switzerland 18; Denmark 16. It is claimed that further increases in the percentages have occurred since then. In the United States a similar position has occurred in that between 1952 and 1956, imports of robusta almost doubled.[1]

The importance of the robustas in Portugal and France is due to colonial policy in encouraging coffee production and permitting imports from colonies under favourable conditions, combined with the fact that environmental conditions in the colonies concerned favour robusta rather than arabica. It is interesting to note that there appears to have been little difficulty in bending national taste to serve the aims of national policy in these countries.

Other Coffee Producing Countries in the Western Hemisphere.

The other principal producing countries are Mexico, Guatemala, El Salvador, Costa Rica, Cuba and Venezuela. The variation in the importance of coffee in some of these countries

[1] Food and Agricultural Organization (1959). World Coffee Survey (Draft), Rome: F.A.O. pp. 4-5.

can be seen from Appendix III. Apart from Venezuela, most of these countries have increased their production of coffee and Mexico has doubled production since the immediate pre-war years.

Asia.

The Dutch were mainly responsible for the spread of coffee culture throughout the southern part of the continent. However, disastrous effects of leaf rust resulted in the disappearance of coffee as a major crop or its replacement by other crops or the substitution in varying degrees of arabica finally by robusta coffee.

Prior to World War II, Asia held second place in the world output of coffee but since 1945 Africa has occupied this position. Pre-war, Indonesia was the principal producer in Asia, and in the three-year period (1937-39) exports accounted for five per cent. of world trade. However, since the end of the war, production has seriously declined and over the last three years for which figures are available exports only made up about one per cent. of total world trade. (Appendix II.) This decline in production was mainly due to the devastation of the Japanese occupation, the political turmoil following the cessation of hostilities and the deterioration of research and technical facilities.

Production in India has increased over recent years and more than doubled between 1948-49/1952-53 and 1959-60; increasing from 21,600 metric tons to 47,500 metric tons.

Exports have declined, however, as domestic consumption of coffee has increased.

WORLD CONSUMPTION.

The most marked feature of the world demand for coffee is the concentration of importing countries. Over the past five years for which figures are available, seven countries imported 89-90 per cent. of the world trade in coffee (Appendix IV.) Of these, the U.S.A. accounted for between 52-56 per cent.

World coffee consumption was retarded during the 1930's when Brazil endeavoured to maintain artificially high prices in a period of world-wide declining incomes. Furthermore, World War II also seriously interrupted world trade and the post-war period, which was characterized by periodic shortages of foreign exchange prevented the world coffee trade from returning to a normal pattern for about twelve years. With the gradual build-up of unsold stocks in the most important producing countries since 1955 it could be argued that the world coffee economy has returned to normal, where supply exceeds demand.

In many European countries, consumption per head of population of coffee has not returned to pre-war levels. Appendix V shows per capita consumption for elected countries, and Sweden, in 1958, retained its position as the world's greatest coffee drinking nation. The U.S.A. was the second most important although a comparison of these two countries is a little difficult, in that, over recent years soluble or "instant" coffees have become very popular in the United States. It is estimated that such coffees give approximately one-third more cups than ground coffees, and therefore, it is likely that consumers in the U.S. drink more cups of coffee per head than any other country.

Consumption of coffee depends upon several factors of which income levels, import duties and special taxes are the most important. It is generally agreed that income levels are the main determining factor and therefore increased consumption of coffee rests largely upon continuing rises in income.[1] This assumption is only applicable to the industrialized countries of North America and Western Europe and does not apply to the bulk of the world's population in the underdeveloped countries.

Consumption in many industrialized countries is restricted by the levying of import duties and special taxes on coffee. The effect of these can be judged by reference to Appendix VI. The highest taxes in 1958 were imposed in Finland and amounted to 49 per cent. of the ruling retail price. In Western Germany, the combined taxes made up 36 per cent., while in Spain, import duty alone accounted for 36 per cent. of the retail price. Such heavy taxation places coffee in the luxury class in many countries.

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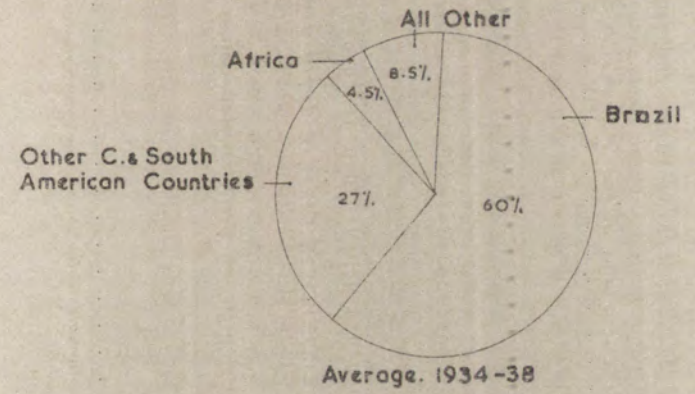
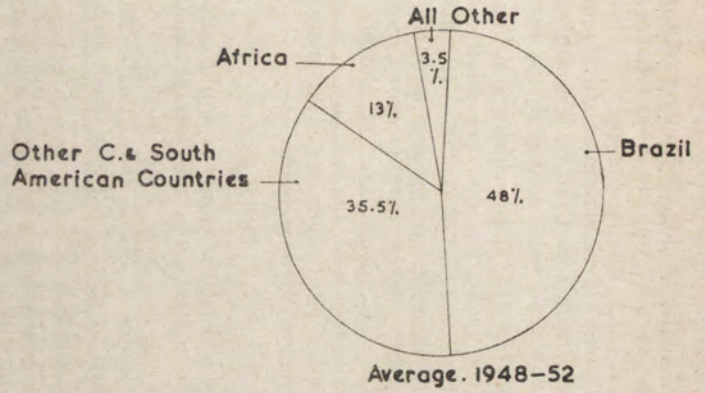
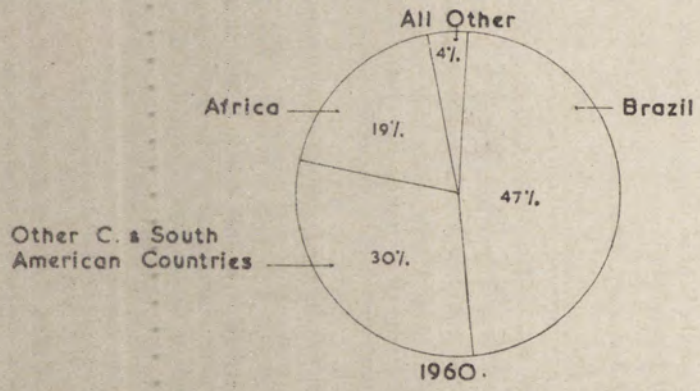
[1] A recent study has indicated that in countries where both tea and coffee are consumed, the consumption of coffee increases at the expense of tea as income increases.

Figure 1.—World Production Percentage Selected Years.







World consumption of coffee cannot be adequately reviewed without reference to rival beverages, especially tea, although in several countries wine is the dominant drink. It is accepted that once consumption habits are acquired any shift to substitute products is extremely difficult to accomplish. Because of its generally higher price than tea, coffee has a relatively inelastic demand and therefore consumers are more sensitive to price changes. Tea costs less per cup and despite price changes, the demand tends to be more constant. Although an increase in the price of coffee will not automatically result in a shift to an alternative beverage, consumers may react against it by drinking fewer cups or weaker coffee, with the resultant decline in total consumption.

United States of America.

No discussion of world coffee consumption would be complete without some special reference to the United States market which takes more than half the total world exports (Appendix IV.) Until 1957, coffee was the most valuable single commodity imported into that country and only after that date was it ousted from chief rating by petroleum and petroleum products. Imports from Brazil, Colombia and Africa made up more than 75 per cent. of the total although over recent years coffee from Africa has gained at the expense of Brazil and Colombia. In 1949, Africa supplied less than two per cent. of the imports of green coffee but in 1955 the proportion had increased to 11 per cent. Imports from Africa in 1960 had risen to 17 per cent. and for the first four months of 1961 the figure was 21 per cent[1].

Much of this increased purchasing from Africa seems to have stemmed from the growth in the consumption of soluble or instant coffees. It is claimed that the advent of the instant coffees was largely the result of the high coffee prices from 1949-1954, as more cups of coffee could be made from one lb. of beans.

High coffee prices also reduced per capita consumption of coffee in the United States. Appendix VII shows the effect of price increases on per capita consumption of coffee for the coffee drinking section of the population (i.e., those over 10 years of age).

(1) *The Economist*, July 19, 1961, p. 480.

The future world consumption of coffee cannot be assessed without some reference to the U.S.S.R. and Eastern Europe[1]. This region of the world is entering more actively into international trade and it can be reasonably assumed that this trend will continue in the future.

The U.S.S.R. is principally a nation of tea drinkers unlike the countries which constitute Eastern Europe. Appendix VIII shows the imports of coffee and tea into these two groups and coffee imports have increased, but in the U.S.S.R. tea imports are considerably higher. Nevertheless, total imports are relatively unimportant when compared with those of the countries of Western Europe.

PRICES.

The general movement of world coffee prices can be judged from the average annual spot prices on the New York market. (Appendix IX.) Santos 4, Mama and Uganda Native can be taken as representative of the coffees traded on the world market.

Prices gradually increased from 1950 until 1953; largely due to the aftermath of the "engineered" price rise in the United States in 1949 and the Korean War. However, this steady increase changed to an upsurge in 1954 when reports of severe frost damage to crops in the Brazilian states of Parana and Sao Paulo caused panic buying. These frosts damaged or killed 400 million of the 700 million trees in Parana and destruction in Sao Paulo amounted to 20 per cent. of the producing trees.

Since 1954, when the commencement of a downward phase in the world coffee economy was noted, world prices have steadily declined. The accumulation of unsold stocks in the major producing countries, although successfully isolated from the world markets, has tended to act as a further depressing factor on the market. During 1959 and 1960, prices remained somewhat stable but the level of Brazil and mild coffees were 38 and 30 per cent., respectively below average prices for 1950-57[2]. In the early part of 1961, export quotas under

(1) The countries included in this region are Albania, Bulgaria, Czechoslovakia, Eastern Germany, Poland, Roumania.

(2) Commodity Notes—Coffee: Recent Developments—*Monthly Bulletin of Agricultural Economics and Statistics*, Vol. 10 No. 3 March, 1961. F.A.O. Rome pp. 15-16.

the International Coffee Agreement were reduced by 10 per cent. to maintain the 1960 price level.

The prices for robusta coffee moved somewhat differently. The major market weakness began in mid 1959 when the first International Coffee Agreement was operating, and the rate of decline accelerated in 1960. The annual average price for robustas in 1960 was 55 per cent. lower than the 1950-57 average[1]. This market weakness was the result of a number of factors of which the following were the most important, the large size of the robusta crop, the intense competition from cheap arabicas which were plentiful and the resultant competition among robusta producers and the outlook for further increases in production.

WORLD COFFEE AGREEMENT.

It is generally recognized that coffee has been subjected to artificial controls, both national and international, for a longer period than any other major world agricultural commodity. Its normal pattern of over supply and importance to the economics of the producing countries has led to this situation.

Conferences between producers were first convened in 1902 while during the 1930's, Brazil attempted to call together the main producers in the Western Hemisphere in the hope of stabilizing world trade and so world prices. However, these attempts accomplished very little.

The first international co-operative scheme for the regulation of the world coffee trade and for the support of the price level occurred in 1940, when the 14 coffee producing countries of Latin America and the U.S.A. signed the Inter-American Coffee Agreement. This Agreement was essentially an export quota scheme but had one unusual feature ; it was the first important international commodity agreement in which a consuming country, not also a producer, exercised a dominant role. However, this agreement was primarily political arising out of World War II and the closing of the European coffee market. The Agreement lapsed in 1948.

The high coffee prices of the immediate post-war period, the alleged " engineered " price rise for Brazilian coffee in the U.S.A. in 1949 and the outbreak of the Korean War, all encouraged additional coffee plantings. By 1954 some doubts in the world coffee economy began to emerge as the downward phase of the coffee cycle became apparent. However, it has taken on a new aspect. World interest and assistance were now directed at encouraging the economic development of the less advanced countries. The major coffee producers constitute a sizeable portion of these (Appendix III) and any drop in major earnings could only hinder economic developmental schemes. As foreign exchange is essential for these plans, the coffee producers could not afford to see future development hindered by falling foreign reserves.

With the accumulation of unsold stocks the lessons of the 1920's and 1930's were remembered although now the problem was faced by more countries than Brazil. The advent of the African producer added new problems for international agreement. However, the coffee countries of the Western Hemisphere met in Mexico in 1958 and the Latin American Agreement was signed. This covered seven countries but as the unsold stocks continued to increase all the Western Hemisphere producers became signatories.

Although these agreements assisted in easing the price fall, it soon became apparent that increased consumption due to declining world price could not keep pace with production and therefore some wider form of agreement was essential. As a result, the International Coffee Agreement was signed in September, 1959 for one year—to be renewed if members wished. For the first time a number of African countries, the French African Community, and Portugal on behalf of her African possessions co-operated in the Agreement. Their participation was no doubt due to the steady build-up of stocks in the colonies. (Appendix I.) Although the United Kingdom and Ethiopia were not parties to this Agreement, the Territories of British East Africa, the Belgian Congo and Ruanda Urundi, agreed voluntarily to limit exports during the duration of the Agreement.

As there was some direct competition between poor quality arabica, particularly from Brazil, and robusta coffee, the robusta producers of Africa formed the Inter-African Coffee Organization in December 1960. The aims of the Organization were to secure greater stability in robusta coffee prices and to avoid unnecessary price competition between producers. The inference can be drawn that this organization was

(1) Ibid.

partly formed in response to the International Coffee Agreement as the robusta producers felt it was largely the making of the Latin American producers.

The International Coffee Agreement.

The purpose of the Agreement " is to adapt the supply of coffee to the demand for it, to insure the orderly placement of the product in world markets, and to foster its consumption throughout the world, thus contributing to the intensification of trade between producing and consuming countries "[1].

Members of the Agreement were aware that the solution to the periodic overproduction of the world coffee economy was not possible by short term means and that the only attack on this cyclical pattern of overproduction must be a long term one. The aim is to find new markets, attempt to increase consumption in all markets and to stabilize world price by means of export quotas.

Quotas were established while taking into account :—

(*a*) " a figure of 90 per cent. of the exports that took place during the best calendar year of the last decade (1949-58) ; and

(*b*) " a maximum figure of 88 per cent. of the actual exportable production, according to the estimates of the United States Department of Agriculture "[2].

For countries with an exportable production of less than two million bags, the Board of Directors, at the request of those countries, can adjust their quotas to a maximum of 88 per cent. of the exportable production estimated by the United States Department of Agriculture in January and March of 1960.

The member nations of the Agreement have divided the world into market areas, " old " or traditional and " new " markets. The agreed quotas only apply to the traditional markets and exports from the signatories to the " new " markets are not charged against their respective quotas. The following countries were designated " new " markets in the original Agreement : Bulgaria, Ceylon, People's Republic of China, Formosa, Philippines, Hungary, Iraq, Iran, Japan, Poland, North Viet Nam, Republic of Viet Nam, Roumania, Thailand, U.S.S.R., North Korea and Republic of Korea. In September 1960, the following were added to the " new " market list, Bahrein, Basutoland, Bechuanaland, Federation of Rhodesia and Nyasaland, Jordan, Kuwait, Muscat and Oman, Qatar, Saudi Arabia, Somalia, South-West Africa, Sudan, Swaziland and the Union of South Africa.

One of the suggested methods of increasing consumption is through publicity campaigns in the markets and signatory members must contribute up to 25 cents, U.S. currency, or its equivalent in convertible currency for each 60-kilo bag exported during the year of the Agreement. However, the levy's equivalent may be paid in coffee.

In June, 1960, it was agreed to extend the Agreement until the end of September, 1961. All the former signatories re-signed, but the United Kingdom, on behalf of the East African countries, became an active member of the Agreement.

The Future Decade.

The success or failure of the International Coffee Agreement could be the key to the future of the coffee economy, as there must be some adjustment to the disequilibrium between supply and demand. The allocation of quotas will be the main hurdle for complete agreement. The method of allocation favours the largest of the old producers and, under the original method of determination, Brazil was allotted approximately 53 per cent. of the total, despite the fact that over the last five years for which figures are available the percentage of world exports from Brazil averaged about 38 per cent. Subsequently, Brazil's quota has been reduced slightly as the new agreements were signed and other producing countries became signatories. An examination of the means of determining quotas shows that only Brazil and Colombia are eligible under the 90 per cent. of export. All the other producing countries exported less than 2 million bags in the decade 1949-58. Therefore, all these countries must have their quotas adjusted by the Board of Directors of the Agreement.

(1) *International Coffee Agreement.* Article 1, Purposes—Final Act for the Conclusion of an International Coffee Agreement. (English Translation.)

(2) Ibid. Article 6. Quotas—Final Act of the Negotiations for the Conclusion of an International Coffee Agreement. (English Translation.)

It is most unlikely that the " new " markets will play any important part in rising world consumption levels of coffee. Although the list is impressive in number the potential increases are limited to a few countries, namely, Japan, U.S.S.R. and the Eastern European countries. Practically the entire list comprises areas of low per capita income. In 1959, the imports of coffee for all these countries amounted to only 57,900 metric tons out of total world imports of 2,550 million metric tons. Seven of these countries, namely Bulgaria, Hungary, Poland, U.S.S.R., Japan, Thailand and the Union of South Africa, imported 55,800 metric tons of the total " new " market consumption. In each case, these seven countries increased their purchasing of coffee in 1959 over that of the previous year. The U.S.S.R. imported 4,100 metric tons in 1958 and 13,300 metric tons in 1959. No doubt the lower world prices stimulated buying by the Communist Bloc nations. Any success for encouraging coffee consumption in these countries will depend upon low prices plus some degree of education in the drinking of coffee where it is not normally considered a beverage. Furthermore, intensive inspection of these " new " markets will be necessary to prevent re-exports to the traditional markets.

At the present stage the future of the Agreement still rests on the U.S.A. becoming a signatory and although that country has given active support in attempts to stabilize the world coffee market, its influence has been only indirect. There also seems to be a need for active participation of the main consuming countries before the Agreement can function adequately. By such means some of the special taxes levied against coffee may be reduced.

Although hope seems to be pinned on increasing population and rising average disposable incomes it seems doubtful if these two factors alone can make any real impact on the increasing world production of coffee.

The demand for coffee is relatively inelastic which means that a given change in price results in a less than proportionate change in the demand for the product. For example a Coffee Study Group report has calculated that the demand elasticity for coffee in Germany is—0.75, the Netherlands—0.75 and the U.S.—0.25. This means that a one per cent. change (drop) in price will only call forth less than one per cent. change (rise) in quantity demanded ; in the case of Germany, only 0.75 per cent. increase in demand, similarly for the Netherlands, but only an 0.25 per cent. increase in the demand for coffee in the U.S. Therefore this places the world's coffee producers in a dilemma as there is little hope of increasing export earnings by lowering price and there is the danger that income from coffee exports may fall.

This raises the point that the underdeveloped countries must advance economically and export earnings seem to be the only acceptable means of doing this. However, as world prices for the major products fall foreign exchange reserves decline and the financing of developmental plans is in jeopardy. Because many of the underdeveloped areas rely on coffee as the main means of acquiring foreign exchange, the problem of the inelastic demand for coffee becomes a real one. Falling world prices can threaten economic collapse ; a factor often expressed by the Brazilian government.

The International Coffee Agreement has been extended for another year from 27th September, 1961, with no major changes. However quotas were reduced by three per cent. Although it was hoped that the signing of the new agreement would lend some stability to the world coffee economy this did not occur and the downward trend in prices continued. One well-known private firm in the industry stated, " perhaps the greatest difficulty lies in the difference in the fundamental approaches of Brazil as compared with the African producers . . . . Brazil plans to eliminate two billion low yield trees within the next two years, reducing coffee production by 12 million bags . . . . Increasing productivity of the remaining coffee land is expected to meet coffee needs in the future, with production planned to reach 28/30 million bags in the next five years. However, Brazil's portion of the market is being steadily eroded by the low price, maximum penetration policies of the African producers. The substantial discount of African coffees under Brazilian coffees has increased Africa's share of the market from 22.5 per cent. in 1956 to 26.44 per cent. in 1960. Brazil should counter this trend by lowering the price of Brazilian coffees, but given the inelasticity of demand for coffee such a move might well result in lower revenues for all. The other alternative for Brazil is to have quotas set at such levels that further encroachments into

her market cannot be made. It is precisely over this difference of interests that a long-term Agreement is likely to encounter real difficulties, especially if, as advocated by the U.S., quotas are geared to consumption rather than production "(1).

Reference has already been made to the preference for robusta coffee in the countries of Western Europe, except in the Republic of West Germany and this must react most adversely against the hard arabica coffee of which Brazil is the main source. The countries of the European Common Market, under the provisions of the Treaty of Rome, propose to include a uniform 16 per cent. duty on coffee with the exception of the product from the former territories or colonies of members. These proposals will further strengthen the position of the African producers at the expense of Brazil. The seriousness of this can be judged from the fact that pre-war, the countries of Western Europe took about 30 per cent. of Brazil's exports.

The International Coffee Agreement has a difficult task ahead and without the active participation of the United States and the other major consuming countries the chances of success are limited. The International Wheat Agreement has been quoted as a model for the mechanism of international commodity agreements but the members of the two are quite separate and distinct. The signatories of the agreement on coffee are primarily underdeveloped, coffee for many of them is the only means of financing economic advancement. The members of the wheat agreement are mainly developed countries or those well advanced in economic development and are therefore more able to withstand price fluctuations. Although the future of the world coffee economy is not buoyant some successful solution must be found if economic development of the producing areas is to be achieved.

(1) Coffee—Weekly Bulletin, October 4, 1961. Merrill Lynch Pierce, Fenner and Smith Incorp. 70 Pine Street, New York, 5.

Appendix I.

COFFEE

Production and Stocks.

(Thousand Metric Tons.)[1]

	Average 1934-38.		Average 1948-52.		1957.		1958.		1959.		1960.	
	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%
Production—												
Brazil	1,446.1	60.0	1,076.6	48.0	1,409.3	44.0	1,696.0	48.5	2,646.0	58.0	1,800.0	47.0
Colombia	251.2	10.0	359.2	16.0	468.4	15.0	462.0	13.0	480.0	10.5	....	....
Other South America	71.9	3.5	74.2	3.0	102.3	3.0	122.0	3.5	113.0	2.5	....	....
Central America	326.3	13.5	370.0	16.5	510.0	16.0	460.0	13.0	580.0	13.0	1,150.0	30.0
Africa	111.8	4.5	290.0	13.0	540.0	17.0	610.0	17.5	670.0	14.0	715.0	19.0
All other countries	212.7	8.5	80.0	3.5	150.0	5.0	153.0	4.5	84.0	2.0	162.0	4.0
TOTAL WORLD	2,420.0	100.0	2,250.0	100.0	3,180.0	100.0	3,503.0	100.0	4,573.0	100.0	3,827.0	100.0
Stocks—Export—												
Brazil	....	....	....	....	....	....	846.0	84.0	1,446.0	85.0	2,658.0	87.0
Colombia	....	....	....	....	....	....	160.0	16.0	208.0	12.0	300.0	10.0
Ivory Coast	....	....	....	....	....	....	....	....	44.0	3.0	54.0	....
Uganda	....	....	....	....	....	....	....	....	....	....	28.0	....
Angola	....	....	....	....	....	....	....	....	....	....	9.0	3.0
TOTAL	....	....	....	....	....	....	1,006.0	100.0	1,688.0	100.0	3,049.0	100.0
Stocks—Import—												
United States	....	....	213.0	....	....	....	141.0	....	137.0	....	150.0	....
Six European Countries	....	....	....	....	....	....	....	....	75.0	....	98.0	....

(1) Metric tons equals 0.98421 long ton equals 2204.63 lb.

Source: Monthly Bulletin of Agricultural Economics Statistics; F.A.O. Vol. IX, No. 11, November, 1959, p. 20; Vol. X, No. 3, March, 1961, p. 15.

Appendix II.

Exports—Principal Countries.

(Thousand Metric Tons.) (1)

	Average 1937-39.		Average 1948-52.		1957.		1958.		1959.		1960.	
	1,000 tons	%	1,000 tons	%	1,000 tons	%	1,000 tons	%	1,000 tons	%	1,000 tons	%
South America—												
Brazil	916.1	55.0	1,006.5	52.0	859.2	38.0	773.0	34.0	1,046.2	39.0	1,009.1	39.0
Colombia	241.1	14.5	303.7	16.0	289.4	13.0	326.4	14.0	384.8	15.0	356.6	14.0
TOTAL South America	*	....	1,355.0	69.0	1,206.1	54.0	1,165.2	51.0	1,482.6	58.0	....	55.0(*a*)
Central America—												
El Salvador	59.1	3.5	67.4	3.5	83.2	4.0	80.5	3.5	83.0	3.0	*	....
Guatemala	46.6	3.0	53.9	3.0	61.8	3.0	71.4	3.0	82.7	3.0	79.8	3.0
Mexico	35.0	....	46.0	2.5	88.8	4.0	78.7	3.5	74.6	3.0	83.0	3.0
TOTAL	*	....	261.0	13.5	351.1	15.5	389.6	17.0	377.8	15.0	....	....
Asia—												
Indonesia	77.4	4.5	12.8	1.0	51.0	2.0	27.2	1.0	38.1	1.5	*	....
TOTAL	*	....	31.0	1.5	93.8	4.0	58.4	2.5	62.9	2.5	....	....
Africa—												
Angola	19.4	1.0	49.9	2.5	72.2	3.0	77.3	3.5	89.0	3.5	87.3	3.0
Congo	21.6	1.0	32.0	1.5	66.0	3.0	69.4	3.0	91.8	3.5	*	....
Ivory Coast	....	....	....	....	101.2	4.5	112.5	5.0	104.7	4.0	147.5	5.0
Madagascar	31.1	2.0	32.5	1.5	48.3	2.0	47.8	2.0	37.9	1.5	40.2	1.0
Uganda	14.9	1.0	28.2	1.5	85.4	4.0	80.0	3.5	89.8	3.5	118.7	4.0
TOTAL	....	....	282.0	14.5	491.3	22.0	510.9	22.0	548.9	21.0	*	....
WORLD TOTAL	1,661.5	100.0	1,939.0	100.0	2,268.0	100.0	2,271.0	100.0	2,550.0	100.0	2,565.0	100.0

(1) Metric tons equal 0.98421 long ton equals 2,204.63 lb.

Source: *Plantation Crops*. Commonwealth Economic Committee 1960. H.M.S.O., London.

Monthly Bulletin of Agricultural Economics and Statistics. Vol. 10, No. 6, June, 1961, p. 32. F.A.O., Rome.

* Not available.

Appendix III.

Relative Value of Raw Coffee to Total Exports—Principal Countries
(Per cent.)

	1938	1957	1958
Brazil	45.0	51.1	39.7
Colombia	54.4	77.6	77.1
Mexico	3.1	14.1	9.1
El Salvador	86.9	79.3	72.5
Guatemala	63.6	75.6	75.6
Venezuela	4.8	1.5	1.6
Uganda	7.0	42.3	40.4
Angola	10.9	42.2	40.8
Indonesia	2.0	3.0	2.4
Ivory Coast	5.5	57.2	59.6

Source: *Plantation Crops*, p. 69, 1960. Commonwealth Economic Committee, London, H.M.S.O.

Appendix IV.

Imports—Raw Coffee—Principal Countries.

(Thousand Metric Tons) (1)

	Average 1936-37 to 1938-39.		Average 1948-52.		* 1957.		1958.		1959.		1960.	
	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%	1,000 m.t.	%
Europe—												
Belgium—Luxembourg	*	....	68.6	3.5	50.6	2.0	51.9	2.0	58.3	2.0	65.8	2.5
France	178.0	....	124.1	6.5	181.6	8.0	189.0	8.0	196.8	8.0	197.7	8.0
West Germany	165 (*a*)	....	32.1	1.0	154.0	7.0	159.7	7.0	186.8	7.0	199.4	8.0
Italy	32.0	....	54.2	3.0	77.7	3.5	81.4	3.5	84.0	3.0	99.2	4.0
United Kingdom	23.0	....	45.0	2.0	45.3	2.0	44.2	2.0	53.0	2.0	55.2	2.0
TOTAL Europe	*	....	483.0	25.0	740.2	33.0	780.2	34.0	857.7	33.0	918.8	36.0
North America—												
Canada	19.0	....	41.2	2.0	50.2	2.0	53.7	2.0	60.9	2.0	59.8	2.5
United States	861.0	....	1,223.9	64.5	1,252.1	55.0	1,263.7	53.0	1,390.2	54.0	1,329.2	52.0
TOTAL North America	....	....	1,269.0	67.0	1,302.3	57.0	1,317.4	55.0	1,451.1	56.0	1,389.0	54.5
WORLD TOTAL (2)	*	....	1,896.0	100.0	2,268.0	95.0	2,271.0	95.0	2,550.0	95.0	2,565.0	95.0

(*a*) All Germany.

* Not available.

(1) Metric tons equals 0.98421 long ton equals 2,204.63 lb.

(2) Countries listed in source material account for about 95 per cent. of world total.

Source: *Monthly Bulletin of Agricultural Economics and Statistics*. June, 1961. Vol. 10, No. 6. F.A.O. Rome.

Plantation Crops 1960. Commonwealth Economic Committee. H.M.S.O., London.

Appendix V.

Estimate per Capita Consumption—Coffee—Selected Countries.
(lb. per annum.)

	(Aver.) 1937-39	1952	1955	1956	1957	1958
Sweden	18.3	15.0	15.9	17.2	17.4	18.3
U.S.A.	14.4	16.9	15.3	15.5	15.7	15.9
Belgium	13.4	12.9	11.2	14.2	11.3	11.5
France	9.4	8.3	8.9	9.3	9.1	9.3
Netherlands	9.8	4.9	6.4	8.2	7.7	8.6
Switzerland	10.3	7.9	7.5	9.3	8.8	7.9
Canada	3.8	6.7	7.4	8.1	8.4	8.6
West Germany	4.3(a)	2.5	5.1	5.7	6.4	6.6
Italy	1.7	2.9	3.3	3.5	3.5	3.7
U.K.	0.7	1.5	1.3	1.5	1.6	1.7
Australia (*b*)	0.6	0.8	1.1	1.3	1.6	1.5

Source : Plantation Crops, p. 77, 1960. Commonwealth Economic Committee, London, H.M.S.O.
(*a*) All Germany.
(*b*) Figures for 1959 and 1960—2.0 lb. and 2.2 lb. respectively, *Statistical Bulletin*, No. 15, 1959-60. Bureau of Census and Statistics ; Canberra, p. 46.

Appendix VI.

Special Taxes and Import Duties on Coffee—Selected Countries—1958.

Countries.	Import unit value.	Special taxes.	Total import duties and special taxes.	Retail price.	Share in retail price of. Special Taxes.	Share in retail price of. Import duty and special taxes.
Countries with Special Taxes and Import Duties	U.S. $ per kilogram.				Percentage.	
Finland	0.95	0.53	1.47	3.56	18	49
West Germany	1.30	0.72	1.10	4.62	19	28
Italy	1.02	0.80	0.90	3.64	27	30
France	0.93	0.42	0.61	2.50	20	30
Sweden	1.14	0.07	0.16	2.27	4	8
Countries with Import Duties only						
Spain	1.30	....	0.82	2.74	....	36
Austria	1.15	....	0.69	3.45	....	24
Greece	0.94	....	0.37	3.10	....	14
Denmark	1.01	....	0.25	2.82	....	11
Switzerland	1.10	....	0.13	2.25	....	7
Canada	1.07	....	0.11	1.92	....	7
United Kingdom	0.93	....	0.04	2.42	....	2

Source : Coffee Taxes and Consumption in Importing Countries. *Monthly Bulletin of Agricultural Economics and Statistics*. F.A.O. Vol. IX, No. 9, September, 1960, pp. 8-13. F.A.O. Rome.

interior of the nest should be used. This usually requires about 1/3 pint of solution.

2. *Prevention of future infection.*

Dead wood on the trees provides an entrance for the insect, so care should be taken when pruning. When a branch is removed the cut should be made, preferably with a saw, as close as possible to the point of origin of the branch so that no part is projecting. The wound should be covered with a protective coating. If pruning is carried out correctly, callus tissue will grow over the wound and thus prevent entry of the termite.

Once initial control has been gained, it can be maintained by ensuring that pruning operations are carried out correctly, and that all nests are treated as they are found. It is important to remember that *Neotermes* will attack the shade tree, *Leucaena glauca,* as readily as cocoa, and remedial and preventive measures should extend to these as well.

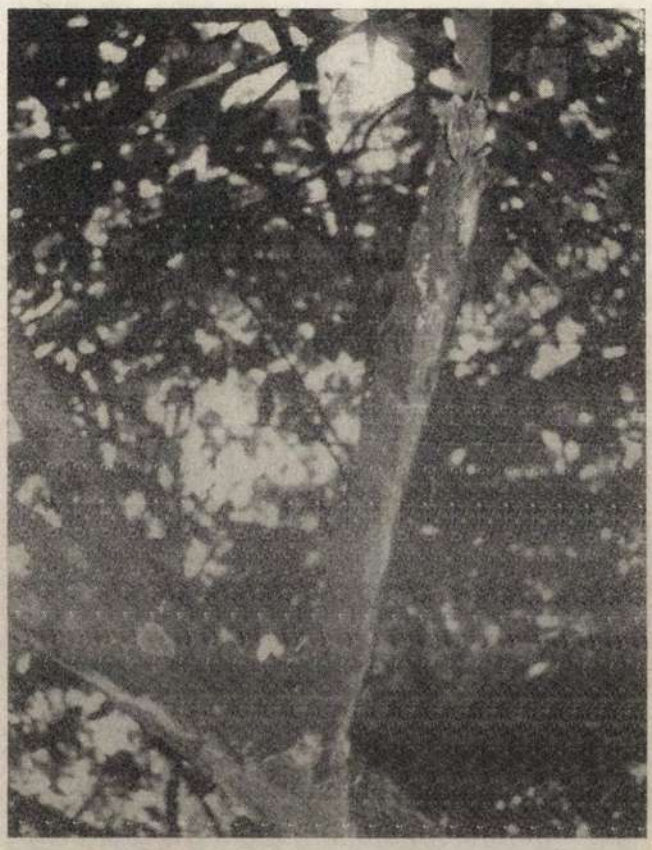


Plate II.—A badly pruned branch of cacao which has been attacked by Neotermes.

Book Reviews.

Surplus.

The Riddle of American Agriculture.

ALAN R. BIRD.

New York, Springer 1962. 128 pp. $3.75U.S.

The U.S. agricultural surplus problem is commonly viewed as a fairly recent phenomenon of that country but in fact, it commenced well before the last world war. The outbreak of World War II and the Korean War delayed the appearance of the present proportions of this surplus. Despite governmental piecemeal attacks, both Republican and Democrat, the surplus has continued to grow and, with present control and elimination methods, the size will increase.

Governmental restrictions, mainly of the voluntary type, have only tended to illustrate to the U.S. and the remainder of the world, the efficiency of U.S. farmers in increasing production despite acreage restrictions and removal of land from production.

This book aims at providing a broad appreciation of the problems facing the U.S. in solving this surplus and is written in non technical terms. Each chapter heading is one of the more commonly expounded solutions to the problem and is followed by impartial analysis of the implications of each suggestion. In all cases, these common answers tend to view agriculture as a separate and distinct sector of the economy but the author is careful to show the integration of agriculture within the economy. The usual solutions advanced range from new uses for agricultural commodities, gifts of surplus food, eat more food, slowing down technical and scientific advances, marketing controls, getting more farmers off the land, taking more land away from farming etc.

The overall failure of present and past attacks on the problem shows the need for a new approach. Thus, the author calls for more direct governmental action. Despite some degree of compulsion, the size of the farm sector of the economy must be reduced in terms of area and number of farms. Such a method over a period of time would still allow the essential technical and scientific advances to continue.

From a Territory of Papua and New Guinea and perhaps a U.S. viewpoint, the publication could have included more detail of the growing tendency for the unsolved agricultural surpluses to become a permanent feature of U.S. foreign and trade policy. Under legislation, the Agricultural Trade Development and Assistance Act of 1954 (commonly referred to as Public Law 480), U.S. surplus agricultural commodities enter world trade under particularly favourable conditions. Thus, existing trade relations between primary producing nations and their traditional markets are disrupted. Large sales of surplus U.S. wheat to India caused strong protests from Australia, the latter claiming that traditional markets were being threatened by such disposal. To date, the main effects of this policy have been to primary producing nations of the temperate regions of the world. However, surplus stocks of edible fats and oils, both vegetable and animal, have already been traded with a number of Western European countries, thus threatening normal markets for tropical edible vegetable oils such as coconut, palm, palm kernel and groundnut oils. The author also criticises the growing U.S. policy of supplying aid to underdeveloped countries in the form of surplus agricultural commodities.

Despite these comments, the book is admirably suited for the audience to which it is aimed and offers an excellent basis for discussion of the U.S. agricultural problem. No attempt is made to show any clear short cut solution to the problem as readers are left to think over the implications throughout the economy. It is also pleasing to note that commercial policy techniques are called their appropriate name e.g. the "two price" system is called what it is—dumping.

G. R. Spinks.

Committee on Work on Plantations.

Fourth Session. General Report. International Labour Office, Geneva, 1961. 143 pp. Price unknown.

Because this publication is a General Report, review is difficult but its value comes from the general information about labour in the plantation system, world trends in the plantation economy and recent developments in world markets for the principal plantation crops, coffee, tea, cocoa, cane sugar, copra, rubber, cotton and sisal. All the major aspects of the plantation system of agriculture are mentioned and there-

fore the publication is of direct interest to managers and appropriate government departments.

The first part of the Report covers a brief summary of the procedures taken by governments as a result of conclusions adopted at the previous or third session of the Committee. These are related to labour problems associated with the plantation system and include recruitment, hours of work, housing, regulation of wages, supply of food, clothing and other necessities, education and training, industrial relations, productivity etc. Although the various measures adopted by the individual countries are mentioned, the brief summaries do not permit any comparison.

The second section of the Report is concerned with the work being carried out by the International Labour Office in response to assistance sought by the Committee. Much of this is research into data required for policy implementation and is linked with further inquiries into questions raised in the previous section of the Report. However, the Committee is concerned about the need for international commodity regulation so that plantation workers also benefit from export income stabilization. It laments that despite the great deal of attention to commodity price fluctuations, little data are known of the effect of "falls in commodity prices on the level of employment and wages".

To complete the coverage of the problems of plantation agriculture, the last section of the Report discusses the latest trends in the world plantation economy. A brief summary of the recent developments in world markets, price stabilization and endeavours by countries to diversify their agriculture so that export income is not reliant on one or two commodities is included.

Perhaps one of the most controversial aspects of plantation agriculture since the end of the last war is the competing and supplementary role of the traditional plantation and the small holding. This structural change in plantation economy is discussed and is of interest to those concerned with policy matters in the tropical and sub-tropical regions of the world. Despite governmental action in nationalizing and subdividing plantations to foster small holdings, a number of economic factors has been operating to alter the plantation system. Of these the most important is the tendency for the producing nations to consume increasing proportions of their production. The number of small holdings producing for the export market has increased throughout the world but the trend is "not confined to a single area or continent or a few staple commodities. Some commodities lend themselves better than others to production by smallholders, but in many cases it is impossible, because of the lack of detailed statistics to make direct assessment of the relative importance of small and large holdings".

The remaining sub-sections deal with employment problems, productivity and output with some mention of the implications of mechanisation and living and working conditions.

G. R. Spinks.

World Facts and Figures.

United Nations, New York. 1962. 40 pp. 1s. 6d. stg.

This pamphlet provides a summary of the basic statistics of the world for the year 1959 and is of particular value to those who require such data in a readily available form. It is a summary of the United Nations Statistical Yearbook 1960, the twelfth of this series.

The information refers to world population, food and agriculture, industrial production, external trade, transport, national income, public finance and the standard of living. In each case, the figures cover as near as possible the decade of the 1950's thus allowing some evaluation of trends. Perhaps the most spectacular of the data relates to world population growth which in 1959 stood at 2,905 million of which the continent of Asia made up 1,624 million or about 56 per cent. The annual world rate of increase is more than 48 million, thus population will double in 35 years. The indications are that "from 6,000 million to 7,000 million people will enter the year A.D. 2000".

G. R. Spinks.

The Development of Agriculture and Forests in the Tropics.

Patterns, Problems and Promise.

JOHN PHILLIPS.

London: Faber and Faber. 1961. 212 pp. 42s. Sterling.

Professor Phillips has had wide experience in tropical agriculture: mainly in Africa but also in Central and South America and in Asia. From this he has written *The Development of Agriculture and Forestry in the Tropics.*

If the political freedom of newly independent nations is to mean anything then they must develop economically. Professor Phillips points out that although some " emphasize the industrial possibilities of these regions . . . very much greater opportunities and concomitant problems are presented by agriculture and . . . . forestry ".

He is particularly interested in the " biotic balance " which he defines as " the ecological relationships binding the community of plants, animals and men—the *biotic* community—with its environment, throughout the development of both ". Through his discussion of this, which seems more of a system of philosophy than a scientific measure, Professor Phillips has shown his homely wisdom and particularly his understanding of the human aspects of development in the tropics.

Like anyone who knows the tropics well Professor Phillips is under no delusions as to their potential. He recognizes that whilst poor human and animal health, low standards of general education, complex traditional land tenure systems and poor cultural techniques, may in time be overcome, there is more difficulty in modifying significantly the controls of production imposed by climate, vegetation and soils.

Economic development in the tropics through agriculture will need an " agricultural revolution " affecting the outlook of each of the millions of subsistence farmers. They must be won over to improved methods by individual demonstration and instruction. Professor Phillips rightly points out that injections of American and other technical assistance do not always produce enough practical improvement in the field. That requires capable and well trained field workers. If extension is to be sound it must be backed by adequate research facilities. Here too lies another problem which is emphasized—" the difficulty of inculcating into educated nationals of tropical and sub-tropical countries a sense of the dignity of 'clean' dirt in agricultural practice. Dust, mud, blood and oil on the farm do not sully nor should they lower prestige ".

Administrators of tropical countries (and especially newly independent ones) are cautioned against taking undue risks by hastening with insufficient caution the planning and implementation of agricultural and related projects. The author points out that much ill-founded optimism exists regarding the benefits that accrue through mechanizing as many operations as possible and to emphasize his point he later mentions the East African Groundnut Scheme (naturally !) and also Le Tourneau's attempt to clear the *selva* of Peru for pasture.

People from temperate areas often find it difficult to realize that the much criticized shifting cultivation of many tropical areas, including Papua and New Guinea, is a conservation measure and not simply a method of mass destruction of forest. Let them read " ' Shifting cultivation ' itself is the most salutary practice that has been evolved under the prevailing circumstances of : intense radiation ; heavy and uniformly distributed rainfall ; rain of high intensity irregularly distributed ; readily oxidized organic matter, and highly leachable as well as highly erodible soils in the *forests* ; and in the *savannas*, soils that often are highly susceptible to sheet and gully erosion when deprived of their vegetative protection ". There is no simple method of providing a more economical land use system in such areas, and Professor Phillips cautions that " in the nature of the task awaiting him the average technical assistance officer from abroad has much to learn before he himself can be of much practical significance locally".

Professor Phillips does not offer any panacea for the problems of the development of tropical areas. He knows that they are intricately intertwined and that little is known about many of them. He does, however, stress the need to understand the importance of the human factors in any development and the absolute importance of careful, *in situ*, well planned and ably conducted pilot projects to test the viability of all propositions for agricultural and other development before they are implemented on a large scale.

The style of the book is not always pleasing—it is often repetitive and sometimes note-like. The author has devised a classification of bioclimatic regions which he often abbreviates to capital letters. It is doubtful whether these abbreviations need have been used in the text. Professor Phillips uses italics too frequently and particularly irritating is his habit of employing them whenever the words of the sub-title "Patterns, problems and promise" are used. But these are quibbles ! The book should be read by all who are interested in the economic development of tropical areas.

W. R. Stent.

Why Labour Leaves the Land.

A Comparative Study of the Movement of Labour out of Agriculture.

Studies and Reports—New Series, No. 59.

INTERNATIONAL LABOUR OFFICE.

Geneva 1960. 229 pp. Price unknown.

Recent interest in the theory of economic growth has been largely responsible for changing the attitude of politicians and sociologists towards the movement of labour out of agriculture. The emotional appeals to stop the drift from the land have dwindled considerably as the reasons and results of this migration have become better understood in relationship to economic development.

For many years, the International Labour Organization has been actively engaged in studying the consequences of this migration and this Report is a " review and record of recent movement ". The ground covered is not new. However, the approach of the study to this migration is broader than most as it is principally concerned with the occupational changes within the economy and places emphasis on the social and economic factors which cause migration together with the effects of this movement, particularly on farm labour force and farm efficiency.

The proportion of labour actively engaged in agriculture is a measure of economic growth. In 1950, for example, the percentage of the total labour force in agriculture in the United Kingdom was 5 per cent. while the corresponding figure for Thailand was 85 per cent. Both the U.S.A. and Australia in the same period had 13 per cent. of their total labour forces engaged in rural industries.

The movement of labour out of agriculture is fairly well understood in the advanced countries although the factors causing it vary. The Report is pertinent to the underdeveloped nations many of which are actively encouraging the movement of labour out of agriculture without any consideration of the longer term economic and social effects. Labour if it is displaced must be utilized efficiently in the other occupations and to illustrate this problem underdeveloped nations have been divided into two, those with a large farm population surplus and those in the process of rapid development. In many cases the displacement has not been accompanied by more efficient labour usage and in most instances labour productivity in agriculture has declined.

Unfortunately, data from the underdeveloped countries are limited to a few countries but the study challenges the assumption so often stated that the present situation in the less developed nations is a reflection of an earlier stage through which the advanced countries passed. The query is raised " whether their development is taking place in conditions so dissimilar from those of the advanced countries that it is unlikely, if present conditions continue, that the movement of labour can bring about this desirable evolution "; that is, ease of occupational change and greater labour efficiency in agriculture.

This publication should be read by those concerned with policy decisions so that some of the main problems associated with rural migration can be examined before policy implementation. Many problems associated with the movement of rural population into urban areas are of interest in the Territory of Papua and New Guinea.

G. R. Spinks.

Port Moresby: V. P. Bloink, Government Printer.—8130/10.62.

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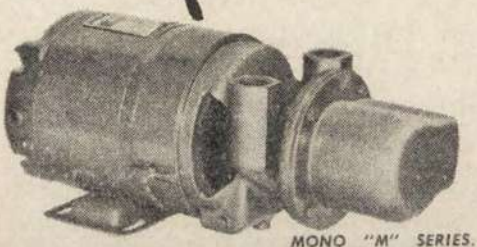

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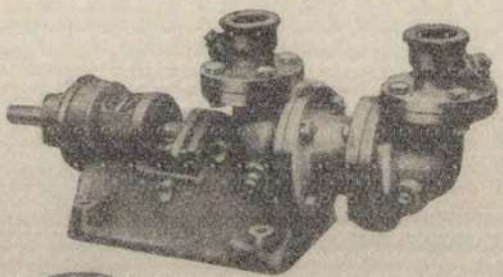

Above:—
MONO "D" SERIES. 25 ft. suction lift. 100 to 8,000 g.p.h. capacities against heads of up to 300 ft.

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

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