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Department of Agriculture, Stock and Fisheries,
Konedobu
Papua New Guinea

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Cover photograph: Brahman cross cattle on Rumoin Plantation in the Markham Valley.
D. J. Purdy

Rural Wages

D. R. J. DENSLEY, Chief Agricultural Economist

In January, 1970 a Board of Inquiry into Rural Minimum Wages was appointed by the House of Assembly. After a thorough investigation, the Board made many recommendations, some of which have now become law, while others are still being considered by the appropriate authorities. These comments on the Report are summarized from a paper presented by Mr Densley to the Fifth Waigani Seminar, Port Moresby, May, 1971. The full text of the paper appeared in The Industrial Review *Vol. 9, No. 2 (June 1971) published by the Department of Labour.*

THE Board of Inquiry consisted of four members. Professor Cochrane, Dean of the Economics Faculty at Monash University, was Chairman and the other members were Mr Dirona Abe, Dr R. T. Shand, and Rev. Zurewe Zurenuo. The Board visited almost every district to give all interested parties adequate opportunity to express their views. The Board presented its Report* in September, 1970.

The principal recommendations of the Board were—

(*a*) that the cash and kind wage, valued at 1st January, 1971, at $4.86 per week, be increased to $5.90 per week and in one year's time be further increased to $6.40 per week;

(*b*) that the wage should be an all-cash wage, and that this should be introduced over a three-year period. The Board stated that employers could continue to deduct at specified rates for rations, issues and accommodation where these are provided by agreement between the employer and the employee;

(*c*) that special allowances and rations to families accompanying workers to properties be discontinued, and that accommodation standards be more flexible so as to encourage the employment of married workers; and

(*d*) that a Wages, Income and Prices Board be established to determine and review future wage movements.

As well, recommendations were made on the discontinuance of the Agreement System, recruitment and repatriation costs, leave, workers' compensation and superannuation, deferred wages, rural research and extension, labour relations and other social favours.

Action Taken on the Report

In March this year, legislation was passed in the House of Assembly providing for the establishment of a Minimum Wages Board. Matters which can be referred to this Board include minimum rates of pay, any allowable deductions from wages for food, accommodation or issues supplied by employers, and for repatriation or recruitment, deferred wages, penalty and overtime rates, hours of work and leave. The Board is empowered to determine varying minimum rates between areas, industries or occupations.

This legislation also provides for the introduction of a uniform minimum wage of $5.90 per week. Deductions which may be made from this wage, where the items listed are actually provided by agreement between the employer and employee are—

(*a*) accommodation—87 cents per week;

(*b*) rations—$2.50 per week; and

(*c*) clothing and other issues—36 cents per week.

Tobacco and matches and special issues to family members accompanying workers will no longer be required under the provisions of the new legislation.

The legislation also provides for a deduction of 25 cents per week to be used towards the payment of repatriation costs. If the total deductions over the contract period do not fully cover repatriation costs, the employer is obliged to pay the difference. If the total deductions are in excess of costs, then the balance is refunded to the employee. If the employee does not wish to return home after completion of his contract of employment, then the full amount of deductions for repatriation are refunded to him.

*Report of Board of Inquiry Investigating Rural Minimum Wages under the *Native Employment Ordinance*, 1958-1968. Minimum Wage Fixing Machinery and Related Matters, Port Moresby, September, 1970.

At the time of going to press, this legislation had been passed by the House of Assembly but had not been brought into force. The date of commencement of operation of the new legislation will appear in the *Government Gazette*.

The Ministerial Member for Labour has announced his intention of introducing further legislation to amend some of the existing employment ordinances.

Impact of Higher Wages

Most of the rural wage employment in Papua New Guinea is on larger scale properties. Labour employment on smallholdings is fairly limited, although increasing, and often in the past has been based on the use of family and village labour. Most of the economic impact of higher rural wages will therefore be felt in the larger scale plantation sector. The current number of workers employed in the various rural industries on plantations has been estimated as follows:—

Coconuts/cocoa	30,000
Coffee	8,000
Tea	7,500
Rubber	6,000
Cattle	800
Other rural	3,500
TOTAL	55,800

The amount of profit which a plantation can make depends on prices received for the produce sold and on the cost of production of that produce. The cost of producing one ton of a product is itself dependent on yields per acre, processing and marketing costs and labour costs. If labour costs increase as a result of higher wages and if prices remain at existing levels, then plantations, to remain viable, will be forced to reduce costs either by increasing yields or by decreasing processing, marketing and general administration costs. It is not easy to increase yields of tropical tree crops quickly, especially if it means replanting the property with higher yielding varieties. This is of particular importance to the rubber industry in Papua New Guinea, where 62 per cent of all estate rubber is currently planted to non-clonal (lower yielding) varieties. Estimates indicate that more than 25 per cent of all plantings on coconut plantations are more than 50 years of age, that is, beyond what is usually considered the useful bearing life.

Usually, larger properties in Papua New Guinea have lower per unit costs of production than smaller properties, because it costs them less per ton of production for processing, marketing and general overhead expenses. An analysis of plantation rural industries in Papua New Guinea indicates that 64 per cent of all coconut plantations have less than 400 acres of coconuts; that 47 per cent of all cocoa holdings have less than 200 acres of cocoa; 72 per cent of all coffee estates have less than 100 acres of coffee; that only three tea estates have over 1,000 acres of tea; and that only 11 rubber properties with mature rubber have over 1,000 acres of rubber. These are the sizes of large scale properties which the Board selected as being necessary to provide a reasonable profit to any new investor in these industries.

The above discussion indicates that the effects of higher wages will be greatest on those smaller rubber plantations which have predominantly lower-yielding varieties. The effect on coconut, cocoa, coffee and tea plantations will be felt more on those smaller plantations with higher processing and overhead costs. Again, plantations with lower yielding varieties or trees approaching the end of their economic life will be most affected. Properties which have only recently been established and which have borrowed substantial sums of money for development will be more affected than those properties which have been established for a longer period. Properties which have combinations of enterprises, such as interplanted cocoa/coconuts may not be affected to the same extent as properties dependent on only one product.

The fact that both indigenous and non-indigenous employers will be required to pay the same minimum wage will present some difficulties to the smallholder and village producer who employs labour. The effect is difficult to measure because of the dependence of many such employers on family labour.

Methods of Increasing Productivity to Offset Cost Increases

To increase productivity in plantation agriculture (which will be most affected by increased wages), plantations must invest large sums of money in higher yielding planting material, fertilizers, improved processing equipment, better worker accommodation and

other facilities. The return from such investment is long-term. An investor therefore will consider future political stability, likely price and wage movements and work availability before making such an outlay of capital.

The Board of Inquiry in discussing the need for increased productivity suggested that this could be achieved with greater work-force stability, resulting from the employment of more married workers resident on properties with their families. This should be the case. However, because of the need to provide housing and land for food gardens and other facilities for families, this may not be practicable on those plantations employing very large numbers of workers.

Increased attention will need to be given in the future to the increase in crop yields of Papua New Guinean plantation crops through the use of higher yielding planting material, fertilizers, disease and pest control and other agronomic practices. As well, processing, marketing and general overhead costs will need to be reduced. This will generally require larger scale of operations, especially of processing facilities.

Book Review

INTRODUCTION TO TROPICAL AGRICULTURE

by J. A. Sutherland. Angus & Robertson 1971. 242p.

ALL those involved in the teaching of agriculture in Papua New Guinea are plagued by the lack of suitable texts related to the conditions of this country. Any text which helps to fill this gap is welcome. Mr Sutherland's book attempts the difficult task of presenting an overall picture of tropical agriculture to secondary school pupils. Given intelligent teachers who are aware of the book's rather serious shortcomings, it should be successful.

The book claims to be aimed at the junior secondary level, but this is somewhat optimistic in a country where English is a foreign language. *Introduction to Tropical Agriculture* has a place in the country's education but it would be more appropriate for students in senior secondary school and even as an introduction to post-secondary agricultural courses.

The book uses refreshing self-educating practical activities and projects as a vehicle for introducing some simple principles of agriculture. However, this approach necessarily means that the book concentrates on short term crops and livestock which best fit themselves to student projects. Thus coffee, the country's most important cash crop, is dealt with in only three pages while poultry has two chapters; even goats have a full chapter to themselves. Accepting the need for this specialization on selected areas, and the difficulties of explaining agricultural principles in simple language, there is little room for criticism of Mr Sutherland's handling of the purely technical aspects of agriculture. Agriculture is however, a socio-technical system, involving people. Wherever he discusses the social aspects of tropical agriculture the author falls into the old trap of assuming that economic development in underdeveloped countries is only possible if the social relations are reformed to resemble those of his own Western capitalist country. The result is a paternalistic pleading for reform of traditional "bad" ways in favour of "good" Western ways. This takes a ludicrous flavour in Chapter 1 "What is Agriculture" and Chapter 26 "Farm Management", but becomes outright dangerous when he deals with "Land Tenure" (Chapter 8).

It is to be hoped that this book will be used only by experienced teachers who can recognize the dangers of these chapters and avoid them in favour of the more valuable technical descriptions.

R. F. McKillop.

The Marketing of Abattoir Offal

B. L. MOORE, Regional Veterinary Officer, Goroka

During the slaughtering of animals, all parts removed except the skin are considered to be offal. This offal is classified as edible or inedible. In Papua New Guinea until recently the only offal considered edible was the liver, heart, kidneys, tail, tongue and in some cases the cheek meat. The rest was burnt, buried or used for pig food. Now at Goroka the lungs, spleen, fat and cheek meat are being sold through the local market to the people for food. It contains high grade protein which is in such short supply in the Highlands, and a thriving and profitable business has been established. This article describes the establishment of the marketing scheme and gives facts which will help people in other areas to start similar schemes to use offal as food for people.

THE visit in 1969 of Mr Dorman, an F.A.O. Consulting Specialist on the use of animal by-products, stimulated interest in the efficient use of edible offal. He recommended in his report that all offal which could be safely eaten by the people should be made available for direct sale, rather than fed to animals. He suggested marketing through commercial firms or local markets with the assistance of Local Government Councils.

PLANNING AND ORGANIZATION

The Administration through the Animal Industry Division of D.A.S.F., operates abattoirs throughout the country as a service to the developing cattle industry. Cattle and pigs are slaughtered for a set killing fee and the price paid to the producer is generally set on a cold carcass weight basis. When the butcher pays the killing fee, as is generally the case, the heart, kidneys, liver, tail and tongue are considered to be the property of the butcher and the cheeks and brain if requested. The remainder of the offal is the property of the abattoir.

The Kamaliki slaughterhouse just out of Goroka was chosen to see if the sale of offal could become an established industry. At this slaughterhouse the main slaughtering is of cattle. Until 1971, the offal apart from the liver, heart, kidneys and tail, was burnt except on occasions when an animal was slaughtered for a traditional feast and the owner insisted on taking every part of the animal to eat, just as is the custom with pigs.

Thus in the region there were no sociological or aesthetic barriers to the general acceptance of all parts of the offal as food. Indeed, indigenous cattle owners and members of the Local Government Council were concerned at the waste of protein food.

A plan to incorporate a tripery at Kamaliki with special cleaning, cooking and bleaching equipment so that the stomach and intestines could be processed, was accepted. There was however a delay of two years before the buildings could be completed and the equipment in operation. Local established meat retailers were approached about selling offal other than tripe but there was no interest. However, members of the Local Government Council, who were still concerned at the waste of offal, held discussions with D.A.S.F. and Department of Public Health officers. They decided on action to organize the sale of edible offal through the local market. The Council undertook to erect a fly-proof stall with display counters and facilities for keeping the stall clean. Refrigeration was not considered necessary as one of the conditions was that all offal had to be sold on the morning of collection.

Plate I.—The proprietor, Auwo, at his stall at Goroka market. He is holding one of the plastic bags in which all offal is pre-packaged for sale at the market

The Administration advertised tenders for the purchase of the offal in the *Government Gazette*. The tender specified that the offal must be sold for human consumption and that the tender price included packaging at the abattoir.

The local Business Advisory Officer made sure that all the prominent local businessmen in Goroka knew about the tender notice, yet it attracted surprisingly little interest, even amongst members of the Council who had been most vociferous in condemning the burning of offal. The tender was let to an established entrepreneur, Auwo of Masikalaiyufa village at five cents per pound.

BUSINESS OPERATIONS

Although the Council had not completed the stall, Auwo started selling cheek meat, dripping, spleens and lungs (known in the trade as "lights"). The approximate weight of each product, its preparation, packing and cost are shown in *Table* 1. All offal is cleaned on the day of slaughter, stored in the chiller at 32°F overnight, and packaged the next day. Collections are made on Wednesday and Saturday, the main market days.

Table 1.—Offal preparation and costs

Product and Total Weight Per Animal	Preparation	Packaging	Cost Price Per Pound
Lungs 8 lb	Inspected and washed	Pieces 1 to 2 lb packed in plastic bags	5 cents
Spleens 1½ lb	Inspected and washed	One per plastic bag	5 cents
Cheeks 4 lb	Removed from head	1 cheek (2 lb) per plastic bag	10 cents
Dripping 3 lb	Omental fat heated	½ lb per plastic bag	12 cents

To prepare the dripping, the fat is minced and heated in a container with a small amount of water. When the surface crackling begins to turn brown, the molten fat is strained through muslin into a large tray. After solidification the dripping is cut into blocks. This work adds another seven cents to the cost of the dripping. Its cost price is therefore 12 cents per pound and it is sold at the market for 20 cents per pound. Similarly, the cheek meat has to be cut off from the bones of the head. This raises costs to 10 cents per pound.

Plate II.—**The packaging of offal and dripping at Kamaliki abattoir**

Table 2 shows the turnover during March 1971 when 50 cattle were slaughtered and all offal was collected and sold. Additional expenses were the cost of running a light vehicle to Kamaliki twice a week, payment of a salesman approximately $10 per month and gate fees of $4. Thus, for the month, the business showed a profit of about $150. The throughput of the slaughterhouse is expected to increase rapidly to 30 to 40 cattle a week, so assuming that the increased supply does not cause a lowering of profits, the business could be very substantial. When tripe becomes available, this will increase the amount of offal per animal by 15 to 20 pounds.

Table 2.—Turnover and profit for 50 cattle

	Total Purchase Price	Total Sale Price *	Profit
Lungs 400 lb	$20.00 (5c/lb)	$100.00 (25c/lb)	$80.00
Spleens 75 lb (1½ lb each)	$3.75 (5c/lb)	$25.00 (50c each)	$21.25
Dripping 160 lb	$19.20 (12c/lb)	$32.00 (20c/lb)	$12.80
Cheeks 200 lb	$20.00 (10c/lb)	$70.00 (35c/lb)	$50.00
Total			$164.05

* Sale price based on the minimum prices charged on a number of market days.

The main problems which arose were an initial reluctance to buy dripping and the maintenance of hygiene between collection and sale. Dripping is now readily sought. The offal is packaged in twist-closed plastic bags to prevent fingering by prospective purchasers and easily cleaned drums have been made available for transporting the offal from the slaughterhouse to the market. With the completion of the stall, hygiene will be excellent.

Plate III.—The new stalls at Goroka market almost completed

EXPANSION

During the last six months, 3,000 cattle and 1,200 pigs were slaughtered through slaughterhouses in Papua New Guinea. Except at Goroka, the offal has been destroyed or fed to pigs. Much of it is obviously valuable human food and the way is open for other centres to organize marketing to ensure efficient utilization.

ACKNOWLEDGEMENTS

Mr T. Gleeson, Goroka Council Clerk, gave his enthusiastic support in the Council, and Mr C. Schafer, Manager of the Kamaliki slaughterhouse, assisted in packaging of the products and generally encouraged the project. The co-operation of officers of the Department of Public Health also has been greatly appreciated.

Auction of Stud Brahman Cattle

AT the cattle auction held in conjunction with the 1971 Port Moresby Show on Monday, 14th June, the Department of Agriculture, Stock and Fisheries offered 17 high grade, purebred and full blood Brahman cattle for sale from its "Konedobu" stud. These cattle were bred at two of the Department's Livestock Stations, Bisianumu and Moitaka, near Port Moresby.

The sale, conducted by New Guinea Pastoral Supplies, was well attended by buyers from many parts of Papua New Guinea and the demand for both bulls and cows was high.

Four purebred bulls, sired by bulls imported from Cherokee and Burnside studs in Australia and out of the progeny of full blood Brahmans originally imported from the U.S.A., sold for an average price of $1,750. Top price of $2,200 was paid by Mr D. Ottley of Jimi River Cattle Company for a two-year-old bull sired by Burnside Baron.

Three $\frac{7}{8}$ Brahman bulls sired by top full-blood bulls from Bisianumu sold for an average of $1,270, with top price of $1,420 being paid by Mr T. Leahy of Maralumie Estates, Lae.

A fullblood cow, judged Champion cow at this year's Port Moresby Show and in calf to the Champion bull at last year's Show, attracted spirited bidding before being sold to Gusap Downs, Lae, for $1,600. Three purebred cows were also in high demand, with an average price of just over $1,000 being obtained. Six Appendix B registered cows, all but one of which was in calf to fullblood bulls, realised an average price of $350.

The Ministerial Member for Agriculture, Mr Tei Abal, said after the sale that he was pleased with the results, particularly in view of the valuable contribution the Department's Brahman stud was able to make to the developing cattle industry of the country. He said that it was gratifying to know that the larger graziers, on whom the smallholder cattle industry was so dependent, were anxious to make use of such top quality animals in their breeding programmes.

Prospects for Natural Rubber

C. BARLOW, Australian National University

Is natural rubber losing the battle with synthetic rubber on the world market? Is there even a danger that synthetic rubber will completely replace natural rubber? Or will natural rubber always have superior qualities to the synthetic product? These questions are of vital concern to rubber planters.

Dr Colin Barlow presented a paper on this subject at the ANZAAS Congress in Port Moresby in August 1970. *The paper was subsequently published in* The Economic Record, *Vol.* 46, *No.* 116 (*December* 1970). *An abbreviated version of the paper is printed below. The co-operation of Dr Barlow and the Editor of* The Economic Record *in giving permission for the reprinting is gratefully acknowledged.*

NATURAL rubber is still undoubtedly the best all-round elastomer available, being particularly distinguished by high tear strength, resilience, and abrasion resistance; and by excellent heat dissipation properties. About 60 per cent of world production is exported as "Ribbed Smoked Sheet" (RSS), which is made through acid coagulation of latex followed by rolling into sheets and smoking to prevent deterioration. RSS is a good general-purpose rubber. A further 30 per cent of natural is exported as crepe, chiefly made from auto-coagulated or "scrap" rubber by appropriate dirt removal and drying procedures. This is also a general purpose material. Most of the remaining 10 per cent is exported as latex concentrate, obtained through centrifuging. Concentrate is employed for specialized purposes like foam rubber or extruded products manufacture.

The commonest synthetic rubber is SBR, a co-polymer of butadiene and styrene which are obtained from petro-chemicals. It comprises over half the synthetic manufactured, and is used for general purposes. Other synthetics are all tailored to specific uses. BR or polybutadiene rubbers have good abrasion resistance, resilience and heat dissipation properties, but poor tear strength and skid resistance. They are most suitable for heavy duty tyre treads in combination with natural or SBR.

Major Uses

The chief use for rubber, natural or synthetic, is in the manufacture of tyres. In Western Europe heavy truck tyres contain about 70 per cent of natural rubber and 30 per cent synthetic. For car tyres the proportion is reversed—30 per cent natural and 70 per cent synthetic. These relative proportions differ somewhat between the world's main consuming regions.

After tyres, the next most important uses are for foam products (mattresses and cushions) and footwear. These products contain roughly equal quantities of natural and synthetic rubber.

Production and Consumption

Production of all rubbers in the non-Communist world rose from 3.9 million tons to 6.6 million tons over the years 1960-1968. In 1960, the amounts of natural and synthetic rubber produced were roughly equal, whereas by 1968 natural rubber had dropped to 40 per cent of the total. The three big consumers, North America, Western Europe and the USSR together account for 73 per cent of the total rubber consumption of the world. There is great variability between these areas in the proportionate use of natural and synthetic rubber. In North America, natural rubber amounts to only 24 per cent of all rubber used, while in Western Europe, 42 per cent is of natural origin. It is interesting that the proportionate use of natural rubber in North America has declined only marginally over the last few years, probably because further substitution of synthetic is neither economically nor technically desirable.

In all countries for which statistics are available, the consumption of rubber is increasing, although there is great variation in the rate of increase. There seems to be no doubt that the total consumption of rubber will continue to rise, and that despite its proportionate decline natural will continue to occupy an important share of consumption increases.

Prospects in Competition

Important aspects of competition between natural and synthetic are now outlined. In many instances, there are good reasons to expect an improvement in the relative position of natural rubber.

1. *Production Costs.*

The introduction of high-yielding trees in West Malaysia has greatly reduced the production cost per lb of natural rubber, as shown in *Table* 1.

***Table* 1.—Estimated estate and smallholding costs in W. Malaysia**

Items	Estates with only high-yielding trees	Smallholdings: with only high-yielding trees	Smallholdings: with only low-yielding trees
Yield (lb/acre)	1,100	1,064	503
Costs (U.S. cents/lb)			
Management	1.1		
Tapping and collection	5.1	5.9	8.9
Processing	1.3	2.3	1.7
Maintenance	1.0	0.8	0.8
Other	1.4	1.7	2.3
Total farm	9.9	10.7	13.7
F.O.B. and freight	2.0	2.0	3.0
Grand total	11.9	12.7	16.7

Notes.—The estate figures are budgeted estimates, based on recorded input and output levels, for units with *only* high-yielding material in the early years of tapping. The smallholding figures are taken directly from surveys of over 1,000 farms in 1963-1964.

Source.—Rubber Research Institute of Malaya (1970).

The grand total natural rubber production and dispatch costs of 11.9, 12.7 and 16.7 US cents per lb compare favourably with costs of around 18 cents per lb for comparable synthetic rubbers. Furthermore, there are prospects of reducing the natural rubber costs still further. Work on high-yielding trees is still continuing, and good yield capacities are being combined with other features such as resistance to wind and disease and better latex quality.

Yield stimulants applied to the bark to prolong the flow of latex have received much attention, and the recently introduced compound "Ethrel", or 2 chloroethyl phosphonic acid has achieved spectacular long-term average yield increases of over 100 per cent from renewed bark over wide areas of Malaysia. Compensatory fertilizer applications are recommended, but no ill-effects on trees have been noted yet.

Another big area of cost reduction is the development of new tapping procedures, requiring the tapper to make a longer cut every fourth day. This greatly decreases labour costs.

2. *Quality and Presentation.*

Grading of ribbed smoked sheet is a visual process, and results in a product lacking in uniformity. Furthermore, the sheets are exported from most countries as large unwieldly bales. In contrast, all synthetic rubbers are graded according to precise technical standards, and marketed in small compact bales.

The introduction of "Standard Malaysian Rubber" (SMR) has done much to overcome the grading problem, especially as it is associated with the production of "block rubbers".

Since 1960, several new processes have been designed for making "block rubbers", which replace individual smoked sheets and other products by material of homogeneous quality. These rubbers can be made from both latex and scrap, and lend themselves to the production of a series of rubber grades of strictly defined technical properties. The SMR scheme exploits this advantage. The new block rubbers are also well adapted to chemical modification. One example of this is the development of viscosity stabilized rubbers which, because of easier subsequent processibility, permit a 10 per cent reduction in end manufacturing costs. SMR rubbers now parallel the synthetic product in being marketed in 75 lb polythene-wrapped bales, grouped together in large specially designed pallets.

Conversion to new block rubber plants is proceeding on a massive scale in Malaysia, where 224,000 tons, or almost one-fifth of total production, was sent overseas in block form in 1970. Total block manufacturing capacity is rising rapidly, and the annual production rate is expected to exceed 750,000 tons by 1975. Indonesia and Ceylon have also begun to install block plants. As might be expected, these rubbers earn good premiums over the original grades, reaching 4 to 5 cents per lb in some instances. Both the Australian and New Zealand markets are showing keen interest in these new rubbers, and took 4,500

and 3,000 tons of SMR respectively in 1970. The overseas marketing of block rubbers is being pushed by an expanding group of technical advisers and salesmen. The Malayan Rubber Fund Board, which co-ordinated the introduction of the SMR scheme, now maintains central advisory offices in all the major industrial areas of the world.

3. *Adaptability to New Uses.*

Natural rubber is normally employed as a general purpose material, with certain special applications in items like heavy-duty tyres for which its properties are undoubtedly superior. In the past, synthetics have figured almost exclusively in new rubber use developments, which have often involved producing materials specially tailored for particular situations. The continued demand for natural rubber has thus depended on a rising consumption in traditional uses.

Great progress has recently been made in widening the manufacturing applications of natural rubbers. Most work here has been done by the Natural Rubber Producers' Research Association at Welwyn Garden City in England, a unit financed by the Malayan Rubber Fund Board. One big advance, for example, was the pioneering of low cost oil-extended natural rubber for use in winter tyre treads. The new treads, for which detailed manufacturing formulations were worked out, have been found to give 30 per cent more grip than the equivalent synthetic product.

Another important contribution has been the development of natural rubber for particular engineering uses such as conveyor belts and engine and bridge mountings. Appropriate vulcanization techniques to produce such rubbers have now been perfected. Work on a range of smaller new applications, individually of more limited impact, is also going on. A minor example is the establishment, by the Ceylon Institute of Scientific and Industrial Research, of natural rubber latex grafted with the styrene monomer as a film binder in emulsion paints.

It can be expected that this new trend will, subject to the other difficulties of quality and presentation being overcome, lead to a broadening of natural rubber uses. The difficulties of establishing sophisticated new rubber using techniques capable of widespread practical application should not, however, be underestimated. Apart from the intensive research process involved, manufacturers incur large costs in altering their raw material from one form of synthetic to another or to natural. They must be assured that the new developments hold long-term economic advantages.

4. *Prices.*

Prices of natural rubber have always fluctuated considerably, whereas synthetic rubber prices have remained fairly stable over the past ten years. Three major reasons for the fluctuations have been the difficulty of changing the supply of a plantation crop, the erratic demand springing from the unpredictable purchasing behaviour of the Soviet Union and China, and the considerable influence of short-run speculative forces, especially in Singapore. The most recent large fluctuation was from 17 U.S. cents per lb in February 1968 to 30 cents per lb in August 1969. In general, however, price fluctuations have lessened since 1950, probably due to the increasingly dominant role of synthetic rubber whose prices are altered little.

Means of lessening natural rubber's price fluctuations have frequently been considered. The most popular suggestion, an international buffer stock scheme, is probably out of the question. One obvious barrier would be the various political animosities between the rubber producing countries concerned. Although an Association of Natural Rubber Producing Countries was set up late in 1967, it is not thought likely to achieve much producer co-operation in practice. Despite this, action by individual governments to lessen fluctuations within their own areas may sometimes be helpful. The Malaysian Government's purchasing activities on the Singapore market in 1967-1968 helped counter the activities of speculators endeavouring to depress prices below the extremely low level they had already reached. The rubber stockpile thus formed was eliminated in a subsequent period of higher price.

5. *Political Factors.*

The major initial development of synthetic rubber was made necessary by the Japanese invasion of Malaysia and Indonesia. The continuing post-war instability of South-east Asia has kept alive fears of a similar occurrence, and has therefore justified the establishment of more synthetic rubber factories. Iron Curtain

countries, aiming to be completely self-sufficient in rubber, have tended to use synthetic raw material in preference to natural rubber.

Practically every country has tariffs to protect its home industries against cheap foreign imports. This policy inevitably favours the synthetic rubber industry at the expense of the natural rubber industry. Already considerable pressure to reduce tariffs has been exercised through the U.N. Conference on Trade and Development.

An aspect which should be mentioned here is the captive market structure for a good proportion of synthetic rubber. According to a recent estimate, 44 per cent of U.S. synthetic capacity is owned by rubber fabricators, and a similar situation prevails in Western Europe and Japan.

6. *Other Substitutes.*

New forms of synthetic rubber possessing superior characteristics are sure to be developed in time, but the same may be said of natural rubber. Plastics also present a limited challenge to rubber. But so far there is no evidence that plastics will be able to replace rubber in tyres, and there is certainly not any serious alternative to the wheeled automobile. The production of tyres is likely to grow tremendously in the next decade, and this means a great increase in the use of both natural and synthetic rubber.

CONCLUSION

This brief review has shown that future prospects for natural rubber are still good, and certainly better than some pessimists with inadequate knowledge of this industry have been wont to predict. One important reason for this is the undoubted trend towards much increased consumption of rubber-like materials. The other major factor is the promised impact of new techniques developed in research. In these circumstances the rapid expansion planned in the Territory's smallholding rubber area would seem to be well vindicated. Rubber almost certainly has a superior outlook to most of the other large-scale export crops now being grown, and it is especially well-suited to peasant farmers due to its low working capital requirement and great flexibility in cultivation.

Pasture Notes

MR G. D. HILL, formerly an agronomist with DASF, has published a paper entitled "Improved Pastures for Papua and New Guinea" in the *Papua and New Guinea Agricultural Journal*, Volume 22, No. 1 (1970).

These notes summarize currently available information on pastures in Papua New Guinea. They discuss special Papua New Guinea problems, including storage of seed in lowland conditions, possible need for fertilizers and their efficient use on pastures. Grasses and legumes which will maintain forage production during the dry season are discussed.

A comprehensive list of pasture grasses and legumes which have been tried in Papua New Guinea is included with recommendations as to the environment to which they are best suited. Brief information is given on suggested methods for sowing pastures. There is also a discussion of different grazing management practices.

Pasture Research at Aiyura

With the great increase in the cattle population of Papua New Guinea, a greater knowledge of suitable pastures is required. Pasture grasses and legumes have been imported from several countries, particularly Africa, and work is now being done at the Highlands Agricultural Experiment Station at Aiyura to determine which species are best suited for beef production.

ONE aspect of this work which has attracted considerable attention has been the comparison of productivity of grass species in association with legume species.

The two grasses which have shown up best are Para grass (*Brachiaria mutica*) and *Setaria anceps*. Three cultivars of *Setaria anceps* have been studied in detail; these are Kazungula, Nandi and Aiyura.

The legumes which have shown the best performance include *Vigna oligosperma, Desmodium intortum* (Greenleaf) and *Desmodium uncinatum* (Silverleaf).

1. GRASS SPECIES ALONE

One of the first trials carried out at Aiyura compared the dry matter production of 20 different grasses (without legume) on fertilized and unfertilized plots, also taking into account the effect of grazing on the growth of the various species. The grass was harvested every 6 to 12 weeks, and after each harvest the plots were heavily grazed for a short period, then trimmed to a height of 6 in with a slasher. Fertilizer rates per acre per year were 200 lb N as urea, 50 lb P_2O_5 as superphosphate, 25 lb K_2O as muriate of potash and 1 cwt magnesium—minor element mixture.

The species tested were—

Common Name	Botanical Name
Para	*Brachiaria mutica*
Ruzi	*Brachiaria ruziziensis*
Tarewinnabar (Buffel)	*Cenchrus ciliaris* cv. Tarewinnabar
Nunbank Buffel	*Cenchrus ciliaris* cv. Nunbank
Rhodes	*Chloris gayana* cv. Tanganyika Giant
Pangola	*Digitaria decumbens*
Smutsi	*Digitaria smutsii* cv. Notham
Hyparrhenia	*Hyparrhenia* sp.
Bambatsi	*Panicum coloratum* cv. Bambatsi
Makarikari	*Panicum coloratum* cv. Makarikari
Guinea	*Panicum maximum* cv. Guinea
Coloniao	*Panicum maximum* cv. Coloniao
Hamil	*Panicum maximum* cv. Hamil
Scrobic	*Paspalum commersonii*
Kikuyu	*Pennisetum clandestinum*
Elephant	*Pennisetum purpureum*
Rhonpha	*Phalaris tuberosa* x *Phalaris arundinacea*
Aiyura	*Setaria anceps* cv. Aiyura
Kazungula	*Setaria anceps* cv. Kazungula
Nandi	*Setaria anceps* cv. Nandi
Kabulabula	*Panicum coloratum* cv. Kabulabula

Note.—The Nandi and Kazungula cultivars of *Setaria anceps* were formerly identified as *Setaria sphacelata.*

The trial was laid down on two sites—one on a valley floor and one on a hillside site. The trial was continued until six harvests had been taken.

At each harvest the yield of grass of a small area for each species was weighed and the weight recorded. From these figures the yield in thousands of lbs per acre per year was calculated for each species. These results are given

below with the species arranged in order of decreasing yield. *Table* 1 gives the results for the grass grown on the valley floor and *Table* 2 gives the hillside results.

The results showed a major response to fertilizer after the first harvest, although there was a considerable amount of variation within the plots receiving the same treatment. In later harvests, there was less response to the differences in fertilizer application.

The ten highest species (ranked in order of yield) gave consistent results throughout the duration of the trial.

Tarewinnabar cultivar of Buffel grass showed extreme seasonal variation; during dry periods the growth was very poor.

Hyparrhenia, although ranking high in dry matter production, is not recommended because it tends to become rank, with a subsequent drop in digestibility and protein content.

Hamil and Makarikari showed susceptibility to overgrazing and would be of use only in a rotational grazing regime.

The species which showed most promise for general use were the three cultivars of *Setaria anceps* (Aiyura, Nandi and Kazungula), Para grass and Rhodes grass.

Table 1.—Production of grass on valley floor soils (lb per acre per year)

Fertilized		Unfertilized	
Elephant	27,000	Hyparrhenia	24,000
Aiyura	26,000	Nandi	23,000
Para	26,000	Para	22,000
Hyparrhenia	25,000	Hamil	21,000
Nandi	25,000	Aiyura	21,000
Kazungula	23,000	Kazungula	20,000
Makarikari	23,000	Rhodes	19,000
Hamil	22,000	Rhonpha	19,000
Rhodes	22,000	Makarikari	18,000
Tarewinnabar	22,000	Scrobic	17,000
Scrobic	21,000	Bambatsi	16,000
Rhonpha	20,000	Elephant	14,000
Bambatsi	19,000	Coloniao	14,000
Coloniao	18,000	Smutsi	11,000
Guinea	16,000	Guinea	11,000
Ruzi	16,000	Tarewinnabar	11,000
Nunbank	14,000	Nunbank	9,000
Kikuyu	14,000	Ruzi	8,000
Smutsi	13,000	Pangola	7,000
Pangola	12,000	Kikuyu	6,000

2. GRASS AND LEGUME MIXED PASTURES

Another trial laid down at Aiyura on valley floor soils compared the productivity of fifteen different legumes, each planted in association with the same grass—the Nandi cultivar of *Setaria anceps*. The legumes were all inoculated with Rhizobium.

Plots were allowed to become well established before grazing commenced. Each plot was sampled, then grazed, then slashed back to uniform height. The plots were fertilized initially at the rate of 4 cwt of superphosphate per acre, 2 cwt of potassium sulphate per acre and 1 cwt of mixed minors per acre, with a yearly top dressing of potash and phosphate.

The sampling involved making a complete harvest of a certain area of each plot, separating the legume from the grass, drying each component and weighing each separately. From the dry weight figures obtained, the harvest for the whole plot was calculated. Further calculations were made to give an average figure for 11 harvests of the production rate in terms of pounds per acre per year.

Results

The yield of grass and legume (dry matter production) expressed in lb per acre per year is given in *Table* 3.

Table 2.—Production of grass on hillside (lb per acre per year)

Fertilized		Unfertilized	
Kabulabula	27,000	Hyparrhenia	17,000
Kazungula	26,000	Kabulabula	17,000
Nandi	24,000	Aiyura	16,000
Para	23,000	Kazungula	16,000
Aiyura	23,000	Rhodes	16,000
Coloniao	23,000	Para	16,000
Hyparrhenia	21,000	Rhonpha	15,000
Rhodes	21,000	Coloniao	15,000
Elephant	21,000	Elephant	15,000
Hamil	20,000	Nandi	15,000
Tarewinnabar	16,000	Hamil	14,000
Guinea	16,000	Makarikari	12,000
Rhonpha	16,000	Guinea	12,000
Kikuyu	16,000	Bambatsi	10,000
Makarikari	14,000	Smutsi	9,000
Smutsi	13,000	Ruzi	8,000
Nunbank	13,000	Tarewinnabar	7,000
Bambatsi	12,000	Kikuyu	6,000
Ruzi	12,000	Nunbank	6,000

Table 3.—Legume and grass dry matter production expressed in lb per acre per year

Common Name	Botanical Name	Legume	Grass	Total
	Vigna oligosperma	5,400	16,000	21,400
Silverleaf	*Desmodium uncinatum*	4,800	17,000	21,800
Greenleaf	*Desmodium intortum*	3,700	13,000	16,700
Cooper Glycine	*Glycine wightii* cv. Cooper	3,300	15,000	18,300
	Trifolium rupellianum	3,200	15,000	18,200
	Clitoria rubiginosa	3,100	15,000	18,100
Tinaroo Glycine	*Glycine wightii* cv. Tinaroo	3,000	14,000	17,000
Siratro	*Phaseolus atropurpureus*	2,800	16,000	18,800
Stylo	*Stylosanthes guyanensis*	2,600	13,000	15,600
Calopo	*Calopogonium mucunoides*	1,700	15,000	16,700
Centro	*Centrosema pubescens*	1,600	15,000	16,600
Phasey Bean	*Phaseolus lathyroides*	1,400	20,000	21,400
Clarence Glycine	*Glycine wightii* cv. Clarence	1,100	15,000	16,100
	Dolichos uniflorus	900	14,000	14,900
Townsville Stylo	*Stylosanthes humilis*	600	13,000	13,600

N.B.—*Glycine wightii* was formerly known as *Glycine javanica. Stylosanthes guyanensis* was formerly known as *Stylosanthes gracilis*. Townsville Stylo was previously known as Townsville lucerne. *Dolichos uniflorus* was previously known as *Dolichos biflorus*.

Plate 1.—Aiyura cultivar of *Setaria anceps*

After 11 harvests (extending over 23 months) it was evident that *Vigna oligosperma* gave the highest yield of legume dry matter, and the Nandi grass growing with it also gave high yields, although not the very highest. *Vigna oligosperma* also gave good results in terms of percentage ground cover, vigour of growth, colour and encroachment on other species. Its chief drawback seems to be that it does not produce much seed, which makes propagation a problem.

The two *Desmodium* species gave good results with little to choose between them. There were no great differences between performances of Cooper and Tinaroo glycine, *Clitoria rubiginosa, Trifolium rupellianum,* stylo and Siratro, but the remaining species gave low yields. Stylo does not grow well on heavy soils and is susceptible to overshading.

The order of preference by the cattle appeared to be Silverleaf, Greenleaf, Tinaroo glycine, Clarence glycine, *Vigna oligosperma* and Siratro.

A similar trial was established on a hillside site, but owing to difficulties in establishment, results are not comparable.

3. SETARIA/LEGUME GRAZING TRIAL

In the two previous trials described, the value of the pasture was measured by the amount of grass produced per acre. In this trial, the value of the pasture was measured by the gain in weight of the cattle grazing on it. Three different cultivars of *Setaria anceps* were grown, each with the same legume (equal

proportions of Greenleaf and Silverleaf *Desmodium*). Nine plots, each of one acre, were laid down as shown in the diagram—

Plot 1 Kazungula	Plot 2 Aiyura	Plot 3 Nandi
Plot 4 Nandi	Plot 5 Kazungula	Plot 6 Aiyura
Plot 7 Aiyura	Plot 8 Nandi	Plot 9 Kazungula

Each area was planted first with a 50/50 mixture of Greenleaf and Silverleaf (*Desmodium intortum* and *Desmodium uncinatum*) at the rate of 2 lb/acre.

Plate II.—Silverleaf Desmodium (*Desmodium uncinatum*) in a mixed pasture

One of the three cultivars of *Setaria anceps*, Aiyura, Nandi and Kazungula was then planted in each plot at the rate of 2 lb/acre. Thus, plots 1, 5 and 9 were planted to Kazungula and legume, plots 2, 6 and 7 to Aiyura and legume, and the remaining plots to Nandi and legume.

After 10 months the pastures were well established and grazing commenced.

Nine beasts were used in the trial. They were all $\frac{3}{8}$ Brahman cross steers initially of 500 to 700 lb live weight. Three beasts grazed only on Nandi pasture, another three on Kazungula and the others only on Aiyura. Every three weeks they were moved on to a different plot of the same pasture. At each move the cattle were fasted for 24 hours then weighed and all the weights were recorded. The pasture in each plot was sampled before and after grazing.

At each sampling a small area of the plot was cut and all the pasture was collected and separated into grass and legume, dried and weighed. An estimate was then calculated of the pasture content of the whole plot.

Beasts were replaced when they reached 1,000 lb live weight as their rate of gain from this weight onwards is not the same measure of the productivity of the pasture as it is from 500 to 1,000 lb. At the time of replacement, when the grass was eaten down, the pasture was fertilized at the rate of 1 cwt of superphosphate per acre.

Results

Figures 1 and 2 show the average weight gains for the cattle on each pasture species. There was little difference in performance on the three strains of Setaria, although Kazungula gave lower weight gains in the second period of recording.

Average weight gains per day for the two periods were—

	Period 1	Period 2
	lbs	lbs
Nandi	0.98	0.72
Kazungula	0.97	0.53
Aiyura	1.03	0.70

Weight gains by the $\frac{3}{8}$ Brahman steers were higher than gains of the British breed steers used in Period 2. There were no marked seasonal effects on the rate of growth of the cattle.

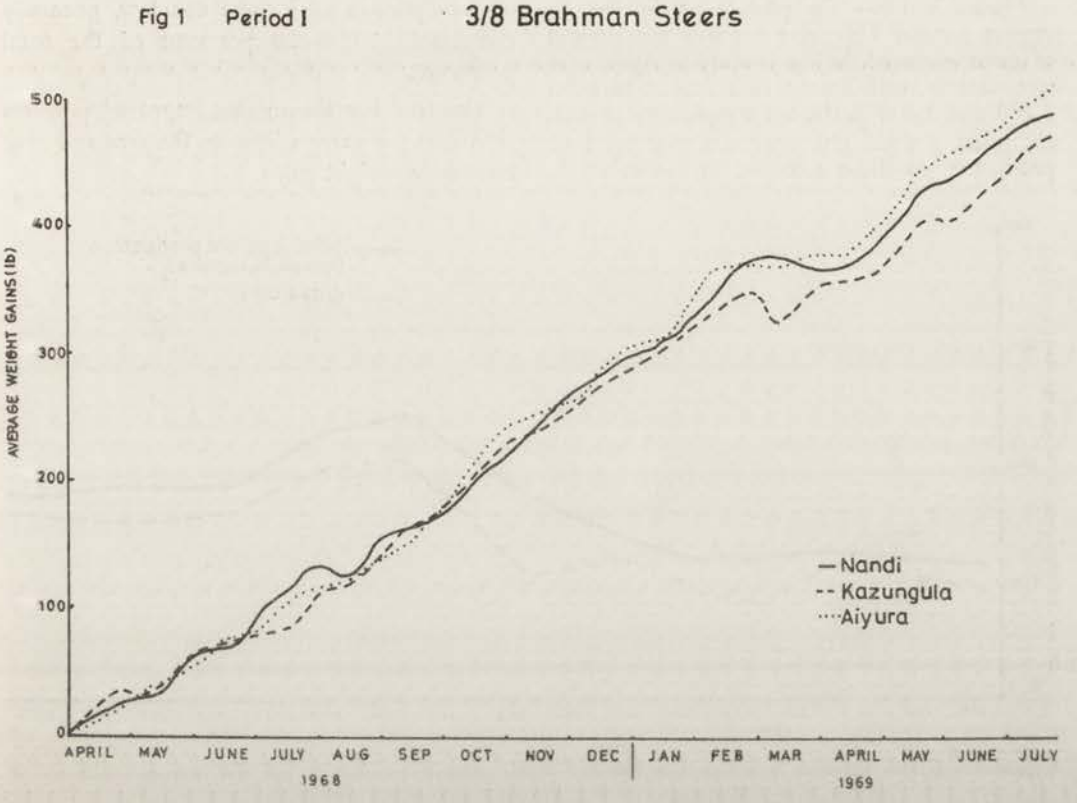

Figure 1.—Graph showing the average weight gain of the $\frac{3}{8}$ Brahman steers during the first period of the trial

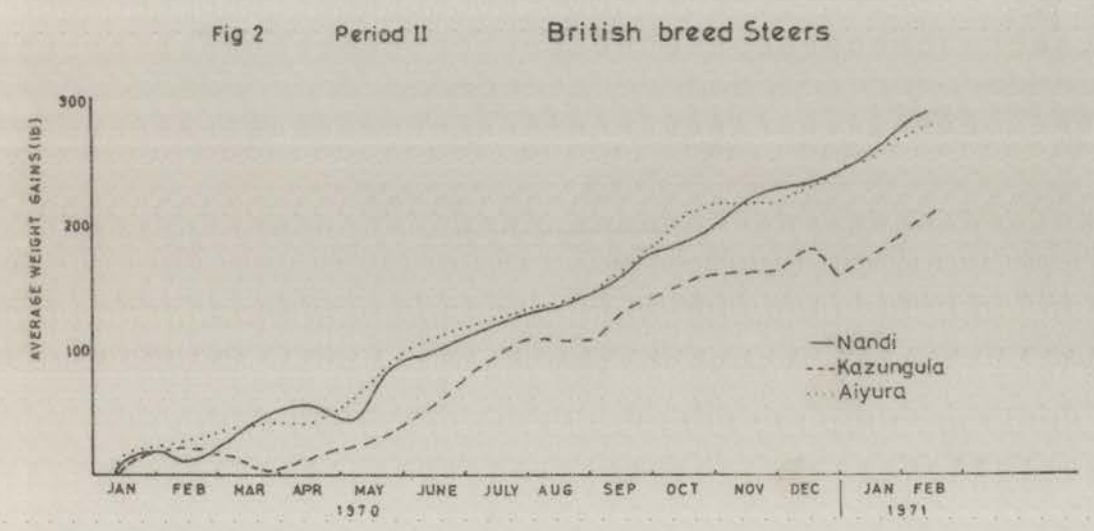

Figure 2.—Graph showing the average weight gain of the British breed steers during the second period of the trial

Figure 3 shows the pasture production on Aiyura *Setaria*. This indicates that the growth of grass increased during January to April (the wet season), with figures estimated at between 1,200 and 2,400 lb dry matter per acre at each recording period. This was a similar level of production to those recorded in earlier trials. The proportion of legume was low, generally comprising 10 to 20 per cent of the total pasturage.

The trial has shown that improved pastures at Aiyura can carry a beast to the acre and give reasonable weight gains.

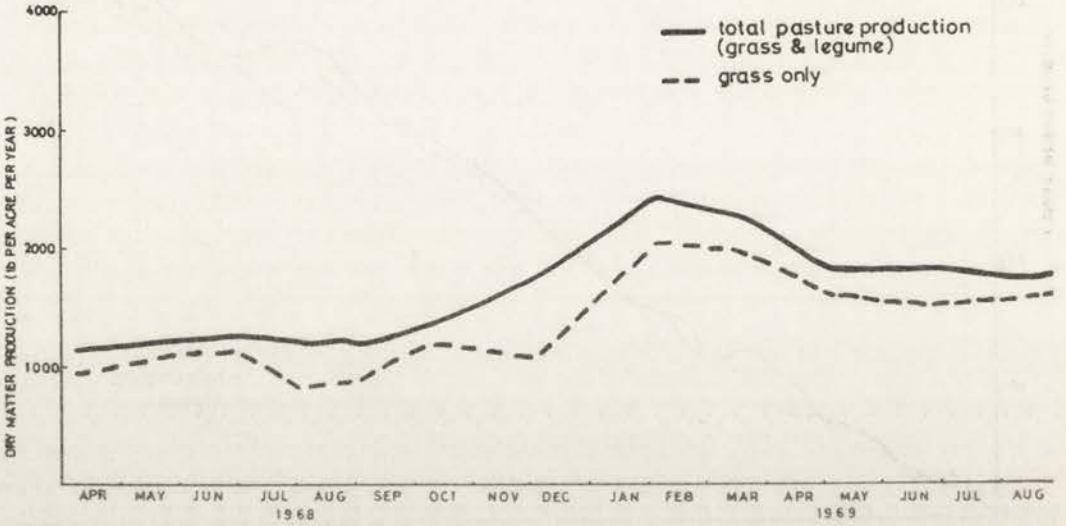

Figure 3.—Graph showing grass production and total pasture production of the Aiyura cultivar of *Setaria anceps* during the first period of the trial

Behaviour of Beef Cattle

J. H. SCHOTTLER, Animal Production Officer (Cattle)

New Guinea Lowlands Livestock Station, Erap, Morobe District

How much do we know about the behaviour of cattle? Of course we know they spend their days eating grass, chewing their cud, lying down, walking, drinking, etc., but just how much time is spent in these ways? And do they eat at the same time every day, or at any time of day or night?

TO answer such questions as these, a research project was recently initiated at the N.G. Lowlands Livestock Station at Erap in the Markham Valley. A 12 ft tower was erected in the centre of a five-acre paddock containing shade and water. There were about 20 head of cattle grazing in the paddock but only three or four were observed at a time. It would have been physically impossible to observe all 20 at once, but if there had been only four or five in the paddock the cattle would not have displayed normal herd behaviour. Observations lasted for 48 hours continuously with sufficient observers to maintain a continuous watch. The cattle were observed on moonlit nights, with binoculars and a spotlight to assist the observers. The observers noted down everything that the selected animals did—how much time they spent eating grass, in chewing the cud, how often they had a drink from a water trough, when they lay down and got up and when they moved into the shade of the trees.

The observers did not interfere with the cattle in any way and there is no reason to think that the behaviour of the cattle would have been different if the observers had not been there.

The observations were repeated several times, always on moonlit nights, and some were on different pastures. Bulls and calves were included in some of the trials. All the cattle had medium to fine coat types with the exception of two cows. The cows were approximately half Zebu content and the bulls from half to purebred.

The total average time spent grazing by the cows was $8\frac{3}{4}$ hours per day, while for the bulls observed, the average time was $6\frac{1}{4}$ hours. The time spent grazing by calves depended primarily on their age. As they became older their grazing time increased and they spent less time sleeping. It is not known how milk consumption was affected. Other activities which were noted included number of defecations (on average, 5 per day), urinations (4 per day), drinks (2 to 4 per day) and the time spent in walking, standing and lying down. Time spent ruminating could not be observed accurately but probably included a large proportion of the time that the animal was resting.

Plate I.—An observer on the tower. Normally two observers were on duty together

From the graph of grazing duration (*Figure* 1) it can be seen that tropical breeds of cattle in fact do most of their grazing during the daylight hours (0600 to 1800 hours) with peaks in the early morning and late afternoon. The

Plate II.—Cattle grazing in the shade

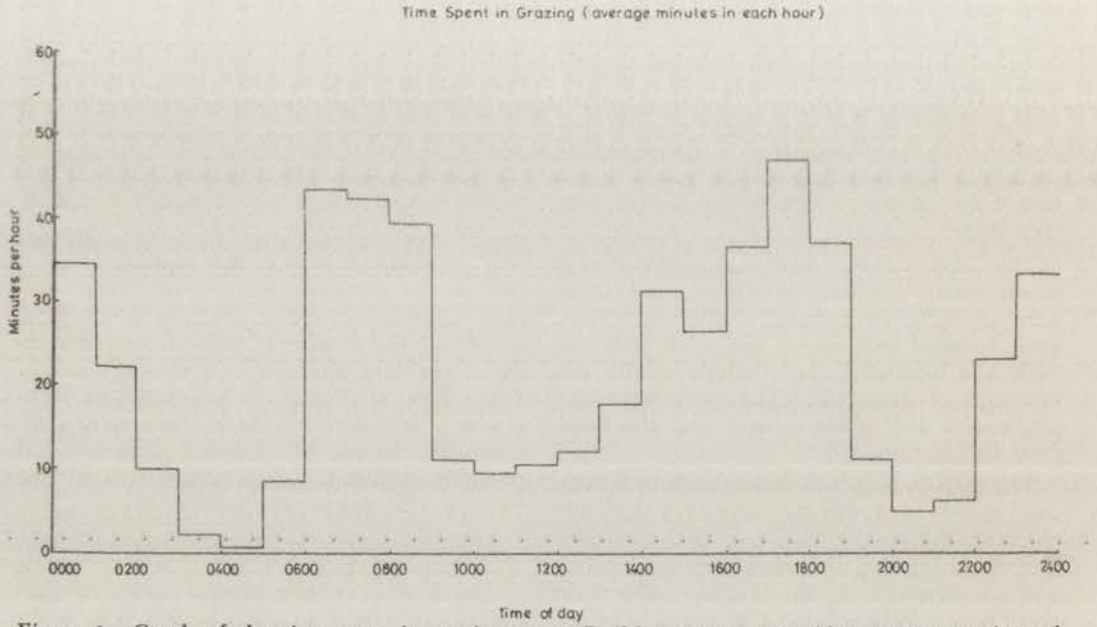

Figure 1.—Graph of the time spent in grazing on a Buffel grass pasture (the average number of minutes in each hour calculated from figures obtained from observations on 28 cows)

reduction in grazing activity during daylight hours corresponded to the hottest part of the day. Of the total of 8¾ hours per day spent grazing, 5½ hours (62.8 per cent) was during daylight and 3¼ hours (37.2 per cent) during the night.

Only two cows with long coats were available for this trial. It was expected that they would graze more at night than the other cows, but this was not so. They did however, graze for longer periods during the early morning and late afternoon, when conditions were cooler. But their grazing time was an average of 1½ hours shorter than the other cows.

The graph shows the number of minutes out of each hour that the cows spent in grazing. These are average figures obtained from observations on many cows grazing a buffel grass/legume pasture. From the graph (*Figure* 1), it can be seen that from midnight to 1 a.m. the average time spent in grazing was 35 minutes, but by 4 to 5 a.m. most cows had stopped grazing and the average time out of the hour spent in grazing was only half a minute. With the coming of daylight at 6 a.m. however, they spent two-thirds of the time in grazing. The graph shows that there was little grazing between 9 a.m. and 2 p.m. Grazing was resumed again in the late afternoon until dark. There was a less amount of grazing around midnight.

These observations are part of a programme designed at obtaining maximum utilization of pastures. The productive output of the animal is determined by the amount and quality of the food the animal eats, so that it is important to have knowledge of the animal's grazing habits for efficient management, particularly on smallholder farms.

High Grade, Purebred and Fullblood—What's the Difference?

THESE three terms were used in the news item on page 82. Mr David Purdy, Chief Animal Production Officer, gave this explanation.

1. A "high grade" Brahman is a crossbred with a high percentage of Brahman blood, but not high enough to be called "pure".

2. A "purebred" is one which is not 100 per cent Brahman but is close enough (say 15/16) to be registered by a breed society. Such a situation often arises in the early years ("early" meaning the first 50 or so years) of the introduction of a breed to a country. Because there are usually limited numbers of cattle of the new breed, they are crossed with other breeds and the cattle are then "graded up" to the new breed. First progeny are ½, then by breeding back to the fullblood every time, succeeding generations are ¾, ⅞, 15/16, 31/32, etc.

During those early years breed societies are usually prepared to register, say, ⅞ cattle and then they progressively get stricter. After a number of generations, as the cattle get closer to 100 per cent of the breed, the breed societies may finally call them fullbloods. Since the two bulls mentioned in the cattle auction news item (Burnside and Cherokee) were registered when they were ⅞ and 15/16 respectively, they and their progeny are called purebreds.

3. "Fullbloods" obviously are 100 per cent. The Department's imports from U.S.A. can be traced right back to the original Indian and South American cattle and are legitimately called fullbloods.

Fullbloods generally demand higher prices, particularly in this case where the blood we have is not readily available in Australia—hence the "spirited bidding" for the fullblood cow at the auction, compared to the other cows.

The "Appendix B registered cows" mentioned in the news item are an example of the grading up process. These cows were ¾ Brahman (high grade) and can be registered in an appendix of the herd book so that it will then be possible to register some of their progeny as purebreds. As a matter of interest, the Brahman breed in Australia has progressed to the stage that ⅞ bulls (which would be the progeny of these cows) now cannot be registered as purebreds—it is necessary to go one step further to 15/16. The ⅞ heifers are however, registered as purebreds and some of these are already in the Department's stud herd.

Brucellosis in Cattle

F. C. WILKINSON

Chief Veterinary Officer (Services)

Brucellosis infection in cattle causes infertility, and the birth of dead calves (abortion). The disease once introduced into a herd can spread rapidly, resulting in very few calves being born alive, thus reducing expansion of the herd and profitability. The disease can also be transmitted from infected cattle to man causing a serious painful disease known as undulant fever.

A PROGRAMME arranged for the eradication of brucellosis has prevented the disease from becoming widespread in Papua New Guinea. It is now confined mainly to herds which have recently been imported from Australia where brucellosis is present in all states except Tasmania. As brucellosis has not been completely eradicated, everybody involved in the cattle industry should be aware of the disease and the problems it poses.

What Causes Brucellosis?

Brucellosis is caused by one of the brucella group of bacteria. The most common means of cattle becoming infected is by ingesting bacteria with food or water. Very occasionally infection occurs through cuts or when an infected bull services a cow.

How does Infection Occur?

The infection is almost always introduced to a herd by an infected cow which may calve normally or abort. The brucella bacteria present in the membranes and the fluid discharged during calving contaminate the surrounding grass. Other cattle will eat the infected grass and so the disease is passed on through the herd. An infected cow may also pass brucella bacteria in her milk, so infecting the calf.

Steers are rarely affected and are not known to spread the disease.

Infection can also spread from a neighbouring infected farm by contact of cattle through the boundary fence, by animals straying on to the land, by contamination of drinking places, or through dogs and vermin transferring unburied afterbirth and other infected material. People contaminated by infected discharges on their hands or clothes can introduce infection. A vehicle used to carry infected cows may become contaminated and be a source of infection.

What Happens in an Infected Herd?

When a clean herd becomes infected, there are initially many abortions. Brucella bacteria picked up by pregnant cows invade the uterus where they cause damage to the membranes of the calf, resulting in the death of the foetal calf, which is then aborted. Most abortions occur between the fifth and eighth month of pregnancy, when the calf is one or two feet long and hairless, but fairly well formed. Following abortion, the uterus is infected for a varying period of time, and there is a visible discharge of liquid containing blood and pus. The cow is infertile during this period, but as infection is overcome, the discharge ceases and the cow will conceive. The infected cow which has aborted then develops a resistance to the disease and rarely aborts at subsequent pregnancies. These resistant cows frequently remain infected, however, and contaminate the pasture at their next calving.

In calves, sexually immature cattle and mature cows which are not pregnant, the infection causes a fever which is usually not apparent, then the brucella die. However, in a small percentage of cattle the brucella remain alive in the genital organs, lymph glands and udder. When these cows, which are carrier animals, become pregnant the brucella bacteria again invade the blood stream, are carried to the uterus and can cause abortion.

Plate I.—A sample is taken from the stomach of an aborted calf. The fluid will be tested to see whether brucellosis was the cause of the abortion

How is the Disease Diagnosed?

The brucella bacteria may be present in the blood or milk of the cow, on the skin of the aborted calf, and in the fluid discharged during calving. To diagnose the disease, a bacteriological culture is made from any of these sources and from the culture the brucella bacteria can be identified if present.

For large-scale diagnostic work, blood tests are the most practical. They have proved successful in routine testing and in repeated testing during an eradication programme.

What is the Routine Testing Programme to Detect Brucellosis?

Blood tests are carried out on all breeding cattle herds at least every four years. In the case of herds offering breeding stock for sale or importing cattle, testing is required every two years. All breeding cattle slaughtered at abattoirs or slaughter-houses are blood-tested.

What Happens when Brucellosis is Detected?

Brucellosis is a notifiable disease, and cattle owners who suspect the presence of the disease are legally obliged to report the matter immediately to an officer of the Department of Agriculture, Stock and Fisheries, who will arrange an investigation. For this, blood samples are taken from all cattle in the herd and if brucellosis is confirmed, the herd is placed in quarantine, so restricting the movement of infected animals. The cattle which show evidence of brucellosis are slaughtered, for which the Government pays compensation.

The only movement of infected cattle allowed is to slaughter. A permit may be obtained to move steers over twelve months old, if they give negative results to blood tests.

Blood tests are carried out on the herd in quarantine at monthly intervals until three consecutive herd tests are all negative. After a

further three negative tests at three monthly intervals, the herd is released from quarantine. During the eradication programme, the owner is encouraged to adopt management procedures to prevent further spread of the disease within the herd, for example, placing pregnant cows in a separate herd away from cows with calves.

What are the Restrictions on Movement of Cattle?

At any time, a permit is required to move cattle from one property to another. Such a permit will be issued only if:

1. There have been two tests of the whole herd separated by at least 12 months, both of which have given negative results.
2. The last complete herd test was within 24 months.
3. There have been no positive brucella tests within 24 months.
4. There have been no imported stock introduced within 12 months.
5. There have been no stock introduced from an infected herd within 24 months.

In all other cases, testing of the whole herd or stock to be moved must be undertaken, and all cattle must show a negative test before a permit will be issued.

How are Imported Cattle Tested?

All imported cattle must pass stringent brucellosis tests before importation is permitted. Further tests are undertaken on arrival in Papua New Guinea, and at six and twelve months after importation.

Unfortunately heifers and cows which are not in calf can be infected with brucella bacteria but give negative blood tests before and after importation. To help detect these carriers, all cattle intended for importation are required to be given one injection of killed 45/20 strain at the time of the first blood test. Carrier cattle which react to the injection and show a positive blood test at the next test 42 days later are not allowed to be imported.

Despite these elaborate precautions, brucellosis still might be introduced in imported cattle. Farmers are advised to keep imported cows separate from other breeding cattle for twelve months or at least until after they have calved.

Brucellosis eradication has commenced in all Australian states, and as progress is made there, the risk of introducing the disease in imported cattle will be reduced.

Why is Vaccination not Allowed?

Vaccination can be used to decrease the effect of the disease in an infected herd. However, although vaccination prevents most abortions, it does not prevent infection. So the cows can carry the disease without any visible symptoms—and in the long run, this is worse than abortions which do, at least, let the owner know at once that the infection is present. Furthermore, when an animal is vaccinated, the interpretation of the blood test is complicated. Vaccination is therefore not merely discouraged, it is absolutely prohibited.

With strict veterinary supervision, the Administration has used the killed 45/20 strain of vaccine in Papua New Guinea as a diagnostic aid to help detect carrier animals on infected properties in the same way as it is used for cattle prior to importation.

Is it Worth the Trouble?

If brucellosis can be completely eradicated, the cattle industry will be able to expand without the deleterious effects of a disease causing abortion and infertility. Furthermore, the human population will not be exposed to the risk of undulant fever. Although there have been no cases recorded of undulant fever in Papua New Guinea, it is common in Australia amongst abattoir and dairy farm workers and the possibility of its occurrence here cannot be ignored.

Thanks to the co-operation of cattle owners, the disease has been reduced to a low incidence, but there is no room for complacency, and owners must be continually aware of the possibility of brucellosis infection in their cattle. Constant vigilance is needed if the disease is to be eradicated, and re-introduction prevented.

The Behaviour and Population Dynamics of Pantorhytes Weevil

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How far can a Pantorhytes *weevil walk? Does it have any sense of direction? Does it prefer sun or shade? Dr Errol Hassan is studying the population dynamics of the* Pantorhytes *weevil in the Northern District. In other words, he is examining the factors which cause an increase or decrease in the cacao weevil population in a cocoa block. One question he doesn't have to answer is "How far can a weevil fly?" Fortunately it can't fly, so its rate of migration is fairly slow, when compared with flying insects.*

These studies are not just of theoretical interest. They have a definite practical value. Finding out what conditions cause a reduction in Pantorhytes *population is surely the first step to the desired target of reducing the population below an economic level.*

THE population dynamics work is mainly centred in 9 blocks of cocoa—2 under rubber, 2 under Leucaena, 1 under coconuts, 2 under primary bush and 2 without shade.

1. POPULATION MOVEMENT

In the block of 300 trees under coconuts (approximately one acre) a detailed study is being made of the population increase and movement. Each month the entomology assistants hand-pick every adult weevil they can find on the 300 trees. This has been going on for 31 months, and each month all the new adults found have been marked with a different coloured paint. In subsequent collections therefore, they can be recognized. All the unpainted ones are examined to see if they are male or female, so that statistics on the proportion of males to females can be determined. The weevils are not then killed; they are returned to the trees (not necessarily the same tree, but any one in the "test area").

The paint mark is only a pin point of a certain colour in a certain position on the body of the weevil.

Thirty trees of the 300 are also studied for larval channels. These also are marked with paint of a distinctive colour (the bark of the tree is painted, not the actual larvae). So the active larval channels are known and new ones noted when they appear.

An examination is also made of one line of cocoa trees outside the test area, each tree in the line being progressively further and further away from the test area. A careful note is made of every marked weevil that is found on these trees, and afterwards it is replaced on the same tree so that its progress away from the test area can be traced. This study has shown that, for their size, the weevils can move fairly fast. Of the 290 weevils collected outside the sampling site, 87 had moved a distance of over 100 yards in 9 months, while a few weevils had moved over 300 yards. The factors which control movement are still not understood, although it is clear that a continuous cocoa canopy aids the movement of weevils, because they can walk from one tree to the next without coming down to the ground.

In the previous issue of *Harvest* (Second Quarter, 1971) it was recommended that a vegetative barrier of *Pueraria* should be grown around each cocoa block. This will not completely keep out the weevils, of course, because they can still walk along a path through the *Pueraria*, or be carried in on the back of a plantation worker. But it does materially reduce the migration into a cocoa area.

2. POPULATION AND SHADE

The course of an infestation varies with differing conditions of shade. Some blocks have no shade, some have light or heavy shade from primary bush, Leucaena, coconuts and rubber.

The heaviest infestations of *Pantorhytes* occur where there is no shade; conversely, the weevil population builds up only slowly where

Plate I.—The entomology team working on the population movements study. On the right Dr Hassan examines a new adult to determine and record its sex. The weevil is then passed to the assistant on the left for its distinguishing paint mark. The paint tins in the foreground indicate that it is sometimes necessary to touch-up an old paint mark. The weevils are then placed in the wire cage and later returned to the trees in the test area

the shade is heavy. For cocoa growing under rubber and coconuts, it appears that the population will stabilize at a level that does not result in economic damage to the trees.

3. MICROCLIMATE STUDIES

"Microclimate" means "climate on a very small scale". As you walk through a cocoa block the temperature will vary as you move from sun to shade or to a hollow with no breeze. For a weevil the changes are on a smaller scale still. It is hotter on a leaf exposed to the sun than in the shade. The humidity can vary with sun and wind over a distance of a few inches. So the weevil prefers some places to others on the tree for living and for laying eggs, and a study of their preferences will assist in making control measures more effective.

In collaboration with the Physics Department of the University of Papua and New Guinea, entomologists have set up instruments for a detailed study of the microclimate in a cocoa block. Electronic instruments record the temperature and humidity in the jorquette (main fork of the trunk), the temperature of the leaf surface and of the bark surface, the temperature under the surface of the bark and actually inside the larval channel. In addition, there are instruments to measure wind velocity and energy from the sun.

For 2 months all these instruments were on an unshaded block. Now they have been moved to a block with primary bush shade.

From the microclimate study will come the data needed to establish what are the optimal conditions for the growth of the weevil. These

Plate II.—Fine wire probes are inserted under the bark and into a larval channel to measure the temperature and humidity

conditions will then be reproduced in the laboratory for further study of the behaviour of the weevil.

4. STUDIES WITH RADIOACTIVE ISOTOPES

Radioactive isotopes provide a very useful tool for tracing the movement of weevils. The electrons emitted by the isotope can be detected by a Geiger-Muller counter. The weevil can be made "detectable" by painting a radioactive varnish on its back, or by giving it food containing a radioactive ingredient.

This technique can assist with all three studies mentioned so far—population movement, shade and microclimate effects. Last year the entomologists, again in collaboration with the University of Papua and New Guinea, painted radioactive varnish on the backs of weevils then released them and traced their movement.

It is now planned to extend the work further by feeding the adult weevils with food containing the radioactive isotope Phosphorus 32. The "labelled" phosphorus will become part of the body of the weevil and some of it will be carried over into the eggs. Some experimental work will be needed first to establish the dosage of the isotope to be used in the work. With too little, the isotope will not be passed on into the eggs to enable them to be picked up with a Geiger-Muller counter; with too much isotope, of course, the weevils will die.

It is known that, in the field, only a fraction of the eggs and larvae grow into adult weevils; a high proportion of them die before reaching sexual maturity. It is hoped that the use of Phosphorus 32 will show just how high the death rate is, and will give more evidence on the factors that are causing the death of the weevils at all stages of development.

This method also has great possibilities in showing movements of the weevils on a small scale (from one position to another on the same tree). In conjunction with the microclimate study, it should reveal a great deal of useful information on the conditions for growth or death of the *Pantorhytes* weevil.

Weed Control in Coffee

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Over the last few years, herbicides have become an accepted alternative to hand-weeding for weed control in coffee plantations in the highlands. Trials which examine the effectiveness and economics of various weed control programmes have been part of the herbicides trial work at Aiyura since early 1968. *Progress results of two of these trials are reported here. A more detailed account of both trials, with further information on herbicides, is given in* The Papua and New Guinea Agricultural Journal, *Vol.* 22, *No.* 2 (*May,* 1971).

IN this article, herbicides are generally referred to by the common name of their active ingredient, but, where details of trial treatments are given, the commercial product used in the trial is quoted and the quantity is the quantity of that product (not of the active ingredient). Naming of a commercial product does not imply any preference over another product containing the same active ingredient. *Table* 3 at the end of this article lists trade names of formulations of the herbicide chemicals referred to in this article.

Most of the weeds mentioned are illustrated in the booklet *Weeds of Coffee in the Central Highlands, Botany Bulletin No.* 4, by E. E. Henty, published by the Division of Botany, Department of Forests.

Herbicides can be divided into two groups. The soil-acting ones work on the principle of "prevention is better than cure". The herbicide is usually sprayed onto bare ground, and is taken up by the weed seedling along with the water from the soil before it germinates. The young weed is killed before it has time to grow.

The other group of herbicides act through the leaves of plants. They are therefore effective against established weeds. Some of this group kill only the leaves they contact, and not the whole plant. Others can be carried through the plant to the growing points which are then killed. This ability to move through the plant is important when treating perennial weeds which are able to regenerate from underground stems or rootstocks. A weed such as couch grass will not be killed if only its leaves are killed.

Spray programmes are based either on the herbicide paraquat (Trade name: Gramoxone) or the soil-acting herbicide diuron (Karmex, Diurex) but a number of other herbicides are also used to combat weed species not controlled by these two broad-spectrum herbicides. There is no one herbicide that will control all weeds encountered in highlands coffee.

Plate I.—Spraying with a knapsack spray

TRIAL 1

The first and largest trial compares four treatments, both on a hillside and a pit-pit site. Each treatment is being tested under three

shade conditions, namely fairly dense Casuarina, less dense Albizia, and unshaded, on plots which are 0.625 acre in size. The four treatments are—

1. *Paraquat-based treatment,* with no soil-acting, residual, herbicides. Applications were made as required. Spraying with other herbicides for specific weeds not controlled by paraquat was done as necessary, although for the first 30 weeks only paraquat was used. The other herbicides used were amitrole, dalapon, 2,4-D and MSMA.

2. *Diuron-based treatment.* Blanket applications (that is, spraying over the whole area) of diuron were supplemented with spot-sprayings of other herbicides on specific weeds as necessary. The Albizia and unshaded plots received three applications of diuron in the first year and two applications in each of the second and third years. The weed growth under Casuarina was considered too slight to justify expensive blanket applications, and apart from one initial blanket application on the hillside site, only spot applications were made, at the same frequency as on the other plots. Other herbicides used were dalapon, 2,4-D, MCPA30, paraquat, amitrole and MSMA.

3. *Hand-weeding.* Weeding was done as necessary, except that during wet weather it was postponed because in such conditions the weeding of perennial grasses is ineffectual. Hoes were used for most of the first 2 years but thereafter spades were used.

4. *Hand-weeding plus diuron.* The diuron application was made during the peak harvest period to recently weeded ground, except on one occasion, when standing weeds were treated with a spray mix of diuron and amitrole. As in treatment 3, weeding was done with hoes initially and then later with spades. Diuron was applied as 4 lb Karmex per acre in each year in the unshaded plots, while in the Albizia plots it was applied at 4 lb per acre in the first year and 3 lb per acre in the following years. In the Casuarina plots where weed growth was slight, it was generally not necessary to apply diuron to the whole area, and only the plot margins were blanket sprayed.

Costs

The weed problem in the trial area at the beginning of the trial was severe on the unshaded and Albizia plots, with perennial grasses, particularly thurston grass (*Paspalum conjugatum*), forming a high proportion of the weed population. For this reason, the costs of the herbicide treatments, particularly in the first year, and the cost of the hand-weeded treatment in all years, were high. The costs of the treatments for each of the first 3 years are given in *Table* 1. A summary of the performance of each treatment is given below.

RESULTS

1. *Paraquat-based treatment.* Under the dense Casuarina shade, weed growth was slight and much of the spraying was done around the edges of the plots. Control throughout was good. In the other shade plots, the first paraquat sprays reduced the heavy stand of thurston grass, but did not eradicate it. As long as the grass remained, frequent applications of paraquat at relatively high rates were necessary, and the costs of the treatment remained high. By applying amitrole four weeks prior to applications of paraquat, virtual eradication of the grass was achieved after two such double applications.

During the second year the sedge *Cyperus brevifolius* and to a lesser extent, *C. kyllingia* and couch grass (*Cynodon dactylon*) became serious weeds on the pit-pit site, particularly in the unshaded plot. The sedges had initially been present as small insignificant plants hidden under taller weed growth. With the elimination of other weeds (mainly thurston grass) the sedges spread to form a dense cover over about one third of the unshaded plot. Paraquat sprays had little effect on them but amitrole and MSMA achieved good control by the end of the third year. Relatively high rates of these herbicides were needed, however, and this, along with dalapon sprays to control couch grass, caused the cost of the treatment in the second and third years to remain high.

On the better drained hillside site, the sedges, although present, grew much less vigorously and reasonable control was maintained without using expensive applications. However, at the end of the third year they were then prominent weeds on plots which were otherwise substantially clean. Under Albizia shade on the hillside plot in the second and third years, weed control was maintained with applications of paraquat at a concentration of half a pint per 45 gallons of spray, and this is reflected in the lower costs obtained on this plot.

Table 1.—Costs per acre of weed control treatments in Trial 1

Treatment	Shade	Site	Costs			
			Year 1	Year 2	Year 3	Total
			$	$	$	$
Paraquat-based	Casuarina	Hillside	12.43	6.19	7.19	25.81
		Pit-pit	9.90	3.33	6.42	19.65
	Albizia	Hillside	27.22	10.90	10.54	48.66
		Pit-pit	33.61	21.84	27.58	83.03
	Unshaded	Hillside	37.20	18.72	22.89	78.81
		Pit-pit	39.56	33.52	42.26	115.34
Diuron-based	Casuarina	Hillside	20.64	11.08	10.33	42.05
		Pit-pit	10.57	7.67	7.36	25.60
	Albizia	Hillside	47.94	23.05	22.68	93.67
		Pit-pit	50.85	16.11	19.34	86.30
	Unshaded	Hillside	61.51	26.29	25.01	112.81
		Pit-pit	65.14	23.72	27.90	116.76
Hand-weeding	Casuarina	Hillside	12.82	12.82	9.87	35.51
		Pit-pit	10.10	10.10	10.65	30.85
	Albizia	Hillside	32.73	32.73	26.75	92.21
		Pit-pit	31.69	31.69	29.90	93.28
	Unshaded	Hillside	47.85	47.85	36.98	132.68
		Pit-pit	50.72	50.72	38.98	140.42
Hand-weeding plus diuron	Casuarina	Hillside	9.24	14.44	11.17	34.85
		Pit-pit	10.97	11.26	10.56	32.79
	Albizia	Hillside	28.00	24.39	17.53	69.92
		Pit-pit	31.14	21.53	16.89	69.56
	Unshaded	Hillside	50.52	38.48	28.33	117.33
		Pit-pit	42.27	34.61	28.96	105.84

Prices Used in Compiling Costs:

Agral 60 (wetting agent)	$6.20 per gal.	Teepol	$1.18 per gal.
Ansar 529	$8.00 per gal.	Weedazol TL Plus	$7.50 per gal.
Gramevin	$0.55 per lb	Weedkiller D (and Amoxone-50)	$5.19 per gal.
Gramoxone	$21.50 per gal.	Labour	10.1c per man hour
Karmex	$3.25 per lb		
Methoxone-30	$3.40 per gal.		

Although there was a range of paraquat concentrations used in this trial, in most situations 1 pint of Gramoxone per 45 gallons of spray is sufficient for initial applications, and lower concentrations down to half a pint per 45 gallons can often be used subsequently. The manufacturer recommends that half a pint of non-ionic surfactant such as Agral 60 be included, but other wetting agents have also been successfully used.

2. *Diuron-based treatment.* Weed growth under the dense Casuarina shade was slight and good control was maintained throughout. In the other shade plots the infestation of thurston grass was reduced to negligible proportions by the end of the first year. At this time, *C. brevifolius* was the most prominent weed although it was covering only a small proportion of the total plot areas. Diuron gives some control of the sedge even when applied to emerged plants, but at lower rates larger plants usually recover, so that spot treatment with other herbicides (amitrole or MSMA) is necessary. Eradication was attempted at the beginning of the third year by the spot application of a mixture of diuron and paraquat, but other plants subsequently appeared from seed.

The plots were maintained predominantly clean during the following 2 years. The main weeds which required spot applications with other herbicides during the 3 years were *C. brevifolius, C. kyllingia,* thickhead (*Crassocephalum crepidioides*), couch grass (*Cynodon dactylon*), *Paspalum orbiculare,* wandering jew (*Commelina diffusa*), and sweet potato regrowth (*Ipomoea batatas*). In this trial some plots initially received 5 lb of Karmex per acre, but elsewhere 4 lb per acre has been found to be adequate. For subsequent applications, 2 lb per acre is used giving a total of 8 lb per acre in the first year. In the following years, two applications of 2 lb per acre is sufficient.

3. *Hand-weeding.* Visual assessment indicated that there was no reduction in the weed density or change in the proportion of weed species present over the 3 years.

4. *Hand-weeding plus diuron.* Over the 3 years, the weed cover on these plots decreased and there was a change in the weeds present. In the unshaded plots on both sites, thurston grass decreased and wandering jew increased, while *P. orbiculare* increased on the hillside plot. In Albizia plots, thurston grass decreased only on the hillside site.

COMMENTS ON RESULTS

1. *Paraquat-based treatment.* Over the 3-year period, the paraquat-based treatment was the cheapest on shade conditions on the hillside site. On the pit-pit site, it was the cheapest treatment under Casuarina, but in Albizia and unshaded plots it was equal second with the diuron-based treatment, while hand-weeded plus diuron treatment was the cheapest.

The costs of paraquat-based treatments were higher on most plots in the third year than they had been in the preceding year. This was due to the cost of controlling the two sedge species and was most pronounced on the pit-pit site. These weeds now seem to be under control, so costs should decrease in the fourth year. Because control costs in the paraquat-based treatment remained relatively high on the pit-pit site, it was a more expensive treatment on this site in the second and third years in the Albizia and unshaded plots than the diuron-based treatment. On these plots it was only the high cost of the diuron-based treatment in the first year which resulted in the total costs of this treatment for the three years being greater than those of the paraquat-based treatment.

2. *Diuron-based treatment.* Although blanket applications of diuron maintain the treated area predominantly clean for extended periods, the presence of a few resistant species can mean that the total number of applications of all sprays is no less than in a paraquat-based treatment which uses no residual herbicides. In this trial, although many of the spot-applications in the diuron-based treatment required only small quantities of spray, it was only on the pit-pit site in the second and third years that this treatment required appreciably fewer applications than the paraquat-based treatment.

3. *Hand-weeding.* Hand-weeding costs were high in this trial, and should be much less in situations where perennial grasses are uncommon. It is possible that hand-weeding would be less costly than paraquat-based treatment in the first year but in later years the paraquat-based treatment would probably be less expensive treatment.

The figures given for the first and second years of the hand-weeding treatment are the same. It was felt that the actual figures obtained for the first year were unrealistically high, and that costs for the second year gave a more accurate picture of the situation.

At the end of the second year, the workers started using spades instead of hoes for hand-weeding. This explains the drop in costs between the second and third years.

4. *Hand-weeding plus diuron.* The hand-weeding costs in the "hand-weeding plus diuron" treatment decreased considerably in the second year because the diuron applications had decreased the weed cover. This continued into the third year, when the change from hoes to spades further reduced costs.

In some areas it is difficult to obtain casual labour during periods of high labour requirements. This makes it necessary to maintain a large permanent work force which during slack times could well be used in a "hand-weeding plus diuron" treatment. As wages rise, any treatment that involves hand-weeding will increase in cost compared with treatments that are based solely on herbicides.

Plate II.—Careful records are kept so that it is known which weedicide kills which weed

Effect of Shade

Table 1 clearly shows that weeds grow best in unshaded conditions, so lack of shade undoubtedly adds to maintenance costs, whatever method of weed control is used. Unshaded trees, however, give higher yields of coffee which more than offset the extra maintenance costs. Over the 11 years 1959-1970, the average annual yield of clean coffee per acre from unshaded plots was 600 lb higher than the Albizia plots and 500 lb higher than from the Casuarina plots in the area used for this herbicide trial.

TRIAL 2

A second smaller trial compared four herbicide treatments in unshaded coffee on the pit-pit site. Each treatment was applied to a plot of 0.625 acre which initially was infested predominantly with thurston grass. The four treatments were:—

1. *Paraquat and amitrole*: The amitrole applications preceded paraquat applications by four weeks, for as long as this proved necessary. Amitrole was used at concentrations of 2 to 4.5 pints of Weedazol TL Plus per 45 gallons for most of the first year. Later, rates of up to 8 pints per 45 gallons were used against the sedge *C. brevifolius*. Paraquat was used throughout at a concentration of 1 pint Gramoxone per 45 gallons.

2. *MSMA* applied as necessary, usually as a double treatment, with the two applications 4 or 5 weeks apart. Spray concentrations varied from 2 to 5 pints of Ansar 529 per 45 gallons, with most treatments at 3 or 4 pints per 45 gallons.

3. *Diuron plus amitrole*, applied together, the first application as a blanket spray (to existing weeds) and all subsequent applications as spot-sprays when required. The blanket application was at the rate of 3 lb of Karmex plus 4 pints of Weedazol TL Plus per acre in 43 gallons. The spot-sprayings for the first 18 months were made with sprays containing the

same concentrations of herbicides as the blanket application. After this time, the spray concentration was reduced to 2 lb Karmex plus 2 pints Weedazol TL Plus per 45 gallons.

4. *Diuron plus paraquat* applied together as for Treatment 3. As in the larger trial, it was not feasible to use only the prescribed treatment, and all plots required supplementary applications with dalapon (for couch and para grass (*Brachiaria mutica*)) and with MCPA (mostly for wandering jew and sweet potato). The blanket application was at the rate of 3 lb of Karmex plus one pint of Gramoxone per acre in 43 gallons. For the first 18 months, the spot applications were made with sprays containing the same concentrations of herbicides as the initial blanket application. Subsequently, the spray concentration was reduced to 2 lb of Karmex plus 2/3 pint Gramoxone per 45 gallons.

RESULTS

The costs of each treatment for the first 2 years are given in *Table* 2.

Table 2.—Costs per acre of weed control treatments in Trial 2

Treatment	Costs		
	Year 1	Year 2	Total
	$	$	$
Paraquat and amitrole	25.31	22.16	47.47
MSMA	39.82	34.16	73.98
Diuron plus amitrole	33.55	18.11	51.66
Diuron plus paraquat	39.53	18.37	57.90

All treatments eradicated the thurston grass, mainly within the first year and except for the MSMA plot, all plots were maintained predominantly clean throughout the first two years of the trial. MSMA controlled a smaller range of weeds than the basic treatments on the other plots. This resulted in more applications of other herbicides being required than was the case on the other plots. In spite of these additional applications, it remained the weediest of the four plots.

COMMENTS ON RESULTS

In the first year the paraquat-amitrole treatment was the least costly. In the second year there was a decrease in the cost of all treatments. This decrease was not great in either the paraquat-amitrole or MSMA treatments, but it was considerable in the two diuron-containing treatments. The cost of the paraquat-amitrole treatment was kept high by the need to apply high doses of amitrole to the sedge *C. brevifolius* which appeared towards the end of the first year. During the first year, amitrole was applied four weeks prior to paraquat as part of a sequential treatment but from the second year on was used only when necessary to control the sedge.

Although the diuron-containing treatments were less costly than the paraquat-amitrole treatment in the second year, the latter treatment was the least costly over the two year period.

COMPARISON OF COSTS IN THE TWO TRIALS

A comparison can be made between the results of the smaller trial and those of the larger one on the adjacent unshaded pit-pit plots.

The paraquat-amitrole treatment in the smaller trial was considerably less expensive than the paraquat-based treatment of the larger trial, for several reasons. In the smaller trial, treatment started on recently slashed vegetation, and not on growth that was knee-high. Amitrole was used from the start, quickly removing the thurston grass which had been the cause of high early costs in the larger trial, and later the sedge species were treated at an early stage before they became a serious problem. Lastly, areas of coffee in the larger trial were unhealthy and the absence of ground shade allowed more vigorous weed growth.

The diuron-containing treatments in the smaller trial were also less costly than the diuron-based treatment in the larger trial. This was true particularly in the first year, when the main difference in costs was due to the amount of diuron used. The smaller requirement for diuron when it was used as a spot-spray could be attributed to placing the herbicide only where it was needed. However, it was expected that more spot-applications would have been required in the first year than proved to be the case. After the initial blanket application, the two treatments received only two or three spot applications. In the second year there were either five or six spot applications and the total amount of diuron used was about the same as that used for the two blanket applications in the larger trial.

If diuron is used as a spot-spray, the possibility of lowering costs must be weighed against the disadvantage of not knowing how much diuron is being applied over a period to given small areas of coffee. In spot-spraying, there is some danger that a small area may get an excessive dose of herbicide which will damage the coffee.

CONCLUSION

The Aiyura trials have confirmed that herbicidal weed control can be cheaper than hand-weeding of coffee, at current labour costs. Coffee groves may be kept cleaner with herbicides than was ever practicable with hand-weeding.

No single herbicide will give control of all weeds found in coffee, and persistent use of one chemical is likely to result in a rapid build-up of species resistant to it. However, all the important weeds may be controlled by intelligent selection from the range of chemicals available. The information given in this article (and the more detailed paper in *The Papua and New Guinea Agricultural Journal*) should enable coffee growers to choose the right materials to eradicate problem weeds before they become too dense.

The trials are continuing, together with other large scale trials. They will be reported when results are available.

Table 3.—Glossary of trade names and common names

Common Name	Trade Names *
Paraquat	Gramoxone
Diuron	Diurex, Karmex
Amitrole	Weedazol TL Plus
Dalapon	Basfapon, Dowpon, Gramevin
2,4-D	Amoxone-50, Weedkiller D
MSMA	Ansar 529, Daconate
MCPA	Methoxone-30

*This list is not exhaustive, but includes products most readily available in Papua New Guinea.

Botanical Names

"BOTANICAL NAMES", said someone, "provide a method of insulting plants in Latin and Greek." The botanists, of course, would not agree. To them, botanical names provide a method of bringing order out of chaos.

The great value of a botanical name is that it is the same everywhere in the world, and therefore there can be no confusion on exactly which particular plant is being talked about. For example, what in English is called "sweet potato", in Pidgin is "kaukau", in Toaripi is "Kauari", in Motu is "kaema", in Kiunga is "ombarap", and so on. To make matters worse, in America they call a sweet potato a "yam", while in Papua New Guinea these are two different things.

But anywhere in the world, a botanist will call it *Ipomoea batatas*, and every other botanist will know what he is talking about (even if nobody else does!).

For those who would like to learn some of these names, and for those who ought to know them but have forgotten them, the list below gives the botanical names of a few well-known plants.

Common Name	Botanical Name
Coconut	*Cocos nucifera*
Tea	*Camellia sinensis*
Oil Palm	*Elaeis guineensis*
Rubber	*Hevea brasiliensis*
Cocoa	*Theobroma cacao*
Peanuts	*Arachis hypogea*
Highlands coffee	*Coffea arabica*
Lowlands coffee	*Coffea canephora*
Rice	*Oryza sativa*
Sweet Potato	*Ipomoea batatas*
Sugar cane	*Saccharum officinale*
Pitpit	*Saccharum edule*
Pyrethrum	*Chrysanthemum cinerariaefolium*
Passionfruit	*Passiflora edulis*
Orange	*Citrus sinensis*

Can Stone Boats Float?

M. MITCHELL, Fisheries Superintendent

Stone boats? Well, not exactly. The material is now known as "ferrocement" and as the name implies, the boat is a framework of steel plastered with a cement mixture. Nowadays the thin-shell method gives a light and strong hull which is ideal for hard work, especially for the tropics.

MANY such boats were built and used during World War II, some being as large as 10,000 tons. But even then they were not new. There is one twenty-footer, still afloat on a lake in the Netherlands, which was launched in the 1890's.

Since the war, techniques have improved immensely, largely owing to the work of Professor Nervi of Italy, whose success with commercial and pleasure craft is well known in naval architect circles.

There are several advantages in ferrocement boats—

(1) They are cheap to build, as the main materials are only cement and wire.

(2) Cement burns with difficulty.

(3) Marine borers do not like cement.

(4) A well made ferrocement hull stands up to knocks well, and can often be repaired on the spot.

(5) The type is suited when employing one method to one-off vessels. Further, several people have successfully tackled ferrocement vessels, usually yachts up to 50 feet although they had never built any boat before. One drawback to ferrocement is that for boats under 30 feet, they are heavier than traditional materials. Over 40 feet weights are about equal; with larger boats you may save some weight. This being the case, we look at ferrocement boats as displacement types at present. It is better to stick to round-bilge designs as these are stronger in ferrocement. Hard-chine designs would require extra strengthening at the turn of the bilge. This can be done if required.

Ordinary reinforced concrete, however, is not good enough for boatbuilding, mainly owing to the presence of free lime, which dissolves and creates water channels within the structure. This causes breakdown of the metal inside after a while, and the whole frame becomes weak.

The ancient Romans had it made however, for they knew about pozzolan, which is a natural by-product of volcanic eruptions. Pozzolan eventually sets so well and is so impervious that the old original products are still good today. Luckily, pozzolan is also a by-product of modern industrial furnaces so we can get it at the supermarket without having to pack a mule to the thermal regions. The only drawback is getting pozzolan from Australasia to Papua New Guinea. No comments required!

So, if we mix two parts of the right sand to one part of Type 5 Portland cement but replace 10 per cent of the cement with pozzolan, we get the right plaster. Sand should be a good silica type and it should all pass through a No. 8 sieve. In actual fact, boats have been built without pozzolan and using local sand and the results seem quite good. So possibly the care in application has a lot to do with the final product.

It is advisable to carefully inspect your sand for salt and debris and wash well if necessary. One test which you can do is to put a few ounces of the sand into a narrow jar. After filling with water and shaking, allow to settle and the silt layer on top of the sand should not be more than $\frac{1}{8}$ in.

The framework of the boat can be built several ways. Firstly, one can suspend the frames of the boat from overhead points and build on that. Secondly, one can build a wooden mould, full size, of cheap timber, and go to work on that. A male mould, built upside down on the ground is quite good, but the whole work needs a crane to right it before the mould can be extracted. On the other hand, a female mould, constructed right way up and bolted together in two equal sections, is most handy, for the mould can be split when finished and the boat trundled out, having been built inside.

Most amateurs choose to use the suspended frame method as shown in the photographs.

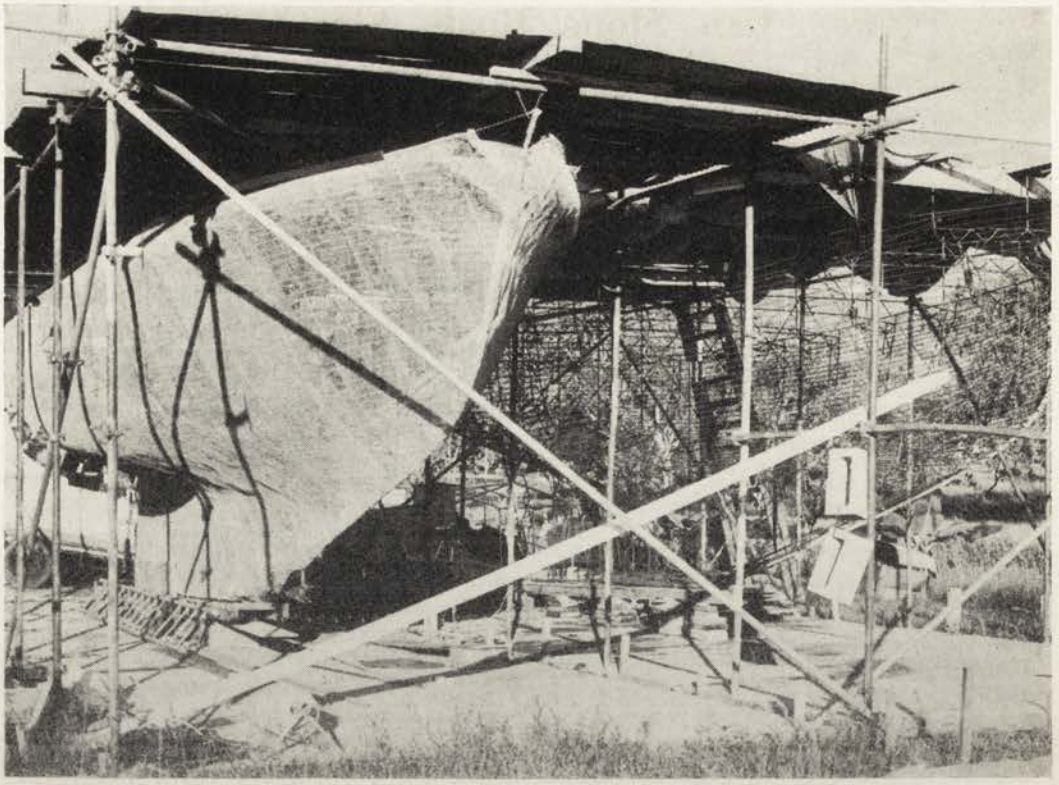

Plate I.—The suspended frame method showing two boats, one partly covered with mesh

This is the obvious choice when only one boat is to be made. Briefly, you should build a temporary structure of timber, or use an existing shed with a strong roof. Each of the vessel's frames, which are cross-sectional shapes of it at equidistant points, is suspended from a matching beam of your shed. A rod can be tack-welded to each frame and if the top end is threaded, then a nut can be used to raise or lower the frames when aligning. The frames will also be tacked to the keel, hornpiece and stem of the boat which has been prefabricated out of water pipe or heavier steel rod. Once the frames are fairly well set up, one then lays stringers of reinforcing rod (about .20 in or .25 in) lengthways from stem to stern at about 2 in centres, from deck level down to the keel. You may tack-weld them at one end, but only there, and the other ties should be made with 16 gauge black wire. If you tack-weld each time the stringers touch a frame, then you will be unable to adjust the frames and true-up the structure, for once you have laid on all the stringers you will invariably have to move the frames slightly to fair up the job. If you do not fair up then the boat will emerge lopsided in the end—a hideous sight.

Once all the stringers are in place, your boat will look very much like a ship, except that she is fairly transparent. Next job is to lace on the $\frac{1}{2}$ in diameter galvanized chicken-mesh. Seven or eight layers are used, some inside and some outside the framework. By passing small staple-shaped pieces of tie wire through the mesh, the mesh can be pinned to the stringers quite nicely. Don't tighten too severely or the mesh shape will be uneven over the whole surface. Do not use strips of mesh more than about 9 in wide, otherwise you will have difficulty in working round the curves encountered. Cut your 36 in wide mesh into four or you can cut it in half and bend each 18 in strip so that you get a double layer. Do not get too enthusiastic with the left-over ends at the stem, stern and keel, for if you get too

much accumulation of mesh there, then the plaster will have difficulty in penetrating unless you use a mechanical vibrator. And of course, if plaster is present elsewhere on the hull, the vibrator will cause it to drop through.

Laying up the materials on wooden moulds is more or less the same but you should put a polythene layer over the timber to prevent plaster sticking to it. The tie wires are replaced with a staple-gun and of course, non-ferrous staples are better. The resulting hull is frameless and there is nothing much inside to fasten on your interior joinery, which is a nuisance. For commercial production in quantity, the wooden mould would provide a quicker method. Some builders spray the plaster mix on with a gun but there have been one or two unfortunate incidents, probably caused by too wet a mix being required for the gun process.

Many builders feel that they are not skilled enough to plaster up the hull. They are probably right in this, especially where skilled people are available. Most people favour a "one hit" method of plastering, so that the entire hull (less deck) can be done in one day. Certainly the employment of one or two skilled plasterers plus some labour for one day is within the means of the would-be owner. Skilled plasterers will do a better job in the surfacing of the plaster, so that it has a beautifully smooth and rounded finish. Nevertheless, experience has shown that where no skilled plasterers are available, then you may as well do it yourself, for the result may be much the same because you, being the fond owner, will take care to prevent air-pockets forming in the hull plaster.

One well-known plasterer in New Zealand favours the "two-stage" method. This means that the outside of the hull is plastered to about half-way through the wire and then left to cure before finishing off inside. A layer of cement grout or epoxy bonding agent is used

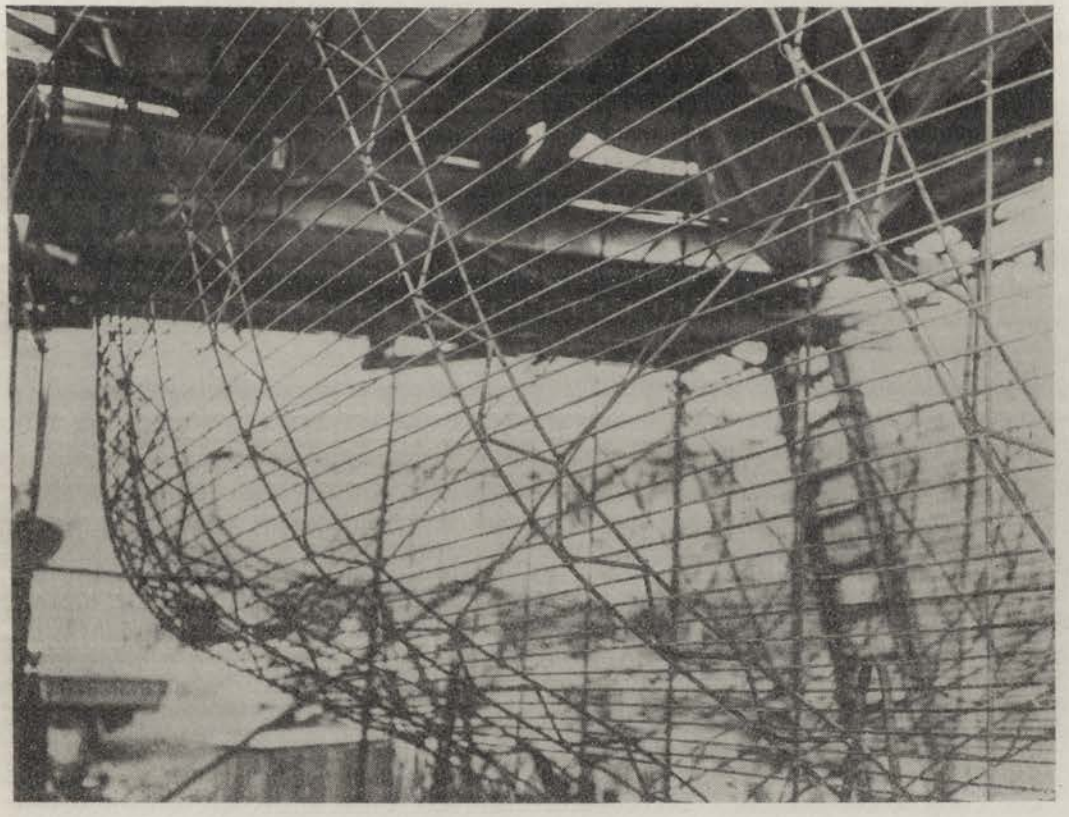

Plate II.—Frames, stringers and vertical suspenders

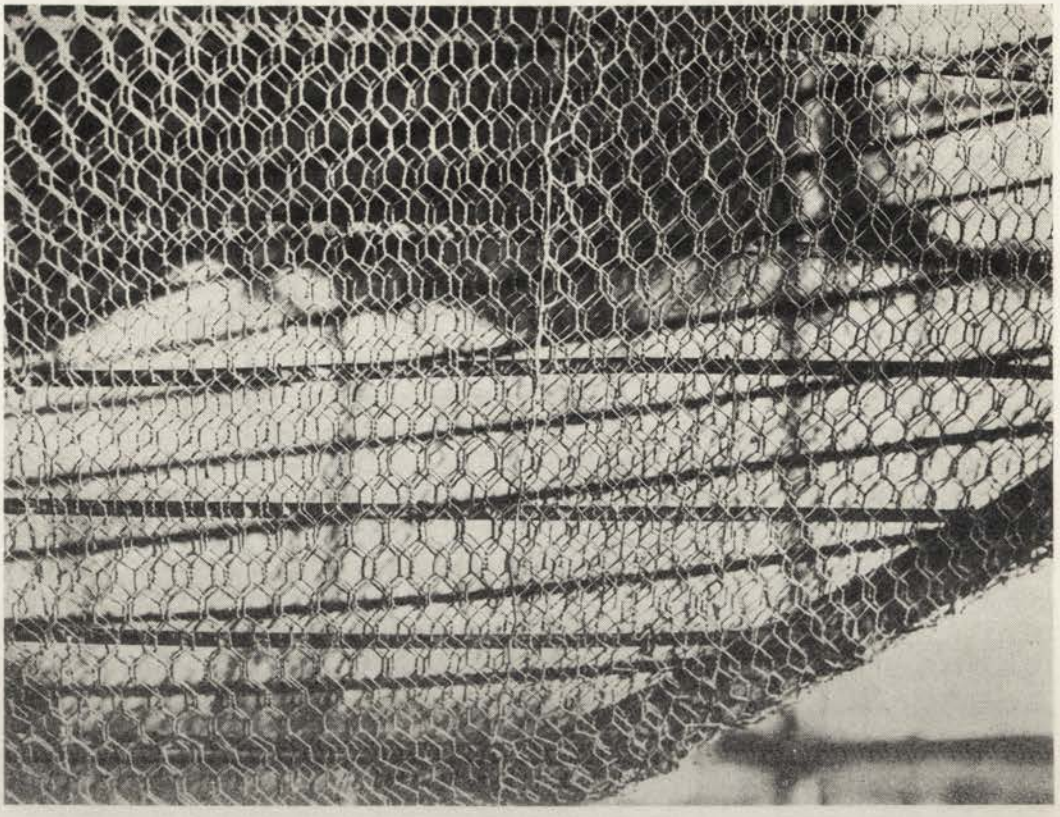

Plate III.—Bow section with three outer layers of mesh not fully tied down

between the two cement layers. The deck should not be attempted until the hull is cured and dried, otherwise the weight of the workmen can spoil the whole show.

Curing the plaster simply means keeping it damp for about 28 days so that the mixture dries out evenly from within and no uneven stresses are set up which may weaken the final result. Alternatively, one may steam-cure the job in as little as 24 hours. Usually the owner will merely put garden hose sprays or sprinklers everywhere and take a well-earned rest. A polythene tent round the whole is an improvement, and you can use less water then as the humidity inside at tropical temperature is amazingly high.

You can build the entire ship, including deck and coachroof in ferrocement, but some people stop at the decks and carry on with marine ply or timber. It is a matter of choice. For hard use and dryness, cement everywhere is recommended even for bunks and bulkheads.

Engine beds are usually of ferrocement and can be included in the original design. Some people suggest water and fuel tanks of ferrocement but this suggestion should be treated with caution. Water tanks should be well lined with epoxy surfaces, and baffle plates will also be required. This also means that large removable sections will be required so that access can be gained when working inside. Diesel fuel penetrates most things in time, so if you have ferro fuel tanks, put them where a little diesel will not matter. Refrigeration and ice boxes should have air spaces between them and the hull.

Tar epoxy paints are most suited to cement and they come in several different colours. Take care to paint the bilges well inside or it

may happen that diesel fuel spillage will penetrate the cement, taking minute amounts of salt with it and thus perhaps affecting the metal work within the hull skin.

With regard to marine surveys, it appears that in some countries, authorities are reluctant to commit themselves, but it seems clear that the main reason for this is a marked lack of data on ferrocement vessels. Even Lloyds, the great marine insuring agency, has little in print on the matter. It is probable that the most authoritative works on ferrocement come from New Zealand, which seems to be the home of this method. The New Zealand marine authorities are in the process of laying down rules for the building of ferrocement craft and their publication should be available in the near future. It is generally accepted that "down-under" is well ahead in this field.

There are two builders of ferrocement craft in the Territory.—Yule Shipbuilders, Central District and D. Wells, Madang Ferroconcrete Products. Three 28 ft extension boats are being built for coastwise fisheries work for D.A.S.F. Since the 24 h.p. diesel engines consume ½ gallon of fuel per hour at full speed of about 8 knots, it will be seen that working range is ample for our coastline. As the boats have bunks, washing and cooking facilities, plus echo sounder and marine radio, it will be realised that a reasonable distance extension tool is now available to us. Less radio and echo sounder, the boats are produced at $6,200 each, which surely is good value for money. A Fisheries Officer could recommend such craft to the general public with a clear conscience as to running costs, spares, and maintenance problems, added to which, in difficult times, fishermen could always do a little cargo work to keep the business going.

When it is known that commercial yards can produce such reasonably priced boats, it can further be realised that the amateur builder can do a very cheap job if he utilises

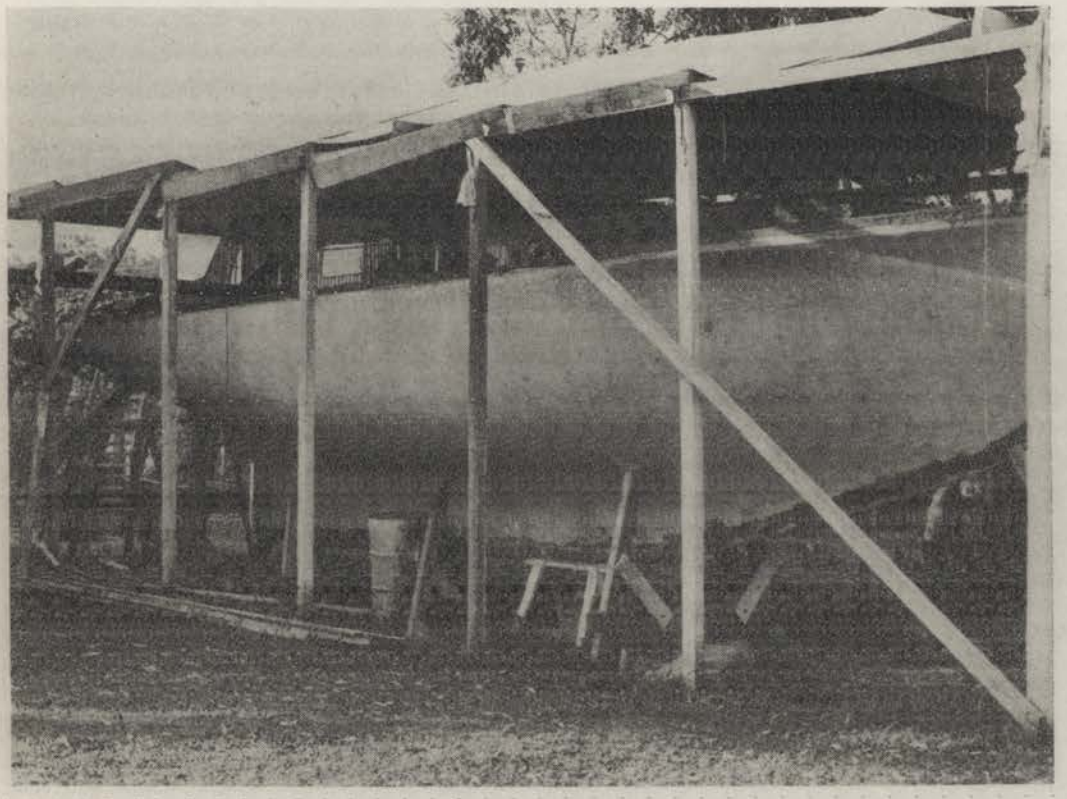

Plate IV.—38 ft yacht built by Mr Peter Williamson of Boroko, amateur with no previous experience. The dark line is glassfibre overlay

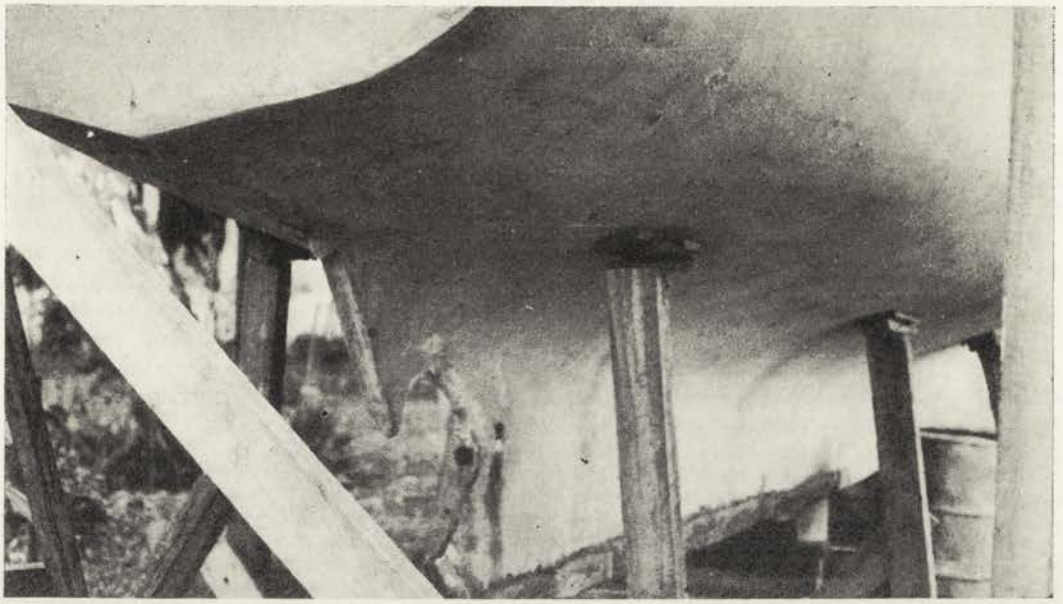

Plate V.—A close-up of the hull before being painted, showing the smooth finish of the cement

his otherwise spare time. One photograph shows an amateur built yacht which, to the stage shown, including all materials and professional plasterers, cost the owner $1,500. For a 38 ft hull, this is very cheap.

You can run a ferrocement yacht onto a reef just like any other boat and the results are worth studying. There have been one or two unfortunate incidents, such as the one where a brand new prawner was caught in a cyclone off Queensland and was lost. This has caused some critics to condemn ferrocement without further ado. There have, however, been too many well authenticated instances of ferrocement boats coming off very well after collision or grounding. The most recent case was off Madang where a 40 ft yacht went on to the reef nearby and for three days was lifted and dropped with each successive wave. A witness stated that each time the boat fell on the reef it seemed enough to split her apart. Actually for three and a half days she withstood the repeated impact without real damage. Unfortunately it was over a long weekend and the message did not get through to the rescue services until the third day. The tug arrived just in time for the boat to finally split along one bilge. Soon afterwards she was not worth saving. The witness, a timber hull man himself, said that he needed no further convincing that ferrocement was an ideal medium.

To repair an eggshell depression in the hull, caused by impact, is fairly simple. In any case the fragments of plaster will remain locked by the wire mesh and no sudden hole will appear. As soon as possible, dry the ship out enough to work on the fracture. With a heavy dolly held on one side of the repair job, gently pulverise the small pieces from the other side with a suitable hammer. Straighten out the mesh remaining and then fill up with plaster or epoxy filler. The epoxy is the quickest and you can be on your way when the tide comes back. The thing to remember is—and this goes for the whole boat—do not plaster more than about 1/16in thicker than your wire mesh. To do so weakens the job considerably. In fact, if you have plastered properly you are bound to have odd meshes showing through the hull when finished. You can just grind them off gently and cover with epoxy filler.

If we can just get the message through, I'm sure that fishermen everywhere will be having a shot at making a ferrocement boat. The thing to do is to make sure that information is available.

Floating Cages for Fish Culture

J. GLUCKSMAN, Freshwater Fisheries Biologist

Fish cages are useful for holding fish in a stream, river or lake, where it is not convenient to build fish ponds. They are also useful for holding fish caught in larger waters. Keeping "caught" fish alive is an excellent solution to the preservation and distribution problems found throughout Papua New Guinea.

IN some areas it is difficult to build fish ponds because the only land available is very steep. In other places there are extensive natural waters such as large rivers or lakes which are suitable for fish culture, but are too large to be managed. In large areas of water, or in running streams where there is no shortage of oxygen, a fish cage is the answer.

An ideal design for a fish cage is given in *Figure* 1. The cage is a box with wire mesh sides and floor, and a wooden cover. The box has styrofoam floats at the top on each side so that the cage floats, but only the top is above the water. Since the sides of the box are of wire mesh, the water continually passes right through the box, so the fish have a never-ending supply of oxygen.

The cage shown in *Figure* 1 has a frame of 2 in by 2 in hardwood, and the sides are made of ½ in by 1 in welded mesh, 16-gauge, galvanized wire. Floats are blocks of styrofoam, 10 in in cross-section. A 10 in wide strip of aluminium screenwire is attached at the waterline to prevent food from floating out of the cage. The cover is made of plywood and has a hinged door for feeding.

All sorts of local materials may be used instead of those listed above. For example, metal sheeting or planks can be used instead of plywood, plastic bottles or light wood can replace the styrofoam, and split bamboo or woven pitpit can be used for the sides and bottom. If pitpit or split bamboo is used, the

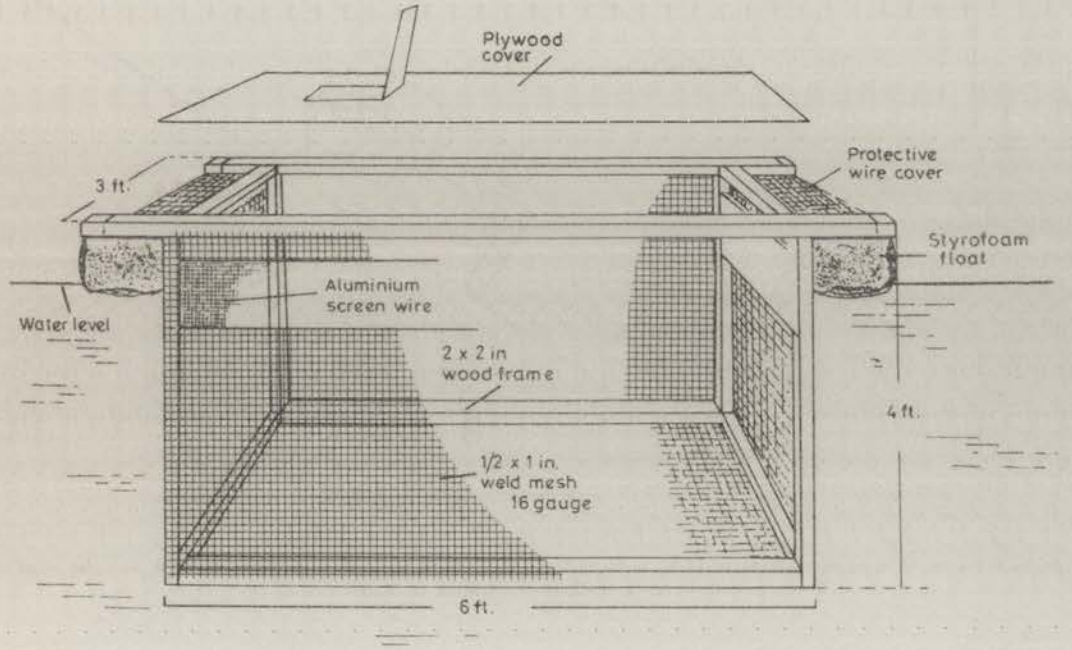

Figure 1.—A suitable design for a floating fish cage

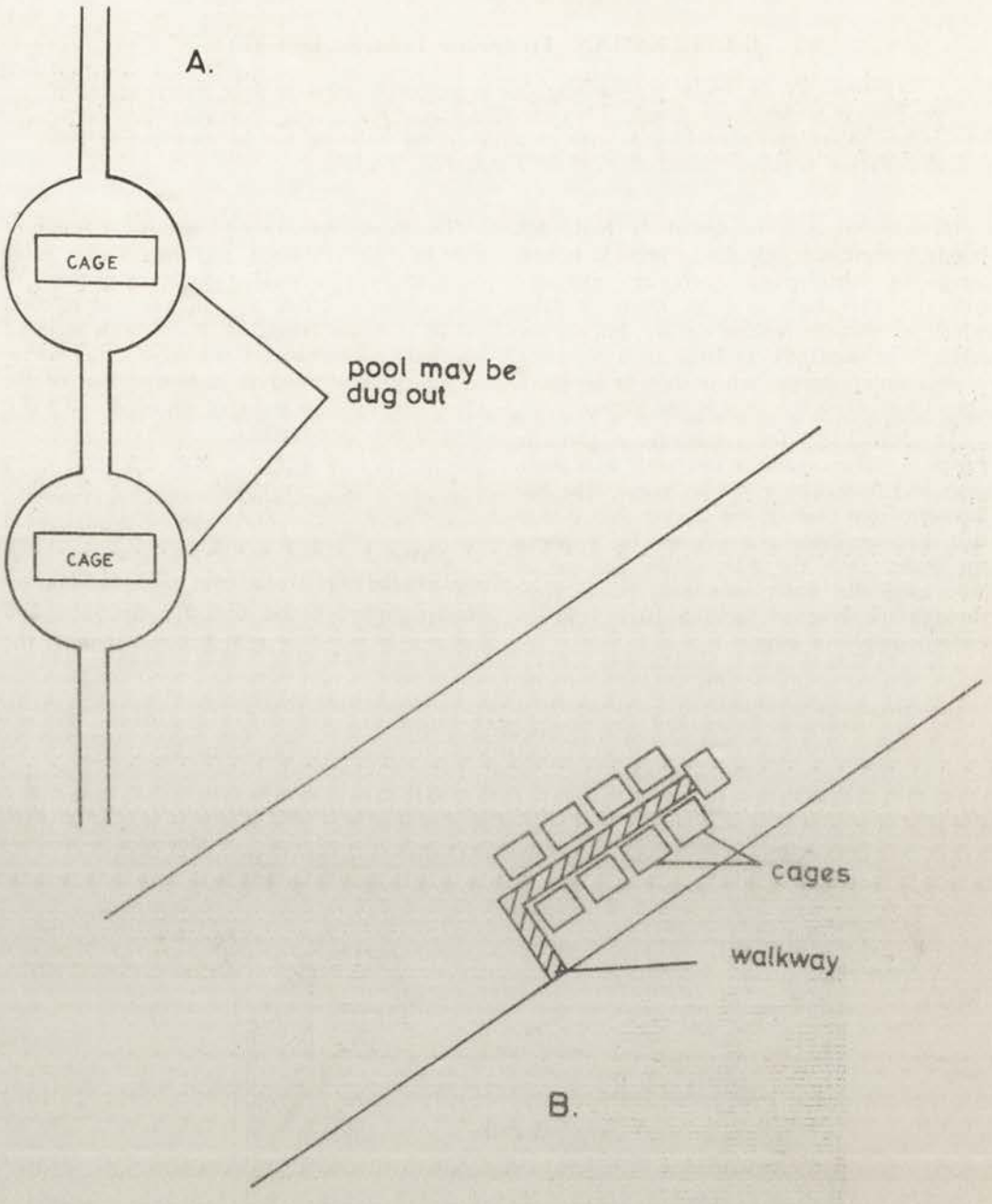

Figure 2.—A. A narrow stream may be enlarged at one point to make it wide enough for the cage B. On a wide river a walkway is useful to reach the cages

cage will not need floats and may need stones for ballast, to keep the cage deep enough in the water.

Cages can be made to larger dimensions than those given in *Figure* 1, as long as the same proportions are used. (There is less work in making one large cage than two small ones.)

The cages are floated at least 6 to 12 in free of the bottom. A cage of the dimensions given in *Figure* 1 can be stocked with up to 160 fingerlings (5 in or larger) or 80 per cubic yard. At this density the fish can grow to a size of 1.5 lb without being overcrowded. The fish in the cage require more oxygen than would free-swimming fish. Cages can be used only in running or large waters. They cannot be used in small stagnant fish ponds (see *Figure* 2).

Feeding

Caged fish do not have access to any natural food. They must be fed regularly, and properly. Golden and Cantonese carp can consume up to one-fifth of their body weight daily so the ration must increase as they grow. Food must include protein and carbohydrate. For carp, a ration similar to that fed to pigs will result in very good growth. Cheap local sources of protein include maggots, ants and ant eggs and insects captured at night with a light. Sources of carbohydrates are sweet potato, taro, tapioca, broken rice or rice bran, and corn. The fish can be fed as many times daily as they will take food.

Tilapia

Tilapia do not grow very large when they are kept in ponds, because of their tendency to reproduce at a size far below that desirable for the table.

Recent investigations have shown that tilapia grown in cages suspended in a pond will not reproduce, both because the altered environment interferes with egg fertilization and because the eggs, which must be incubated in the mother's mouth, drop through the cage floor.

Tilapia may be stocked in cages at about twice the rate of carp and must be fed similar foods, well pulverized, regularly.

With stunting eliminated, tilapia are ideal for fish culture because of their fast growth, good food conversion ratio and hardiness.

Sheep for Papua New Guinea?

IN many of the densely populated areas of the highlands, particularly where the hills are steep, beef cattle are rather large units to be incorporated satisfactorily into village farming systems. In order to find a suitable alternative for these areas, the Department has recently commenced an investigation into the possible use of both tropical and temperate breeds of sheep for meat and blanket wool production. The research programme will be based on small flocks to be established at three centres in the highlands—the Wabag/Wapenamanda area, Mendi and Kundiawa.

Sheep have evolved essentially as "dryland" animals (compared to cattle which are generally better adapted to non-arid conditions) and consequently their use in the Papua New Guinea situation poses some problems. Although sheep have performed satisfactorily in many areas of the tropics, these have generally been "dry tropics" areas or in the highlands of tropical countries experiencing a continental climate. Papua New Guinea's insular humid tropics climate therefore represents a relatively new field of investigation.

The major factors to be studied will be reproduction, disease and grazing management. These are, of course, important aspects of any livestock enterprise but they are expected to be the main problems which could affect the successful development of sheep enterprises in Papua New Guinea.

Many temperate breeds of sheep are seasonal breeders. Their breeding activity is stimulated, in part, by decreasing daylight hours in autumn. At the latitude of Papua New Guinea, there is much less seasonal change in day length than in temperate zones. The reproduction of temperate breeds might be disrupted, at least temporarily, by the change to this environment and it will be important to determine the extent of this reaction. For example, there is evidence that when temperate breeds are transferred to tropical environments, it may take a year for them to adapt to the new conditions and resume breeding.

Breeds native to the tropics have adapted to these lighting conditions and they breed throughout the year. The only tropical breed available in Papua New Guinea at present is the Priangan, a Javanese breed introduced in the pre-war period. A small flock of sheep with Priangan blood has been purchased for study in the programme, and these will be compared with introduced temperate breeds.

Internal parasites will probably be the major disease problem. Experience with sheep in the highlands, as limited as it is, has shown that internal parasites can seriously hinder production, even when the sheep were treated every three weeks. Research will be required to find ways to control parasite levels at reasonable cost.

Sheep generally graze close to the ground and the tall coarse grasses (both natural and improved) common to tropical countries are difficult for them to handle. Although it would seem desirable to investigate shorter improved pasture species such as Kikuyu, Paspalum, Para grass, etc., it will also be necessary to know how effectively sheep can use natural pastures and what methods of grazing management will have to be used, since there will be many instances where pasture improvement may not be possible. If it is found that natural pastures cannot be used at all, a considerable amount of detailed work will have to be done with improved species to make certain that the grasses and legumes used are suitable for smallholder management systems. The ease of planting and of management, resistance to overgrazing and ability to provide a quick ground cover will be some of the more important attributes which will be required.

The Department is making no attempt at present to set up village sheep projects. This will depend on the results of the research now being conducted, and we would expect that an intensive research programme over some two to three years will be necessary before the Department can offer sound advice on the management of sheep and the uses to which they can be put. Dr Terry Leche, the Senior Animal Production Officer carrying out this work, will however be reporting progress results through this journal from time to time.

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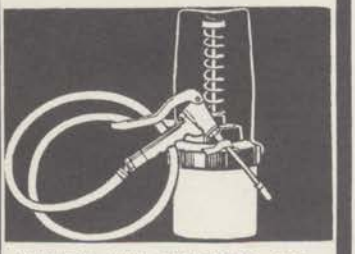

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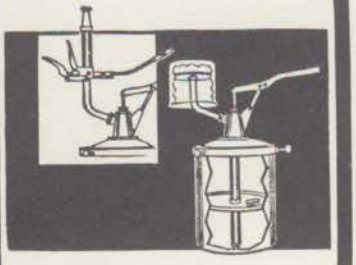

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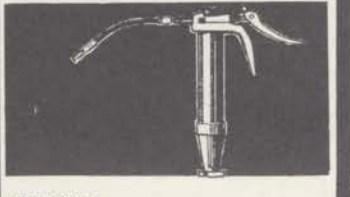

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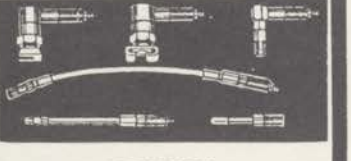

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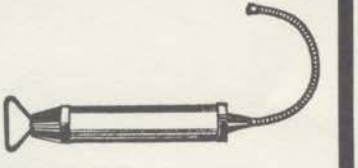

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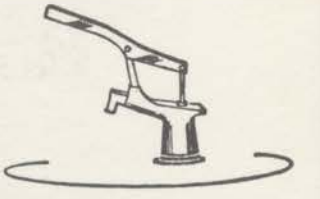

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