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EDITORIAL NOTES.

THE subject of copra deterioration with age is one which has received considerable discussion of late. It has been thought by some that the length of time which copra can be stored is limited to a few months, while others were of the opinion that it will keep indefinitely.

The results of experiments which have been in progress in this Department for some months indicate that copra can be kept for a considerable number of years without deterioration providing it is properly dried in the first place. This is confirmed by the following findings.

In a copra store in Rabaul there are some hundreds of bags of copra at least three and a half years old. Some of these were recently opened, the copra examined and found to be almost as good as the day it was made, and still of sufficient quality to be exported as first class. Other batches of copra—fifteen, twelve, and nine months old—were also examined with the same result.

If copra is to be stored for a prolonged period it will gradually lose or gain water until it is at last in equilibrium with the moisture of the atmosphere; but, if the copra contains considerable water, moulds and insects will ruin it before it has dried to the equilibrating point. On the other hand, if the copra is well dried, no damage will be caused during the slight absorption of moisture which takes place.

As the result of experiments in this Department, it would appear that for prolonged storage the copra should contain less than 7 per cent. moisture, although this figure is only tentative. The best Rabaul hot-air copra usually contains approximately 5 per cent. moisture, so that, if it is properly stored, it should keep for a considerable period without deterioration.

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COPRA DETERIORATION DURING STORAGE AND SHIPMENT.*

(By F. C. Cooke.)

Introduction.

Copra is a perishable commodity. The amount of deterioration and loss of actual copra which can occur varies in different circumstances. Commencing with a given quantity of fresh coco-nut meat, the ultimate quality and the quantity of copra received at the mill depend on four factors:—

(*a*) Care exercised in the preparation of the product.

(*b*) Moisture content of the freshly prepared copra.

(*c*) Treatment during bulking, storage and transport.

(*d*) Length of time elapsing between production and milling.

Period of Storage.

The time elapsing between production and milling is dependent on locality of production, difficulties of collection and local transport, seasonal variation in crop, freight charge fluctuations, amount of cargo space available in ocean-going steamers, and the state of the copra market.

In the case of Straits copra, when shipments keep pace with purchases, the normal interval is just over two months, but, in exceptional circumstances, the copra may be held in store for two or three months prior to shipment. Thus, for example, during the Great War it was impossible, on occasions, to obtain cargo space from certain ports and, more recently, a long period of low prices resulted in considerably reduced shipments. When such situations arise, stocks accumulate in the warehouses, and small dealers, and even producers, may be forced to hold up their copra.

Table I. provides a rough detailed estimate of the time taken to pass copra from the small-holder in this country to the miller in Europe.

TABLE I.

Approximate times for various operations which may occur between producing and milling small-holders' copra.

Operation.	Time.
	Days.
House storage	1 to 7
Shophouse storage	0 to 7
Local dealers' stores	0 to 7
Road, river or coastal transport	1 to 4
Warehousing at export centre	0 to 150
Ocean shipment	30 to 40
Bulk storage before milling	3 to 14
Total	35 to 229

* From the *Malayan Agricultural Journal*, Vol. XXVII., No. 11, November, 1939.

Some of the operations shown therein may be omitted or all may be included in full, so that small-holders' copra which is exported may take from one to seven months to reach the oil mill.

Estate copra is nowadays generally exported from the estate direct to Europe on a through bill of lading and little more than a month need elapse between production and milling. Copra milled locally is seldom kept for more than a month after production.

Copra Trading.

In the case of the small producer, a small quantity of "raw", half-cured or somewhat under-dried loose copra may perhaps be kept for as long as a week before the collector calls or delivery is arranged. Whenever possible the copra is sold without delay. These small parcels of copra are bulked by a succession of buyers—the shopkeeper, the transporter, the small local dealer, and ultimately the export dealer and shipper—into consignments of gradually increasing size.

Since he usually buys his copra at a flat rate from producers and then may sell it on a dry-weight basis to the merchants, the local dealer will usually lay the wettest copra out in the sun for further re-drying, particularly when it is likely to pay him to delay re-sale. Conversely, when copra is sold at a flat rate, cases have occurred where the lowest grades of copra have been deliberately moistened by the seller to increase the weight.

The bulked copra which ultimately arrives at the export centres, Singapore, Penang and Port Swettenham, from the different production centres is variously dry and exhibits different features and degrees of deterioration depending on the treatment accorded to the product and effect of weather conditions on production, storage and shipment. It is for this reason that it is described as "mixed" copra, i.e., a mixture of f.m.s. and f.m. copra;* the geographical origin is added to this description, e.g., Kelantan "mixed" copra, and this serves to identify the quality, since each coco-nut district has its particular standard of quality, or a recognized f.m.s./f.m. ratio for "mixed" copra.

The small-holders' bulked copra now being received from most districts is reasonably dry and of high quality and the "ratio" for copra from these districts has distinctly improved; nevertheless some of the copra coming generally from the more remote regions still continues to be of inferior quality. In exceptional cases, such copra is wholly f.m. quality and is offered in a "raw" condition.

Conditioning of Copra by Storage.

"Raw" or half-cured copra, if produced near the export centres, is usually received at the export warehouses in a fresh condition, but that from the more distant and inaccessible regions, or from those places where collection is difficult, is more often badly deteriorated, except when the local dealers or shippers have re-dried the product before sending it to the export centres.

Fresh "raw" copra, as received, is warm, has a pale-yellow, gummy surface, is free from mould, and exudes a not unpleasant yeasty odour. Deteriorated "raw" copra is hot, black, soft, matted and glutinous, insect-ridden and dirty; it is covered with a thick layer of wet slime and black mould and has a revolting sour smell.

* The terms f.m.s. and f.m. are expressions of quality and denote respectively "fair merchantable sundried" and "fair merchantable", the latter being the inferior quality.

All bags of "raw" copra are usually emptied without delay, and the contents built up into a huge stack.

Continuous records show an initial rise in temperature inside such a stack from 35° to 52° C. in about three hours. Subsequently the temperature declines slowly to about 38° C. on the eighth day of storage and after that even more gradually to about 30° C. in about three weeks, by which time the moisture content has been reduced to between 4 and 5 per cent. During this period the temperature of the stack rises each night when the warehouse doors are closed.

The condition of fresh "raw" copra which has been expeditiously reconditioned may be surprisingly good in spite of previous superficial development of bacterial slimes. In one instance, although a sample of such copra after reconditioning had a dirty greyish-yellow appearance, it showed little internal discoloration while only 4 per cent. of the pieces were deeply corroded and there were only 8 per cent. of "smalls" The copra had a not unpleasant smell and the acidity of the contained oil was only 0.8 per cent., calculated in terms of lauric acid.

"Raw" copra which has been permitted to deteriorate seriously before warehousing cannot be satisfactorily reconditioned. After warehousing, the whole of the copra is internally discoloured, the range of colour being light-brown to black. The bulk of the pieces are very deeply corroded and all are in process of breaking down into small fragments. There is very high percentage of "small", foreign matter and dust, and the acidity of the contained oil, calculated as lauric acid, is usually in excess of 5 per cent. Such copra is therefore below Straits f.m. quality and requires to be "brightened" with copra of somewhat better quality before shipment.

Irrespective of their condition, the various consignments of "mixed" copra received at the warehouses are usually all made up into large stacks of loose or bagged copra as described above. In this way, copra is self-dried by its own heat of decomposition,* the contained moisture being reduced from anything between 7 and 25 per cent. to between 4 and 7 per cent. according to season. A relatively stable and reliable product is thus obtained which may be sorted, blended and graded for export. The length of storage required depends principally on the moisture content of the copra on receipt, but occasionally self-drying may be curtailed to make up a consignment when copra is short. Dry copra requires about a week's storage, fairly dry copra about fourteen days, and very wet copra as much as three weeks, before it is ready for shipment.

Blending and Bulking for Shipment.

Copra is exported in two grades, Straits f.m.s. and Straits f.m. After warehouse drying the various lots of "mixed" copra are either up-graded by the removal of defective pieces or down-graded by the removal of good pieces whichever is necessary to produce the required grade. Occasionally there is no picking over, since a parcel may be used to brighten up or bring down a consignment of bulked copra to the desired standard. The method of bulking is to build up, layer upon layer, the various parcels of copra from different sources, so that blending and

* For discussion on heat of decomposition *see* Special Bulletin No. 28, General Series, Department of Agriculture, S.S. and F.M.S. Copra Deterioration, pp. 20 to 22.

mixing takes place when this stack of loose copra is broken up and the copra shovelled into sacks. The copra then remains in bags until shipment can be arranged.

During ocean shipment a certain amount of self-heating again occurs in the copra, which is subjected to considerable pressure and disturbance due to the movement of the ship. The individual bags of copra enter the ships' holds at about air temperature (28° C.); subsequently there is a slow daily rise for three days to about 35° C., or more, according to the efficiency of ventilation in the holds and the condition of the copra; ultimately when more temperate regions are reached the temperature gradually declines.

The merchant shipper who prepares the copra for export takes full responsibility for the ultimate quality of the copra on arrival and for any serious loss in weight in transit.

The foregoing remarks do not usually apply to estate copra which is nowadays mostly of uniformly good quality and can, in consequence, be shipped direct from the estate to Europe without any warehousing, inspection or blending being necessary. Such copra is classified as Straits f.m.s. although for copra to be forwarded without inspection or warehousing it has, of necessity, to be above normal quality to avoid the possibility of subsequent disputes and arbitration. It is obvious that the interval between production and milling will be much reduced with direct shipment and the amount of handling will also be considerably less. For these reasons, copra of this type usually obtains a small premium.

The agents of deterioration during transport and storage are yeasts, bacteria, various moulds and insects, and the heat of decomposition, but it is the moisture present in the copra which makes deterioration possible and determines which (if any) of the agents may operate and the extent of the deterioration and loss which occurs.

The individual effects of these several agents cannot be separately determined, as it is not practicable to restrict deterioration to a single factor. Nevertheless, it is possible to determine, by experiment, the total deterioration and loss which may be expected to occur with a given set of conditions. Even then it is still not possible to follow normal trading, transport, storage and blending practice since copra under observation has to be periodically sampled and cannot therefore be mixed with other copra.

Storage Trials.

In order to ascertain the extent of the loss which occurs when different types of copra are kept for long periods under normal conditions of storage, two storage trials have been carried out with the six different types of produce copra shown in Table II. These may be regarded as representative of the different types of copra produced in Malaya. The majority of estates nowadays produce copra corresponding to grade W1, while the best small-holder producers offer grades W1 and W2. Nevertheless, copra of grade W3 does still continue to be made in one or two inaccessible regions and this degenerates, according to the absence of care in production or to the treatment accorded to it by the local dealer, to yield copra corresponding to grade R1, R2 and R3.

TABLE II.
Types of copra used in storage trials.

Lot.	Initial Condition.	Moisture Content.
		Per cent.
W1	Dry smooth white copra	About 8
W2	Fairly dry white copra	9 to 12
W3	Half-dried " raw " white copra	About 20
R1	Dry unscorched " red " copra	About 8
R2	Fairly dry " red " copra	9 to 12
R3	Half-dried " raw red " copra	About 20

The various lots described in Table II. were each prepared from 100 nuts collected from the same estate. The " red " copra was produced by allowing bacterial decomposition to be initiated prior to drying and to continue to develop subsequently through deliberate carelessness during drying. All the copra was carefully kiln-dried over open smokeless fires.

Two methods of storage were used, the period of storage being two months in each case. In one, Trial " A ", the six lots of copra were sent immediately after manufacture for bulk storage in a Singapore warehouse with copra of corresponding qualities (continuous warm storage). In the other, Trial " B ", there was an initial period of fourteen days during which the six lots of copra were kept in a cool place as individual isolated bags (cool-storage). Subsequently this copra was warehoused as in the first trial.

It was not possible in either of these trials to simulate exactly the handling and movement, and the conditions of temperature and pressure to which copra is normally subjected during local trading, warehousing and ocean shipment. The conditions of the first trial may nevertheless be considered roughly to correspond to the treatment accorded to the copra from large producers, while those of the second trial are meant to simulate the treatment accorded to the copra made by small producers, amounting to about two-thirds of the total copra produced in Malaya.

The various lots of copra were each examined, weighed and sampled before, during, and after storage. These samples were analysed for moisture, and the acidity of the contained oil was also determined. At the conclusion of the period of storage, the amount of " smalls " and dust associated with each lot, which in practice is reckoned as copra, was also ascertained and the copra was examined qualitatively by a Singapore merchant.

Thus it was possible to estimate the true loss of copra which occurs during storage and to measure the amount of deterioration under the various conditions stated.

The comparative results of the two trials are shown in Tables III. to IX. inclusive—

TABLE III.

TOTAL LOSS IN WEIGHT DURING STORAGE. (WEIGHT CORRECT TO NEAREST ¼ LB.)

Lot.	Trial A. Continuous Warm Storage.			Trial B. Cool and Warm Storage.		
	Original Weight.	Loss in Weight.	Loss.	Original Weight.	Loss in Weight.	Loss.
	lb.	lb.	Per cent.	lb.	lb.	Per cent.
W1	63.75	1.50	2.3	56.25	3.25	5.8
W2	68.75	5.50	8.0	64.25	6.00	9.3
W3	78.75	18.75	23.8	79.75	20.50	25.7
R1	60.50	3.25	5.3	58.50	3.25	5.6
R2	67.50	6.00	8.9	64.25	10.00	15.6
R3	78.50	17.00	21.6	74.50	20.25	27.2

The total loss in weight in storage includes not only loss of free moisture, but also loss of actual dry copra through decomposition. The loss is expressed as a percentage of the original weight of copra, including contained moisture. It is to be noted that in the transportation of "raw" copra (W3 and R3) about a fifth by weight of the consignment consists of avoidable moisture, thus increasing freight costs.

The final moisture content of the copra after warehouse drying was between 4 and 5 per cent. in all cases.

TABLE IV.

LOSS OF ACTUAL COPRA DURING PREPARATION AND STORAGE. (WEIGHT CORRECT TO NEAREST ¼ LB.)

Lot.	Trial A. Continuous Warm Storage.				Trial B. Cool and Warm Storage.				
	Original Dry Weight.*	Preparation Loss.	Storage Loss.	Total Loss.	Original Dry Weight.*	Preparation Loss.	Cool Storage.	Warm Storage.	Total Loss.
	lb.	lb.	lb.	Per cent.	lb.	lb.	lb.	lb.	Per cent.
W1 ..	59.25	N	N	N	52.00	N	0.50	1.50	3.8
W2 ..	61.75	N	1.75	2.8	56.50	N	N	1.50	2.6
W3 ..	63.25	N	6.00	9.5	65.00	N	6.75	2.25	13.9
R1 ..	55.25	1.50	0.25	3.2	55.25	1.50	2.00	1.00	8.1
R2 ..	59.25	1.50	0.25	3.0	58.25	1.50	5.25	1.25	13.7
R3 ..	61.25	1.50	2.50	6.5	58.50	1.50	5.25	2.00	15.0

N = nil or negligible.

* The figures in these two columns were determined by converting the actual weight of each lot according to its moisture content.

It is perhaps surprising that lot W3 ("Raw" white copra) Trial A showed a greater loss than lot R3 ("Raw" red copra) of the same trial. It was also more rank and infested by insects. This is doubtless because smoke adheres readily to the surface of slimy "red" copra and this film of smoke serves to provide a temporary check to insect attack and bacterial deterioration during the short period before warehouse-drying. Where there is prolonged cool storage before warehousing, as in Trial B, the agents of deterioration are able to operate freely once the protective smoky film has been broken down and penetrated.

The high spoilage for lots W3 and R3 of Trial B is not exceptional. Such extensive deterioration and breakdown can and do occur in practice.

In the extreme, with abnormally prolonged storage of deteriorated "raw" copra, maintained continuously in a wet condition, it is even possible for the loss to be in the neighbourhood of 99 per cent., since long-sustained insect attack and progressive decay due to moisture produced during decomposition may leave only fragments of brown testa, or skin.

Attention is next drawn in Table V. to the high production of "smalls" resulting from the storage of "raw" copra in Trial B. Individual pieces of copra were so deeply corroded as a result of deterioration during the period of cool storage that they readily broke down when pressure was applied to the copra or if the copra was disturbed.

TABLE V.

REDUCTION OF COPRA TO "SMALLS" AND "DUST".

Lot.	Trial A. Continuous Warm Storage.				Trial B. Cool and Warm Storage.			
	Original Dry Weight.	"Smalls."	"Dust."	Percentage Spoilage.	Original Dry Weight.	"Smalls."	"Dust."	Percentage Spoilage.
	lb.	lb.	lb.		lb.	lb.	lb.	
W1 ..	59.25	N	N	N	52.00	0.75	N	1.4
W2 ..	61.75	0.25	N	0.4	56.50	0.75	0.25	1.8
W3 ..	63.25	0.75	0.25	1.6	65.00	10.25	0.75	16.9
R1 ..	55.25	N	N	N	55.25	1.00	N	1.8
R2 ..	59.25	N	N	N	58.25	0.50	0.25	1.3
R3 ..	61.25	0.75	0.25	1.6	58.50	11.75	0.75	21.3

In Malaya any "smalls" and "dust" are included and sold as copra, but their presence in any quantity is a serious matter to the miller. Seriously deteriorated copra will suffer further size reduction during shipment and transport to the oil mills, so that a larger surface is exposed to the agents of deterioration and losses of small pieces and dust will occur when the material is transported loose in conveyors.

It is to be observed from Table VI. that the development of acidity is not serious during the period of cool storage when the loss of copra is greatest (W3, R1, R2, and R3 of Trial B). Samples W3 in both trials had a revoltingly sour smell.

TABLE VI.

ACIDITY OF OIL IN STORED COPRA. (CALCULATED AS LAURIC ACID.)

Lot.	Trial A.	Trial B.	
	After 2 months' Warm Storage.	After Cool Storage Only.	After Cool and Warm Storage.
	Per cent.	Per cent.	Per cent.
W1	0.17	0.11	0.30
W2	0.22	0.16	0.32
W3	2.61	0.81	3.11
R1	0.25	0.17	0.47
R2	0.58	0.15	0.39
R3	2.20	0.40	6.12

Table VII. gives the average depth of discoloration in the stored samples of copra. Actually the extent of deterioration varied considerably from piece to piece. Some pieces showed only localized deterioration whereas in others discoloration was complete.

TABLE VII.

AVERAGE EXTENT OF DISCOLORATION IN COPRA ON STORAGE.

Lot.	Trial A.	Trial B.
W1	All white	One-third
W2	One-third	One-half
W3	Three-quarters ..	Total
R1	One-sixth	One-third
R2	One-quarter	One-half
R3	Three-quarters ..	Total

The six lots of stored copra were inspected by a leading exporter and the results of this examination are given in Table VIII. It will be seen that the various lots were classified with respect to the export grades Straits f.m.s. and Straits f.m. as is the case with all copra after it has been stored and when it is ready for blending.

TABLE VIII.

EFFECT OF STORAGE ON QUALITY OF COPRA.

Lot.	Quality of Copra after Storage.	
	Trial A. Continuous Warm Storage.	Trial B. Cool and Warm Storage.
W1	Straits f.m.s. ++	Straits f.m.s.
W2	Straits f.m.s. +	Straits f.m.s.
W3	Straits f.m. +	Straits f.m. —
R1	Straits f.m.s.	Straits f.m. ++
R2	Straits f.m. +	Straits f.m. +
R3	Straits f.m.	Straits f.m. —

The ratings above and below the recognized export standards indicate to what extent each parcel needed to be blended with inferior or superior copra before export. Two plus and one plus mean "well above" and "above" respectively, while a minus indicates that a consignment is below the export standard for the specified quality. It will be noted that with only one exception, viz., lot R2, each lot from Trial A is superior to the corresponding lot from Trial B.

Sub-grade copra, i.e., f.m. — can easily be recognized when the copra is purchased from the dealer and so can be and is usually penalized, but parcels of copra which may ultimately prove to be superior to the two recognized export grades receive no special premium above the recognized quotation, although they have an added value when the various parcels are being blended for shipment.

Finally, Table IX. gives the comparative values of the various types of copra derived from the same theoretical amounts of fresh coco-nut meat. The necessary calculations were based on the losses of actual copra as scheduled in Table IV., the ultimate quality of the material (whether f.m.s., f.m. or sub-grade), and the following prices of copra per picul*:—

	Per picul. $
Estate copra, shipped direct ..	3.40
Straits f.m.s. ..	3.30
Straits f.m. copra ..	3.00
Sub-grade copra ..	2.70

TABLE IX.

RELATIVE MARKET VALUES OF PRODUCE OBTAINED FROM THE SAME THEORETICAL WEIGHT OF COCO-NUT MEAT.

Lot.	Trial A. Continuous Warm Storage.			Trial B. Cool and Warm Storage.		
	Final Dry Weight.	Price of Copra per picul.	Value of Copra.	Final Dry Weight.	Price of Copra per picul.	Value of Copra.
	Piculs.	$	$	Piculs.	$	$
W1 ..	100	3.40	340.00	96.2	3.30	318.00
W2 ..	97.2	3.30	321.00	97.4	3.30	321.00
W3 ..	90.5	3.00	271.50	86.1	2.70	232.00
R1 ..	96.8	3.30	319.00	91.9	3.00	275.70
R2 ..	97.0	3.00	291.00	86.3	3.00	258.90
R3 ..	93.5	3.00	280.50	85.0	2.70	229.00

The figures show clearly the extent to which deterioration can affect the value of the copra. Thus in the case of Trial B, lots W3 and R3, the value of the copra is only about two-thirds that of the highest grade.

Conclusions.

(i) Copra is subject to loss and deterioration during storage and transport, unless properly prepared and promptly warehoused.

(ii) Such deterioration proceeds most rapidly at air temperatures and is reduced or checked at higher temperatures and temporarily by a film of smoke on the surface of the product.

(iii) Loss and deterioration are very considerable in the case of "raw" half-dried copra if there is delay before it is suitably bulk stored.

(iv) When there is serious deterioration, the individual pieces of copra readily break down to yield "smalls" and "dust".

* 1 picul = 133–136 lb.—Ed.

Discussion.

Since the foregoing investigations reveal that half-cured copra is such an unstable and unsatisfactory product, it may seem strange that well in excess of half the world's copra is produced in this condition while, here in Malaya, much of the imported copra and some even of the copra produced in this country still continues to be of this quality. It is an unfortunate fact that such copra has a trade value and so is saleable. It offers peculiar opportunities for profit-making to the small dealer which are not realizable with a more stable and reliable copra. Where all producers offer the same low grade of product, they cannot readily appreciate that they are not obtaining the maximum return from their palms.

It is not appreciated sufficiently, if at all, that not only are deterioration, previous to, during, and immediately after production, and the moisture content taken into account in the prices paid by local traders for "mixed" copra but also that the ruling or basic price, paid in any one district, is a reflection of the ultimate general quality of the copra from that particular district, and includes adequate compensation to the dealer to discount all loss and deterioration which normally occur with such copra during transport and storage subsequent to production.

Small dealers have never been found willing to encourage the production of a stable and reliable product as they claim that small lots of such copra are of little use to them. In those districts where a market for low-grade "raw" copra is firmly established it is therefore quite useless for an individual small producer to make drier and better copra, since he then obtains less copra, which is nearly always paid for only at the current local price. The most he can ever expect in return for his extra trouble is a price strictly proportionate to the reduction in moisture, but this allows no extra profit whatever for improved appearance and quality.

The best copra is usually made and the best local prices are paid in the immediate neighbourhood of the export centres and the oil mills. This is because little time normally elapses between production and storage in bulk, and thus any "raw" copra which may be produced will not seriously deteriorate subsequent to sale. It is thus possible for a high standard of quality to be established, and in such circumstances low-grade copra is exceptional and is likely to be penalized if offered.

The worst copra is usually produced in the more inaccessible regions whence parcels can be shipped only at irregular or long intervals, with consequent long delay before bulk storage. Despite the desirability of producing only dry copra in such regions, there is here, as elsewhere, an unfortunate natural tendency for the quality of copra produced to decline during periods of low or falling prices, particularly the latter, since drying is then liable to be curtailed so as to obtain a greater weight of copra or to make a quick sale while prices are still high.

This is a trend which it is not easy to reverse for it is not reasonable to expect individual producers to lose money by producing copra which is above the local standard of quality and dryness. It is frequently stated that producers are apathetic but it would be more correct to say they are helpless in the face of existing trading conditions.

INSECTS ASSOCIATED WITH THE COCO-NUT PALM.

(By J. L. Froggatt, B.Sc., Entomologist, and B. A. O'Connor, B.A., B.Sc.Ag., Assistant Entomologist, Department of Agriculture, Rabaul.)

INTRODUCTION.

In this and subsequent articles it is intended to deal with all insects which have been found in direct association with the coco-nut palm in this Territory. Much of the information has been given in previous articles, but now all available data, including sections that have not been previously published, are gathered together in this series.

Some of the insects listed are of considerable economic importance, while others are only of such status for a relatively short period during the growth of the palm, or, in some cases, the insects apparently do little or no damage, although found commonly on the palm.

A full account of the research work carried out on the problem of the "Coco-nut Tree-hoppers", *Sexava* spp., over the period 1930-38 is now presented, and as this insect is the most serious pest of coco-nuts in this Territory, it will be considered first.

In the following list of insects found in association with the coco-nut palm, the species are grouped in accordance with that portion of the palm with which they are associated:—

INSECTS ASSOCIATED WITH THE COCO-NUT PALM IN THE TERRITORY OF NEW GUINEA.

Foliage and Mid-rib of Fronds—

ORTHOPTERA ..	*Tettigoniidae* ..	*Sexava novae-guineae*, Branes. *Sexava nubila*, St.
	Gryllidae ..	*Cardiodactylus novae-guineae*, Haan.
COLEOPTERA ..	*Hispidae* ..	*Promecotheca papuana*, Csiki. *Brontispa froggatti*, Sharp. *Brontispa simmondsi*, Mlk. *Brontispa longissima*, Gestro. *Oxycephala papuana*, Gerst.
	Curculionidae ..	*Rhabdocnemis obscura*, Boisd. *Diocalandra frumenti*, F.
RHYNCOTA ..	*Coccidae* ..	*Aspidiotus destructor*, Sign. *Mytilaspis* sp. *Chionaspis* sp.
	Aleyrodidae ..	*Aleurodicus destructor*, Mackie. *Aleurocanthus cocois*, Cork.
LEPIDOPTERA ..	*Hesperidae* ..	*Telicota bambusae*, Moore.
	Lyonetiidae ..	*Decadarchis ophiocypha*, Meyr. *Opogona Taochroa*, Meyr. *Erecthias flavistriata*, Wals

Spathe—

RHYNCOTA ..	*Pentatomidae* ..	*Axiagastus campbelli*, Dist.
LEPIDOPTERA ..	*Pyralidae* ..	*Tirathaba rufivena*, Walk.
COLEOPTERA ..	*Dynastidae* ..	*Xylotrupes gideon*, L. *Scapanes grossepunctatus*, Sternb.
	Curculionidae ..	*Meredolus cocotis*, Mshll. *Barystethus cleutsi*, Heller.
	Cetonidae ..	*Lomaptera batchiana*, Thoms. *Panglaphyra nigerrima*, Voll. *Panglaphyra douboulari*, Thoms. *Poecilopharis emilia*, White. *Ischiopsopha wallacei*, Thoms.
	Lucanidae ..	*Eurytrachelus egregius*, Moll. *Metopodontus bison*, Ol. *Cyclommatus speciosus*, Boid. *Dorcus intermedius*, Gestro.
HYMENOPTERA ..	*Apidae* ..	*Halticus* sp. on blossom.
	Formicidae ..	*Oecophylla smaragdina virescens*, F. in head of palm.

Trunk, Head of Palm and Bole—

COLEOPTERA ..	*Dynastidae* ..	*Xylotrupes gideon*, L. *Scapanes grossepunctatus*, Sternb. *Trichogomphus semmilinki*, Rits. *Papuana laevipennis*, Arr. *Oryctoderus nanus*, Arr.
	Curculionidae	*Rhyncophorus papuanus*, Kirsch. *Rhyncophorus schach*, F. *Sparganobasis subcruciata*, Mshll.

The major pests in the insects listed above are—

Foliage—

Sexava novae-guineae, Brancs.
Sexava nubila, St.
Promecotheca papuana, Csiki.
Brontispa spp.

Trunk, &c.—

Rhyncophorus spp.
Papuana laevipennis, Arr.
Sparganobasis subcruciata, Mshll.
Xylotrupes gideon, L.
Scapenes grossepunctatus, Sternb.
Trichogomphus semmilinki, Rits.

SEXAVA SPP. (COCO-NUT TREE-HOPPERS).

Outside the Territory of New Guinea, the only record of *Sexava* as an economic pest is in that portion of the Netherlands East Indies, bounded by the coast of Dutch New Guinea, the Aroe Islands, Amboina, Boeroe, Soela Islands, Halmahera and Talaud Islands; the species recorded are *S. nubila* and *S. coriacea*. There are portions of this area in which the pest seldom, if ever, assumes serious proportions, and there are others in which it is of definite economic importance. Even in the worst infested areas there is a period of severe attack followed by a period of very slight activity.

In the Territory of New Guinea, *Sexava* spp. are fairly generally distributed, with the exception of the Kieta District (the northern end of the Solomon Island group), where they are as yet unknown. In some districts, or even portions of districts, they are always present to a slight extent, but seldom, if ever, cause any material damage to the palms, while there are others in which they periodically cause severe defoliation, resulting in loss of production for one and a half to two years. It must, however, be stated that in the latter cases, when the palms do recover and come into bearing again, the crops carried are very heavy ones; unfortunately, there are no figures available to compare the actual loss of production during the infested period with the increased crop after recovery.

As a general rule, the records show that *Sexava* infestation is always worst, and of most frequent occurrence, in areas in which no regular dry period occurs during the year, this factor causing desiccation of eggs and also very adversely affecting the first instar nymphs in particular.

In the Territory of New Guinea two species are recorded, *Sexava nubila*, St. and *Sexava novae-guineae*, Brancs., the former occurring on New Ireland, New Britain and in the Madang District and New Hanover areas, and the latter in the Manus District and on New Hanover.

The adults and nymphs are essentially arboreal in habit, living in the head of palms, where they shelter on the undersurface of the pinnae of the fronds during the day; they are able to cling very firmly to the foliage, but are often dislodged by high winds. Feeding usually occurs at night, but on dull days it may be observed during the afternoon.

In 1931 detailed field research was instituted into the problem of *Sexava* on coco-nuts with the appointment of an Assistant Entomologist, who was first stationed in the Manus District, the worst infested "hopper" district in the Territory; the field laboratory was later moved to New Hanover, then to the Arawe District of New Britain, and finally back to Manus.

In 1933 the senior author was sent to Amboina, in the Netherlands East Indies, where three egg parasites of *Sexava* spp. had been recorded by Dr. Leefmans. These parasites were *Leefmansia bicolor*, Waterst., *Doirania leefmansi*, Waterst., and *Ooletrastichus dubius*, Waterst. The first of these had been reported by Leefmans as being the most promising, and a satisfactorily large colony of it and a smaller one of *D. leefmansi* were bred in Amboina, and successfully brought by direct transport to Manus, where breeding and study of life-history, &c., was immediately begun. At this time, the only egg parasite of *Sexava* known in this Territory was *Doirania leefmansi*, Waterst., which had been bred from eggs collected on New Hanover by the senior author in 1930.

The rate of increase of population of *Sexava* in any area, is relatively slow, as shown by the very long life cycle and manner of breeding. This insect never occurs as a huge swarm in a similar manner to the locust plagues in many parts of the world. On one plantation kept under regular observation for more than twelve months, there was a heavy infestation in April at one end of the plantation, and by November of the same year, the pest had spread over a considerable portion of the whole area, but had nowhere become serious, while the portion at first severely attacked was then showing definite signs of decrease in activity of the pest, new foliage on the palms showing little or no signs of feeding.

Life-history and Habits.

The Egg.

The eggs are always deposited singly, although several may be found close together, as though laid in succession by the one female; they lie, micropilar (head) end upwards, just under the soil surface or to a depth of half an inch. When freshly deposited, they are a deep biscuit colour with flattened sides; the colour deepens to dark brown and the sides swell out as development proceeds. The eggs at first measure about 9 mm. in length, increasing to 11 mm. before maturity. In some parts, there are considerable numbers of eggs deposited in the fibre in the crown of the palms, and in the epiphytic growths on the trunks of the palms; this is most prevalent on New Hanover, and to a slightly less extent in the Manus District. When the infestation is severe, eggs may also be found in the rotting bases of fronds, in coco-nut skins, rotten logs and amongst palm roots lying above ground at the base of the palms.

In the plantations, oviposition apparently always takes place at night, but where the insects are caged up in the laboratory, this act may occur during the day. In the field, the sites most favoured for deposition of eggs are bare surfaces of moist, loosely compacted sandy soil, dry ground being avoided. The orientation of the egg in relation to the surface of the ground does not necessarily affect the emergence of the baby "hoppers".

The period for the eggs to reach maturity shows considerable variation, ranging from 45 to more than 100 days, although the majority of nymphs emerge in 45 to 60 days from deposition. From a large series of observation, the average number of eggs laid by a single female in her lifetime has been 30, while as many as 49 have been recorded.

With eggs laid in cages, the percentage of fertility (determined by dissection) has been about 91, with a percentage of hatching of 69 to 86; eggs collected in the field over the same period gave percentage of fertility about 76, and the hatching percentage about 74.

The eggs can withstand a very wide range of abnormal conditions without entirely losing their fertility. Eggs were kept in very dry soil for 110 days, and then the soil was moistened; within ten days after watering, approximately 40 per cent. of the eggs yielded normal nymphs. In plantations, however, where not only dryness but heating of the soil occurs a much heavier mortality by desiccation is found to take place. Eggs kept in moisture saturated, but drained, soil, gave a normal percentage of hatching.

Eggs laid by the one female on the same night usually mature at about the same time, but those laid on different, even successive nights, show wide variations in reaching maturity.

In order to determine the danger of dispersion of the pest by birds, feeding on female "hoppers" with mature eggs in the ovaries and passing these in the faeces, a number of dissections were made, and eggs apparently ready for deposition were incubated in the ordinary way, using others separated from soil in breeding cages as controls; in no case was a single nymph bred from the former.

The Nymphs.

When the egg reaches maturity, the shell splits along the dorsal ridge for about one third of its length, and then at right angles to this line for about two-thirds of the circumference, thus freeing the vermiform larva, which pushes its way to the surface and sheds its skin; these may be seen on the surface of the soil in emergence jars in the laboratory, although not so readily noticed in the field. The nymphal moult then takes place immediately. The head and thorax are freed first, and by twitching of the legs and body the nymphal skin is gradually cast off backwards; the antennae may still be contained in their sheath at this stage, but these are freed by the insect passing them slowly through the mouth parts by bending the head downwards and then backwards; this portion of the operation occupies about three minutes. The antennae are at first flaccid, but within one minute of being freed, they harden and are capable of normal movement. The full emergence occupies about five minutes. Emergence normally takes place in the early evening, the nymphs commencing the ascent of the palms the same night.

Development of the nymphal stages takes place by a series of moults of which there are six or, in some cases, seven, in the males, and seven in the females; the act of moulting always occurs at night. Two types of male nymphs were observed during the research work carried out at Manus, one having six instars, and the other seven; the former have been called "micropterous" and the latter "macropterous". The macropterous males, in the fifth instar, develop wings and elytra which reach back over the third abdominal tergite, the elytra being superimposed on the wings. The micropterous males, in the fifth instar, only have small wing-buds which do not reach back over the abdominal tergites, and which are situated one in front of the other. In the sixth instar, the micropterous type attains a development similar to that reached by the macropterous type in the fifth instar while the latter type develops much larger wings and elytra, and corresponds to the sixth instar of the nymphs noted on New Hanover.

The average duration of the instars observed at Manus are given in the following table:—

——	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Total Length Range.	Average.
Macropterous male ..	13.8	13.3	11.5	13.0	14.2	17.7	..	78– 91	83.5
Micropterous male ..	13.8	13.3	11.5	13.0	13.1	14.1	18.1	91–117	96.0
Female	13.8	13.3	11.5	13.0	14.5	15.4	19.4	90–124	100.9

It has been noticed that the numbers of nymphs caught by adhesive bands is much greater for the first two or three nights after rain, and it appears probable that climatic conditions play a considerable part in regulating the rate of emergence of the nymphs from the eggs.

The following description of the various instars, prepared by Mr. N. E. H. Caldwell, B.Sc., formerly Assistant Entomologist in this Department, has proved a satisfactory key for the differentiation of the instars, with the addition of the modification for the macropterous male nymphs given above:—

Males—

1st. Wing rudiments. A very slight differentiation of the sides of the meso- and meta- thorax is discernible.
Genitalia. The hypandrium may be seen as two small buds on the ninth abdominal segment.

2nd. Wing rudiments. Quite easily distinguishable, the elytra being pointed and narrow, and the wings being much broader and still rounded at the tip. Both at right angles to the longitudinal axis of the body.
Genitalia. The hypandrium now takes the form of two prongs directed straight back, with little or no basal portion.

3rd. Wing rudiments. The wings are now pointed, the elytra slightly curved and both slanting slightly backwards, thus making the anterior margins longer than the posterior. There may be a trace of venation on the anal area of the wing.
Genitalia. The hypandrium now definitely consists of a basal portion and a bifurcated portion, of about equal length, the whole reaching about half way along the paraprocts, and with the points of the bifurcated portion incurved.

4th. Wing rudiments. Both wings and elytra now slanting backward markedly. The elytra are decidedly curved, and there may be one or two raised lines thereon. The wings now somewhat longer than the elytra, and the venation is quite distinct in the anal area.
Genitalia. The points of the hypandrium are strongly incurved, and the whole reaches to the divergence of the paraprocts or beyond.

5th. Wing rudiments. The rudiments are now lying along the back, the wings overlying the elytra and both reaching to about a third of the way along the second abdominal segment. Longitudinal veins well developed on the wings, but no cross veins, only two or three longitudinal on the elytra and cross veins can be seen on holding up to the light.
Genitalia. Hypandrium reaches back beyond the paraprocts, and as far back as the cerci.

6th. Wing rudiments. The wings occupy the same relative positions, are considerably increased in size and extend back to at least the end of the third abdominal segment. Both longitudinal and cross venation well developed.
Genitalia. The hypandrium now extends beyond the end of the body and two short styles have appeared, one on the end of each prong of the bifurcated portion.

Females—

1st. Wing rudiments. The same as in the male of the same stage.
Genitalia. Two pairs of buds can be distinguished, one on the eighth and one on the ninth abdominal segments. Under high magnification, the posterior pair resolve into pairs.

2nd. Wing rudiments. The same as in the second male stage, except that the wings are still rounded.
Genitalia. The valves of the ovipositor have increased considerably in size. The lateral and posterior valves can now be distinguished closely appressed in pairs. All valves are the same length, but the anterior pair reach only to the base of the others.

3rd. Wing rudiments. Both pointed, but the elytra not curved, both slanting slightly backward. No venation.
Genitalia. Another marked increase in size, the lateral and posterior valves being more clearly distinguishable, but still closely appressed, while the anterior pair are relatively slightly longer.

4th. Wing rudiments. Both rudiments slanting backward, the elytra somewhat curved, and there is a suggestion of venation on the anal area of the wings.
Genitalia. All the valves are about the same length and closely appressed to each other thus forming a compact organ, which is about one tenth of an inch long, and reaching to the end of the paraprocts.

5th. Wing rudiments. The elytra markedly curved, slightly shorter than the wings, clearly-visible venation on the anal portion of the wings.
Genitalia. The ovipositor had doubled its length and now reaches to about the end of the body.

6th. Wing rudiments. The rudiments are now lying along the back and corresponding to the fifth male stage.
Genitalia. The ovipositor is now about half an inch long, and extends for a considerable distance beyond the body.

7th. Wing rudiments. These are in the same position as in the sixth male stage.
Genitalia. The ovipositor is now an inch or slightly more in length.

One of us (B.A.O'C.) has worked out a further means of separation of the various instars by measuring the hind tibiae, as per the appended table.

IDENTIFICATION OF INSTARS BY MEASUREMENT OF HIND TIBIAE.

(Measurements in 1/40th".)

Instar.	Males.		Females.	
	Range.	Average.	Range.	Average.
First	13–14	13.3	13–14	13.3
Second	17–18	17.5	16–18	17
Third	21–25	21.7	20–22	21.4
Fourth	26–31	27.3	24–27	26.1
Fifth	34–37	35.3	31–35	33.1
Sixth	42–48	44.7	38–44	41.3
Seventh	..	..	48–55	41.3
Adult	55–67	60.5	66–75	70.8

The nymphs, when newly hatched, are always a deep green, but the colour lightens in the second instar; there is usually little or no subsequent change in colour of the other nymphal stages, although it becomes somewhat lighter in tint before moulting. There is a brown variant not uncommonly found but it is not usually abundant; this usually has a plum coloured tinge, the full brown colour not being assumed until the adult stage is reached. Brown and green nymphs may emerge from the one batch of eggs.

Immediately after moulting, the nymph is definitely macrocephalic (head larger than the remainder of the body), and the body tapers down to the pointed telson; as the instar develops, the abdomen increases until just before the moult, when the head is microcephalic. The abdomen is swollen as far as the penultimate segment, which is to be expected, for the last segment bears all the external genetalis in the male, and most of them in the female, and these change in size only at moulting.

The size of the various instars, taken from a large series of measurements, is given in the following table, the measurements being in millimetres :—

Instar.	Males.	Females.
1st	10–17	10–17
2nd	16–20	17–21
3rd	21–26	22–26
4th	25–31	24–30
5th	31–39	35–38
6th	38–46	36–45
		45–53

In insectaries in Rabaul, it was observed over a period of three years that within two weeks of the dry season setting in, all first to fourth instar nymphs on the palms were killed, even although the foliage was sprayed with water.

Experiments were carried out in breeding cages to ascertain the rate of feeding of the nymphs; difficulty was experienced in keeping alive the first four instars in these trials, but figures were obtained for some of the others. Sixth instar males and seventh females, in lots of mixed sexes, ate approximately 3.3 square inches of leaf surface per individual in 24 hours; batches in which female nymphs predominated averaged 3.9 square inches, while with males predominating the amounts consumed were about the same as the first figure given.

Just before moulting, the food consumption is very much reduced, and may even cease for three days, and always for 36 hours before the moult takes place.

In tests on longevity of nymphs without food, it was found that first instar nymphs will live under such conditions for seven days, although some will be dead at the end of four days. Nymphs of the last two stages will live under such conditions for seven days, although some will be dead at the end of four days. Nymphs of the last two stages will live as long as seven days, unless they are almost ready to moult. Under such conditions they will survive longer; one specimen lived for twelve days, when it transformed into the next instar.

There is a heavy mortality in the early instars, especially in the first, which may be aggravated in the later stages of an infestation when all the older foliage has been eaten and only fronds are available. If first and second instar "hoppers" are fed on young leaves, the fuzz along the edges of the leaf apparently clogs the mandibles, and the insects will be observed attempting to clean the mouth parts with the tarsal claws. It is regularly found that if old and young foliage are put in the same cage together with *Sexava* at any stage of development of *Sexava*, that the old foliage will be consumed first, and the young left entirely, or almost entirely, untouched.

From the information already given, it is evident that the life-cycle is a long one, and may be summarized as follows :—

	Days
Egg period	49–107
Nymphal period, male	78–117
Nymphal period, female	90–124

This gives a full cycle for males of 127–224 days, and for females 168–241 days, or 18–32 weeks in the former and 24–34 weeks in the latter.

Adults.

The adult insect is, in most cases, rich green in colour with the distal margins of the wings and elytra brownish; when the wings are folded this marking forms a medium brown line along the back. Otherwise there are no prominent markings. A brown variation in colouration is not uncommonly met with, but is not usually abundant; in these cases the colour is a light chocolate brown, with no markings. These remarks hold good for the species occurring in all districts except New Hanover; most of the "hoppers" in this locality are brown in colour with the elytra marked with darker markings in an irregular pattern, while the inside of the femur of the hind legs is almost black.

The following measurements are an average of a large series:—

	mm.
Body length, male	48–57
Body length, female	57–63
Head to tip of distal extremity of folded wings, male	74–83
Head to tip of distal extremity of folded wings, female	86–92
Antennae, longest	209
Antennae, average	204
Ovipositor	31–33

Emergence of the adult usually occurs at night, the cast skin being consumed by the insect shortly after emergence is completed.

Copulation has been observed in the field shortly before sundown, but is probably most common at night. In breeding cages, females have been observed with the spermatophore attached to the genitalia as early as 5 p.m.; this has also been noticed in the case of females collected in the field between 8 and 9 a.m., but in such cases copulation could have taken place the previous night.

When about to copulate, the male ranges alongside the female, facing in the same direction, depresses the abdomen and passes it underneath that of the female. When the genitalia of both sexes are in juxtaposition, the male extrudes a gelatinous blob containing the semen (the spermatophore), and fastens it to the genitalia of the female, where it remains for a considerable time, probably 12 to 24 hours. The whole act of copulation occupies only a few seconds.

From observations made in the adults bred in captivity and kept in field breeding cages, the period from emergence of adult to copulation has been 10–12 days, while the period from copulation to first oviposition has been 21–31 days. Adults kept in these cages have given a length of life of 35–110 days (average 72.3) for males, and 28–91 days (average 67.1) for females.

The number of eggs laid by a single female in captivity has averaged 40, although as many as 52 have been counted.

Although oviposition continues throughout practically the whole lifetime of the female, the rate is greater in the earlier than in the later portion. Mating has been observed to take place a number of times during the life of the female, so that it would appear that more than one mating is required for the fertilization of successive batches of eggs.

The period covered by a complete generation, i.e., from deposition of egg to deposition of egg by the female of that generation, averages 212 days, made up as follows:—

	Days.
Egg period	78
Hatching to adult	101
Adult to oviposition	33

In night collection of "hoppers" in the plantation, it has been found from counts made of adults coming down the trunks of the palms that the percentage of females is very much greater than that of the males. This movement is, however, very largely influenced by the local climatic conditions. The number collected is always greatest on dark cloudy nights after rain, especially when the rain has fallen late in the afternoon, and is least on bright clear nights after a dry day, or on bright moonlight nights. A long series of counts has given the following percentages for males and females collected at night: males 14 (range 4–31), females 86 (range 69–96).

The proportion of the sexes has been difficult to obtain. From collections made by natives from palms in the plantation over a period of six months, the figures were males 55 per cent. and females 45 per cent. On the other hand, in conjunction with insecticidal dusting trials (*see* "Control Measures"), the *Sexava* population of a large number of palms was counted by cutting off the fronds of selected palms, lowering the fronds carefully to the ground, and there counting the number of adult and nymphal forms present in the foliage. A watch was kept for any "hoppers" that might have left the frond when being cut or lowered, any such being collected and added to the count. The proportion of the sexes of adult *Sexava* determined in this way was an average of 70 per cent. male and 30 per cent. females. On the other hand, in the counts of the nymphal forms in the above cases, the proportion of sexes was 49.5 per cent. males and 50.5 per cent. females.

In field cages with ample food, the longevity of male adults was 35 to 110 days (average 82.8), and of female adults 28 to 91 days (average 67.1). Without food the adults lived 3½ days.

The adults and nymphs require water in addition to the moisture contained in the foliage, as shown by the fact that when kept in captivity and the foliage sprayed with water, all stages were noted sucking up the droplets of water.

The powers of flight of the adults are very poor, wings used more to volplane from the head of the palms to the ground. When disturbed, they may fly from one palm to the next, but this is practically the limit of flight, and even then loss of elevation is noted. In trying to take off from the ground, it is always noted that they can only rise 2 to 3 feet and, after covering a distance of about 30 feet, they fall back again, alighting on the grass, &c.

Stridulation is not apparently entirely a sex call and although particularly strong at night, it may be heard during the day, especially when the pest population is large. Migration from one centre to another is only likely to take place when coco-nut foliage on which *Sexava* nymphs or adults are present is carried about. Fronds carried around on native canoes have been observed to carry *Sexava* in this manner, and the pest may be thus dispersed over appreciable distances.

Within the confines of a plantation movement of adults and nymphs may take place from palm to palm where fronds of adjacent palms are overlapping, or by adults descending at night from one palm and re-ascending another further away. But as it has been noted that dispersion is so slow, any such movement is probably governed more by food supply than any other factor.

Feeding mostly takes place after dark, but on dull, cloudy or rainy days, feeding may occur also during the day.

Tests have been carried out in field breeding cages to try and ascertain the quantity of leaf eaten per diem per insect; in all these tests mature coco-nut foliage was used for feeding the insects, and fresh leaves were added once or twice every 24 hours. Under these conditions, the average consumption of the adult "hoppers" per 24 hours per insect was 3 to 4 square inches of leaf tissue, i.e., about the same as for the final nymphal instars.

Although coco-nut foliage is the preferred food of *Sexava*, other plants on which the insects have been observed to feed in the field are Sago palm (*Metroxlyn sagu*), Banana (*Musa* spp.), *Pandanus* spp., Betel nut (*Areca catechu*), *Heliconia* spp., *Ravenala* spp., Nipa palm (*Nipa fruticans*). In cages the foliage of *Pennisetum macrostacium* ("karapai" in pidgin) has been fed on freely by *Sexava*.

CONTROL MEASURES.

Mechanical measures, when efficiently carried out in the initial stages of an infestation, will give a satisfactory control of the pest, but where the value per acre of the agricultural product is relatively low, costs must necessarily be closely studied, and if there is an alternative scheme of attack requiring less expenditure, such as biological measures (i.e. the utilization of parasites), it is worthy of the fullest study. Particular attention was paid to this line of research from the very beginning of the work on the *Sexava* problem.

The search for indigenous parasites resulted in finding the egg parasites, *Doirania leefmansi*, Waterst. on New Hanover in 1930. In 1932, a species of *Encyrtidae* and a species of *Trichogrammatidae*, later identified as *Leefmansia bicolor*, Waterst. var. and *Doirania leefmansi*, Waterst. were bred from *Sexava* eggs in Manus; these were apparently rare as they were only bred on a single occasion with each species. Further breeding in the Manus District showed two species of *Scelionidae*, *Prosapegus atrellus*, Dodd. and *Scelio* sp., and *Ootetrastichus dubius*, Waterst. (fam. *Eulophidae*) to be present, but only in very small numbers.

On New Hanover, the following species were later bred from *Sexava* eggs, *Doirania leefmansi*, Waterst., *Leefmansia bicolor*, Waterst. var. and a species of *Mymaridae* (genus near *Anaphes*), all occurring in appreciable numbers, and also *Prosapegus atrellus*, Dodd. and *Ootetrastichus dubius*, Waterst. occurring to a much lesser extent.

In the Arawe District of New Britain, *Prosapegus atrellus*, Dodd. and *Ootetrastichus dubius*, Waterst. were bred from *Sexava* eggs collected locally; the latter species was noted to be more plentiful in this area than elsewhere in the Territory.

On New Ireland, *P. atrellus*, Dodd. and a small species of *Mymaridae*, distinct from that bred in Manus and New Hanover, have been bred from this host, while on Lihir Island, off the east coast of New Ireland, *P. atrellus* and a species of *Eulophidae* were fairly numerous in two lots of *Sexava* eggs sent in.

From both the Rabaul and Talasea sections of New Britain, a species of *Eulophidae*, apparently identical with that from Lihir Island, has been bred on several occasions.

Of the species of parasites indigenous to the Territory of New Guinea, *D. leefmansi, Leefmansia bicolor*, the *Mymarid* from New Hanover and possibly the species of *Eulophidae* from Lihir Island have been found in sufficient numbers and of such frequency as to warrant closer study to determine their possible economic importance, and in the course of the research work, especially on New Hanover, the first three species received particular attention.

All the parasites mentioned belong to the *Hymenoptera*, a group of insects which are popularly known as "wasps", but as the general idea of what constitutes a "wasp" is that of a relatively large insect, a brief note on each of these useful insects may perhaps give the layman a more accurate appreciation of the size of such parasitic wasps.

Doirania leefmansi. Waterst. is approximately half a millimetre* in length, which to the naked eye appears as a minute dark speck: when examined with a magnifying glass it is seen to have a light-coloured thorax and a dark abdomen.

Leefmansia bicolor. Waterst. measures approximately one and a half millimetres in length, and has a reddish thorax and dark abdomen.

Mymaridae sp. (genus near *Anaphes*) measures approximately one-third of a millimetre in length, and is generally dark in colour. An interesting feature with this species is that the males are quite distinct in appearance to the females, being much more robust and wingless and with antennae of thirteen segments. The males emerge on to the surface of the host eggs, and copulate with the females as they emerge: they do not move away from the egg, and die in not more than half an hour.

Ooietrastichus dubius. Waterst. is a black insect with light-coloured legs; it measures approximately one and a half millimetres in length.

Prosapegus atrellus, Dodd. is a dark-coloured insect with reddish-brown legs; it measures approximately seven and a half millimetres in length.

All the other species referred to are less than one millimetre in length.

In the course of the research work carried out on New Hanover during July and August, 1934, a large series of dissections were made of Sexava eggs collected in: (i) the soil; (ii) the fibre in the head of the palms; and (iii) the epiphytic growths on the trunks of the palms to ascertain the relative percentage of parasitism of the indigenous parasites; the results are given in the following table:—

Sexava eggs coll. in—	Percentage of Parasitism by—					Total.
	D. leefmansi.	*L. bicolor* var.	*Mymarid* sp.	*P. atrellus.*	*O. dubius.*	
Soil	6.7	2.3	4.7	Nil	Trace	13.7
Fibre, head of palm ..	11.7	4.4	5.2	Nil	Nil	21.3
Epiphytes	16.3	6.0	3.7	.1	Nil	26.1

On only one occasion were two species found together in the one *Sexava* egg, *D. leefmansi* and *L. bicolor* larvae occurring together; it is indicated, therefore, that parasite interference did not occur between the various species.

* Note.—25 millimetres = 1 inch.

The life-cycle was worked out for four species, as below:—

D. leefmansi	39–41 days (av. 39.8)
L. bicolor var.	31–35 days (av. 33.0)
O. dubius	30–36 days (av. 33.1)
Mymarid sp.	23–25 days (av. 27.8)

With the exception of *L. bicolor,* great difficulty was experienced in breeding these parasites in the field laboratory, regulation of moisture in the breeding tubes being the main cause.

Parasites Recorded in the Netherlands East Indies.

In 1927, Dr. Leefmans recorded *Doirania leefmansi,* Waterst., *Leefmansia bicolor,* Waterst. and *Ootetrastichus dubius,* Waterst. as parasites of eggs of *Sexava nubila,* St. in Amboina.

In 1930, Dr. Reyne recorded *Prosapegus atrellus,* Dodd. and *Ootetrastichus dubius,* Waterst. as parasites of *Sexava* eggs along the coast of Dutch New Guinea; *Ootetrastichus dubius,* Waterst. from Halmahera; and *Doirania leefmansi,* Waterst. from the Banngai Islands.

D. leefmansi and *L. bicolor* were reported by Dr. Leefmans as being of economic importance as parasites of *Sexava* and, as previously stated, a small colony of the former species and a strong colony of the latter species were bred in Amboina by the Senior Author, and successfully brought to this Territory in April, 1933. Particular attention was paid to *L. bicolor* owing to the ease with which it could be bred in the laboratory, and this was commenced immediately to build up stocks for liberation in the plantations, and for distribution to other parts of the Territory. A study was also made of the binomics of the parasite under local conditions, these in most centres being markedly different from those in Amboina.

Leefmansia Bicolor.

The average life-cycle of this parasite in the field laboratory in Manus was 26 days, with a range of 24-29 days. On New Hanover, however, where the night temperatures especially were lower than in Manus, the cycle averaged 28.8 days with a range of 26-31 days.

From *Sexava* eggs parasitized in Amboina, parasites emerged in 28-29 days; this may have been influenced by the varying temperatures and the vibrations on the schooner experienced in the fourteen days' trip from Amboina to Manus.

The age of the host egg has a marked effect on the life-cycle of the parasites, as shown by the following figures of observations made in the field laboratory in Manus:—

Age of host egg in days.	Duration of life-cycle.	
	Minimum.	Maximum.
2– 3	37	49
4– 6	30	35
7–10	35	38
11–14	29	36
16–21	20	27
22–27	18	26
28–37	20	27
38–44	20	26

It is, therefore, evident that the life-cycle of the parasites is considerably prolonged when host eggs of under sixteen days old are placed in the submission jars with the parasites. Apart from the lengthening of the life-cycle, this factor does not appear to have any influence on the number of parasites emerging, their size, virility, &c.

The average longevity with feeding of the adult parasites is seven days, although some have lived for as long as fourteen days; males apparently live longer than females.

Copulation takes place within a few minutes of emergence, and continues throughout life, and oviposition commences soon after copulation. The duration of active parasitism covers several days.

Both sexes are markedly phytotropic (i.e., attracted to light), although this appears to vary according to the container in which they are confined; from a narrow tube they will move towards the light much faster than from a wide tube or a bottle. This habit can be utilized in transferring the parasites from one jar to another or into tubes for liberation of adults.

In laboratory breeding of these parasites, glass preserving jars of two-quart capacity were used for submission of the host eggs to wasps, the eggs forming a thin layer over one side of the jar lying side down; slightly diluted honey was used for food for the live insects.

The total percentage of *Sexava* eggs parasitized in the laboratory averaged 82.4 with a range of 73.7 to 91.6, of which an average of 64.5 per cent. yielded live parasites.

The average number of parasites per host egg was twenty.

In order to test the practicability of emergence of the parasites through the soil, parasitized *Sexava* eggs were buried in loose soil at various depths, and examined periodically; tanglefoot paper was placed on the surface around the sites of burial. It was found that the adults of *L. bicolor* could reach the surface through 1½ inches of loose soil.

Liberation of parasites in the field in bulk lots of host eggs was carried out by placing the eggs in small wire-gauze cages which were suspended by wire from a stake, or the fronds of young palms, in the plantation. Observations made over a long period have shown that the emergence of wasps from these field cages was much heavier than from control lots held in jars in the laboratory.

With continued liberation from laboratory stocks, *L. bicolor* became established in the field fairly readily and rapidly; in most cases, however, it failed to maintain itself after liberation from stocks had ceased. In one case of native groves in the Arawe area, this species was recovered in fair numbers, and in small numbers from a plantation in the same area three years after liberations stopped; on New Hanover this parasite has maintained itself satisfactorily for several years. It may be stated that the latter centre more closely approximates to the field conditions existing in Amboina than most other parts of the Territory where this parasite has been liberated.

With the idea of increasing the number of species of parasites liberated, and on account of the difficulty experienced in the laboratory breeding of *D. leefmansi* and the *Mymarid* sp. on New Hanover, bulk lots of *Sexava* eggs have been collected from time to time from that area, and mixed lots of them have been distributed to other centres of *Sexava* occurrence. The reason for mixing host eggs in this way was that when the junior author was stationed on New Hanover he found that the distribution of the various parasites mentioned was not regular, but that one species would be more prevalent in one or more centres than any of the others; mixing thus gives a better chance for all species to be represented in any lot of host eggs sent out.

Mechanical Measures.

In conjunction with the parasite breeding work, attention was given to other lines of attack on the problem, in order that if one line failed another could be taken up, or a combined scheme of two or more lines might be undertaken to obtain the required result.

Large numbers of adults and nymphs can be collected and destroyed by stacking the old coco-nut fronds along the rows of palms through an infested area, and lighting them from the outside rows inwards to the centre; the heat will cause most of the "hoppers" to lose their hold in the palms, and fall to the ground, as the adults have very poor powers of flight.

Collection of eggs systematically through an infested area will lead to the destruction of many potential "hoppers". Turning over the soil with hoes, or by ploughing where this is possible, so as to bury the eggs below the surface, will prevent large numbers of nymphs reaching the surface; ants, lizards, &c., will attack eggs exposed on the top of the soil during such operations.

The habit, of female adults in particular, of coming down to the ground at night to lay can be made great use of in night collections from about 7 to 9 p.m. It is possible that the use of flame-throwers or even flares made from dry fronds would obviate the hand collection of the "hoppers" without causing material damage to the trunks of the palms.

In cases of a very localized infestation, such as occurs in the initial stages of *Sexava* plague occurrence, "tanglefoot" bands may have an economic value in preventing considerable numbers of first instar nymphs from reaching the crown of the palms. Several series of tests have been carried out with two types of "tree tanglefoot", one with a resin base and the other with a wax base; the latter was quite unsuitable for the purposes required. Although the tackiness is greater when the bands are fresh, this can be "rubbed up" at intervals to break any film on the surface. Such bands made with the resin base material have remained actively tacky for two and a half months, but the initial precaution must be taken of removing any moss or other plant growth from the palm trunk before applying the "tanglefoot". The most satisfactory type of band found in the field trials was 3½ to 4 inches wide and was put on with the hand; where a piece of wood was used, the band was often too thin to last.

Tests were made with these bands to which different poisons had been added, and it was found that nymphs crossing a band of "tanglefoot" to which 10 per cent. of sodium arsenate was added showed 100 per cent. mortality in from 7 to 39 hours. With 10 per cent. mercuric chloride, all the nymphs were paralysed within five hours, and of twelve nymphs used, five were dead in 24 hours, one more in 48 hours; three lived for 72 hours and one for 96 hours, which is approximately the longest period nymphs can live without food. With sodium fluoride, there was 25 per cent. mortality in 24 hours, and 65 per cent. in 48 hours, while all were dead in 72 hours. Paris green gave a mortality of 35 per cent. in 24 hours and 50 per cent. in 48 hours.

An attempt was made to kill the "hoppers" by means of the standard locust bait, composed of Paris green, bran, sodium arsenate, molasses and lemons; this was scattered both in the head of the palms and around the base on the ground, but there was no evidence to show that the insects fed on it at all.

Insecticides Applied to the Palms.

In order to test out the use of insecticides applied tó the coco-nut palm foliage, small coco-nut palms were sprayed with arsenate of lead at the usual strength, and the leaves placed in observation cages with adult and nymphal *Sexava*. It was found that feeding ceased after the first night and 100 per cent. were dead within three days. This proved to be toxic eight days after spraying, even although 147 points of rain had fallen in the interim.

Spraying of coco-nut palms on a plantation presents the great difficulty of obtaining an adequate supply of soft water; even in cases where water is available, the cartage would generally be an appreciable cost. Owing to the height of the palm, a high-powered spray plant would be required with some means of traction, which would be expensive.

The application of the insecticide as a dry dust obviates the need of water, and the plant required is much lower in cost than a spraying outfit for the same purpose.

A dusting machine powered with a 6 h.p. petrol engine was purchased by the administration, and tests were first made in the laboratory in wire-gauze cages to determine the most suitable insecticide for field trials.

The dusts experimented with comprised various proprietary preparations and also straight dusts with arsenate of lead, calcium arsenate, Paris green and derris as the toxic constituents.

The cages used were made of copra-bed wire and were 3 feet high and 2 feet in diameter: coco-nut leaves were suspended in the cages with the "hoppers" and dusted. Fresh foliage was added after one night's feeding, and the relative toxicity of the dust was reckoned in the number of "hoppers" killed in three days.

Derris dusts were very irregular in results—a dust which would give a high degree of mortality on one occasion would give a very poor result on another. The arsenicals, on the other hand, gave a consistently high mortality. Paris green was found, in later trials, to scald the foliage, and was, therefore, eliminated from the trials. Both arsenate of lead and calcium arsenate gave highly satisfactory results in field trials, but the latter appeared to possess one advantage, that it had a delayed action in killing the "hoppers" that was not found with the former. One brand showed itself superior in power of adhesion to the leaf.

From the results obtained, it is evident that dusting would require to be done twice, with an interval of about three months between treatments, in order to obtain effective control.

Owing to the very smooth surface of the leaf of the coco-nut palm, adhesion of most dusts is poor, although there is a definite layer left on the upper surface of the leaves. In an endeavour to improve the adhesion of the dust, various fillers were tested, mostly of a "kaolin clay" nature; one proprietary preparation of this type showed particular promise, especially when dusted over foliage on which the night dew was still present.

In later field trials, it was found to be possible to dust two rows of palms together with satisfactory results; this naturally presents a considerable saving in time and material.

From the field trials, it is definitely proved that calcium arsenate dust will kill practically 100 per cent. of the *Sexava* in the palms provided that there is 24 or preferably 48 hours without rain after application of the insecticide.

Other Natural Enemies.

Crows (*Corvus orru*), white-headed hawk (*Accipiter* sp.), "Willie Wagtail" (*Rhipidura tricolor*), Kingfisher (*Halcyon sanctus*) and various lizards have been observed feeding on *Sexava* on the palms. During a normal condition of low pest population these natural enemies probably assist in destroying a number of "hopper" nymphs and adults, but they are nowhere in sufficient numbers to be of any material benefit during heavy infestation.

"Guinea fowls" (*Numidia meleagris*) were introduced into one plantation as, owing to their insectivorous habits, it was thought they would assist in the control of *Sexava* by killing numbers of the "hoppers". The birds were under continuous observation for several months. They proved a complete failure as pest destroyers on account of their habits of rarely straying far from the bungalow, going to roost well before sundown, and not leaving their roost until well after sunrise. For these reasons they were not even as useful as domestic fowls.

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HOW TO MAKE SOAP.

Ingredients.—6 lb. clean dripping, 2 gallons water, 1 lb. caustic soda, ½ lb. resin and 3 tablespoons kerosene.

Method.—Put dripping, resin and water into a kerosene tin and boil for 15 to 30 minutes until all the fat is melted. Add kerosene and remove from the fire. Next gradually add caustic soda direct from the tin, allowing bubbles to subside between each addition. Boil gently for one or two hours and then pour into a box lined with a damp cloth. When solid, cut into bars and store in a dry place till hardened,

THE FOOD VALUE OF THE COCO-NUT.*

(By Reginald Child.)

The human or other animal requirements for satisfactory growth are air (oxygen), water and food and the food consumed must contain the following factors:—

(*a*) The major food constituents—protein, fat and carbohydrate.

(*b*) Certain mineral salts.

(*c*) Certain accessory food factors, known as vitamins.

It is the purpose of the present short article to discuss what of these essential factors the coco-nut can contribute to the diet. The products concerned are the kernel (and water) of the nut itself, and coco-nut toddy.

Coco-nut Kernel.

The kernel of the coco-nut contains all three of the major constituents: protein, fat and carbohydrate, though, as will be seen, it is not an equally good source of all of them.

In its fresh state as " wet meat ", the kernel contains a good deal of moisture, which may be reckoned to average about 45 per cent. The percentage contents of other constituents are shown in column 1 of Table I., from which it will be seen that the principal constituent is oil or fat.

Freshly scraped coco-nut meat is commonly used in Ceylon as an addition to curries and in other ways in the diet. It does not keep well, since it is readily attacked by moulds and bacteria; it is very difficult to preserve.

Since wet meat so easily goes bad, commercially it is dried to a content of about 6 per cent. of moisture, at which stage it keeps reasonably well. The product is, of course, the familiar copra. When the kernel is thus dried, i.e. moisture content reduced from about 48 per cent. to 6 per cent., the percentages of the other constituents are proportionately increased, and an average sample of Ceylon copra has the composition shown in column 2 of Table I.

Copra.

The very best white copra is consumed as food in parts of India, the demand for edible copra having somewhat increased of late years. But by far the largest proportion of commercial copra is used for the production of coco-nut oil.

As the Table I. shows, copra contains about 68 per cent. of oil (dry weight). Modern presses extract about 62–63 per cent. of oil, the balance oil being left in the poonac.

Poonac.

The residue is coco-nut cake or " poonac ". This has the composition shown in column 3 of Table I. Poonac is a valuable protein concentrate for dairy cows and fattening cattle.

* Extract from an article published in *Young Ceylon*, July–August, 1939.

By a patented process, it has been found possible to extract the protein in a pure form, which may have application for special purposes in animal and human nutrition. By a similar process it is possible to extract part of the carbohydrates, so that the three major food constituents of coco-nut kernel can be clearly summarized, and this is done in Table III. after the discussion of other products.

TABLE I.

Constituent.	1 Fresh Coco-nut Kernel (Typical sample).	2 Number 1 Copra (Average sample).	3 Poonac or Press Cake (Average sample).
	Per cent.	Per cent.	Per cent.
Moisture	48.0	6.8	9.8
Oil	35.5	63.7	8.1
Protein	4.3	7.6	21.0
Crude Fibre	2.1	3.8	10.5
Ash (Mineral constituents)	1.1	2.0	5.5
Nitrogen-free extract (Carbohydrates, &c.)	9.0	16.1	45.1

Desiccated Coco-nut.

The wet meat is also dried in another process to produce desiccated coco-nut for human consumption. The brown parings or skin is removed in this case and the drying is more severe, good desiccated coco-nut when fresh containing 1 to 2 per cent. of moisture.

Desiccated coco-nut has about the same composition as copra, except for this lower moisture content. Since also the parings contain less oil than the rest of the nut, the oil content of the desiccated coco-nut is slightly higher than that of copra and may be between 70 and 72 per cent.

Coco-nut Flour.

When desiccated coco-nut is pressed there is obtained about 65 per cent. of pure white oil. The residue which corresponds to poonac from copra, can be ground and forms a coco-nut flour, which has been put on the market. The following table shows its composition in comparison with wheat flour :—

TABLE II.

Constituent.	Wheat Flour.		Coco-nut Flour
	Minimum.	Maximum.	(Typical sample).
Moisture	9.0	15.0	5.7
Ether extract (fat) ..	0.5	2.0	7.2
Protein (Nx 6.25) ..	8.0	15.0 (Av. 12.0)	20.4
Ash	0.3	0.8	5.4
Fibre	0.1	1.0	9.2

As will be seen, its composition resembles that of poonac.

Parings.

It is not necessary to say much in this article about parings. The dry parings are pressed to give parings oil, which differs slightly in composition from ordinary coco-nut oil and is mostly used for soap making.

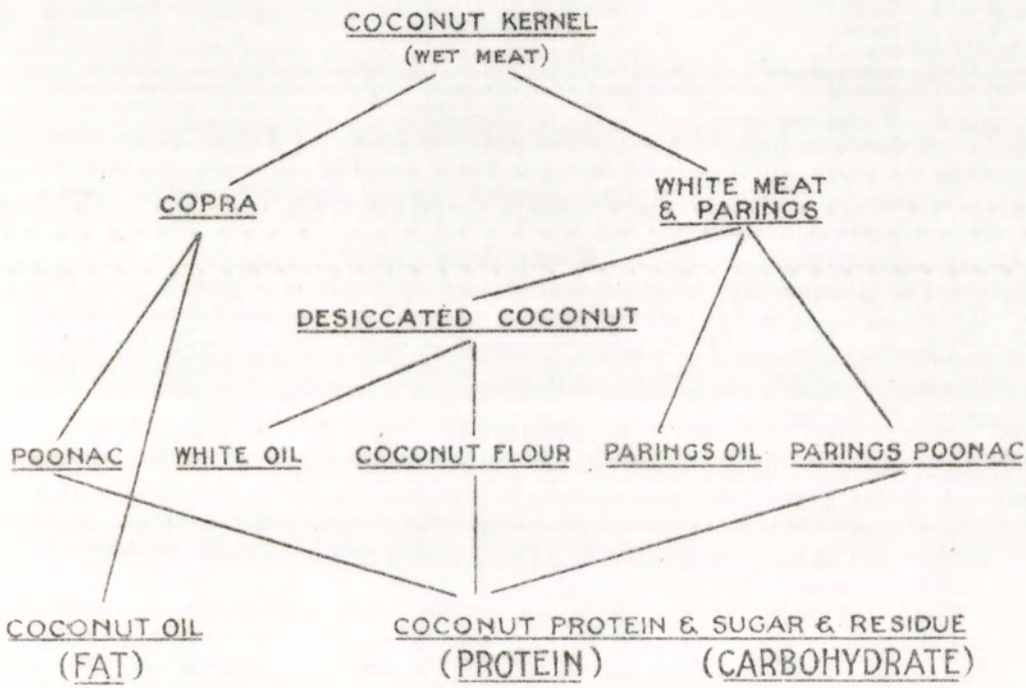
The parings poonac has about the same composition as ordinary poonac, but there is some evidence that its vitamin content is higher and it is now largely preferred in Ceylon for cattle feeding.

Coco-nut Oil.

The coco-nut's highest contribution to animal and human nutrition is oil or fat. It is not the intention of this article to give highly technical details, but it must be mentioned here that coco-nut oil has been found to be the most readily digested of all the edible fats in general use in the world, and it is likely that margarine made from this oil is more readily digested even than butter.

Summary of products of coco-nut kernel. The foregoing may be summarized in tabular form—

TABLE III.



Coco-nut Protein

Protein is not a single chemical substance. Proteins from various sources vary considerably in their ultimate composition, animal protein being usually of a different type from plant protein. Certain proteins even if consumed in large quantities are not capable of supporting an animal in health, and in general it may be said that a mixed diet is likely to be better than a single source of protein.

The biologist distinguishes between "good" and "poor" protein. Unlike a number of plant proteins (such as those of maize and barley), that of the coco-nut is fairly satisfactory, and work in America in 1919 and onwards has shown that the globulin (a protein form) of the coco-nut produces normal growth when used as the sole source of protein in an otherwise complete diet. In connexion with animal feeding it was found that poonac furnishes the necessary protein for growth at almost a normal rate.

Carbohydrates.

The carbohydrates in coco-nut kernel have not been so carefully studied as the other constituents. It may be said that at least 7 per cent. of ordinary sugar is present in the fresh dried kernel (copra or desiccated coco-nut). The bulk of the carbohydrate is in the form of cellulose and much of this is digestible.

Coco-nut Milk.

Before leaving the subject of coco-nut kernel, reference must be made to the emulsion obtained by pressing the grated substance known as coco-nut milk so commonly used in Ceylon households. This contains a good deal of the constituents of the kernel without so much of the indigestible fibre. A recent analysis gave the following results:—

	Per cent.
Water	52
Oil	27
Carbohydrate	15.9
Protein	4
Mineral substances	1.1

Suggestions have been made that coco-nut milk and similar preparations from the young nut might be a substitute for cow's milk. It would not, however, be entirely satisfactory as a milk substitute, owing to its deficiency in certain mineral salts and vitamins.

Mineral Salts.

The principal mineral constituent of coco-nut products is potash. But this is only one and not the most important of mineral salts required for maintenance of growth and health. From the Ceylon point of view, calcium (lime) is probably the most important and coco-nut milk and other products do not contain notable quantities of lime.

Vitamins.

It must be emphasized that vitamins are not energy-providing food constituents such as fat, protein and carbohydrate. They are compounds required in very minute quantities and their action may be roughly compared to the lubricating oil used on an engine in comparison with the fuel oil which corresponds to the major food constituents.

On the whole, the coco-nut is not regarded as a good source of vitamin. Reference has already been made to the possible presence of water-soluble vitamins in poonac. Fat soluble vitamins A and E, but not D, have been reported in coco-nut kernel and oil but none of these is present in sufficient quantities. Vitamin C seems to be absent from the kernel, but is present in the young nut water (Kurumba), and particularly in fresh toddy.

Coco-nut Toddy.

Toddy is a good source of vitamin C and the B vitamins are also derived from toddy yeasts. As its major constituent, sweet toddy contains about 16 per cent. of sugar (carbohydrate).

BREAD-MAKING.*

(*By Margaret A. Wylie.*)

The science of bread-making involves some knowledge of both chemistry and physics. A complete study of this art, therefore, necessitates familiarity with some of the fundamental principles of these sciences. Though bread has been made for countless ages, and is the staple food of man, its successful making has been really the result of knowledge gained empirically. Modern hygiene has, however, demanded a more definite basis to justify its continuance as the main part of human diet.

Flour.—Of all cereals, wheat yields the best flour for bread. This is due to the fact that it is the only grain which contains the constituent gluten in the proportion and of the desired quality essential for turning out light, spongy bread. Flour also contains a large proportion of starch. The following is a simple test of their presence:—A cupful of white flour in a muslin bag, if saturated with water and pressed, leaves a yellowish, tough, elastic substance in the bag, somewhat the size of a walnut. This is the gluten, the starch having been expelled. This experiment gives a rough estimate of the proportion of gluten to starch in a standard flour.

White flours are classified differently in different countries. There is the millers' classification, and the classification for commercial convenience in buying and selling, but the housewives' classification is from a very different standpoint, and should be as follows:—

(1) Strong or old flour.
(2) New flour.
(3) Fine flour.
(4) Weak or feeble bodied flour.

The first is of a deep, creamy colour, the kind that tumbles in a fluffy light manner out of a bag. If examined with a microscope, its gluten cell walls will be found to be very strong, having power to hold the gases that are formed by the action of yeast. Old flour is dry, and will absorb a large proportion of water.

The second type is whiter than the above and on account of its inherent dampness absorbs less water. It may be noticed that some flours retain their shape when pressed, an invariable sign that the flour is new.

The third, fine flour, is soft and elastic, not spongy and puffy, and produces a smaller loaf to the same proportion of flour. Its gluten is usually plentiful, its flavour in general being fine and "nutty".

Weak or feeble bodied flour is deficient in gluten, and hence in the capacity to retain the gases produced by the action of the yeast, as well in the power of absorbing moisture.

Strong flours therefore are most suitable for bread, fine flours for Christmas cakes, short pastes and short bread.

Yeast.—The article on jam making showed that various moulds and bacteria were the cause of decomposition and putrefaction of foods, and how the spores of

* From the *Journal of Agriculture*, Western Australia.

moulds float about in the air. It must be remembered, however, that as well as harmful organisms, the air furnishes useful bacteria. Wine, vinegar and cheese are the result of these bacteria, properly employed.

Yeast also enters this category. It is a minute plant of the "fungi" family, so small that 1,000,000 would cover only 1 cubic inch. Warmth and moisture speed its growth, its food being the sugar formed from starch. It thrives best at 78 deg. F. Its chief power is that of changing starch to sugar, and then converting the sugar into alcohol and carbonic acid gas. Provided the right food and conditions are given it, yeast propagates rapidly, at the rate of 1,000,000 an hour.

The gas generated by the action of the yeast is all-important in bread-making, for it is that which causes the sponge to rise, striving as it does to escape from its imprisonment in the gluten cells. It is possible to classify yeasts thus:—

(*a*) Liquid yeast.
(*b*) Distillers' yeast.
(*c*) German or compressed yeast.
(*d*) Dried yeast.
(*e*) A semi-dried form called putty yeast.

Liquid yeast is cultivated from a mixture of potatoes, sugar, water and hops.

Distillers' or brewers' yeast is a natural type, skimmed from fermented rye.

German or compressed yeast is bought in cakes, chiefly in England or the Continent of Europe. Unfortunately this often spoils in transit through the tropics.

The dried variety is made from hops and potatoes, mixed with starch and pressed into cakes.

The last type is built up in layers of semi-dried yeast.

Hops.—Hops act as an antiseptic, i.e., they help to destroy the power of certain bacteria and prevent thus the propagation of wild yeast. Consequently, it is advisable to use yeast made from hops, as the use of poor potatoes and impure materials produces wild yeasts which spoil bread. As well as this negative use, hops improve the flavour of the bread.

To ensure really successful bread the making of yeast should be attended with every care and cleanliness. An old bottle (used before) can be used, but the corks and fittings must be perfectly clean, as the entry of foreign germs tends to spoil the value of the true yeast and start different cultures.

Preparation of Yeast.

Hop Yeast.—1 large potato, 1 pint water, 1 tablespoon sugar, 1 tablespoon flour, 1 teaspoon hops.

Method—

(1) Boil potato, add hops while still boiling. Boil 20 minutes.
(2) Strain, cool slightly, add flour and sugar.
(3) Bottle and cork tightly.
(4) The yeast should work in a few hours in a bottle previously used for yeast, 24 hours in a new bottle.
(5) A fig or a raisin added will make it work more quickly.

Acid Yeast.—A medium sized potato, 1½ tablespoons sugar, ½ teaspoon citric or tartaric acid, 1 cup warm water, 2 teaspoons flour.

Method—

(1) Boil and smash potato, add other ingredients and sufficient water to keep mixture at cupful.

(2) Bottle and cork tightly.

(3) Keep in a warm place 12 hours in an old yeast bottle and 24 hours (at least) in a new bottle.

White Bread.

Small quantity.—1½ lb. flour, ¾ pint tepid water, 2 tablespoons home-made or 1 level tablespoon brewers' yeast, 2 teaspoons sugar, 1 teaspoon salt.

Method—

(1) Sift and warm 1 lb. flour, make a well in the centre.

(2) Beat yeast and sugar to a cream.

(3) Pour yeast and tepid water into flour and stir to a moist dough. Beat well.

(4) Cover and stand in a warm place till the dough doubles its size. (Brewers' yeast takes about one hour and home-made several hours.)

(5) Turn to a floured board and knead in the extra ½ lb. and salt until the dough is of even texture.

(6) Shape into loaves, put into greased and floured tins.

(7) Allow to rise in a warm place about half an hour.

(8) Cook in a hot oven until the loaf is well risen and brown, then place in a cooler part until the bread is cooked through—30 to 40 minutes in all.

(9) When cooked the bread should give a hollow sound when tapped on the bottom.

Wheaten Meal Bread.

1½ lb. whole or half wholemeal and half plain flour, 1 tablespoon yeast, 1 teaspoon salt, ¾ pint tepid water, 1 teaspoon sugar.

Method.—Proceed as for white bread, but more moisture, a hotter oven, and longer cooking is required.

The actual baking of bread is perhaps the most important part. With the utmost care in choosing flour, making yeast, and carrying out the correct procedure for mixing, if the oven is not at the right temperature the bread may be spoilt. The scientific baking of bread is to fix the air cells as quickly as possible by means of the hot oven. A novice would do well to test the oven thus:—Place a tablespoon of flour on a saucer for five minutes in the oven. If the oven is—

(*a*) Hot—the flour becomes dark brown.

(*b*) Moderate—the flour becomes a golden brown.

(*c*) Cool—the flour becomes pale brown.

The yeast will go on working or growing in the flour if the oven is too cool, still splitting up the starch and more alcohol is formed, which cannot escape. The bread thus has a "berry" taste. If, on the other hand, the oven is too hot and the loaf begins to brown in less than fifteen minutes, a crust is formed and the inside of the loaf remains damp and uncooked.

Abnormal Fermentation.—The normal fermentation in bread-making is due to the energy of the yeast plant growing and multiplying in the dough, giving off

CO_2 and producing changes which result in making bread palatable and digestible. Other fermentations, however, sometimes occur.

Sticky or sour bread is due to lactic acid bacteria. These are associated with low-grade flour. The germs of these bacteria often lie dormant until essentials, such as warmth and moisture, necessary to their growth, are provided and they can then develop. Injurious germs also appear with yeast. This is sometimes overcome by the use of hops, which assists true yeast to overpower poor yeast. Dirty utensils and troughs harbour injurious bacteria. All crevices and cracks are teeming with unseen life, which reproduce enormously when given favorable conditions.

Musty or mouldy bread is usually noticed only after bread has been cut. This is due to damp flour in which fungi or mould has developed. Bags, containers, &c., holding the flour should be thoroughly scalded and scoured before being used for a fresh supply.

The same procedure should be carried out if bread is what is termed "ropy", or when tiny red marks appear. These, too, are the effects of wild yeasts, which have found their way into the dough.

METEOROLOGICAL NOTES.

(By R. J. McConnell, Department of Agriculture, Rabaul.)*

To the average planter and miner, as he fills in his monthly rainfall and climatic statistics, it probably seems that the whole business is useless and that the results of his observations only give rise to small-talk and to stock some Government archives. But to-day the weather bureau is an integral part of any successful community and although the observations of a single observer may have little value, the means of a large number of observations taken at selected points are of great value.

In temperate climates, where the weather is subject to sudden changes, bringing frost, heavy rain with hail, &c., ignorance of climatic statistics may spell ruin to the farmer. Many citrus and vegetable crops have been lost through farmers ignoring climatic predictions and being caught by cold spells.

In tropical agriculture it is essential to know the rainfall of a place before successful planting can be attempted and for crops which require protection, such as coffee and cacao, it is equally necessary to have information on prevailing winds and their comparative velocity.

New Guinea, with 8 major reporting stations and 103 minor reporting stations, is rapidly building up an efficient weather organization both for the benefit of the agriculturist and aircraft. The results of observations taken during 1939 at the Rabaul observatory in the Botanic Gardens are appended.

For comparative purposes, other meteorological data for Rabaul are to be found in the following issues of the *New Guinea Agricultural Gazette*:—

1936	Volume 2, Number 1, Page 31.
1937	Volume 3, Number 1, Page 27.
1938	Volume 4, Number 3, Page 23.
1938	Volume 4, Number 4, Page 58.
1939	Volume 5, Number 3, Page 8.

* Relieving B. G. Challis—on leave.

GENERAL CLIMATOLOGICAL DATA.

Month.	Barometer mean for month, corrected to M.S.L. and standard gravity and temperature.	Amounts of clouds. Mean of 9 a.m. and 3 p.m. observation.	Number of clear days.	Highest barometer readings (corrected) 9 a.m. reading.	Date.	Lowest barometer readings (corrected) 3 p.m. reading.	Date.
January	29.755	6.5	16	29.850	18.1.39	29.663	27.1.39
February ..	29.773	7.1	7	29.895	19.2.39	29.647	3.2.39
March	29.764	7.5	5	29.827	30.3.39	29.651	6.3.39
April	29.778	6.5	9	29.887	1.4.39	29.680	15.4.39
May	29.796	5.1	14	29.906	10.5.39	29.680	19.5.39
June	29.815	5.9	13	29.925	18.6.39	29.686	29.6.39
July	29.831	4.3	15	29.950	24.7.39	29.740	3.7.39
August	29.765	5.6	15	29.890	31.8.39	29.649	18.8.39
September ..	29.837	5.8	18	29.969	7.9.39	29.710	18.9.39
October	29.812	6.9	14	29.912	3.10.39	29.703	30.10.39
November ..	29.771	6.3	14	29.863	16.11.39	29.658	30.11.39
December ..	29.801	5.9	14	29.893	27.12.39	29.697	3.12.39
Average ..	29.791	6.1	12.8	29.897	..	29.680	..
Extremes ..	29.837 September	7.5 March	18 September	29.969	7.9.39	29.647	3.2.39

TEMPERATURE.

Month.	Mean of the Maximum Thermometer Temperature.	Mean of the Minimum Thermometer Temperature.	Average Monthly Temperature.	Maximum Thermometer Highest Temperature, Reading.	Date.	Minimum Thermometer Lowest Temperature, Reading.	Date.	Mean of Thermometer Temperature on Grass.	Lowest Thermometer Temperature on Grass.	Date.
January ..	90.7	73.5	82.1	93.9	22.1.39	71.2	11.1.39	71.5	68.2	11.1.39
February ..	88.9	73.8	81.3	92.6	14.2.39	71.0	26.2.39	72.2	69.0	27.2.39
March	88.4	73.4	80.9	91.3	27.3.39	71.2	28.3.39	72.3	69.5	28.3.39
April	89.3	74.0	81.6	93.4	15.4.39	72.3	3.4.39	72.5	69.9	3.4.39
May	88.9	73.9	81.4	91.7	19.5.39	72.0	1.5.39	72.2	69.5	27.5.39
June	88.5	73.8	81.1	91.0	7.6.39	72.1	3.6.39	72.3	69.5	3.6.39
July	88.7	72.8	80.7	90.5	17.7.39	70.3	25.7.39	70.9	67.5	17.7.39
August	88.8	73.5	81.1	92.7	30.8.39	70.0	27.8.39	71.7	68.9	4.8.39
September ..	89.8	73.6	81.7	92.3	20.9.39	72.1	9.9.39	71.5	69.5	29.9.39
October	90.3	73.6	81.9	94.1	15.10.39	70.9	8.10.39	71.8	69.0	28.10.39
November ..	90.8	74.1	82.4	94.9	13.11.39	71.0	24.11.39	72.4	69.0	24.11.39
December ..	90.4	73.4	81.9	94.4	31.12.39	71.0	29.12.39	71.5	68.8	29.12.39
Average ..	89.5	73.6	81.5	92.7	..	71.3	..	71.9	69.1	..
Extremes ..	90.8 November	72.8 July	80.7 July	94.9	13.11.39	70.0	27.8.39	70.9 July	67.5	17.1.39

HUMIDITY AND RAINFALL.

Month.	Humidity.			Rainfall Monthly 1939.	Average Rainfall since 1914.	Greatest Monthly Rainfall.	Year.	Least Monthly Rainfall.	Year.	Wet Days Monthly 1939.	Wet Days Average since 1914.	Greatest Fall in 24 hours.	
	Mean 9 a.m.	Mean 3 p.m.	Mean of All Readings.									1939.	Date.
January ..	79.0	72.0	75.5	9.40	14.13	37.74	1916	4.77	1918	15.0	20.8	3.99	2.1.39
February ..	79.0	72.0	75.5	6.65	10.44	23.54	1923	3.38	1921	21.0	13.1	1.91	4.2.39
March	83.0	75.0	79.0	6.60	9.42	22.23	1919	3.91	1920	26.0	19.5	0.74	7.3.39
April	83.0	72.0	77.5	13.14	9.80	18.57	1925	0.93	1937	21.0	18.0	3.85	24.4.39
May	79.0	72.0	75.5	7.53	5.17	11.27	1930	0.74	1932	17.0	13.3	2.61	1.5.39
June	79.0	72.0	75.5	5.91	3.52	7.78	1923	0.79	1914	17.0	12.7	2.89	16.6.39
July	87.0	72.0	79.5	6.70	5.59	18.00	1930	0.09	1914	16.0	14.7	2.28	25.7.39
August ..	79.0	72.0	75.5	6.21	4.40	12.45	1937	0.36	1924	16.0	14.8	2.39	24.8.39
September ..	75.0	72.0	73.5	3.15	3.65	7.15	1921	0.32	1914	12.0	12.5	0.74	30.9.39
October ..	75.0	68.0	71.5	6.35	5.25	11.86	1928	0.62	1914	17.0	12.7	1.08	22.10.39
November ..	76.0	76.0	76.0	3.55	6.30	14.00	1921	1.73	1913	16.0	15.7	0.58	25.11.39
December ..	75.0	72.0	73.5	6.88	10.19	16.22	1919	3.66	1933	17.0	18.3	2.74	1.12.39
Average ..	79.1	72.3	75.7	6.84	7.32	..	..	..	..	17.6	15.5	2.15	..
Extremes ..	83.0	76.0	79.5	13.14 April	14.13 January	37.74 January	1916	0.09 July	1914	26.0 March	20.8 January	3.99 January	2.1.39

SURVEYING FOR AREA WITH A SURVEYOR'S STAFF.

In the last issue of the *Gazette* instructions for making and using a simple plantation level were given. In this issue the surveyor's staff will be similarly dealt with. This particular staff and the method of using it were first described by Alexander Gordon, of the University of the Philippines.

Construction.

A round block, 2 inches thick, was made. The block was sawed across the centre to about half an inch in depth, then resawed across the centre at right angles to the first cut. These cuts serve as sight lines. The block is set on a staff by means of a peg so that the block may turn about its centre. (*See* Figure 1.)

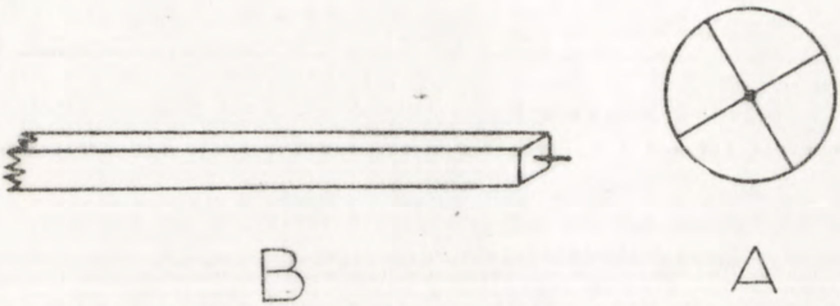


Figure 1.—The Surveyor's staff taken apart. (*a*) a wooden block; (*b*) wooden staff showing peg for block attachment. Note the saw cuts on block.

How to use a Surveyor's Staff.

Set-up.—The surveyor's staff is divided into two parts, the block and the staff. In setting up, the staff portion is first stuck in the ground at the point desired. Then the block is set on the staff. It is important that the staff be vertical. This may be accomplished with the help of a plumb bob.

Erecting Perpendiculars.—To erect perpendiculars with the staff is not a complicated job. The first thing to do is to set the staff on the course at any desired point, say *O*. When stations *A* and *B* are easily accessible, locate *O* by sighting from either one of the stations towards the other and keep *O* in line. When *A* and *B* are inaccessible, however, locate *O* by one of the following methods:—

First Method.—Set two rods, *a* and *b*, at some distance apart, between *A* and *B*. (*See* Figure 2.) Sight *A* from *a* and bring *b* in line. Then sight *B* from *b* and bring *a* in line. Continue the process until *A*, *b*, *a*, and *B* are all in line. Now set the staff on the course *AB*.

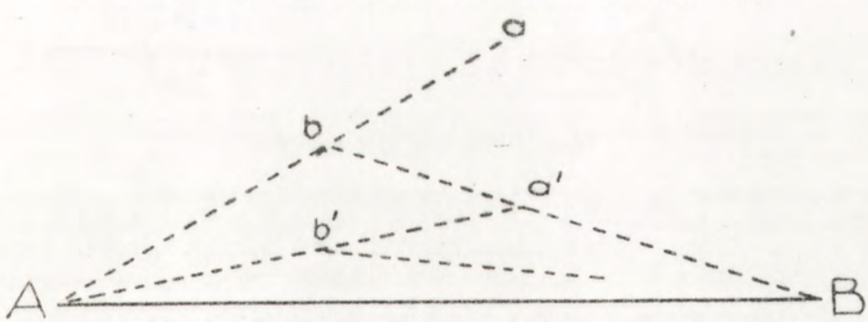


Figure 2.—Locating an accessible point between two inaccessible points.

Second Method.—Set the staff as nearly as possible on the course, AB, at O'. (*See* Figure 3.) From O' sight B through one of the slits, then sight back through the slit. If, on sighting back through the slit, A is not seen, transfer position of staff, say, to O''. From O'' sight B through one of the slits, then sight back through the slit. If, on sighting back through the slit, A is not seen, transfer position of staff and continue process until O' is in line with A and B.

Figure 3.—Locating a point between two points by the use of the surveyor's staff.

Suppose now that the staff is set at a point O, on the course AB. (*See* Figure 4.) Sight B through the slit m–m of the block. Then sight to a point C through slit n–n (Figure 4*a*). Turn the block so that B is sighted through slit n–n. Then sight through m–m to a point D (Figure 4*b*). The line bisecting angle COD is perpendicular to line AB.

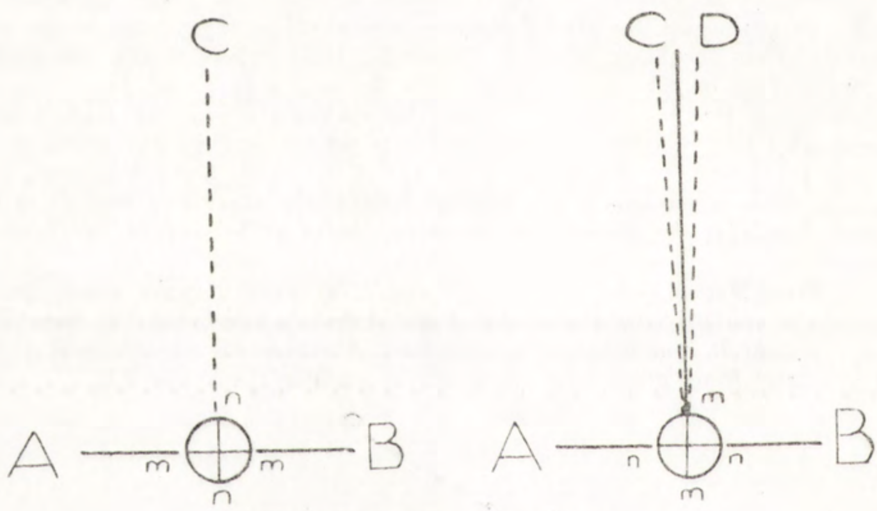


Figure 4.—Erecting a perpendicular.

Finding Areas: A Triangle.—The area of a triangle may be found by multiplying one half of the base by its altitude. The measurement of the altitude is the problem. Suppose we have a triangle ABC. Then guess approximately point O on AB so that CO is almost perpendicular to AB. (*See* Figure 5.)

Set the staff on point O. Erect a perpendicular to AB from O towards C. If C is not on the perpendicular, correct the point O by moving it by the distance d between C and the perpendicular.

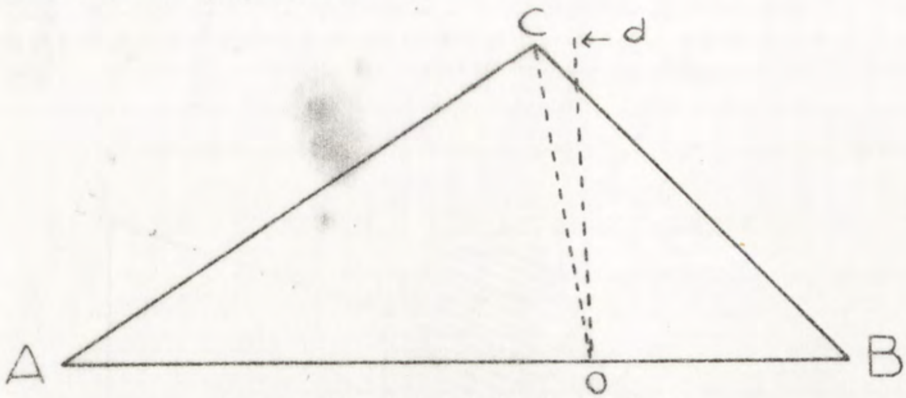


Figure 5.—Determining the altitude of a triangle.

An n-sided Polygon.—The area of an n-sided polygon is the sum of the areas of the triangles into which the polygon may be divided.

An Irregularly Bounded Figure.—The area of a figure with an irregular side may be found by summing up the areas of the trapezoids into which the figure may be divided.

Set a base line through, or by the figure. From the base line erect perpendiculars to the bending points of the boundaries of the figure. Following the course of the boundaries of the figure in a clockwise direction, and supposing all courses due west as negative and courses due east as positive, the areas of trapezoids formed by the base line, the two adjacent perpendiculars, and a course shall be positive or negative depending on the sign that the course carries. The difference between the negative and positive areas is the area of the irregularly bounded figure.

Extension of Lines.—The extension of lines through an obstacle when (1) the two known stations are visible from each other, and (2) the two known stations are not visible from each other, are common problems in fencing, lining and orchard work.

1. *Stations visible from each other.*—Suppose A and B are the known stations. (*See* Figure 7.) Erect perpendicular BC on AB from B. Then erect perpendicular CD on BC from C. Produce CD until the obstacle is passed. Then erect perpendicular DE on CD from D. DE must be made equal to BC. From E erect a perpendicular. This is the required extension of AB.

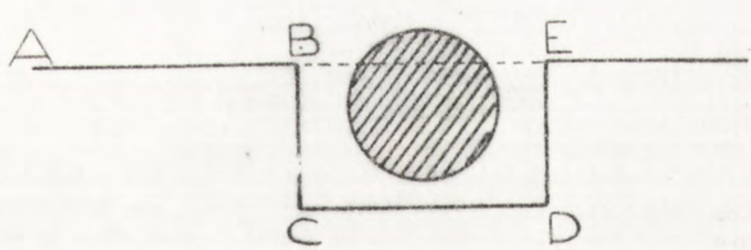


Figure 6.—Extending a line through an obstacle when known stations are on the same side of the obstacle.

2. *Stations not visible from each other.*—Suppose A and B are the known stations. (*See* Figure 7.) From A project a line, AC, passing by the obstacle. From AC erect a perpendicular to B. Then from a point D on line AC erect perpendicular DE, so that AC/CB equals AD/DE. Then erect another perpendicular from a point F on line AC to G, so that AC/CB equals AF/FG. Points A, G, E, and B are then all in line.

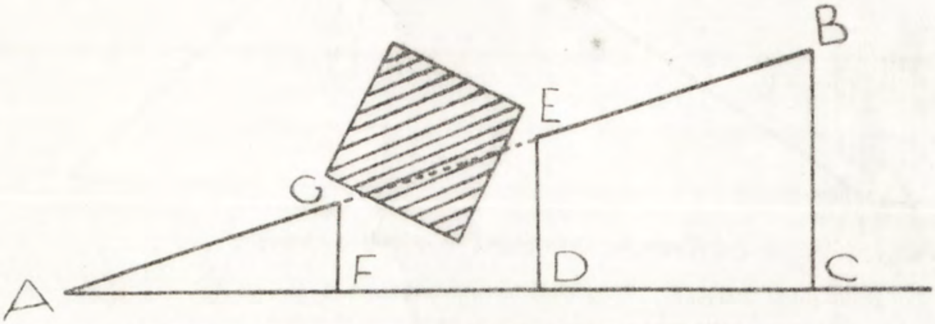


Figure 7.—Setting a straight line between two stations with an obstacle between.

A GATELESS OPENING.

In many places it is desirable to have an opening in the fence that a man can easily slip through without bothering with a gate, but through which horses or cows cannot pass. Four posts are set as shown—two in the fence line, which should be braced, and one each side of one of the centre-line posts. Branch wires are carried from the other centre-line post to the two side posts. These should be made of wire without barbs to catch on the clothes, as it is not desirable to make

the openings larger than necessary. If the centre posts are long enough—say, 5½ or 6 feet above the ground—they can be braced to each other by a piece of strap iron across the top. If this is possible, then the other braces will not be necessary.

REVIEW.

An excellent report on the volcanoes of the Territory of New Guinea was recently published by the Administration. The report (Geological Bulletin No. 2) was written by the Government Geologist, Mr. N. H. Fisher, M.Sc., and may be obtained from the Post Office in Rabaul for 1s. It includes all available information on the volcanoes of the Territory and with the report are numerous well prepared maps which show the locations and extent of the major volcanoes.

By Authority: L. F. Johnston, Commonwealth Government Printer, Canberra.