INVESTIGATIONS

IN

EPIDEMIC DROPSY

BY

W.A.BURNETT, B.Sc., M.B., Ch.B., D.T.M.and H.

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 – 1346

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A pathological condition diagnosed as the Oedematous type of Beriberi has been present for many years in Sierra Leone, culminating at intervals in outbreaks of epidemic severity with a high rate of mortality. This research is a resume of some investigations made into the disease as it affected Freetown, with special reference to Wilberforce Barracks, Freetown Prison and Kissy Asylum, combined with an enquiry, working along biochemical lines, into the relationship of this disease with the nutritional aspects of rice. The work is subdivided to a number of headings, which are dealt with seriatim and finally summarised. A certain amount of statistical data is incorporated, and, in addition, there is an addendum dealing with the conditions at the Wilberforce Barracks Compound.

The problem of Beriberi is one which has been noted in Freetown Prison for at least the last forty-eight years. At this institution it had been reported under several diagnoses, to wit; Oedema, Dropsy, Beriberi, Dysentery with Dropsy. Various spasmodic references have been put on record until recently when an investigation was made by Professor Blacklock (1) in 1922, and later in 1929, when Drs.Leitch and Watson (2)

undertook an intensive and exhaustive survey of the condition at the Freetown Prison. The outcome of their work was that drastic alterations in management were suggested, together with the allowance of a diet very rich in vitamin B and of high calorie value, as much as thirty-five hundred calories daily being allowed to adult male prisoners on sedentary occupation. "There is no excuse for its existence, as it can be guarded against by easily arranged and inexpensive measures; given an adequate diet, all that remains is to see that the vitamin B content of the diet remains up to standard", quote the joint authors of "Beriberi in the Freetown Prison", yet, despite the most strict adherence by the Superintendent of Prisons to this dietary advice, coupled with the daily inspection of the inmates' food rations by the prison doctor, the Medical Officer in charge of Freetown Prison continued to find this "Oedema" cropping up among the prisoners and culminating in a severe outbreak in 1931. A diet rich in yeast, cod liver oil, fresh vegetables and fruits, despite the reputedly high content of vitamin B had failed to prevent a serious recurrence of the condition. At that time large quantities of Marmite and Bemax were being given without the success one would have expected from these "vitamin" foods, if the condition had been one purely of avitaminosis. It was only after an alteration of the diet to consist of new rice, a step suggested by Mr.Biddle, the Superintendent of Prisons, from his lifelong experience of the

condition, that a mass improvement set in and no new cases were reported.

Notes on the circumstances which pertained in 1931 and virtually led up to the investigation of the problem, have been kindly supplied by the Honourable Director of Medical and Sanitary Service. He states that at the end of 1930, the Superintendent of Prisons made his usual annual contract for the supply of paddy to be milled in the Freetown Prison for use at the Freetown and Kenema Prisons, the Hospital, Asylum and Infirmaries, and received an excellent quality from the Compagnie française d'Afrique occidentale (C.F.A.O.). He was then asked to make a contract on behalf of the Royal West African Frontier Force (R.W.A.F.F.), and contracted with another firm for 11,000 bushels. This firm purchased the quantity from Syrian middlemen. The first consignment of this contract, delivered at the Prison in January, 1931, was good. The second, in February, was dusty and contained a mixture of old and new crops. The Superintendent of Prisons protested, but his protest was ignored. He estimated the consignment to contain about 75 per cent. old and 25 per cent. new rice.

This rice was supplied to the R.W.A.F.F. and issued from their store in March, 1931. At the beginning of April a strong protest was made by the Officer Commanding that the soldiers were refusing the rice on the grounds that it was

causing "belly-sickness". In consequence of this the Superintendent of Prisons commenced issuing his good C.F.A.O. rice to the R.W.A.F.F., and also to the institutions.

On 2nd.May, the Superintendent of Prisons went on leave and in his written instructions to the Assistant Superintendent said that no more of this inferior rice was to be accepted from the second firm. At that time there were nearly 6,000 bushels of this rice stored at the Prison. At this time it became evident that the good C.F.A.O. rice would shortly become exhausted, and the Acting Superintendent of Prisons endeavoured to eke it out by alternating the two stocks weekly or so. The first case of "beri-beri" was reported from the Prison in May.

The issues to Kenema Prison were:

March, fifty bushels new rice (C.F.A.O.)
May, forty bushels, uncertain from which stock,
July, fifty bushels Messrs.G.B.Ollivant stock.

The first case of "beri-beri" at Kenema prison was reported in August. The Medical Officer immediately increased the vitamin content of the dietary, at the same time severely criticising the quality of rice supplied. Cases kept on occurring up to the 9th.September, a total of fourteen with three deaths. On 2nd.September the Acting Superintendent of Prisons milled a quantity of new rice and despatched it to Kenema. There were no more cases at that Prison.

On May 11th., G.B.Ollivant appealed to Government

against the Superintendent of Prisons' refusal to take delivery of the balance of his contract, some 3,000 bushels. After correspondence and conferences, the Acting Superintendent of Prisons took delivery in July of 1,640 bushels. Part of this was milled and supplied to the R.W.A.F.F. on August 19th. for issue in September. The outbreak of oedema at the Barracks shows:

September,	1 case.
October,	11 cases.
November,	14 cases.

The outbreak at the Asylum at Kissy commenced in August and continued month by month with increasing severity. It is not recorded from which source the consignments of rice to this Institution were taken. It appears probable that G.B. Ollivant rice was first supplied to the Asylum in July and intermittently thereafter. Many of the patients are feeble physically as well as mentally and succumbed easily to the attack.

The coincidence of all the four outbreaks occurring in close relation to each other, and the fact that the supply of rice from one source was the only known point common to all of them strongly indicated that this rice was the origin of the trouble. It was undoubtedly of poor quality, a mixture of 1929-30 and 1930-31 crops, and had been also infested with weevils.

During the period from August, 1931, to January, 1932,

there was a very considerable outbreak of the oedematous condition here involving Freetown Prison, Wilberforce Barracks and Kissy Asylum. A number of Freetown inhabitants, too, complained of the disease and were treated at the Connaught Hospital.

This was the position in November, 1931, when the Honourable Director of Medical and Sanitary Services (Dr.J.C.S. McDouall) requested me to study the problem with special reference to biochemical observations on the rice as both he and Mr.Biddle had been since 1929 dissatisfied with the diagnosis of Beriberi due to avitaminosis.

The Condition Clinically.

It is considered essential to outline the disease under review in terms of the clinical picture. The syndrome takes the form of a varying degree of non-albuminuric oedema, usually well defined in the limbs; of dyspnoea on the minimum exertion and of tachycardia with enlargement mainly of the right heart; of muscular weakness with deep muscular hyperaesthesia; of gastro-intestinal disturbances, generally constipation, sometimes followed, in the fatal cases, by diarrhoea and faecal blood, and of such nerve changes as are displayed by diminution of, or loss of tendon reflexes, localised and often transient anaesthesia and deep hyperaesthesia. Difficulty of vision is present at times. There may be, and generally is, a slight

pyrexia, but the fever does not usually exceed a range of 99°F. to 101.5°F.

Were the signs and symptoms to be summarised and depicted in a typical case, it would be observed that the patient complains of weakness and of being easily tired. He has breathlessness and palpitation on exertion, with a variable amount of praecordial pain. The epigastrium may be tender and show fullness and there may be associated a history of nausea and vomiting. There is generally considerable weakness of the calf muscles which are painful to deep pressure; the patient may be unable to raise the legs in bed and to perform the "squatting test", although this should not, I think, be considered a diagnostic test for Beriberi. Foot drop and wrist drop may occur, but were not seen in the cases under review. Often coupled with a previous history of generalised muscular rheumatic pains is one of chronic constipation. In many of the fatal cases this occurrence of intestinal stasis is followed by a sharp bout of diarrhoea with blood at the latter part of defaecation.

With this muscular weakness oedema makes its appearance and it usually starts in the feet extending rapidly to the legs and being well marked over the pretibial area. It may come on with remarkable suddenness, appearing in twelve to twenty-four hours, coupled with praecordial distress and cardiac enlargement to the right. The dropsy is symmetrical and feels more solid

than that of nephritis. Generally, the swelling remains localised to the lower limbs, but, on occasion it may be found extending to the knees, thighs and scrotum, while it may also involve the abdominal wall and, rarely, the face. If the patient is recumbent the sacral area is affected in addition to the limbs. Oedema of the sternum has seldom been recorded and in the cases under observation it was seen only in three men.

In the early stages there occurs a partial anaesthesia to pain, (pinpricks) touch, kinaesthetic sensation and heat but not to intense cold over the oedematous zones. This superficial anaesthesia steadily becomes more pronounced as the dropsy persists until complete loss of cutaneous sensation is the result. On the other hand, when the swelling is successfully treated, the anaesthesia is rapidly abolished although recovery does not set in till about fourteen days after the oedema has disappeared.

The tendon reflexes are altered, diminished and often finally absent in the patella, tendo achilles and cremaster, but the reflexes of the biceps and triceps and of the forearm muscle tendons, together with jaw jerk are present and may be slightly exaggerated. About 15 per cent. of the cases showed no alteration of the tendon reflexes. The abdominal reflexes are not reliable as they cannot be elicited with any degree of accuracy even in the normal African subject. The reactions of the eye to light and on accommodation are normal and unaffected. A few

patients complain of difficulty with the sight; objects become blurred and dim and light has a painful effect on the eyes. The intraorbital pressure is increased together with other allied signs of early glaucoma. The patient will often show a positive Romberg sign and generally he walks with an unsteady high-stepping gait. There is no loss of the sphincter control either of the bladder or of the anus.

Even at rest the heart rate is considerably increased, tachycardia being most consistently present. The cardiac muscle is dilated in all directions, especially to the right, and there may be a soft systolic murmur with equal spacing of the heart sounds. Except in the final stages of pericarditis with effusion, there is no muffling of the cardiac sounds. In all cases complaints are made of palpitation and of praecordial distress with pain that does not radiate outwards and down towards the left arm. The onset of pericarditis with effusion is very rapid and very common. Many patients have a marked venous pulsation in the neck. The pulse rate is steadily increased from the normal to one hundred to one hundred and twenty per minute. Although constantly rapid, the pulse has good volume and tension and the rhythm is regular.

The blood examination does not reveal any obvious pathological change. There is a slight hydraemia associated with diminished red cell count (average 4,300,000 per cu.mm.) and with a lowering of the haemoglobin content to 70 per cent.

The colour index is generally found to be in the region of 0.81. Although the white cell count ranges from a value of 7,000 to 11,000 per cu.mm., the most marked change in this aspect of the blood is the decided shift to the left in the Arneth Index. Quite a considerable proportion of bilobed and trilobed polymorphonuclear leucocytes is to be seen.

Records of the blood pressure are found to vary in the people affected in accordance with the state of the bowel and of the heart. During the phase of sub-acute or chronic constipation, there is a definite elevation to 156-170 mm. Hg. systolic (90-106 mm. Hg. diastolic) but when recovery sets in or the intestinal stasis is relieved for a few days this blood pressure steadily falls by 20-30 mm. and is maintained at a lower level, 136-140 mm. systolic (70-84 mm. diastolic). Where the signs of pericarditis with effusion are present coupled with diarrhoea, the blood pressure is constantly low (100 mm. systolic 60 mm. diastolic); when these patients are recovering, which they do very slowly, the blood pressure is equally tardy in rising to the normal and in the cases under review, no one exceeded a final reading of 118 mm. systolic, 72 mm. diastolic.

The urine shows none of the ordinary abnormalities. It is free from sugar, diacetic acid, acetone bodies and albumin, but although just slightly diminished in amount it contains an excessive quantity of phosphates, which separate on cooling.

The results of the post-mortem examinations will be

given in a separate record included in the section on laboratory observations.

Wilberforce Barracks.

The conditions at Wilberforce Barracks, where are stationed soldiers of the Royal West African Frontier Force, render the study of epidemic and general diseases much simpler than among the general African populace. The Commanding Officer, (Lieutenant-Colonel Greene) and his colleagues gave every possible assistance towards the work and they are to be complimented highly on the tact with which they dealt with their men and on their indirect persuasive powers among the "camp followers", with the net result that routine inspection, generally a difficult affair in the concern of the undisciplined, was facilitated and became a matter of pleasure.

The Barracks: The Barracks Compound, of which a plan is submitted, is situated on a hill sloping fairly gently downwards in all directions. The lines of huts are placed in parallel rows running north and south. The huts occupied by the soldiers are of mud construction, measuring over all 45 feet by 34 feet. They are separated from one another by a minimum clear space all round varying from 18 feet to 33 feet wide. On each long side is a verandah 6 feet wide. The huts are subdivided by mud walls 8 feet 6 inches high and 6 inches thick, into eight rooms each measuring 10 feet square. The walls do not extend to the roof, which, at the highest point, is 11 feet. A ceiling is formed

by stretching over the top of the walls a horizontal layer of wide mesh wire netting. The floors, including the verandahs, are built up 3 feet 6 inches above the ground level. Each room has one window, capable of opening, and one door, but in some of the huts the partition wall has been cut to make an internal communication between adjacent rooms. During the day the rooms are cool, chiefly on account of the covering of thick thatch on the corrugated iron roof, which is carried well down over the verandah to provide shade and to reduce the ingress of reflected heat from the ground. All the rooms are more or less infested with bedbugs (Cimex lectularius, Leptocimex boueti and Cimex rotundatus) and the possibility of migration, not only from room to room, but from hut to hut, is far from remote.

Cooking: Generally, the cooking is conducted in communal kitchens, which are huts with freely opened partition walls. Individual fires are employed and the cooking is performed by the women, who use the kitchens as convenient places wherein to beat the rice by the native mortar and pestle method.

Latrines: The latrines are well isolated and at least fifty yards from the huts of the Compound. Men and women use separate buildings, which are erected to accommodate the dry bucket system. The faecal matter is buried in a large pit, 200 yards from the nearest hut and to the prevailing leeward side of the Compound. These conveniences are kept clean and tidy and are inspected regularly by the Sanitary Inspector allocated to the

Barracks.

Drainage: Open surface gutters are in use for drainage with water channels running away from each hut. As the Compound is built on rock on an exposed sloping hill the drainage is ample, well designed and sufficient.

Water Supply: The water supply is brought in by pipe line from the Hill Station supply and laid to convenient automatic stop cocks; no waste is permitted.

Rubbish Bins: Small rubbish bins with steel lids are located near the water taps (about 20 feet from each one). These appear to be used with disciplinary care, as no evidence is visible of indiscriminate scattering of rubbish and there are sufficient bins to accommodate the refuse without piling it up around the receptacles. They are emptied daily and the rubbish is incinerated.

Wash Houses: Wash houses are separated from the Compound on the eastern side of the hill.

On the whole the Compound is tidy, well kept and efficiently managed, as far as sanitation is concerned.

The Epidemic.

At the end of October, 1931, the disease was first brought to my notice by a soldier complaining of swollen legs, constipation and breathlessness on exertion. His heart sounds were soft and muffled but there were no valvular murmurs. The

urine displayed no abnormalities (albumin, sugar, acetone bodies) but it contained an excessive amount of "earthy" phosphatic deposit. It was considered advisable to have the man admitted to and treated at the Connaught Hospital (Ward 2) where, however, he died two days after admission. He had been ill for seven days.

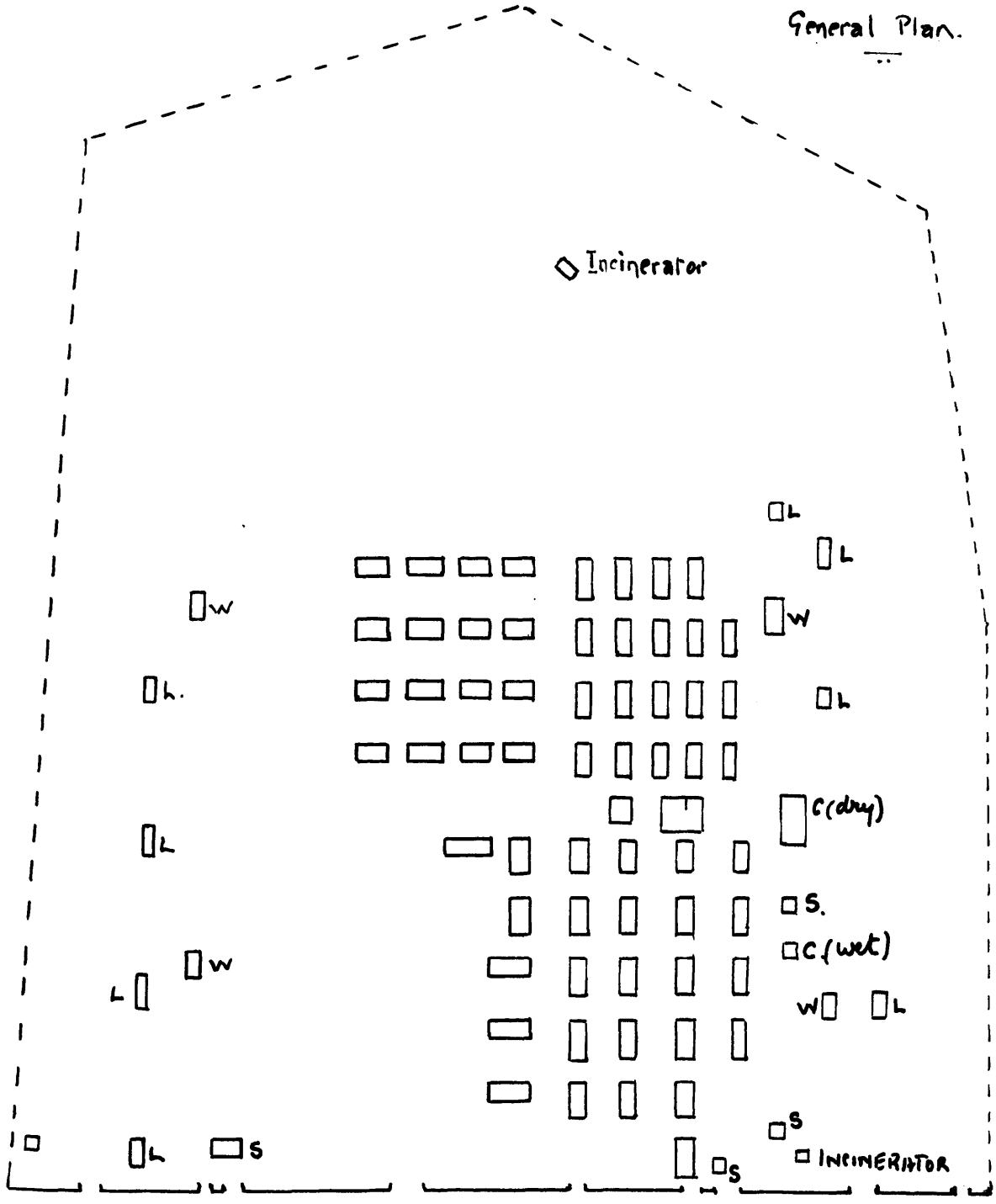
The necropsy revealed acute pericarditis with effusion (8 oz.), cardiac enlargement, pulmonary oedema, scanty volume of fluid in the peritoneum, hepatic oedema, enlarged gall bladder with normal bile and oedema of both legs extending only to the knees. The cause of death was diagnosed as Beriberi of the wet type and pericarditis with effusion.

Survey of Troops: On account of the presence of Beriberi at Freetown Prison and of the information that the Troops were being issued with rice from the same contractor who supplied the Prison, it was deemed essential to take urgent measures to round up all affected soldiers. Consequently, a survey of the entire personnel at the Soldiers' Compound was undertaken to isolate similar patients and to anticipate early cases. To facilitate this work, I drew up a scheme of which the following is a resume.

All the huts and rooms were numbered and a plan was made of the Compound, showing such details as position of huts, kitchens, latrines, drains, rubbish heaps and water supplies. Small metallic discs were figured with the hut and room numbers.

BARRACKS COMPOUND.

General Plan.



W = WASHING PLACE

L = LATRINE

S = STORE.

C = CANTEEN.

They were issued to the responsible occupants of each room, with the instructions that on any complaint of sickness by any inmate, such patient should appear with the disc at the morning sick parade, so that any disease, whether of an infectious nature or otherwise, could, by comparison with the numbered plan at the Medical Officer's hut, be localised immediately and, if need be, suitable steps taken at once. The misuse of discs by persons is an offence punishable on the owner of the disc, and loss of disc is notifiable immediately. This scheme had the approval of the Commanding Officer, and it was of great service to the research.

A census of the soldiers' lines in the Compound was made to find:

(a) Number of persons in each room.

(b) Distribution to adults, children and servants.

(c) Distribution of rooms used as kitchens and as stores (occupied and unoccupied).

(d) Number of beds per room.

(e) Presence or absence of mosquito nets.

(f) Presence of dogs, fowls, and pets (guinea pigs).

With very few exceptions, all complained of the presence of bedbugs.

Appended are the results, of which an extract is submitted below:

Adult.		Children.		Servants.	
Men.	Women.	Male.	Female.	Boys.	
226	185	31	49	63	Total 554

Huts.	Kitchen Huts	
54	7	Total 61

61x8 = 488 units.

Rooms occupied,	304)	
" empty,	41)	
Stores occupied,	17)	All expressed in units of one room
" unoccupied,	34)	that is eight units per hut.
Kitchens, ...	76)	
Huts, derelict (2),	16)	
	488	
Beds screened,	197	
" unscreened,	211	

Oedema Cases.

Men.	Women.	Children.	Servants.	
30	19	Male 1. Female 0.	4	Total 54 (including one fatal)

From the data obtained in the survey of the Compound the cases of oedema are tabulated below in terms of hut, room, sex, presence of pets and screens.

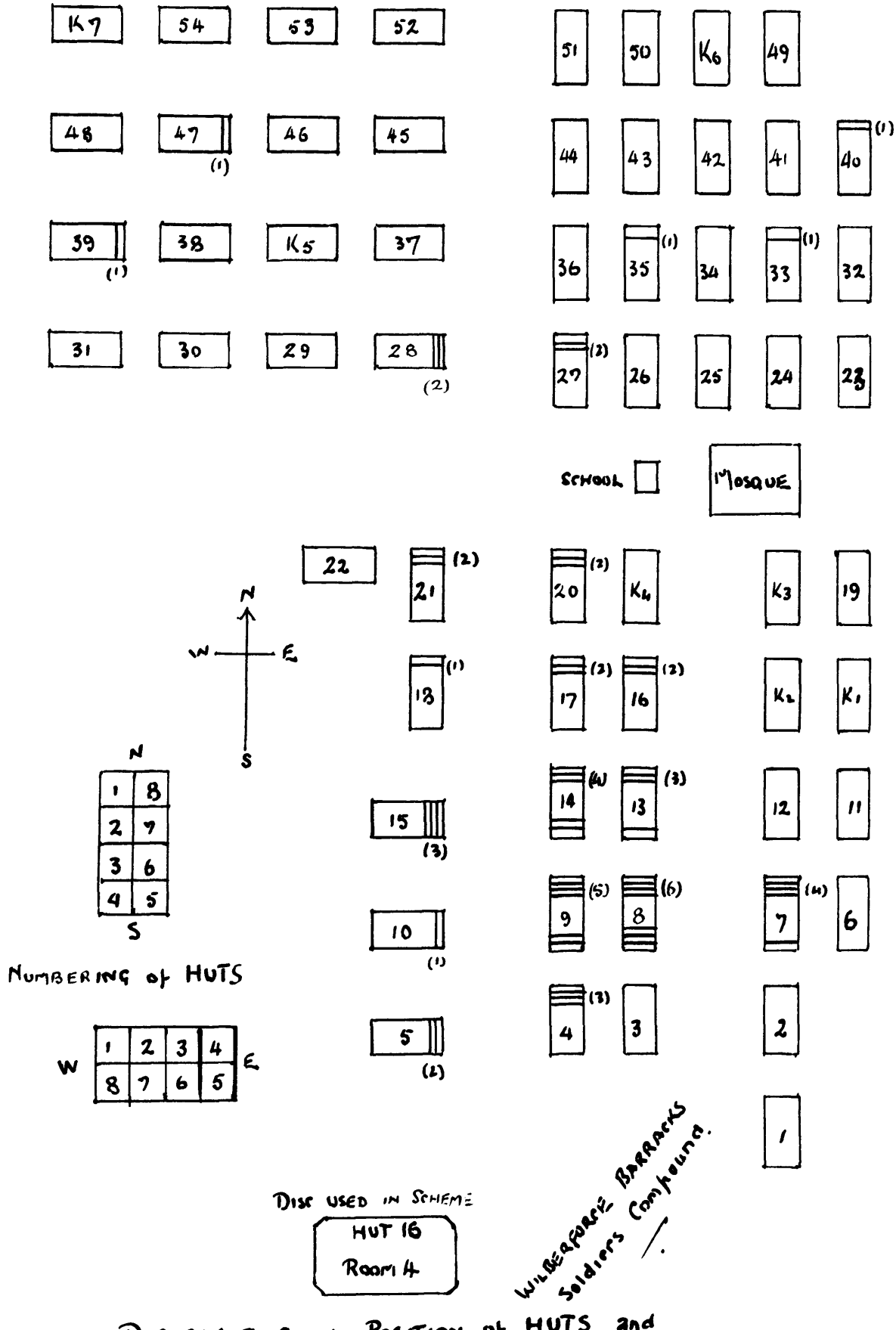


DIAGRAM TO SHOW POSITION of HUTS and DISTRIBUTION of "OEDEMA" CASES.

Resume of Oedema Cases.

Hut.	Room.	Occupants.	Animals.	Bed.	Hut.	Room.	Occupants.	Animals.	Bed.
4	2	M	D	S1	14	2	F		S1
	4	M F	D	S1		4	M F		U2
5	2	M		S1		7	S		U2
	7	M		U1	15	2	M F		U2
7	2	M		S1 U1		8	M	D	S1 U1
	3	M			16	7	F	P	S1 U1
	4	M	D	S1 U1		8	M		S1 U1
	5	M		S1 U1	17	3	F		S1
8	1	M	D	S1 U1	18	5	M		S1 U1
	3	M CM		S1	20	1	F	D	S1 U1
	4	F	D	S1 U1		4	M		S1
	6	M	D	S1	21	1	F		S1
	7	F	P	S1		8	F		S1 U1
9	1	S		U2	27	3	S		S1
	3	F		S1 U1		7	F		S1
	5	F	D	S1		8	S		S1
	6	M	D	U2	28	6	FF		U1
	7	M		U1	30	3	M F	D	U1
	8	M		S1	33	5	F		U1
10	2	M		S1 U1	35	5	F		U1
13	3	M		S1	39	5	F		U2
	4	M F		U1	40	3	M		U1
14	1	M		S1 U1	47	2	M		S1 U1

S1 = 1 Screened bed. U = Unscreened. M = Adult male. F = Adult female. CM = Male child. S = Servant. D = Dog. P = Fowls.

The Oedema Cases: The serious cases of oedema were admitted, some to the Connaught Hospital but others chiefly to the Hospital at the Barracks, where they were treated along several lines to find, if possible, an efficient remedy. In the Barracks' cases the diet was kept unaltered and consisted of rice seasoned with red pepper, palm oil and, occasionally, with the addition of a small piece of beef or fish.

The patients treated at Connaught Hospital will be considered below.

The other patients and early cases were grouped as

ambulatory subjects in experimental classes and various prescriptions were given each group, with the possible object of obtaining better statistical data concerning treatment.

Ambulatory Cases: I am submitting a list of these groups showing the number of ambulatory patients in each, the prescriptions used and the result of treatment:

Group	Number	Sex	Prescription	Medicine Number	Result
1	4	3M 1F	Calc.Lact.gr.10 Aq.Menth Pip ½ oz. T.I.D.	1	One improved - fifteen days; three not improved; given medicine No. 2 then clear in ten days.
2	5	3M 2F	Calc.Lact.gr.10 Mist Alb.oz.ss T.I.D.	2	Well - nine to thirteen days.
3	5	3M 2F	Mist Alb.oz.ss T.I.D.	3	Well - sixteen to twenty days (one to Kissy - smallpox).
4	4	3F 1M	Calc.Lact.gr.10 Sod.Citrat gr.10 T.I.D.	4	Well - twelve to fourteen days (slow at first - rapid later).
5	4	2M 2F	Ferri Tonic oz.½ T.I.D.	6	Not improved eighteen days; rapid after medicine 2 and 4.
6	4	4F	Tr.Digital M5 Calc.Lact.gr.5 Ferri Tonic dr.2 Aq.Ad.oz.ss T.I.D.	8	Not improved; eighteen days; (1 improved) put on medicine 2 and 4 and rapidly cleared.
7	4	1M 3F	Sod.Citrat gr.10 Hexamin gr.5 Tr.Digital M 5 Syr.Aurant dr.1 Aq.Ad.oz.ss T.I.D.	9	Not improved after 18 days; one improved after 14 days given medicine 2 - improved.

(Contd.)

Group.	Number.	Sex.	Prescription.	Medicine Number.	Result.
8	4	2M 2F	Calc.Lact.gr.5 Ferri Tonic ½oz. T.I.D.	11	One improved. 15 days others no improvement given medicine 4 improved.

(Mist.Alb. is a white saline purgative mixture containing Magnesium oxide, Magnesium Sulphate and Peppermint Water. Ferri Tonic contains Iron Citrate, Quinine and Strychnine).

All these subjects were given medical treatment daily for an observation period of eighteen days and the results were noted. They remained on the same diet to which they had been accustomed and no new rice was allowed, nor was there any special issue of foods rich in vitamin B. If improvement did not follow within eighteen days the subjects were switched over to a line of treatment which had been proved to be successful for other groups. Thus, in some classes no betterment was observed, in fact, many patients became worse but when given the "Calcium Lactate Purge" mixture or calcium lactate and sodium citrate, they all cleared up rapidly in ten to twelve days. No fatal issue attended the experiments although many ambulatory subjects had well defined oedema.

During these group tests, two cases contracted chicken-pox and had to be removed for observation to the Kissy Male Isolation Infirmary.

Hospital Cases: Generally, the patients treated in the hospital cleared up more rapidly due to the rest in bed and to

the better conditions of warmth and shelter maintaining in the building.

Hospital Cases.

Group	Number	Sex.	Prescription.	Medicine Number	Result.
9	5	M	Calc.Lact.gr 10 M Alb.oz.ss T.I.D.	2	All improved 7 - 10 days.
10	5	M	Enema Simplex (once daily)	10	All improved 12-14 days.
11	4	M	Calc.Lact.gr.10 Sod.Citrate gr.10 Ferri Tonic oz.ss T.I.D.	5	All improved 15-16 days.
12	4	M	Calc.Lact.gr.10 Salol gr.5 Sod.bicarb gr.15 T.I.D.	7	Not improved after 16 days - given purge in addition and cleared in 7 days.

The food of these patients was what they had been having in their huts at the Barracks' Compound, where it was prepared and then brought over to them. They each consumed daily about 1¼ lb. rice, cooked with the addition of red pepper as curry, palm oil (about 2 ozs.) and some dry fish.

Very few of these patients received beef every day but they all had it twice a week. On other days the protein was obtained in the form of dried fish. In general, as far as protein-rich foodstuffs is concerned, the average soldier lived on what may be colloquially termed the "Hunger and Burst" principle. The meat ration is reduced to a minimum till the

week-end and, especially, till pay day at the end of the month, when, at Wilberforce Barracks, extra cattle are killed to supply the market demand. It was fortunate that the majority of the hospital cases did not receive the surfeit of beef during stay in the hospital. As will be shown later, excessive amounts of meat have a peculiar influence on the course of the disease, in that the oedema tends to be reduced with a diet rich in animal protein. This aspect of the condition was confirmed by observations on the inmates of Freetown Prison.

Treatment Survey: Surveying the treatments, it was considered that, to be successful, it was necessary to include calcium lactate, preferably made easily assimilable by exhibiting also the alkaline effect of sodium citrate and to add an efficient saline purge. Although, however, this calcium lactate and purge treatment made the oedema vanish and enabled the patient to feel well and to be able to resume duty, it cannot be considered a cure provided the subject continues to eat faulty rice. So long as this type of treatment is taken, the rice could be consumed without any considerable increase of the oedema following, entirely, I think, because of the purging effect of the saline and of the vaso-tonic influence of the calcium salts. When the treatment was withheld the dropsy returned in about eleven days and it was always preceded by a bout of constipation. On the other hand the treatment affected a permanent cure of the condition after six months, when the men ate new season's rice,

even despite the onset of attacks of constipation or when the "oedema-producing" rice was cooked as I directed.

Distribution of Cases: Concerning the distribution of oedema among the entire Colony at the Compound, I have submitted below a table to demonstrate the age and sex incidence:

Total Cases,	54	Men,	30:226	13.3	p.cent.
" Population,	554	Women,	19:185	10.3	"
" Incidence,	9.7 per cent.	Servants,	4:63	6.3	"
		Children Boys	1:31	3.2	"
		" Girls	0:49	0.0	

Among the entire inhabitants, the incidence of oedema was 9.7 per cent. with a sex and age distribution as shown above.

That the soldiers are exposed to the strain of physical training, to drill in comparatively heavy equipment and to strict discipline are potential causes of the high relative incidence of the condition among their numbers. Women do not lag far behind in that they have fairly hard work to do washing clothes and preparing rice by pounding in the native mortar with heavy wooden pestle. The boys (servants) come under a special category. Some are attached to the native soldiers and others to the European Officers. Among the latter no oedema was observed; whether or not this is due to the lavish treatment by their employers or to the enhanced opportunity of participating at a better commissariat is unknown, suffice it to remark that none of these boys showed any signs of chronic starvation and they did not eat the same rice as was consumed by the soldiers.

The female children, by a close association with their mothers, are better looked after than the male children. This may be the cause of their increased resistance to the condition.

Multiple Infection: Infection ought to be considered in terms of multiple infection, where two or more people in the same room exhibit the sickness at the same time. Forty cases were found in rooms occupied by more than one individual, yet, although the total number of occupants of these rooms amounted to ninety-eight only seven examples of "dual" infection occurred.

Of the forty, thirty-three were married people but of these only five couples were found to be suffering at the same time. In one case a man and his child were affected and in another two of three sisters, so that in all, seven instances of "dual" infection were displayed or that the disease affected only fourteen people, who were daily in the closest contact with their neighbours. During any part of the work there was no indication of one individual being affected and a neighbour later after a definite incubation period. This idea of infection by contact and by vectors had carefully to be considered because of the peculiar suspicion of an infective agent in the Prison cases. It will be brought up again later.

Effect of Mosquito Nets: That the condition may have an insect vector had to be investigated. In this light the influence of screening by mosquito nets was taken into account, but apparently these have no effect at all on reducing the

incidence of the disease. From the census it was observed that slightly more than half of the personnel does not possess nets (211 unscreened 197 screened beds) but this factor must be reduced to terms of the oedema cases only. Among these it will be observed that almost all their rooms possess screened beds. This would at once suggest that there was ample protection because thirty-two rooms were so equipped out of a total of forty-six. The sleeping arrangements of the African soldier requires explanation. Generally, the soldier himself has his bed provided with a mosquito net and his wife can struggle along as best she can; so that the screen distribution becomes somewhat altered. It works out among the patients in the following ratios:

	Screened.	Unscreened.
Male,	24	10
Female,	6	13

In other words, thirty of the fifty-three cases were protected and in the habit of sleeping under nets. They did not complain of mosquitos, which admittedly were comparatively few, but all made reference to the prevalence of bedbugs.

The theory of an insect vector merits further attention, when the loci of the disease are considered along with the plan of the Compound. The bulk of the cases was confined to Huts 4, 8, 9, 13 and 14, which are all situated together. The possibility of an insect vector disease became apparent, but as the work progressed, it was partly relinquished in view of the

theory of rice poisoning expounded later. After all, even allowing the chance of a disease being carried, these people were all, more or less, eating the same food which, if proved to be toxic, would eliminate at least the necessity of an insect borne disease. It is considered superfluous to promulgate theories of infection and of insect vectors, if in a mass attack all the members of a community partake of the same type of food, which is shown to be detrimental to health.

Pets: Not much cognisance ought, I think, to be taken of any part played by animals kept as pets. Fifty-three dogs roamed the Compound, together with many fowls, all of which share the shelter of their owners. Guinea pigs are quite commonly kept, but, in no case, were they associated with an "oedema" subject. Eleven patients had a dog each and two kept fowls. During the owners' sickness and after their recovery, the animals continued to share the amenities of the household without any detriment to their owners or to themselves. These animals did not show evidence of any disease process.

Rice at Wilberforce Barracks: At the time of the outbreak, I examined, in conjunction with the Superintendent of Prisons, specimens of rice supplied to the Royal West African Frontier Force. The samples had a musty smell. I found the rice to contain a high percentage of old, dead and fungoid-diseased grain (29 per cent.) and to be mixed with a small percentage of bored and broken grains. Weevils, rice bugs and maggots were

present. A large percentage of the rice showed black and dark brown discolouration, extending from the pericarp inwards to the starch.

The soldiers explained that when they ate this rice they suffered from colic and abdominal trouble, some with constipation, others with diarrhoea.

In all cases of oedema at Wilberforce Barracks, there was a history of gastro-intestinal stasis occasionally with colic.

Effect of washing Rice: To make it a safer food, I recommended that the rice be cleaned in water and cooked in a special manner. This consists of washing thoroughly in cold water, placing the rice in a pot with water to cover, just bringing to boiling point and throwing away the yellow-brown boilings. Fresh clean water is then added and cooking is continued till the rice is soft and edible. By these means it is maintained that soluble toxins are dissolved and thrown away but any vitamin B is retained undestroyed.

A number of women in the Compound had been using this method before I recommended it and in no case was any of their family circles affected. On the other hand, in every case of oedema, although quite a number washed the rice in cold water before cooking, all invariably conducted the cooking of the rice by adding just sufficient water and boiling till the grain had softened and absorbed all the water. There was no mention of

throwing away the initial boiling water. Recovery from the oedema became permanent when this method was adopted.

One case is of special interest in this consideration. A Patient (A) had been admitted to the Barracks Hospital and treated with Calcium Lactate and Sodium Citrate. In the hospital he shared the rice of another patient (B), a case of Bronchitis, whose wife threw away the first boilings. Both men recovered and returned to duty but a fortnight later (A) was readmitted to the hospital where he informed the dresser that he had gone back to his own wife's method of cooking, in which all the water was boiled into the rice. (A) recovered and did not show any relapse to the oedematous condition, when he consumed the rice after the initial boiling water had been rejected.

Previous Outbreaks: On account of the difficulty of obtaining accurate data, any reference to previous outbreaks of oedema at Wilberforce Barracks is scanty. The daily record of medical complaints was gone over for the last three years in the hope of gleaning some such information and the results, as well as could be ascertained, for that period, are tabulated and submitted below.

The total number of complaints per month was noted, together with the general prevalence of constipation, rheumatism and oedema. To ensure a small degree of accurate co-relation the notified diseases are all brought to terms of daily incidence, allowing for the numerical daily variation in

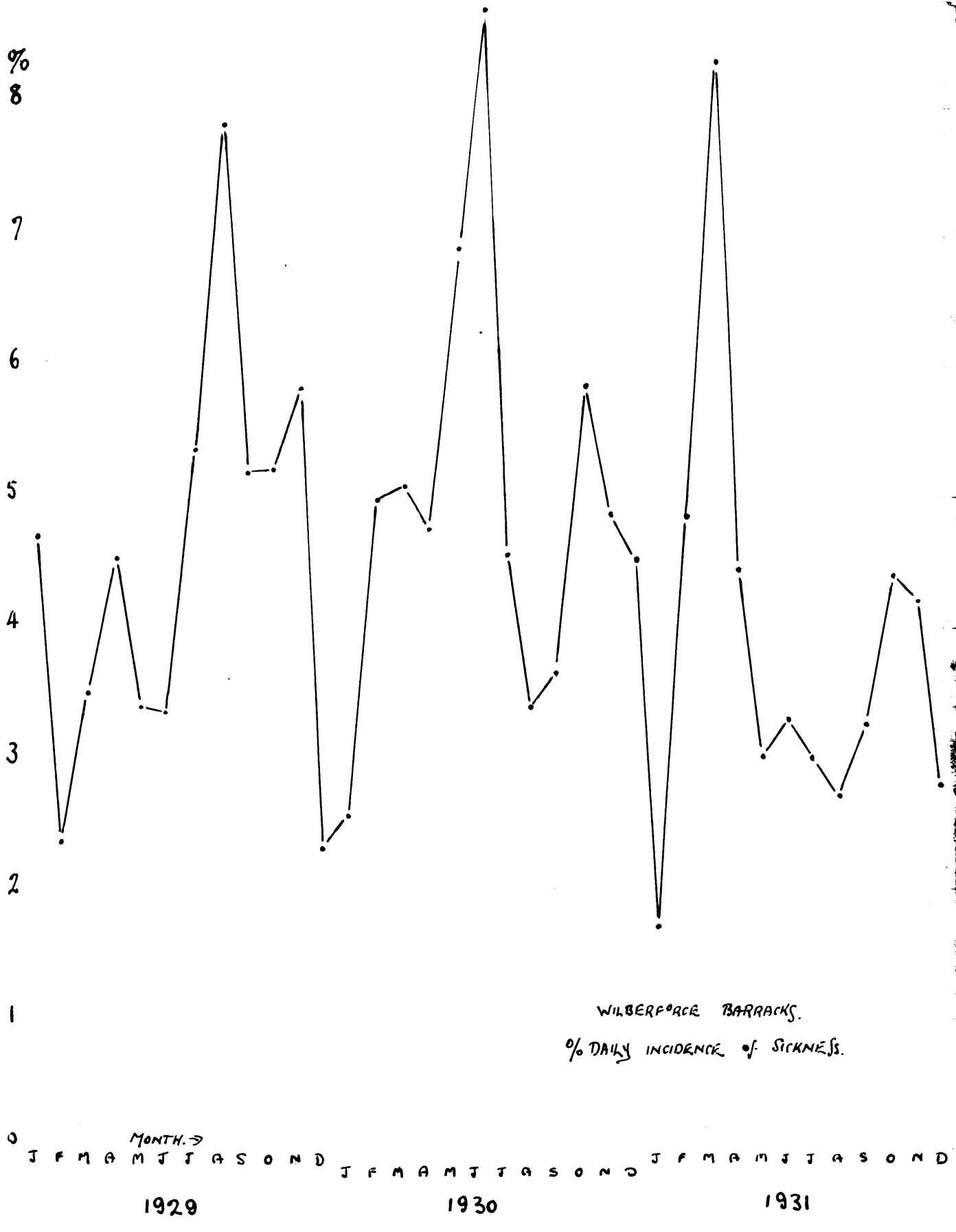
the month. Unfortunately, however, the figures appertaining to the movements of troops were not available in order to make an absolute index of the daily notification of disease. On this corrected value the percentage incidence of the complaints of constipation, rheumatism and oedema is calculated. The table shows the quantity and the dates, as far as could be ascertained, upon which rice was delivered to the Quartermaster of the Troops.

WILBERFORCE BARRACKS.

MONTHLY SICK RETURNS FOR YEARS 1929-1931.

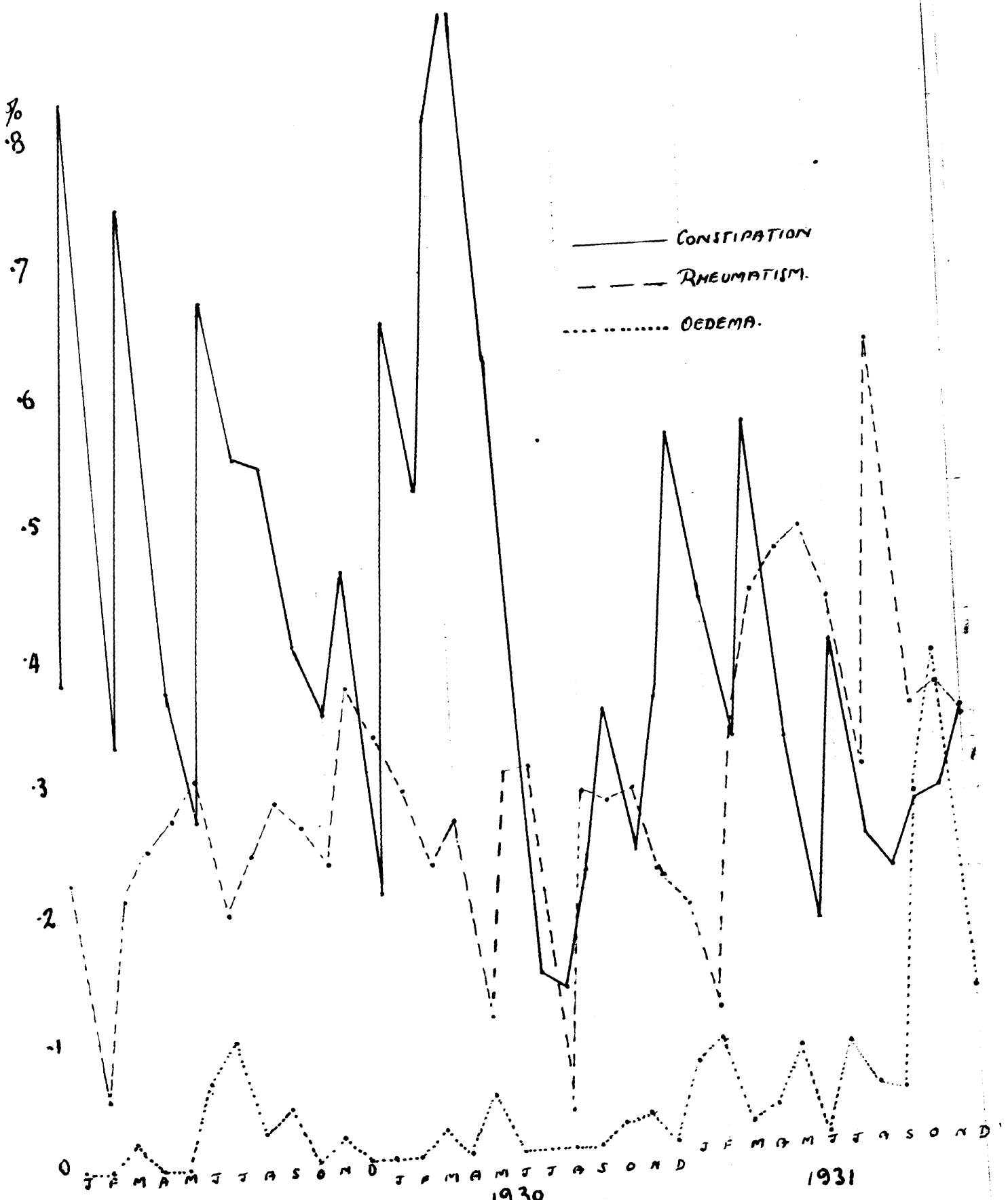
Month.	Total	Cons.	Rheu.	Oed.	Percentage Daily Incidence. T.+D.	Cons.	Rheu.	Oed.	Rice (Bushels)
1929.									
January,	145	17	10	-	4.677	.3781	.2224	-	
February,	65	15	1	-	2.321	.8241	.0549	-	
March,	106	11	7	1	3.483	.3285	.2096	.0229	
April,	135	30	10	-	4.500	.7409	.2470	-	
May,	105	12	7	-	3.387	.3687	.2700	-	
June,	100	8	9	2	3.333	.2667	.3000	.0667	
July,	165	34	10	5	5.323	.6646	.1955	.0977	
August,	242	41	18	2x	7.805	.5465	.2399	.0266	
September,	155	25	13	2x	5.167	.5376	.2796	.0430	
October,	161	20	13	-	5.192	.4007	.2604	-	
November,	174	18	12	1	5.800	.3449	.2300	.0192	
December,	71	10	8	-	2.290	.4542	.3634	-	
1930.									
January,	79	5	8	-	2.548	.2042	.3265	-	
February,	139	25	11	-	4.963	.6423	.2826	-	
March,	157	25	11	1	5.063	.5136	.2260	.0205	
April,	142	34	11	-	4.733	.7981	.2583	-	
May,	213	60	7	3	6.870	.9087	.1060	.0454	
June,	261	48	23	-	8.700	.6130	.2937	-	
July,	141	6	13	-	4.547	.1373	.2973	-	
August,	105	4	1	-	3.387	.1230	.0307	-	
September,	109	7	9	-	3.633	.2141	.2753	-	
October,	181	19	15	1	5.838	.3386	.2673	.0178	
November,	146	10	12	1	4.868	.2283	.2740	.0228	
December,	140	15	9	-	4.515	.3456	.2073	-	

(Contd.)



WILBERFORCE BARRACKS.

% DAILY INCIDENCE of SICKNESS.



% DAILY INCIDENCE of SICKNESS.

Wilberforce Barracks

Month.	Total	Cons.	Rheu.	Oed.	Percentage Daily Incidence. T.÷D.	Cons.	Rheu.	Oed.	Rice (Bushels)
1931.									
January,	53	9	3	1	1.710	.5476	.1825	.0608	5th. -200
February,	136	16	4	3	4.857	.4202	.1030	.0788	5th. -480
March,	258	25	26	1	8.322	.3125	.3251	.0125	
April,	133	22	17	1	4.434	.5548	.4250	.0251	
May,	92	7	13	2	2.968	.3089	.4557	.0701	20th.-200
June,	99	5	14	-	3.300	.1684	.4714	-	6th. -200
									17th.-200
July,	93	11	12	2	3.000	.3815	.4162	.0693	16th.-400
August,	84	6	10	1	2.710	.2304	.3840	.0384	19th.-200
September,	98	6	18	1	3.267	.2041	.6123	.0340	23rd.-200
October,	137	10	14	11	4.410	.2554	.3288	.2590	29th.-112
November,	126	10	13	14	4.201	.2646	.3438	.3704	2nd. -200
December,	89	10	9	3	2.805	.3621	.3262	.1087	250

Cons = Constipation. Rheu = Rheumatism. Oed = Oedema.
T.÷ D. = Monthly total ÷ number of days in month. X = Outbreak of complaints of "sore feet". Factors to correct for movement of troops not available.

The results of these data are depicted graphically. On the same scale the variations of rheumatism, constipation and oedema are shown, while on a smaller scale, is a graph depicting the daily incidence of all notified diseases.

It will be seen that, although there is a fairly constant relation between constipation and oedema (constipation always preceding oedema), the same does not necessarily apply to rheumatism. This may be merely a question of nomenclature. The terms myalgia, rheumatism, lumbago, sciatica, fibrositis, muscular and joint pains have all been employed and it is difficult to know if previous Medical Officers considered rheumatism in the narrow sense of "joint pain" or if they imply

the aspect mooted by Professor R.Stockman of Glasgow University of a disease essentially of overgrowth and inflammation of the fibrous tissue, no matter where disposed this essential packing tissue may be.

In general, Drs.Leitch and Watson's (2) work confirms these observations on the correlation between rheumatism, oedema and constipation, although they do not indicate that gastro-intestinal disturbance may be a forerunner of Beriberi oedema.

The Supply of Rice: In the table above I have submitted data concerning the dates when rice was supplied to the Royal West African Frontier Force, but, although I found diseased rice at the Quartermaster's Store, I am unable to state which of these consignments were faulty.

The last epidemic had been present at the Freetown Prison and at Kissy about August 1931, but it did not break out to any extent among the Royal West African Frontier Force until early October, 1931, when it rose rapidly to a peak value in November and steadily declined. It has since disappeared (January 1932). From information received from Mr.Biddle, there definitely was an issue of diseased rice to the Royal West African Frontier Force in July, 1931. Any inferred incubation period cannot, however, be set because the troops drew this rice from the Quartermaster's store as required, therefore, of necessity, the stocks held by the soldiers were of variable amounts. New season's rice has since been issued to the troops and no

new cases of oedema have occurred.

Outcome of the Work: The inhabitants of the Wilberforce Barracks Compound continue their simple diet of rice, palm oil, pepper, curry, with an occasional portion of fish or beef and a small amount of fresh fruit. No added vitamin products like Bemax, Marmite, yeast, cod liver oil are taken with the food. They live an open air life on an exposed part of the country. Essentially, their conditions are the same as they were during the outbreak of oedema, yet merely by changing the rice and/or method of cooking, oedema has been reduced here to the vanishing point by employing these simple means and by ensuring that, through the Quartermaster's Department a supply of good sound rice is issued to the troops.

All the patients who contracted the disease during the last epidemic have since been examined at intervals and found to be well. There is no evidence of permanent injury in the way of oedema, cardiac disability or nerve changes. In my opinion, this cannot be claimed simply as a victory for treatment by Calcium salts and by purging alone but I consider that it is of foremost importance to ensure that these people are supplied with rice in good condition and not showing signs of deterioration.

Kissy Asylum.

During the enquiry, this institution was under the charge of Dr.Easmon, who kindly assisted me, as far as possible,

with statistical data concerning the condition at the Asylum. There was no history of any previous outbreaks but during the present epidemic no less than twenty deaths occurred from August to December, 1931.

Although I was responsible only for the post-mortem examinations and I performed the majority of the necropsies, I made a few observations on the housing conditions and on the diet of the inmates.

Accommodation: The majority of the patients were accommodated in large wards with beds the regulation distance apart and without overcrowding. The clothing and bedding were clean and did not show signs of verminous infection. The walls of the wards were made of a mud-cement composition, parts of which had been broken in places. No bedbugs were found. There did not appear to be evidence of any patient having the infection carried from his immediate neighbour, as will be presented in cases which occurred at Freetown Prison. In general, the inmates were clean and showed signs of kindly treatment and good care.

Dietary. At the same time I visited the kitchen of the Asylum and inspected the rice bin, where there was stored a quantity of rice containing old fungoid grains, bored and broken grains and discoloured grains. Weevils and maggots were seen in the bin. This rice contained on examination 33 per cent. of pericarp as shown by the Vedder and Feliciano method (3). The

rice was supplied from the Freetown Prison and came from the same source as was used in Freetown Prison and Wilberforce Barracks.

The inmates of the Asylum had their rice cooked in a large open boiler, into which the grain was placed, water added and boiled for the specified time of twenty-five minutes as laid down in the instructions of Drs.Leitch and Watson (2) (pp.91 Report on an Investigation of Beriberi at Freetown Prison). Any surplus rice water was not discarded but was added to soup, although the cook informed me that generally the water more or less all boiled into the rice. During the epidemic there was no doubt that Dr.Easmon relying on the diagnosis of Beriberi due to avitaminosis did all in his power to cope with the conditions by allowing a most liberal diet, high in calorie value and excessively rich in added vitamin products. This had not the slightest effect on the course of the epidemic.

Observations: In the course of my duties, I interviewed several inmates. In November, I found eight cases of oedema most of whom came ultimately to necropsy before the year ended.

On enquiry I learned the treatment consisted of a very liberal diet of rice, greens and meat, with Marmite as an additional source of vitamin B. To the patients suffering from pericarditis a cardiac mixture, called "Mist.Beriberi" was exhibited. This had been advised by Drs.Leitch and Watson (2) and was compounded from the following prescription:

Tr.Belladon - m 20
Tr.Strophant - m 3
Tr.Digital.- m 5
Tr.Nuc.Vom. - m 5
Mag.Sulph. - dr. 1
Aq.Chlorof. - ad.oz. 1

Unfortunately, in all the cases I saw, it did not have the desired effect, even when coupled with large doses of vitamin B (supplied in the form of Marmite). However, as my duties did not extend to treatment of the cases, the observations I made at Kissy Asylum, where the outbreak was very serious, were confined to post-mortem examinations and records of the necropsy findings are given below in the Laboratory Results.

Connaught Hospital.

In the light of scientific research and considered as a suitable experimental subject from whom reliable data may be obtained, the African out-patient at this Hospital is utterly unreliable. He has no conception that his condition may be but the reflection of a train of past occurrences, including the detrimental influence of exposure, lowered resistance, faulty diet, verminous housing and clothing, implicit faith in native applications and "magic" medicine. He has an inborn dread of hospital, which is displayed in his over anxiety to get away from the wards whenever he feels just the slightest improvement and not to return to hospital, if possible. Women are worse in this respect, in that when their sick children are brought to the hospital, often in extremis, they are removed at the earliest

onset of recovery, often considerably to the detriment of the patient. The outcome of this mentality is that on any particular disease, unless it be of an entirely incapacitating nature, research is of no great value because the final results are not seen. One has to assume that in 80 per cent. of the cases, if the patient does not return, he is well or sufficiently recovered to be content with a course of native medicine. Therefore, when making the study of oedema, although it was deemed useful to employ the Out-patient Department of this hospital, the Department was used almost entirely as a clearing and sorting house, from which treatment could be given to ambulatory cases and from which "interesting" cases could be transferred, if possible, to wards in the hospital.

Out-Patient Department: In November, 1931, many cases of oedema cropped up at the Out-patient Department. They displayed the same signs as were present among the troops and among the prisoners at Freetown Prison. Oedema of feet and legs was commonly coupled with a history of chronic constipation. The urine showed no abnormalities but had an excessive amount of "earthy" phosphates, which in these cases, may have been due to reduced water intake with the concomitant result of higher concentration of urinary salts. Many had praecordial distress and breathlessness. In one man, a pauper, who had been consuming black mouldy rice, oedema of the abdominal wall and of the skin over the sternum was found in addition to dropsy of

the lower limbs.

All the cases were requested to furnish samples of the morning urine and of the rice which they generally had been using. Thity-six cases in all were observed.

One young girl (aged twelve years) brought a new sound rice, which turned out to be recently purchased, as she did not like to show the old rice which she had been eating. Two patients, sisters, had been for several months eating parboiled rice, in which the grain was large and white with no pericarp remaining. They were treated as cases of true Beriberi avitaminosis. They were given cod liver oil, fresh tomatoes and other fruits and advised Bemax, upon which the condition slowly abated. They became perfectly well after eight weeks' treatment, but it was learned they had commenced to eat, during the course of their treatment, new season's rice, of which they brought a sample. It was not parboiled and contained 58 per cent. pericarp.

A fourth subject was admitted to the hospital as a case of dry Beriberi. He had been serving on board a ship on which he stated old rice had been issued. He improved on a full diet of bread, butter, meat, fish, eggs, milk, potatoes, fresh fruit without additional accessory food substances and he was discharged with complete recovery four weeks later. This case together with the two sisters just mentioned constitutes the only examples of "dry" beriberi found during the work. All the

other patients were of the typical "wet" or oedematous grouping, a point which is of cardinal importance concerning the bearing of this research on Beriberi.

In the remaining thirty-two cases treated, all the rice samples examined were of poor grade, containing discoloured grains, fungoid grains and signs of weevil activity. These subjects were all treated by the Calcium Lactate and purgative method and all cleared up within twenty days of treatment; at least after sixteen days they showed considerable improvement, had their mixture repeated and did not report again, except for four cases whose improvement was sluggish but positive and who disappeared after twenty-eight days under casual observation.

All these subjects in the Out-patient Department were advised about rice and cooking and most of them stated they used up their rice stock by altering the cooking.

In-patients: Twelve cases were admitted for observation to Ward No.2. Urinary examination in all cases but one revealed no albuminuria or other of the customary abnormalities but at first all had excessive phosphates. The one exception was a case of subacute nephritis with albuminuria and casts. In the remaining eleven, there was a constant history of chronic constipation, rheumatic pains, slight palpitation and breathlessness on exertion, tender calf muscles and oedema of the legs to the middle of the thighs. Ten had partial anaesthesia (loss of heat, tactile and pain but not of cold) over the pretibial area.

The remaining one had diminished sensation only to touch and temperature, pain being present. The tendon reflexes were variable. On admission, they all had slightly elevated blood pressure (average systolic 152-164 mm. diastolic 90-106 mm.) and with the rest in bed and treatment this was steadily reduced (systolic 128-142 mm. diastolic 80-84 mm.). Two cases complained of difficulty with vision and of photophobia. One had increased intraocular tension and signs of early glaucoma, which, however, cleared up on treatment.

The diet was standard for all these patients, termed "full hospital diet", which was composed of rice, greens, beef, tea, sugar and dry bread (except with two enemata patients whose rice was disallowed and replaced by potato and bread). The medical treatment was grouped as at the Wilberforce Barracks Hospital:

Group.	Number.	Prescription.	Result.
(a)	2	Calc.Lact.gr.10 Ferri Tonic oz.ss T.I.D.	Improved seventeen days.
(b)	4	Calc.Lact.gr.10 Mist alb.oz.ss T.I.D.	Improved five to twelve days.
(c1)	3	Enema (simple) twice daily (including the pauper with sternal oedema).	Improved seven to nine days.
(c2)	2	Enema (no rice diet - potato and bread).	Improved eight days.

Results: These eleven patients reported in one month after discharge and all remained normal, except one, who had been unable to purchase good rice or to have his food properly cooked. He received a prescription for Calcium and Mist.Alba. but he did not return to report his condition.

Reverting to the Connaught Hospital groups (a), (b) and (c), it was shown that in:

(a) Calcium Lactate and Ferri Tonic there is a tendency to constipation which is considered to be responsible for the delayed recovery.

(b) Calcium Lactate and purgative act almost as rapidly as simple enemata but at Connaught Hospital the recovery period is faster than at Wilberforce Barracks, where the diet is of poorer quality and less liberal.

(c) The enemata results are of interest. These subjects were allowed (group C-1) the same diet as the others in groups (a) and (b) but they had twice daily a simple water enema without soap, using a quart of water each time. Copious foul-smelling results were obtained at first with hard inspissated faeces. After four treatments the washings were returning clear, except with traces of mucus. The odour had almost gone and the patients were looking obviously improved. The expression was brighter, the eyes less sallow and, most annoying of all it was with difficulty that they were persuaded to remain in the hospital, possibly an aftermath of the strenuous treatment. In group (C-2 enemata and diet, with rice replaced by bread and potato) the speed of recovery was the same. Apart from the interest of this result, no opinion was voiced till more records were made at Freetown Prison under the same conditions.

The clinical observations made on the patients are mentioned in the Laboratory work to avoid recapitulation.

Infectivity: In the early cases at Freetown Prison there appeared phenomena that indicated infection of one man by another, a point to which reference will be made later in connection with Freetown Prison. This has already been considered above under "insect vector and multiple infection" at Wilberforce Barracks. The Connaught Hospital cases, on no occasion, showed any infectivity to their immediate neighbours, despite the presence of fleas and other possible insect vectors. On each side of the Oedema cases were placed such conditions as pneumonia, malaria, dysentery, phthisis, yet despite these enfeebling conditions, none developed the disease, even with prolonged stay in Hospital after the oedema cases had gone.

It is natural to adduce that in these observations at Connaught Hospital, the variable factors are too numerous and this fact is at once conceded. These patients, unlike those in institutions or at the Barracks, have not only medical treatment, but, what is infinitely more important, a complete change in dietary, which, undoubtedly, accounts for all of them clearing up so rapidly. I consider, however, that the treatment by purging enables a more rapid elimination of any intestinal toxin, which may be producing the disease, or, at least, hindering the recovery. There is to be considered, too, the relative recovery rates, which are faster when purging is undertaken. One point, I think, must be allowed, and that is, the success of the treatment does not depend upon the addition of copious

quantities of vitamin B, as would be considered necessary, were this oedema entirely due to lack of this accessory food substance.

Allied Complaints: At the Out-patient Department I undertook observations on the incidence of Myalgia, with rheumatic pain of the limbs and its possible association with avitaminosis, oedema and Beriberi of the dry neuritic type. The subjects, however, proved so utterly unreliable that this work at the Connaught Hospital Dispensary was discontinued.

While in charge of the Out-patient Department at Connaught Hospital, a student of the Wilberforce Training College was brought, suffering from "A" avitaminosis (as described by Wright) (4). She was treated by calcium and cod liver oil and malt with complete recovery in two months. At that time I visited the Wilberforce Training College and requested to be shown the rice store in which were found old fungoid rice, discoloured and broken grains and weevils, but no maggots were seen. At that time I was shown three other cases of early avitaminosis. They were not put under any treatment, but advised merely to keep the intestinal tract cleaned out and to eat good rice. The new rice was the chief dietary change effected. When three months later, I visited the College, I learned that all the cases of "A" avitaminosis had cleared up and that the girls were in good health. At the time it occurred to me that this institution was a new ground

for dietary investigation.

Freetown Prison.

Oedema has been present in the Freetown Prison for at least the past forty-eight years and notifications have repeatedly been made to vague outbreaks of a condition of dropsy with dysentery. It has been only within the past few years that the disease has been labelled "Beriberi", especially when the final stages of the condition have been observed. Recently the work received intensive study in the hands of Professor Blacklock (1) (1922) and Drs.Leitch and Watson (2) (1929).

The Superintendent of Prisons, Mr.Biddle, has remarked that all the epidemics occurring at the Prison since 1914 have invariably been preceded by gastro-intestinal symptoms, chiefly of a dysenteric nature.

The particular causal agent, whether bacterial or otherwise, has never been determined with any measure of success and, although equipped for bacteriological work in the Sir Alfred Jones Laboratory, Drs.Leitch and Watson (2) were unable to track down any organism to which might be attributed the disease. They refer to one case, in which they found only the common organisms (B.coli communis, B.megatherium, B.friedlanderi and B.morgani) to which none of the pathological findings were attributed. They cameto the conclusion that this disease was definitely due to "B" avitaminosis.

The Superintendent of Prisons makes a valuable observation, in that, if within a few days after the Beriberi had been diagnosed, the patient developed a mild attack of diarrhoea, he usually died, whereas all the cases who suffered from a prolonged and severe attack of dysentery recovered from the Beriberi condition. These curious phenomena had also been commented upon by Dr.Butler in 1914 and the late Dr.W.A.Young in 1919. Young went the length of isolating every person on admission until he was proved free from infectious disease. In view of the purging effect of the treatment I adopted at Wilberforce Barracks and at Connaught Hospital, this observation is of great interest, in that a similar absence of intestinal stasis is the net result both of treatment by purgatives and of chronic dysentery.

Theory of Infection: Concerning the possibility of an infectious disease, the Superintendent of Prisons states that during the last epidemic (1929) the first patient was an Assistant Warder, Lamina, who was in charge of the Carpenters' workshop. He died after about ten days' sickness. The next case, also fatal, was a prisoner, Sandi, who worked under Lamina's supervision.

When the epidemic was almost at a peak, another Warder, Yamba, took ill after he had been allocated duty at "D" block, where the majority of the cases were under observation. In this subject a long history of dysentery of two months'

duration was noted and, although he made a remarkable recovery, he was no longer fit for the service.

Continuing his observation, Mr.Biddle makes note of a prisoner, Abu Lemberg, who had been recommended for the radical operation for double hernia. On account of his poor state of nutrition, he was admitted to the Hospital and allowed a liberal diet. His physical state became so much improved as to enable him to be fit for the operation but, just at that time, two epidemic cases were admitted to the Hospital and confined to beds on either side of his. A few days later, in spite of his most liberal diet, including tomatoes and other fruit, Abu Lemberg developed the disease from which he managed to recover.

Mr.Biddle makes reference to the large number of cleaners who suffered during this (1929) epidemic. Although normally eighteen are allocated to the task of removing, emptying and cleaning the commodes of the entire Prison, the incidence of cases in this section was very high, as instanced by the fifty-six who suffered in a population of 218 men. It was considered that there was a grave risk attached to this work and even the men themselves had the impression that it was of a deadly nature. The Superintendent of Prisons tells me of one man, who belonged to a particular group under survey, and to whom this task was allocated. The prisoner did not remonstrate but merely remarked to Mr.Biddle that if instructed to do so he would perform the job but "he go die". A short time later the man fell

ill with the epidemic sickness and succumbed. However, this may have been but an example of the native's fatalism.

On their face value these incidents would appear to support a theory of infection but sight must not be lost of the point that all the men were participating in the rice common to everyone's diet and that the cleaners, who suffered most, also had the hardest physical work to perform, which might possibly be sufficient to overstep the low threshold that the average African Native shows towards disease. Hard physical exercise had been recommended in the treatment, an outcome of the theory (Leitch) that oedema attacked chiefly the sedentary workers. Many untoward and fatal consequences have resulted following this advice.

Coupled with the case of Abu Lemberg are the following two incidents to display that, despite the diet rich in vitamins and of high calorie value, the spread of the disease was not retarded by taking care of calories and vitamins alone.

Prisoner V.Caulker had had, over a long period, an extra ration of one pound of bread and one pint of milk in addition to his ordinary full diet, yet he was badly affected.

Prisoner Sherka was granted extra bread (one pound daily) on account of his old age but he, too, developed the disease.

When I took over the Research in November, 1931, my work did not permit of treatment or of intensive experimental

observations on the patients, who were under the control of the Medical Officer in charge of the Prison and the time had to be devoted to such aspects as were included in the biochemical and biological research. In the early stages, my work consisted of collecting samples of rice, pericarp and dust and of observing the food of the prisoners.

The Rice Mill: Freetown Prison possesses the only power mill in the Colony and all the rice used by the prisoners is treated here. From the contractors it is supplied as "paddy" or rice in the husk which, before being fit for use, is cleaned by the mill, decorticated and milled partly to remove the pericarp. The end products of milling are husk, powdered pericarp and cleaned rice, milled to any desired degree. There is a very large amount of dust in the atmosphere at this mill. This dust was collected from the walls and from the machine parts for analysis. On the whole, no sand was present among the fine floating particles. Sand is chiefly found in the deposit of pericarp dust in the mill and some with the husk deposit.

As many complaints of bronchitis, sore throat and gastritis are made by the prisoners who work the mill, they are supplied at the end of each shift with stimulating cough mixture. The expectorated sputum contained small particles of rice cortex with pericarp dust embedded in the desquamated pulmonary epithelial cells. Had silicosis been present, sand

particles would have been anticipated in these macrophage cells, but none were found. Phthisical sputa were not found.

The Diet of the Prisoners: The diet recommended by Drs. Leitch and Watson (2) was drawn up expressly for its anti-beri-beri value and its high calorie value. I have tabulated the diet they recommended:

	Foodstuff.	Weight of Ration. Ounces.
5.30 a.m.	Cocoa, ...	½
	Sugar, ...	1½
	Wholemeal Bread, ...	2
10.0 "	Foofoo (cooked), ...	24
	Beef (liver), ...	2
	or fish, ...	2
	Greens (leaf), ...	2
	or fresh Yeast, ...	1
	and tomatoes, ...	1
	Fresh Yeast, ...	2
	or tomatoes, ...	2
	Onions, ...	¼
	Palm Oil, ...	1
	Cod Liver Oil, ...	1
	Pepper, ...	3/80
	Salt, ...	¼
	Kaindah, ...	a trace.
	Fresh Banana, Orange, Mango or Pawpaw, ...	1
4.0 p.m.	Rice (raw), ...	12
	Beef or fish, ...	2
	Yam or Cocoa yam or sweet potato,	4
	Ground Nuts, ...	2
	or dried beans, ...	2
	or dried peas, ...	2
	Tomatoes (fresh or tinned),	1
	Pepper, ...	3/80
	Salt, ...	¼
	Kaindah, ...	a trace.
	Rice, millings (a trace cooked in soup)	
	Fresh lime, ...	a half.

Protein	Fat	Carbohydrate.	Calories
3.26 oz.	3.4 oz.	17.2 oz.	3347 (increased later to over 3,500).

I have observed that strict adherence is being made to the new dietary. The quantities are measured with care and accuracy and, when recommended, liberal extra rations are allowed. Judged on accepted standards of vitamin value, there is no doubt but that the diet of the prisoners at Freetown Prison is probably the richest "vitamin" diet in the Colony, coupled with an intake of over 3,500 calories, suitable even for men doing heavy work in Temperate Zones. I am convinced that comparatively few of the general populace in Freetown, except the relatively well-to-do classes and the In-patients at Connaught Hospital are as well fed. The prisoners have commented to me that they have never had such good and copious food in their lives; (except possibly in the complaints that the ration of ground nuts is unappreciated and rejected by many men).

The meals are supplied regularly, warm, and served from clean dishes in clean and tidy surroundings. Unfortunately, despite the fresh meat, greens, spinach, yeast, tomatoes, cod liver oil, fresh fruit, sweet potatoes and ground nuts, Beriberi continued to crop up in the Prison.

I have remarked above that during the earlier part of the work the Prison Hospital was in charge of the Medical Officer and I did not have the opportunity of much experimental work, apart from collecting samples and making observations on diet. Recently, however, since my appointment to be Medical Officer in charge of Freetown Prison, I have had the opportunity

of repeating some of the work done at Wilberforce Barracks and of securing new data along experimental lines.

One week before I had taken over the Prison, the Superintendent of Prisons informed me that owing to shortage of supplies, he was obliged to revert to the remaining stock of old rice, containing a high percentage of discoloured grains. I concurred with his apprehension that he would surely have an outbreak of oedema. However, apparently he was left no alternative and could not at the time alter the dietary supplied. Within twelve days the complaints of pain in the chest with gastric troubles began and there were twenty-two cases of the disease noticed in the following fortnight, six of whom had to be admitted urgently to the hospital, where they made a rapid recovery. Six weeks after the issuing of the faulty rice, new grain was obtained and the disease completely disappeared in five days. The oedema subsided and no fresh notifications were made.

Outbreak of Oedema: The work was directed specially to enquire into the influence of old, "sweated" and fungoid rice and a fortunate opportunity arose for the work.

The Superintendent of Prisons had in the store a large stock of old rice, part of which had been issued to Wilberforce Barracks and to Kissy, and, which, at Freetown Prison had been held responsible for the present epidemic. Although condemned it was still kept in storage. Up to December, 1931,

when the epidemic had been lasting from the time the supply of a mixture of new and old musty rice was delivered in 1931, there had been many reports of the sickness. About January, 1932 new season's rice was obtained and this was milled, part-polished and issued to the prisoners. The epidemic subsided and the cases of oedema steadily cleared up.

The stock of new rice became exhausted, however, and the contractor delivered a large quantity of new season's rice, mixed with the old grain, which from its appearance had probably been in moist storage for a long period. Some of the rice was over one year old and it certainly was not new season's crop. This was milled and polished in the usual way. The rice contained a fair number of weevil-attacked grains and a large number of black fungoid grains and broken grains. I examined this rice and condemned it, but, for lack of other substances, part of it was fed to the prisoners. Seven days later there were complaints of constipation and pain in the praecordial and epigastric regions and twelve days after the issue of this faulty rice there appeared four new cases of oedema. Three days later there were three other cases, all of whom were admitted to the Prison Hospital for observation. At the time Mr.Biddle assured me that if I wanted oedema cases I would be absolutely sure to get them after the issue of this diseased rice. His prophecy was borne out. On inspecting the men I found eight ambulatory cases distributed indiscriminately among the men (one

tailor, one light labour, one mill, two stone breakers, three carriers). All complained of constipation. There was no evidence of nephritis but the general symptoms set out above were observed. They were diagnosed as cases of epidemic dropsy. During this small outbreak, I recommended that the boilings from rice (rice water) should be discarded and not added to soup or given to the prisoners in any form, coupled with the suggestion that the rice be more highly polished to remove the diseased pericarp. The Epidemic has subsided and no new cases have been reported.

The Hospital Cases: When I took over medical charge of the Prison, I was left a case of suspected dry Beriberi, who had been an In-patient in 1929. The man was figured in the Leitch Report (2) as Figure 4, case No.10122/27. He had typical high-stepping gait, muscular weakness, tachycardia and dyspnoea on exertion and anaesthesia of the pretibial region with no oedema. He had Rombergism, Argyll-Robertson pupils, transient lighting pains at the epigastric and praecordial areas and in the hypogastrium. On receiving the blood results (Kahn+++ Wassermann+++) I coupled his history of chancre ten years previously, with the diagnosis of locomotor ataxia. Incidentally, I have treated this case with non-specific protein therapy and he has shown very considerable improvement, especially in his ability to walk without mechanical aid.

The cases of oedema sent to the hospital for

observation and treatment were taken along lines similar to those at Wilberforce Barracks Hospital. All the patients admitted displayed the characteristic signs and symptoms, including praecordial pain and nausea, tachycardia, breathlessness on exertion, oedema of the legs with altered cutaneous sensation, deep muscular hyperaesthesia and constipation. The knee jerks were present in all except one. One complained of his failing eyesight, with pain in the eyes, in which the intraorbital pressure was slightly raised. He cleared up after twenty-four days' treatment. The blood counts were variable, three being normal and three showing a slight hydraemia (4,100,000).

The blood calcium was definitely lower than normal (10 mg.per 100 cc.) and amounted, on the average of four, to 7.6 mg. per 100 cc. In all of the cases, the pulse was increased in tension, without evidence of vascular disease, the blood pressure ranging from 156-168 mm. systolic and 94-102 mm.diastolic. With the rest in bed these values fell to 130-134 mm.systolic and 80-84 mm.diastolic. One week after resumption of their tasks the pressures were still low and normal.

Two of the cases had liq.adrenalin hydrochloride (3 cc. of 1: 1,000) injected experimentally into the oedematous zones of the legs. Localised diminution of the dropsy followed but no generalised improvement of the condition was the result.

In the treatment of these prisoners, two were given calcium lactate and purge and showed improvement with return to labour in nineteen days. One was a case of myocarditis, with mitral stenosis and biliary cirrhosis. He was prescribed digitalin and, although an old case of "Beriberi" reported by Dr.Leitch, he was not considered as such for the purposes of this work. Two were treated with Mist.Alba (purge) and daily enema. They were discharged after thirteen and fifteen days' treatment. Two were given Mist.Alba and an extra ration of meat. They were fit for discharge in twelve days and returned to duty.

The Ambulatory Cases: Two men had been classified with the ambulatory subjects, who had all been put on the calcium and purge therapy but they did not show any improvement. It was considered that admission to the hospital was the best for them but, at that time, new rice came to hand and was issued to the men. Within five days these two subjects cleared up completely without recourse to admission. No cases terminated fatally in this epidemic.

Whether the lines of treatment follow calcium therapy or purgatives, it is considered that the therapeutic measures adopted against this disease must necessarily be entirely palliative. Not for one moment is it maintained that these measures can ever effectively compete with the simple expedient of altering the dietary to exclude deteriorated rice, in short I am strongly of the opinion that this is the crux of the entire

condition. Granted that the disease, especially in the Prison, can be effectively treated, the advocacy of prevention, is, I consider, the solution of the problem.

Technical Work.

Considerable time was devoted in the research to other aspects of the problem, apart from clinical observations. In the main, this other field included post-mortem examinations analyses of urine, blood and faeces, together with a biological survey of the rice. This work had to be done as an addition to the routine duties of my appointment with consequent serious interruptions, after my official duties had been performed.

Post Mortem Findings.

Twenty-four cases were examined after death at Kissy Asylum and one at Connaught Hospital. They were almost all of a stereotyped nature, with oedema of the limbs, pericarditis with effusion and absence of nephritis. In detail, the necropsy in these cases gave the following results:

Externally, oedema, although constantly present in the legs, was elsewhere variable. Some cases had ascites and three had oedema of the face and neck. In some the abdomen was collapsed, in others distended with gas and ascitic fluid. Cutting into the oedematous subcutaneous tissues and muscles showed them to be sodden with serous exudate. The pleural sac contained variable amounts of clear serous fluid, varying in

volume from two to twelve ounces. The lungs were adherent to the pleurae, chiefly behind and some localised adherent patches were present anteriorly and at the mid-lateral right side (near the apex of the middle lobe). The lungs themselves in all cases were oedematous. The pericardium in all the subjects contained clear, free, serous fluid of straw colour. No bile staining, blood cells or blood staining was present in the fluids examined. The volume in the pericardial sac was variable from three to eighteen ounces. The heart showed great hypertrophy in all directions and the right auricle and ventricle were constantly dilated and filled with blood and a small amount of white ante-mortem clot. In all the cases, the valves were competent and revealed no vegetations or other signs of chronic impairment and there were no signs of endocarditis or aortitis. The heart muscle generally was considerably thickened and hypertrophic, without fatty degeneration or infiltration, but showing separation of its muscle fibres by oedema. Except when death had recently occurred, and where necropsy was performed in less than nine hours after death, the abdomen was distended with gas. In the peritoneal cavity of all cases free serous fluid was present, varying in amount from a few ounces to two pints. All the cases showed "pseudo-bile" staining of the abdominal fat. On examination this colour change proved to be due, not to haemolytic products, but to palm oil and no bile reaction could be obtained from this tissue. The distension of

stomach and intestine was of variable amount and this was probably due to decomposition processes with gas formation. At the duodenum were found constantly areas of engorged tissues, with, in only three cases, evidence of ankylostomiasis. The mucosa of the stomach and upper part of the small intestine generally revealed this same type of engorgement and, in three subjects (not those with ankylostomiasis) petechial haemorrhage of the duodenum was added to the hyperaemia. The liver was constantly but slightly enlarged and oedematous and showed evidence of venous congestion. In every autopsy the gall bladder was distended, smooth, glistening and of a dark green colour. There were no signs of adhesions and the surface of the gall bladder did not show the characteristic honeycomb markings of Beriberi avitaminosis as described by Tull (5). The spleen was enlarged on an average to one inch below the costal margin and it was oedematous but not found to contain protozoal infection. The kidneys were of normal size, pale and oedematous, with normal capsule. There was no evidence of nephritis. The suprarenal bodies in five cases were somewhat enlarged and one contained evidence of infarction. No gross changes were observed in the nervous tissues, the bones or the pancreas.

Laboratory Work: The work done in the Biochemical Laboratory, which was specially equipped for the purpose of this investigation by the Honourable Director of Medical and

Sanitary Services, will be considered from its various aspects. It included the chemical assay of rice, biological tests and feeding experiments, together with work on the urine and blood of the patients.

Rice Analysis.

The analyses of the rice for general purposes were estimations of carbohydrate, protein, fat, water, ash, cellulose, phosphorus and amido-soluble nitrogen. They were conducted by using the well known standard methods. Carbohydrate is estimated by the Wood-Ost (34) copper carbonate method after hydrolysing the rice with dilute sulphuric acid.

Cellulose is determined by taking up the washed residue from the carbohydrate estimate, boiling with 1% caustic potash to remove pectins, and after hydrolysing the residue with concentrated sulphuric acid the resultant glucose is estimated.

Protein estimation is conducted following the Kjeldahl method and heating the sulphuric acid digest for four hours after the solution became clear (Dakin and Dudley (35)).

The estimation of Fat is made following Mottram's (36) modification of the Kumagawa and Suto (37) method by converting the fat to fatty acid.

The values for Water and Ash are found by the customary routine of drying to constant weight a quantity of

the material on the steam bath at 100°C. and then incinerating to constant weight.

The ammonium phosphomolybdate method of Neumann (38) is used to determine the phosphorus, which is estimated in terms of P_2O_5. Amido-soluble nitrogen is determined by a method suggested by Chamberlain, Vedder and Williams (39). 0.5 gram of the sample is heated in a steam bath with 100 c.c. water for ten minutes; a quantity of cupric hydroxide reagent containing 0.5 gram of the hydroxide is added, stirred and filtered when cold; wash in cold water, and leaving the residue intact with the filter paper, the nitrogen is determined by the Kjeldahl method as albuminoid nitrogen. The amido-soluble nitrogen is obtained by subtracting this Albuminoid nitrogen from the total nitrogen.

Chemical Analysis: The analysis of the rice husk with special reference to the husk, was not deemed necessary because in the milling this article is a waste produce and is not used for any edible purpose. Attention was directed chiefly to the rice grain and the pericarp, with special emphasis on the type of rice which was known to produce the disease, when fed to human beings.

The Colony's new season's rice was employed as a basis for standard for comparison of the protein, carbohydrate and fat content and calorie value, but it was suspected that these values would not shed much light on the causal factor of the

disease and, in the light of biochemical work done on the decomposition products of the protein layers, I feel sure that the general analysis of the foodstuff, although interesting, is not of paramount importance. However, I have thought fit to submit them.

Standard Rice: Five samples of new husk rice were obtained locally and found on hand milling to be free from bored grain, weevils, maggots, diseased and discoloured grains. This was taken as standard:

Standard Rice.

	Per Cent.
Carbohydrate,	75.87
Cellulose,	0.98
Fat,	1.84
Protein,	8.88
Water,	11.36
Ash,	1.06
P_2O_5,	0.57
Soluble Nitrogen,	0.02

Calorie Value 364.5 C. per 100 gr. or 1,650 C. per lb. Samples of the equivalent rice taken from the Freetown Prison rice mill, after polishing, were put to similar tests. The pericarp remaining was estimated by the Iodine method, which although rough, gives with experience a good index of the degree of polishing. The residual pericarp in the samples analysed was 40 per cent. In the polishing the major part of the pericarp and the sub-pericarpal layers are removed. The most apparent results are the removal of fat and ash from the unpolished grain.

	Polished Rice 40 Per Cent. Pericarp.	Polished Rice No Pericarp.
	Per Cent.	Per Cent.
Carbohydrate,	77.38	78.02
Cellulose,	0.76	0.64
Fat,	0.81	0.52
Protein,	8.12	8.05
Water,	12.13	12.16
Ash,	0.80	0.61
P_2O_5,	0.24	0.18
Soluble Nitrogen,	0.012	0.010
Calorie value per 100 gr.	358 C.	357 C.

The rice polishings, that is the "pericarp dust" were also submitted for chemical analysis. Apart from the interest in the research this aspect has, incidentally, a commercial value in view of the possibility of marketing the polishings for cattle feeding and oil cake. It is a waste product of high oil content. This pericarp dust contains a fair quantity of sand (about 3 per cent.) with an admixture of husk fibre, which tends to stray over from the hulling machine. The oil content is remarkably high, and, although this is essentially a side line, showed indications that the pericarp waste may make a good market price. Its red colour, however, may be against it.

The analysis of pericarp dust obtained from the prison mill, from standard rice freed from sand (3 per cent.) is given below:

	Ordinary. Per Cent.	Freed from fibre. Per Cent.
Carbohydrate,	41.89	48.69
Protein,	11.56	11.71
Fat,	17.60	17.64
Water,	9.96	9.89

(Contd.)

	Ordinary. Per Cent.	Freed from fibre. Per Cent.
Ash,	9.41	8.66
Cellulose,	9.58	3.41
P_2O_5,	-	4.22
Soluble Nitrogen,	-	0.06

Beriberi Standards: Among the conclusions of Vedder and Feliciano (3) (Philippine Islands experiments) are to be found chemical standards for estimating the anti-neuritic (anti-Beriberi) value of a rice in the absence of any direct method of obtaining the exact amount of anti-Beriberi vitamin. These standards include:

(a) any rice having 1.77 per cent. P_2O_5 plus fat, but not less than 0.4 per cent. P_2O_5.

(b) any rice not having less than 0.5 per cent. P_2O_5 with at least 75 per cent. of the external layers of the grain.

Sierra Leone rice comes well up to these standards with:

(a) P_2O_5 - 0.57 per cent. plus fat 1.84 = 2.41 per cent.

(b) P_2O_5 = 0.57 "

and according to their accepted theories, there is little risk of development of true Beriberi, when the staple diet consists of this Colony's rice. The rice has a high anti-neuritic value, is well balanced in terms of Protein, Carbohydrate, Fat and has an energy value of sixteen-hundred-and-fifty Calories per pound.

Diseased Rice: The chemical work, however, was chiefly directed against the "faulty" rice, which, from observations at Freetown Prison and Wilberforce Barracks, was known to be associated with the oedema. When this rice was replaced by new

season's rice or was specially treated in cooking,the oedema subsided and no new cases appeared. This rice was supplied as husk rice (paddy) and milled in the usual way before distribution to the various consumers. In this substance attention was particularly directed to the end products, namely, the rice and the pericarp dust, both of which were submitted to chemical analysis in the usual way, the husk, as before, being discarded.

Fungoid Rice Polished 40 per cent.Pericarp.

	Percentage.
Carbohydrate,	77.24
Cellulose,	0.74
Fat,	0.46
Protein,	8.46
Water,	12.32
Ash,	0.78
P_2O_5,	0.21
Soluble Nitrogen,	0.25

The faulty rice was milled and partly polished (40 per cent.pericarp). The odour was slightly musty. Mycelial hyphae and spores of the Fusaria group of fungi were seen on the surface of the grains. It was a mixture of white and discoloured grains, (yellow, brown, black) up to forty per cent. Evidence of weevil activity was noticed in the bored grain, and weevils themselves (identified as Calandra oryzae, calandra granaria, Tribolium ferrugineum and Silvanus advena) being present together with rice bugs and maggots. Fully thirty-two per cent. of the grain was bored and showed evidence of larvae. The rice had a relatively high percentage of broken grains, amounting to thirty-seven per cent. On an average, the

amount of germ was low; nine per cent. of the grains had all the germ, forty-four per cent. contained a portion and in the remainder the germ had been completely removed either by milling or by parasite activity. The presence of fungoid grain was noted and especially in the discoloured grain could be seen mycelial threads, which were not so common on the sound white grains.

There is at once apparent a deviation from the Standard rice in terms of fat, P_2O_5 and amido-soluble nitrogen; the other constituents being practically unaltered. The combined deviation was thought to be due to parasite activity in the old rice. With this aspect in view, considerable attention was given to the diseased rice products and later to the pharmacological action on animals of extracts of this rice.

Diseased Rice Polishings: The pericarp dust was subjected to the same type of analysis. This dust is slightly acid in reaction, musty to smell and, when inhaled, causes violent sneezing and coughing. The prisoners employed in the mill are given expectorant cough mixture at the end of each shift to relieve the sensation of oppression it causes, which is worse when the old rice is milled. Some of the men appeared to develop asthmatical attacks when they went on the job at first and in the morning when work commenced, an observation which is of interest when compared with the somewhat similar conditions pertaining in the cotton industry (40). The dust floating about

from the mill does not contain free sand in any large volume, even at the outlet of the machines, and it does not cause silicosis; examination of sputa for this condition was entirely negative for the presence of sand and B.tuberculosis, although vegetable fibres are quite commonly embedded in and lying upon large desquamated macrophage cells from the pulmonary epithelium. This pericarp dust was subjected to the same type of analysis before which it was entirely freed from sand and from a large amount of adventitious cellulose fibre derived from the husk.

Pericarp Dust from Fungoid Rice.

	Per Cent.
Carbohydrate,	48.18
Protein,	11.21
Fat,	14.74
Cellulose Fibre,	3.68
Ash,	8.33
Water,	13.86
P_2O_5,	3.61
Soluble Nitrogen,	0.44

Certain aspects are immediately obvious; the increased water content, always generally associated with fungoid activity, together with the diminution of fat and phosphorus and the big increase in the soluble nitrogen into the nature of which obviously it appeared enquiry may be made with profit.

Effect of Washing Rice: Before proceeding to submit the work done on extracts of the faulty rice and of the pericarp, it is considered advisable at this point to state the effect on the grain of washing. From now onward, unless otherwise stated, it will be understood that the rice mentioned is the deteriorated grain, which was known from experience to be faulty and to

produce oedema when eaten and the terms bad and faulty rice will from redundancy be discontinued.

(a) Rice: Apart from removing sand, adventitious insects, weevils and dust, washing with water has a definite effect on the rice itself. The grain is washed in cold (85°F.) running water for ten minutes, as the equivalent of the native method in which the washing is done in large pans with several changes of water. Thereafter the grain is sun-dried and analysed in the usual way. The analyses are tabulated below.

	Before Washing. Per Cent.	After Washing. Per Cent.
Carbohydrate,	77.24	76.97
Cellulose,	0.74	0.74
Protein,	8.46	8.18
Fat,	0.46	0.46
Water,	12.32	12.89
Ash,	0.78	0.76
P_2O_5,	0.21	0.18
Soluble Nitrogen,	0.25	0.16

Very little change takes place in the nutritional aspect as expressed by the calorie value. Carbohydrate, fat and protein are more or less the same, but there is a definite, but slight, loss in the phosphorus estimate, amounting to 14.28 per cent. I consider, however, that apart from obvious impurities soluble toxins, expressed in terms of soluble nitrogen are definitely lessened by the washing. Although the soluble nitrogen quota is reduced considerably from 0.25 per cent. to 0.16 per cent., it is apparent that an appreciable

amount remains, even after the thirty-six per cent.loss. The phosphorus loss has been considered a loss in terms of vitamin B. McCarrison and Norris (6) proved that any rice originally shown to be Beriberi-preventing may, with removal of a large percentage of P_2O_5 by prolonged washing be altered into a Beriberi-producing grain, but, although this holds for poly-neuritis gallinarum, it does not do so for the oedema under consideration, where the vitamin B content of the diet is more than adequate. Some other casual agency was held to be at work.

(b) Pericarp: Results of a similar nature were obtained with pericarp dust. The rice polishings were washed in cold running water for ten minutes, squeezed dry, spread out in the sun and dried for two days. As in the case of the rice, no form of artificial heat or of desiccation was employed.

Fungoid Pericarp Dust.

	Before. Per Cent.	Sun-dried. Per Cent.
Carbohydrate,	48.18	48.92
Cellulose,	3.68	3.66
Protein,	11.21	10.98
Fat,	14.74	14.70
Ash,	8.33	7.02
Water,	13.86	14.72
P_2O_5,	3.61	2.48
Soluble Nitrogen,	0.44	0.29

The results are similar to those obtained after treating rice with water. Washing does not affect, to any appreciable degree, the value of protein, carbohydrate or fat, but the main influence is shown in the soluble nitrogen and phosphorus content. In the former there is a reduction of 34.09

per cent.and in the phosphorus value washing lowers the content by 31.30 per cent.

Washing with hot water: The influence of washing was studied in terms of cooking. The rice is brought to boiling point and the rice water decanted and rejected. It is equivalent to considering that the rice undergoes part of the normal cooking process when it is washed in boiling water.

Two series of experiments were made:

(a) in which the rice was thrown into boiling water.

(b) In which the rice was put in cold water and heated to boiling point.

In both after boiling had continued for three minutes, the water was decanted and strained off and the rice dried in the sun for two days. The usual analyses were made on this final dry rice product.

	(a) Boiling Water Per Cent.	(b) Cold Water Per Cent.	Unboiled & Unwashed
Carbohydrate,	73.53	72.65	77.24
Cellulose,	0.62	0.60	0.74
Protein,	7.88	6.46	8.46
Fat,	0.34	0.22	0.46
Water,	16.93	19.47	12.32
Ash,	0.70	0.60	0.78
P_2O_5,	0.14	0.12	0.21
Soluble Nitrogen,	0.02	0.00	0.25

It is obvious again that, with special reference to all the proximate principles the energy value of the rice is not seriously impaired by this treatment, when it has been boiled and the rice water rejected. This value is, undoubtedly,

not so greatly affected by throwing the rice into boiling water for a few minutes, as when the rice is brought slowly to the boiling point, because then the degree of imbibition of water is less with correspondingly higher value of protein, carbohydrate and fat.

By either method, although the loss is fairly considerable (33.3 per cent. and 42 per cent.), the phosphorus element is not by any means all removed by short immersion in boiling water. Soluble nitrogen, however, shows results which are to be expected from the method of its estimation. The reduction amounts to 92 per cent. of the total original soluble nitrogen (a) and to complete absence in (b) when the rice water is brought to boiling point "from the cold".

Results of a correspondingly similar nature were obtained by extracting the pericarp dust employing these same methods; that is, a large reduction in the P_2O_5 content and in the soluble nitrogen. However, as this is a waste product, it is not deemed essential to submit the results.

Culture of Grains: Inspection of the rice revealed, as was mentioned above, the presence of discoloured grains, mixed with normal white rice. These grains were divided into two groups, yellow and black, for culture experiments and special analysis. The discoloured grains were, in all cases, found to be dead; microscopically, erosion of the starch was in progress and the grains were contaminated with mycelial septate filaments.

Samples of white, yellow and black grain were surface sterilised and put in a warm moist chamber for thirty-two days. All the rice samples increased in water content. The black grain became sodden and soft. Its soluble nitrogen content increased from 0.59 per cent. to 0.85 per cent. with very slight loss in the P_2O_5 due to imbibition of water by the grain. The yellow grain turned to a dark brown colour, almost black, absorbed water but it did not become sodden and soft like the black variety. The soluble nitrogen increased also in this case from 0.28 per cent. to 0.39 per cent., again with slight alteration in P_2O_5. The white grain, like the other two groups, developed a heavy growth of mould, but the colour change was not so marked. Some of the grain (3 per cent.) became brown and some (35 per cent.) was stained yellow, but the rest was more or less unaltered in colour, being, if anything, of a greyish tint. The soluble nitrogen increased in this sample, as in the others, from 0.03 per cent to 0.09 per cent. It was assumed that these conditions, although not by any means similar to normal storage, would reproduce rapidly in the grain that which occurs in storage in the country over a long period of time. Under conditions of moist warmth, with the possibility of increased temperature by fermentative processes in a large mass of grain, heat is generated and cannot escape readily from the decomposing mass. In this way, with heat and humidity, the growth of fungi and of other organisms is exceptionally rapid, with the net outcome that

decomposition proceeds apace.

Biological Work.

Preliminary work was undertaken to determine, if possible, the lines which might be profitably followed. The outcome of this preliminary investigation was the conception that the disease, oedema, was not due to lack of vitamins per se, but to soluble decomposition products in the rice, akin to the "claviceps" disease of rye, an idea that necessitated submitting extracts of the grain to biological tests.

The first simple or watery extracts made of the rice were evaporated in vacuo to small bulk without attention to percentage concentration. They were sterilised, without heating by passing through a fine Pasteur Chamberlain bacteriological filter and injected subcutaneously into normal subjects and to oedematous cases. Localised oedema resulted, associated with a marked reaction. Similar extracts were scratched into the skin and there was produced a flat raised wheal with white centre due to vasoconstriction together with a surrounding zone of slight erythema, such as is obtained when histamine and allied substances are injected intradermally. This effect is too well known to require at the moment detailed description. Subsequently, from the rice polishings, both unfermented and fermented, raw and cooked, extracts were made and tested chemically and biologically.

Method used in preparing the extracts: About 50 grams of the substance (rice or pericarp polishings) are treated at first for two minutes with one litre of boiling water, the washings collected and kept sterile by the addition of a few drops of chloroform. Thereafter the substance is extracted with cold water (2 litres) with the addition of a few drops of chloroform for forty-eight hours, filtered and the filtrate added to the extract made by boiling water. The mixture is made slightly alkaline with sodium bicarbonate and concentrated at low temperature to dryness. The residue is now taken up with absolute alcohol (100 c.c.) filtered and the filtrate again evaporated to dryness. The residue is finally dissolved in distilled water (100 c.c.) and constitutes the extract employed in the subsequent experiments. The extracts were pale straw in colour. Concentrated extracts were made by using large vats capable of dealing with 200 lbs. of material. In the earlier experiments a special extracting fluid was employed. This consisted of:

(a) $Na_2 HPO_4, 12H_2O$ - 14.0 gram.
$K H_2PO_4$ - 13.5 "
Na Cl - 50.0 "
Distilled Water, - 1000 c.c.

(b) 4% Phenol - 1000 c.c.

Equal parts of (a) and (b) were mixed and of the mixture 500 c.cs. were added to two litres distilled water to be used as an extracting medium.

25 gram of fungoid pericarp dust were extracted with 300 c.c. of fluid for two days, filtered through a porcelain filter candle. I inoculated 0.1 c.c. of this extract into the skin of my forearm with the production of the typical "histamine" wheal reaction of a very intense reaction.

As the same result was obtained on injecting a smaller amount (0.05 c.c.) of an extract derived from 25 gram fungoid pericarp dust employing the "water-alcohol-water" method, the special extracting fluid was discontinued on the grounds that with any subsequent experiments on animals exception may be taken to the use of extractives containing a high percentage of phosphates.

Feeding Experiments: Feeding experiments were conducted at Connaught Hospital and at Wilberforce, employing fowls and guinea pigs.

In the earlier observations, four fowls were used and fed with "faulty" rice. Two were fed on washed (method b) grain and two had unwashed rice. These experimental animals were allowed to roam about as they pleased and to eat such green material as they thought fit. After five weeks, one of the latter died and was found to have congested liver and pericarditis with effusion. The lungs were slightly engorged. Its partner on the unwashed diet was killed one week later and found to have slight pericardial effusion with engorged crop and hyperaemia of the stomach and upper intestine. At the same time

the other pair on the washed rice were killed and found to be perfectly healthy.

Guinea pigs were useless for feeding with dry material because they refused flatly to eat the rice. This was, to a large extent, overcome by making a standard extract of the grain, mixing this into bread and feeding the wet product to the animals which ate the mass avidly. The animals thrived on the extract from standard rice and from musty rice which had been washed. When killed the carcases were those of healthy animals.

Extracts from dry, faulty rice and pericarp did not kill the animals immediately but they went off their food after fifteen days and refused to take the quantity they consumed at first. One animal died after twenty-one days on this food (bread soaked in aqueous extract of rice). It was found to have slight oedema of the lungs and acute gastro-enteritis. Three guinea pigs were fed with greens, grass (their usual food) and with the addition of bread soaked in an extract from the fermented discoloured rice grains. Ten days later the first animal died; its two companions succumbed the next day. The post-mortem examinations again showed oedema of the lungs with gastro-enteritis, engorged intestine and haemorrhages at the upper area of the duodenum. These animals apparently suffered intense pain, as they were exceptionally tender to touch, listless and breathless. They became very weak and scarcely had the energy to run away when approached.

Extracts of Rice:

Dermal Tests:

Harris (45) elaborated a method of quantitative estimation of histamine by employing the dermal reactions following the injection of the drug. This is the well known effect which was first described by Eppinger (47) and investigated by Lewis (48) and by Krogh (49).

Following the intradermal injection of histamine is a reaction described as the "triple response"

(a) vasodilatation of the small vessels.

(b) a diffuse flare extending to 2-3 centimetres.

(c) a zone of localised oedema or white wheal extending over the same area involved in the initial vasodilatation. This wheal usually disappears within an hour.

In the experiments the dermal reaction was considered the most reliable test for determining clinically the presence of "histamine-like" bodies.

The material was extracted in the usual way. A drop of the extract was applied over the skin of the forearm on the flexor aspect and several scratches one inch long made through the fluid without drawing blood. If a negative result followed, 0.1 c.c. of the same extract was injected intradermally into the skin of the forearm on the other arm. Again if no reaction followed the extract was considered free from histamine-like substances.

The results are tabulated below:

Material.	Result.
Phosphate extracting medium,	Negative.
Water extract from	
(a) new rice (40% pericarp)	Negative.
(b) pericarp dust (new)	Negative.
(c) fungoid rice treated with boiling water (2 minutes),	Negative.
(d) fungoid rice put in cold water and boiled (for 2 minutes),	Negative.
(e) fungoid pericarp treated with boiling water (2 minutes),	Negative to scratch slight positive to injection.
(f) fungoid pericarp put in cold water and boiled 2 minutes,	Negative.
(g) fungoid rice 7% black grains,	(Scratch (+) (injection (++)
(h) " " 20% do.	Scratch (+) injection (+++)
(j) fungoid pericarp,	(Scratch ++ (injection intense ((+) reaction.
(k) black grains of fungoid rice,	Scratch +++ injection +++
(l) black grains incubated in moist chamber 14 days,	(Scratch +++ (injection intense ((+) reaction.
(m) yellow grains,	Scratch negative injection (+)
(n) yellow grains in moist chamber 14 days,	(Scratch (+) (injection (+)

The extracting media employed were all found to give negative results when used as controls, either chemically or biologically employing intradermal tests as standard.

All the extracts made from new rice gave entirely negative reactions to the intradermal tests. Similar results were obtained from rice that had been:

(a) put in cold water and heated to boiling;

(b) immersed for a few minutes in boiling water.

Dry faulty rice, however, gave positive results in most cases. In the presence of increased proportions of discoloured grain, the reactions were increased in intensity. The polishings from the faulty rice yielded reactions of a very definite type. From the pericarp dust (fungoid) an intense reaction was obtained using 0.1 c.c., the wheal measuring $2\frac{1}{2}$ x $5\frac{1}{4}$ inches, associated with an erythema zone extending the entire length of the forearm and lower half of the arm, together with the presence of an intense frontal headache lasting for 2 hours. It was only, however, when employing the mouldy grain and fermented pericarp dust that the strongest effects were obtained, especially from rice with a high percentage of black moulded grain showing putrefactive changes and from the pericarp dust. It has to be remembered, of course, that as the pericarp dust represents 3% of the rice, the extracts from this substance is considerably stronger than from the whole rice.

There was obtained similar definite increase in these "histamine" reactions employing extracts from the discoloured grains that had been kept for a period in the warm moist chamber. The intensity of the reaction was greatest with black grain, less with yellow and from the white rice no reaction could be obtained.

Inoculation: To ensure absence of bacteria and yeast

spores, the extracts were freshly made and filter sterilised, without heat, which might have altered the toxins. Guinea pigs were used into whose flanks the extracts were given subcutaneously only.

The extracts of new season's rice caused no sickness in the experimental animals. No ulcers or abscesses were produced at the site of inoculation. The animals were injected daily for eight days and found to be normal when killed.

Inoculation of sterile extracts of the old fungoid rice made the animals highly excitable five minutes after injection but in half-an-hour this passed off. Three days after inoculation commenced the animals became listless and refused to take their food. Of the three animals used two died after five days of injection treatment (an injection of one c.c. extract being given daily) and the remaining one died in seven days. All showed similar pathological changes. Around the sites of injections were zones of hyperaemia but no pus or septic condition was observed. The heart was congested, the lungs engorged and distended with blood, and there were punctuate haemorrhages in the small intestine.

An extract made of pericarp dust that had been kept under moist conditions was sterilised and inoculated into a guinea pig. This animal died one-half-hour after injection with bronchospasm. The necropsy revealed hyperaemia around the site of inoculation. The lungs were fully distended but not

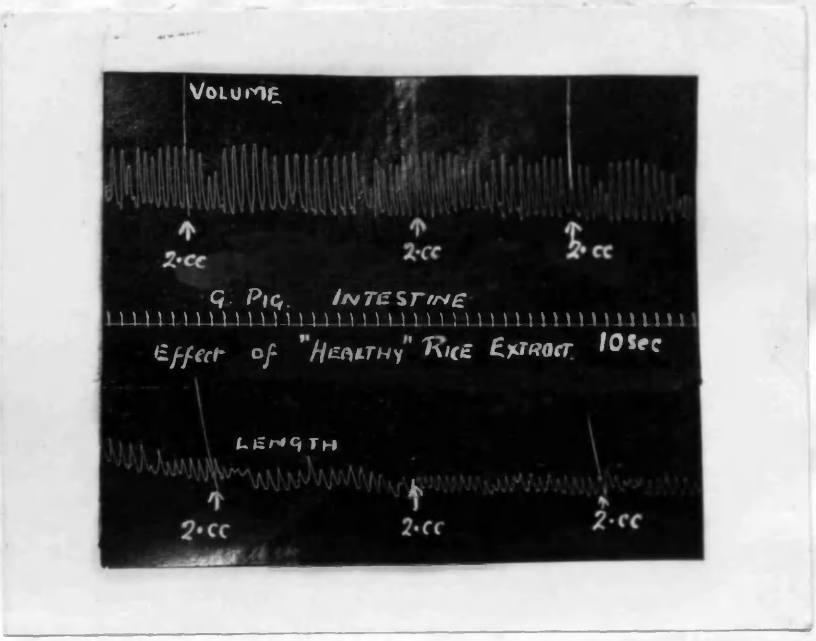
oedematous. The right heart was dilated, the intestine gorged and the stomach contracted in spasm. Entirely negative results were obtained following the injection of sterile extracts of washed rice. A method of quantitative determination has been based by Koessler, Lewis and Walker (41) on this production of bronchospasm, but it was not employed in this research.

The contraction of the isolated involuntary muscle was studied in a roughly constructed piece of apparatus, using preparations of the uterus and intestinal muscle of the guinea pig. The preparation passed into powerful contraction on exposure to an extract of the faulty pericarp dust. This contraction was not, in any way, counteracted by the addition of atropine.

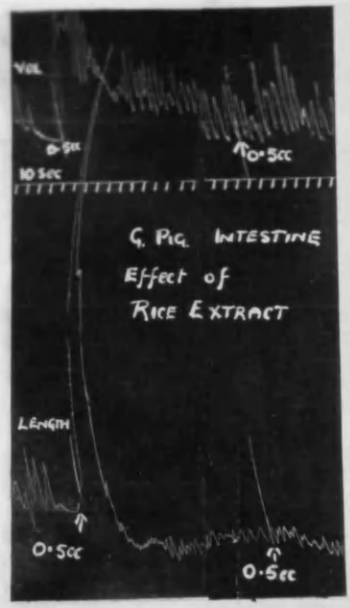
Further work was conducted at Glasgow University.

Animal Experiments: Employing 250 grams each of good rice and fungoid rice (40% pericarp remaining), 100 c.cs. of extract were made and used for further animal experiments at the Institute of Physiology, University of Glasgow.

Although Dale and Laidlaw (42) consider that "histamine-like" bodies are probably best investigated by employing the isolated guinea-pig uterus, the method of Guggenheim and Loffler (43) extensively used by Kendall (44) was preferred. It consists of subjecting the isolated guinea-pig intestine to the drug in the Trendelenburg apparatus. This is a convenient manner of observing the effect both on the

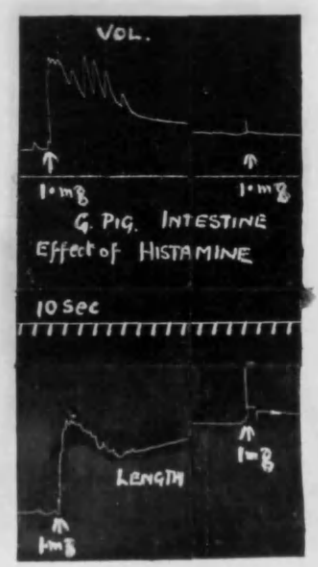


TRACE 1.

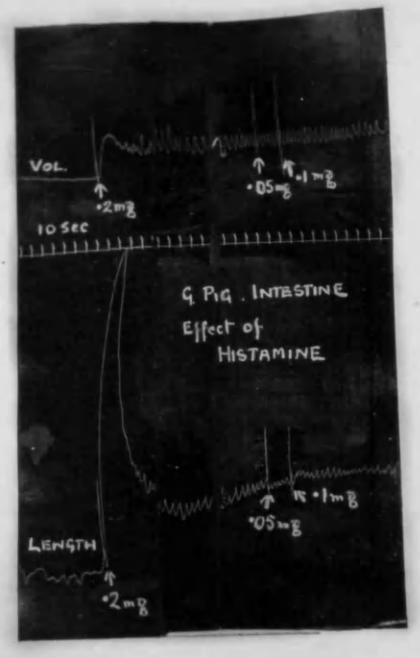


TRACE 2

TRACE 3.



TRACE A.



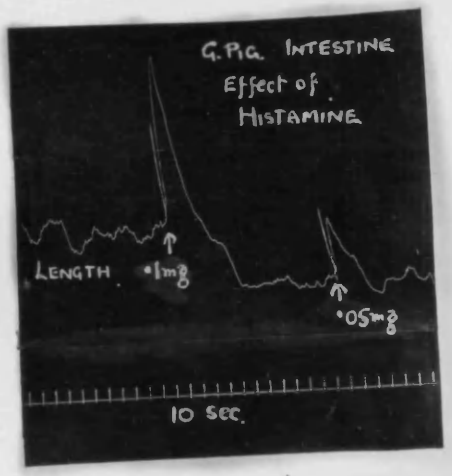
longitudinal and circular fibres, since tracings of length and volume are recorded simultaneously. The gut experiments were compared with tracings taken to demonstrate the influence of histamine acid phosphate.

In addition to the skin reactions which have been described above and which Harris (45) made a basis of quantitative estimations of histamine, corroborative experiments were done employing the method of Burn (46) based on the lowering of the blood pressure of the etherised atropinised cat.

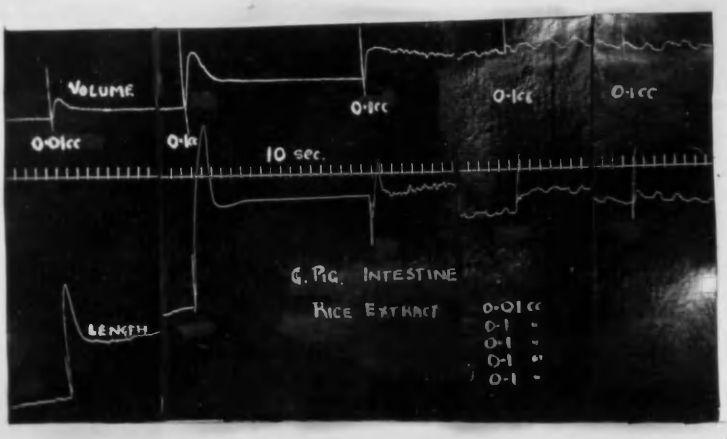
A standard length (3 cm.) of intestine taken from the upper duodenal zone was employed in the Trendelenburg bath which held a constant volume (400 c.c.) of mammalian bathing nutrient fluid. When the tissue had become settled and was contracting regularly the drug (histamine or rice extract) was injected into the bath and rapidly diffused through the fluid producing a dilution of the injected quantity in 400 c.cs. Any resultant response was recorded on a drum time marked in 10 seconds (6 per minute).

Trace (1) shows that the addition of extract from normal or good new season's rice caused no effect, either in volume or in length. No dermal reaction was obtained from this extract even when two c.cs. were injected subcutaneously.

Trace (2) demonstrates the influence of 0.5 c.c. of rice extract (fungoid). There is an immediate and violent response with contraction of circular and longitudinal fibres. Recovery

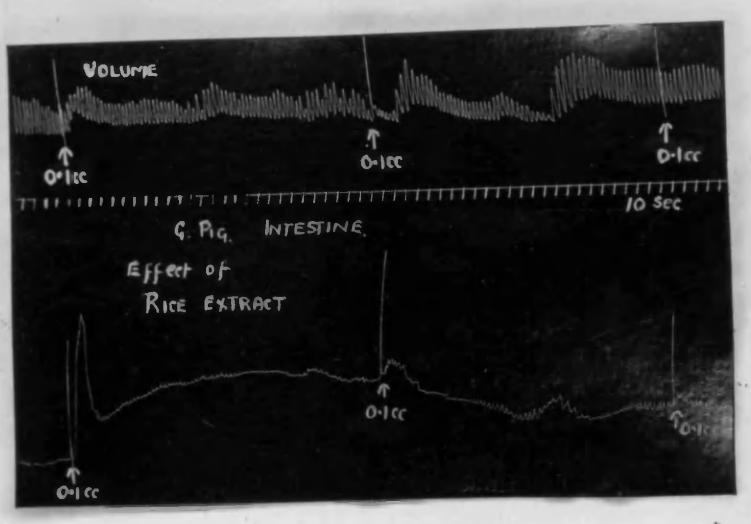


TRACE 5.

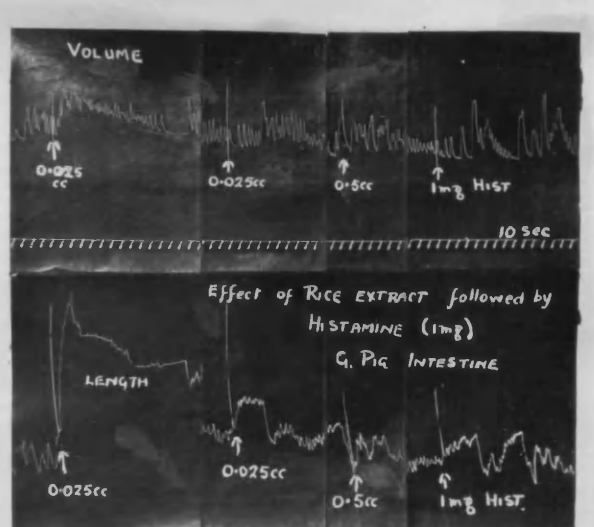


TRACE 6

TRACE 7.



TRACE 8.



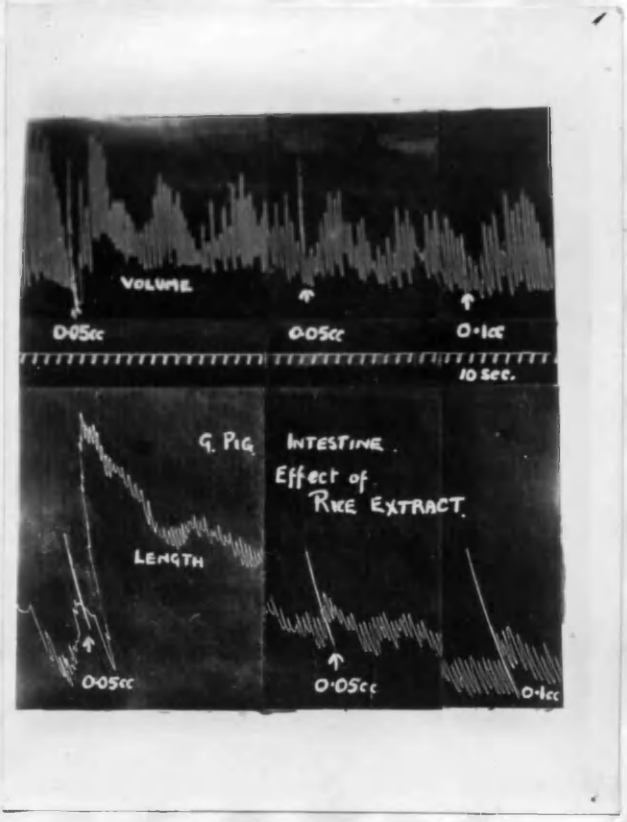
is slow ($1\frac{1}{2}$ minutes) and a subsequent injection of 0.5 c.c. is entirely without effect.

In Traces (3) and (4) the effect of histamine acid phosphate is observed. A large dose of the drug, one milligram in 400 c.cs. fluid causes an immediate response which is not repeated in further exhibition of the drug. The smaller dose (0.2 milligram) used in Trace (4) has the same effect. Less than this initial dose was found to be followed by further contraction when further additions were made to the bath. Trace 5 demonstrates a second contraction when 0.05 milligram is added subsequently to 0.1 milligram. This paralysing effect was alsc observed by Olivecrona (50).

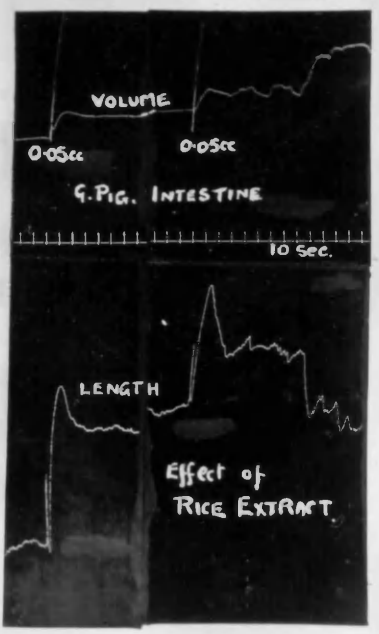
Somewhat similar results were obtained from the rice extract. Trace (6) shows no reaction after 0.21 c.c. have been given; in Trace (7) the same effect after 0.2 c.c. In Trace (8) two small initial doses (0.025 c.c.) making 0.05 c.c. in all, are not followed by any effect on the subsequent addition either of more rice extract or even of one milligram of Histamine acid phosphate.

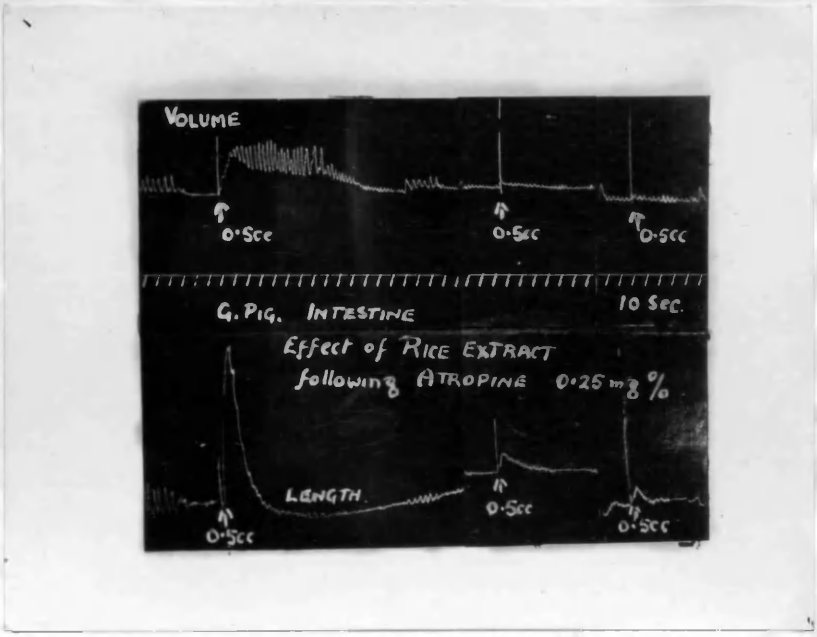
Few variations were observed in the series of experiments to find the minimum dose of extract that would not be followed by response in subsequent exhibition of the rice extract. Generally 0.05 c.c. sufficed (Trace 9) but when an inactive piece of intestine was employed a second injection beyond this dose (0.05 c.c.) caused contraction. Trace (10) is

TRACE 9

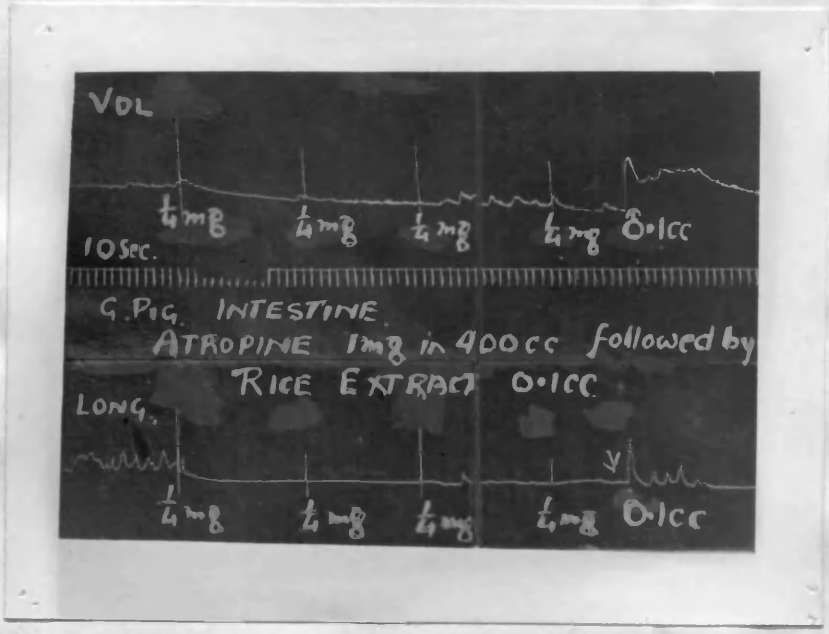


TRACE 10.





TRACE 11.



TRACE 12.

an example of this phenomena which occurred only in inactive or sluggish tissues.

To demonstrate that the effect of stimulating the visceral muscle still follows the addition of the extract subsequent to the application of atropine, tracings 11 and 12 are given. The immediate response to the extract is noted.

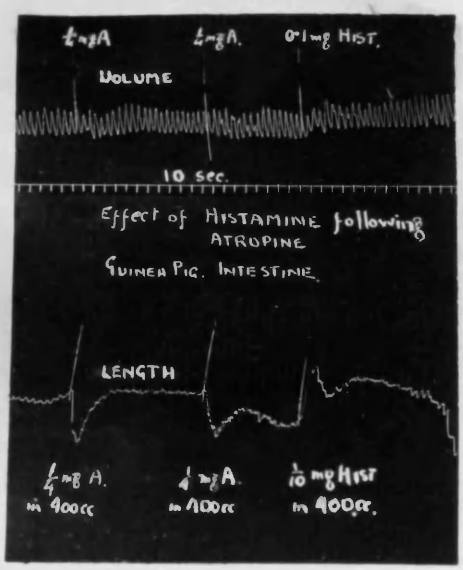
Histamine acid phosphate is similar in this respect (Trace 13).

Observations were made on the effect of rice extract and of histamine on the carotid blood pressure of the etherised and atropinised cat.

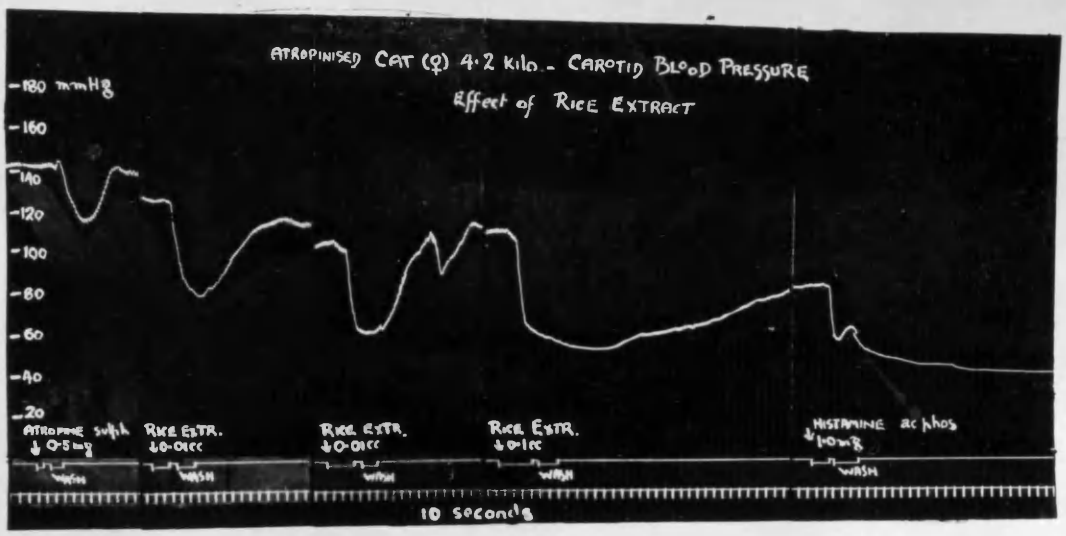
Tracings 14 and 15 are from such animals. In (14) after recovery from 0.5 milligram atropine sulphate administered into the internal jugular vein, 0.01 c.c. rice extract was given by the same route and washed in with saline. A rapid fall of blood pressure occurs (130-80 mm.Hg.) with ultimate recovery. Intense bronchospasm is produced which wears off as the blood pressure recovers. A second exhibition of the same amount (0.01 c.c. rice extract) caused a similar response in the intact animal, but a larger dose 0.1 c.c. rice extract was followed by a prolonged fall in pressure which was very slowly recovered.

Histamine acid phosphate (1.0 milligram) produces a similar fall in pressure from which recovery was not made.

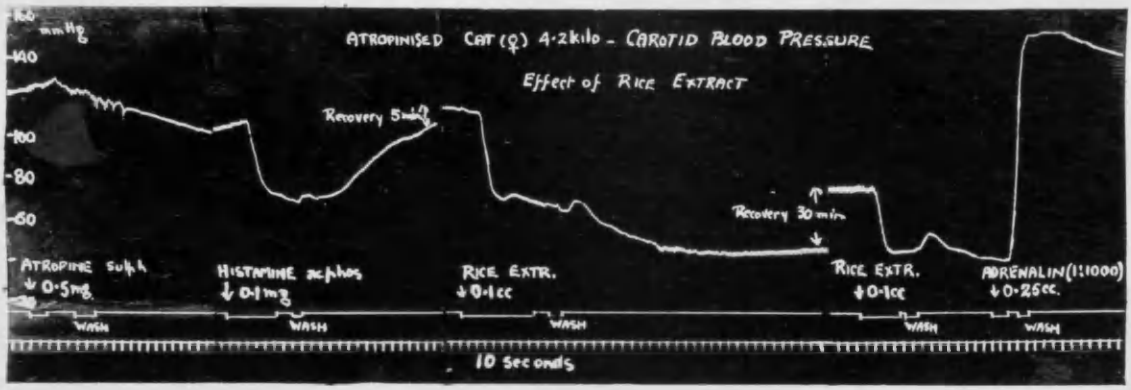
Tracing (15) shows the effect again on the atropinised cat. The initial injection of Histamine acid phosphate (0.1



TRACE 13



TRACE 14.


mm Hg
140
100
80
60
ATROPINISED CAT (♀) 4·2kilo - CAROTID BLOOD PRESSURE
Effect of RICE EXTRACT
Recovery 5 min
Recovery 30 min
ATROPINE sulph
↓0·5mg.
HISTAMINE acphos
↓0·1mg
RICE EXTR.
↓0·1cc
RICE EXTR.
↓0·1cc
ADRENALIN(1:1000)
↓0·25cc.
WASH
WASH
WASH
WASH
WASH
10 seconds

TRACE 15

milligram) caused a rapid fall in blood pressure, bronchospasm and excessive respiratory movement, similar to the rice extract's effect. Recovery ultimately took place in 8 minutes after the injection.

Rice extract (0.1 c.c.) was given. A dramatic fall in pressure was followed by a prolonged and maintained low level with slow recovery-time, the pressure taking in all 37 minutes to recover from the initial application of the stimulus.

A second injection of 0.1 c.c. rice extract was followed by a similar immediate response (fall in blood pressure) which, however, was counteracted by 0.25 c.c. adrenalin solution (1:1000), with the result that the pressure shot up beyond its original level (120 mm.) from 50 mm. to 150 mm.

The reactions of the tissues to rice extract are similar in almost every way to those obtained following histamine There are corresponding effects of stimulating the visceral muscle fibres (longitudinal and circular); the blood pressure response is the same in both cases and the dermal reactions are the same. It is justifiable, therefore, to conclude that the rice extracts contain a substance or substances which are allied to histamine, but chemical tests were employed in addition to confirm the assumption.

Chemical Assay of Extracts: The reactions were suggestive of the histamine grouping of substances, obviously, therefore, the chemical tests, in view of these reactions, were directed to

a study of the iminazole derivatives in the extracts. The main test is the diazo reaction of Ehrlich (51) which was shown by Pauly (52) to be given by the histidine group and later by Koessler and Hanke (53) to be applicable to histamine.

The extracts from the fungoid rice and fungoid pericarp gave a decided pink colour with the diazo reagent, but no reaction was obtained from the new season's rice.

The rose-pink colour struck by alkaline sodium diazobenzine-p-sulphonate is given by dilutions of histamine even to 1:10,000 but this reaction is not, however, absolutely characteristic of histamine alone. It may be given by any iminazole derivative containing a free amino group, together with a replaceable group in one of the two, four or five positions, with the exception that no colour is given should a nitro-carboxyalkyl or carboxyanilide group occupy the four or five position and it may be obtained in the presence of bases in the arginine, purine and tyrosin groups. A negative result is taken to show that histamine is absent, or, if present, only in infinitesimal quantities, but a positive reaction shows that either it or the allied bases may be present.

Hunter's (54) modification of the Knoop (55) test was positive only in the extracts from the "faulty" grain and pericarp. The test is one of treating the aqueous extract with bromine water, adding chloroform to remove colouring matter, and after boiling off any bromine excess a red-brown coloured

residue is left.

Zimmerman (56) has developed a colour reaction which is stated to be given only by histamine. A few drops of cobalt nitrate are added to histamine solution in a Thunberg tube and after evacuating the tube sodium hydroxide solution is mixed with the solution. A violet colour indicates the presence of histamine. Although a purple colour was developed with the "faulty" rice extract and a pink colour with the "good" rice extract, the results were not considered conclusive.

Urine Analysis from Patients: With the exception of two suspected cases of oedema in whose urine was found albumin with granular casts, no obvious pathological changes of the usual types were found.

The urine in general was pale straw coloured, very slightly acid on reaction, having a specific gravity of 1022. When passed it was free from sediment and "mucus" clouding, but on standing till cold, "earthy" phosphates were deposited. The usual ammoniacal phosphates appeared on allowing it to stand for twenty-four hours. In almost all the cases the output of an excessive amount of the "earthy" phosphates was commented upon and considered to be not clinically normal. The buffer action of phosphate in the blood is considerably higher than that of sodium bicarbonate, from which observation it is suggested that the increased urinary phosphate value represents the end product of a successful attempt by the alkali reserve to neutralise the

acidity produced in the toxaemia. The absence of albumin and the presence of these phosphates tend to show that the renal mechanism in this disease is not grossly abnormal; an observation confirmed at the post mortem findings.

Only in the severe cases was the indoxyl reaction obtained to a marked degree but almost all the specimens of urine from the patients gave a positive test indicative of indole B.acetic acid. Albumin, blood, sugar, diacetic acid, acetone bodies and bile products were not observed to be present in pathological amounts in these urines.

Faeces Analysis: Apart from the presence of a trace of occult blood in seven cases, the analysis of the faeces did not shed light on the problem. The faeces didnot show any evidence of helminth infection except in one case from whom ascaris ova were recovered. This case did not show any trace of occult blood.

Blood Calcium: The recognised methods of analysing the amount of Calcium in the blood were employed in a study of some of the prison cases. On an average, the results showed calcium deficiency (7.6 mg. per 100 c.c.) which is a definite deviation from the accepted normal value of 10 mg. per 100 c.c. The work along these lines continues.

In the main I have submitted the results of the observations and findings from the biological aspect of the research, without, in any way, attempting to give every detail

of the technique employed, which followed generally, the standard methods in use.

The results obtained from the various experiments led to the conclusion that the faulty rice yielded extracts in which histamine-like substances were detected.

Discussion of the Problem.

To discuss oedema is to invite contumely with the result that many who have chosen this subject for wordy consideration appear to have sought shelter in the experience of others, rather than to "rush where angels fear to tread". It was Bright, I think, who advised that discussion of such a subject is fraught with hectic controversy and ought to be approached in a chastened tone.

Oedema is the condition wherein accumulation of clear watery fluid occurs in the body cavities and in the tissue spaces, various names being applied to the condition, according to the site of the dropsy. However abnormal may be the final results of this swelling, it has often been considered, not in the light of a qualitative change, but rather as a quantitative departure from the normal state, of which the main factors concerned are the hydrostatic pressure of the body fluids and the osmotic pressure of the tissues, balanced by the osmotic pressure of the blood crystalloids and plasma colloids, together with the permeability of the capillary walls. In this light, therefore,

we should expect to have the essential phenomena associated with oedema grouped as follows:

(a) Increased permeability of the vessels following the effect on the vascular walls of disease, vasomotor paralysis, toxins, prolonged dilatation.

(b) Increased capillary pressure as a result of venous obstruction by tumour and thrombosis.

(c) Obstruction of the lymphatic flow, by the same causes as in (b).

(d) Increased blood pressure.

(e) Decrease in osmotic pressure of blood, especially of the colloid system of the plasma.

(f) Increased osmotic pressure in the tissues.

(g) Increase in the imbibation capacity of the tissue protein.

Although in some cases one of these factors alone may be present to produce the oedema, it is more customary to find two or more acting in unison, in which case there is the difficulty of allocating to the principle role the causative agent. An instance of this may be cited in angioneurotic oedema. It is commonly found in nervous subjects or in emotional people. It has been held to be due to a vasomotor paralysis associated with a circulating toxin. Quincke (7) observed that section of the vasomotor nerves did not alter the dropsy and concluded that the main factor must be in the nature of a circulating toxin.

Causes of Oedema: It has been found convenient to consider oedema under six headings, to include the following:

1. Cardiac.
2. Renal.
3. Inflammatory.
4. Obstructive (venous and lymphatic).
5. Toxic associated with Milroy's hereditary oedema and the angioneurotic group.
6. Nutritional:
   Beriberi - Epidemic dropsy.
   War oedema.
   Anaemia and debilitating states.

The oedema with which we are dealing is not considered to be associated with those found in cardiac, nephritic, obstructive or inflammatory diseases, and, on this account, it is not deemed necessary to enter into a detailed discussion of those conditions. With similar scant treatment has been regaled the oedema of anaemia and cachexia and Milroy's hereditary oedema but in view of the results of the investigation it is proposed to discuss further toxic and nutritional dropsies.

Toxic Oedema: The allergic reactions following the ingestion of certain foodstuffs by peculiarly sensitive individuals are fairly well known and have been fully discussed by Dale (57). These may appear as asthmatic attacks, hay fever, skin rashes, either with small localised wheals or with the extensive urticaria which is now considered to be identical with an angioneurotic oedema. Lewis (8) maintains that the toxic substance is either histamine or an allied iminazol ring derivative. The wheal is the outcome of increased permeability

of the dilated capillaries and may be simulated by the intra-dermal or subcutaneous injection of histamine. The extensive oedema found in the angioneurotic type is held to be the result of circulating toxins of an allied type (Vaughan 58) derived from some articles of diet acting on the vessel walls and not to be due entirely to any vasomotor paralysis because section of these vasomotor nerves has no marked influence on the oedema or on its production. The net result is increased permeability of the tissues. Substances which reduce this permeability, by antagonising the effect of histamine bodies (Dale and Richards 59) naturally should be expected to effect a curative influence. Epinephrine is of such a nature. The injection of liq.adrenalin hydrochloride reduces the dropsy by its vaso-constricting influence. As has been shown above, the oedema constituting the major theme of this enquiry was definitely, although chiefly locally, diminished by the injection of adrenalin. Ionic calcium is also successful in this effect, although the evidence that it has any direct effect of diminishing the permeability of animal membranes is still conflicting. However, the results of the calcium therapy in this outbreak of oedema were too encouraging to permit of its disuse on theoretical grounds alone.

Nutritional Oedema: War oedema was first seen amongst Turkish prisoners of war and in the famine stricken zones of Europe. In Austria, Germany and in some parts of Russia, many

cases of dropsy were reported, without any concomitant signs of nephritis or cardiac disease (Epstein 9). The condition was associated with anaemia, marasmus and gastro-intestinal disturbance; albuminuria being a variable sign. The disease is not a simple matter of deficiency of the accessory food substances, but appears to be the result of a diminution of protein-intake in a diet rich in carbohydrates made palatable by copious additions of water and salt, which, in the starving state is readily retained in the tissues. In the same category may be included the dropsy of marasmus.

Beriberi: Beriberi and allied conditions are diseases particularly associated with people whose staple diet is rice and in the Colony of Sierra Leone it must necessarily assume exceptional importance. In view, also, of the development of rice growing in this Colony, the disease occupies a position of commercial importance as well. Unless great attention, therefore, is paid to these conditions a young and promising export trade may easily perish, almost in infancy.

As is well known, true Beriberi avitaminosis is held to present two aspects:

(1) Wet Beriberi, in which there are oedema and serous effusion into the general body spaces.

(2) a dry paraplegic type with characteristic peripheral neuritis and muscular paralysis.

Although it has been reported on widely separated zones, having been observed in asylums in England and America

and among the British troops in Mesopotamia (1915) it has, roughly, three great endemic areas: Japan, Brazil and Dutch East Indies, with isolated foci in India, Malay, Philippines and on the East and West Coasts of Africa. Stitt (10) informs us that its history is ancient. It was referred to in ancient Chinese writings. It occurred in the Roman Army's invasion of Arabia 24 B.C. The neuritic type was described by Bontius (1642). Rogers (1808) and Marshall (1812) differentiated the wet and dry types.

Theories of the Etiology of Beriberi: Quite a number of theories have been put forward to explain its etiology and many of these have, apparently, been found wanting. Takaki (1884) (11) suggested nitrogen deficiency as the cause of the condition in the Japanese Navy and it was recorded that improvement resulted when an increased allowance of protein was given, especially in the form of beans. Many workers, however, refer the eradication of the disease among these sailors to the improved sanitary conditions of the men.

Manson (12) put forward a theory of toxaemia by micro-organisms associated with conditions of overcrowding, filth and faulty ventilation, whereby the germs gave off an emanation or toxin which acted to the detriment of the patient, who himself was not infected actively by the germs.

In Wright's (13) view there is a definite bacillary invasion of the mucosa of the duodenum from which toxins allied

to those of B.diphtheriae are passed into the patient. Although other workers, Higuchi (14), Mentes (15) have submitted various organisms with this idea in view, so far no germ has been isolated which is known definitely to cause the disease.

Hirsch (1881) (16) was among the earliest to suggest that the cause of the disease was some specifically noxious thing in the food and this was represented by a poisonous property of decomposed rice.

Studying the disease in Malay, Braddon (1901) (17) furthered, most considerably, this idea. He maintained that the cause of the disorder is not rice, qua rice or as an article of diet but diseased rice. Braddon (18) propounded the view "that the condition was associated with rice with which poison derived from decay, due, perhaps, to some fungus or mould, or germ or spore, originally, perhaps, growing in the husk, has become mixed during the process of milling or upon which such fungus may have grown and such poison have been produced after decortication". Inter alia he suggested parboiling of rice before husking, with the conjecture that this process destroys the hypothetical organism. It may also, I suggest, have the same effect as washing before cooking of removing such soluble toxins as have already been produced.

The development of the toxin was thought to occur in rice stored in a damp place but Vedder (19) (20) disputes this, by stating he found no evidence of loss of anti-Beriberic

properties in rice so stored after one year. He does not state whether he was dealing with the wet or dry type of Beriberi.

Wydooghe's (21) observations in East Africa are most interesting. Although he favours the theory of infection borne by an insect vector, he passes the remark that the epidemics are worse during the wet seasons, when moulds have every opportunity of growth on rice in storage.

The position in Brazil is remarkable, where the medical men state that, although a diet of polished rice may produce a disease with symptoms of Beriberi, they believe that the disease they call by this name is an infectious disease. They advise, states Couto (22), that such patients who complain of the ailment should go to the South, where, although the same rice is eaten, Beriberi is unknown. The relative humidity of the North and South of Brazil should, I think, be borne in mine, together with the concomitant facility for rapid fungoid activity.

Several references have been given concerning the presence of proteolytic organisms in rice used by people suffering from Beriberi and Epidemic Dropsy, particularly in the researches of Bose (23), Mentes (15), Bernard and Guillerm (24), and Higuchi (14). Drs.Leitch and Watson (2), however, cannot credit that these proteolytic organisms can be the causal agent of epidemic dropsy, which, they state, is a comparatively rare disease.

Fraser and Stanton's (25) work on the subject is

monumental. They demonstrated that polyneuritis gallinarum and beriberi, especially of the dry type are undoubtedly due to deficiencyof or absence of vitamin B. Their work has received considerable support by the researches of Shiga (26) and McCarrison (27), and their conclusions are now accepted almost universally. Their work, however, was done almost entirely on the "dry" type of beriberi.

Recent work has shown that vitamin B, whose absence is the cause of Beriberi avitaminosis is a pyrimidine substance, trimethyluracil, a derivative of nucleic acid, which is exceptionally prone to putrefactive changes, with the result that diminution of or destruction of its value as an accessory food substance is produced. The absence of vitamin B does not, therefore, necessarily, indicate that the causal agent of diseases simulating Beriberi is deficiency of the vitamin per se. With its destruction must be considered any concomitant putrefactive products of these higher heterocyclic and amino-acid compounds so that these diseases held to be due to absence of or diminution of any accessory food material per se, may equally well be due to the effects of antointoxication following absorption of the decomposition products, resulting from the activity of bacteria and fungi. It is this latter conception of the etiology that is maintained to be proved in the present epidemic especially in view of the fact that ample supplies of vitamin B in other forms of food had no effect in averting the

disease.

Epidemic or Famine Dropsy: Apart, however, from all the work on Beriberi and polyneuritis gallinarum, there is that remarkable disease Epidemic or Famine Dropsy, which has signs and symptoms peculiarly akin to Beriberi of the wet type.

History: McLeod (28) first described the condition in Calcutta (1877) whither, in famine years till 1926, it has returned repeatedly. Large masses of rice-eating people, both natives and poor Europeans, were affected by this disease which was reported to occur in the wet seasons and to abate in the hot dry seasons.

Acton (29) and others, making observations on the Calcutta Epidemic (1926), state that, although it affected the rich as well as the poor, the condition was worse among the poor families living in damp, unhealthy houses. It was considered that there was no deficiency of Vitamin "B" but that the cause of the disease was bacterial decomposition of the rice, which, the main diet of the people, had been damaged by flooding. Other workers regard the condition to be one due to deficiency of calcium salts.

Signs and Symptoms: Gupta (30) gives the major signs and symptoms of this disease as follows:

> Fever, usually 99-101°F., rarely above 102°F., oedema, gastro-intestinal disturbances with diarrhoea, cardiac dilatation, tendency to haemorrhages, enlargement of the liver, pulmonary congestion and a variable peripheral neuritis.

Neil Campbell (31), I.M.S. in the Indian Medical Gazette described as occurring in Dacca Lunatic Asylum (1908) an epidemic of this disease, which bears remarkable similarity to recent conditions at Freetown Prison. From a population of two hundred and seventy, one hundred and forty-seven cases were affected within a period of five days, although all had been having copious, varied and wholesome diet. A consignment of faulty rice was held to be responsible for this "explosive outbreak".

With conspicuous clarity, Megaw (32), I.M.S. described the scope of the disease designated Epidemic Dropsy. His remarks are summarised in the following outline:

> "It affects rice eaters who have been partaking of parboiled rice, which has been stored for months in a hot moist place. Unhusked rice or paddy stored under similar conditions causes the disease. All the affected persons have eaten rice from the same store, although households may be widely separated from each other. Many of the outbreaks are "explosive" - the patients' symptoms occurring within a few days of each other, even when they live far apart".
>
> "The disease does not run a course like an ordinary fever but stops, excepting in the very advanced cases, when the faulty rice is removed from the diet. The seasonal distribution in India is remarkably uniform, commencing just after the beginning of the rains and ending after the rains have ceased. When the new season's crop is used the disease disappears. Outbreaks occur always in people who have eaten rice which had been stored under hot moist conditions".
>
> "There is no evidence that the diets of the patients have been defective in any obvious respects

> compared with diets of the unaffected people in the same locality. Some patients, in fact, are better off as regards vitamin foods than their neighbours. The occurrence of the disease is not associated in any way with an obvious change of diet. The food may seem the same but this does not obviate the possibility of a food poison (c.f. death from botulism) although certain changes may be detected. When several people in the same house or locality are affected in rapid succession, there is no need to presume infection, if the same morbid agency, faulty food, is common to all".

> "In no case has infection by contagion been recorded. Most of the outbreaks are best explained as being due to a toxic agent, which is present in the rice before it is eaten. No immunity is conferred but, on the contrary, one attack predisposes to further attacks. The "incubation" period is variable, two to ten days elapsing before the onset of the symptoms. Convalescence, except in severe cases, is rapid, when the case is properly handled from the onset of the condition".

With all these features, the most reasonable explanation is that, under certain conditions of storage, rice becomes toxic. The poison by ingestion causes gastro-intestinal irritation and, on absorption, damage to the peripheral nerves and involuntary muscular system.

I am convinced that such a remarkable parallel exists between the conditions pertaining at Freetown Prison, Wilberforce Barracks and Kissy Asylum and the outbreaks of Epidemic Oedema in India, as to make one hesitant of accepting, without considerable proof to the contrary, a diagnosis of avitaminosis or Beriberi in the disease which is the subject of the present investigation.

Histamine: The majority of proteins contain the substance

Histidine, which is an amino-acid derivative, containing the heterocyclic iminazole ring. Histidine is B. iminazole-a-amino-propionic acid, and, by the process of decarboxylation is converted into ergamine or histamine (B.imanazole-ethylamine) a substance commonly found as a product of putrefaction. It is obtained as a constituent of ergot and of putrified flesh and it occurs in some quantity in the intestinal contents (Barger and Dale 60). Histamine has also been isolated from beans (Yoshimura 61) and from cotton dust (40).

Pharmacology of Histamine Group: The action of Histamine is akin to a number of the derivatives of the split protein molecule, in which, often, a very slight alteration is sufficient to convert a non-toxic substance into a poison with the characteristic actions of the Histamine group.

Secondary shock following severe wounding and crushing has effects so closely allied to those of Histamine inoculation as it has been maintained that this type of shock is due to the production of Histamine in the damaged tissues Cannon (62). Anaphylactic shock is probably of a similar nature,Wells (63).

The results of exhibition of members of this group in the human subject vary with the dose and with the tissue reactions of the individual. At the site of injection a slightly raised white wheal is produced, having a circumscribed zone of intense erythema. The wheal is tender to pressure and later

the area may be very irritable. Dyspnoea often occurs with the expectoration of sticky mucus. The pulse is rapid and the blood pressure may fall, although this varies with the individual. Sickness, with vomiting, may occur and the stomach undergoes powerful contractions, sometimes with the production of small haemorrhages. The circulation becomes sluggish and all the symptoms of severe shock with collapse follow, especially if any physical efforts are made.

Effect on Animals: The effects of this group of substances, tested experimentally on animals, have been found to vary with the species and, also, with the feeding habits of the animal, whether carniverous or herbiverous.

Circulation: In the herbivora the arterioles are constricted and the blood pressure, consequently, is increased, whereas any initial vaso-constriction is absent in the carnivora, in which the capillaries become widely dilated and the blood pressure rapidly falls. This vaso-constriction is due to a direct action on the muscles of the arterioles, with the result that products of metabolic activity cause loss of capillary tone and dilatation, so that the animal finally bleeds into its own capillaries. The venous return is, consequently, insufficient to distend the heart and collapse supervenes.

Following the accumulation of blood in the capillaries and the consequent stasis of metabolites in the tissues, with increasing osmotic pressure, the escape of plasma from the

capillaries is facilitated and oedema is produced. In the excised heart preparation the outflow is usually augmented and accelerated.

Stomach and Intestines: According to Cushny (33), these organs contract more powerfully and may pass into spasm. Small haemorrhages may be produced as a result of this condition. Most sensitive of all is the uterus, in which the contractions are sudden, prolonged and powerful.

It has been maintained that, in small quantities, amine bodies are known to cause intestinal stasis, with consequent absorption of poisonous nitrogenous waste products. These act on the vaso-motor system, producing constriction of the arterioles and relaxation of the capillaries; the opportunity results then of exudation into the tissues of plasma, together with a partial stagnation of the movement of the tissue fluid. On this theory of toxic absorption was based the treatment. Purging and enemata keep the intestine in an active state and prevent or reduce the rate of absorption.

Calcium improves the tone of the vessel walls and aids in the reduction of the oedema. In this condition the blood calcium was found definitely to be low, so that the calcium lactate is of benefit, especially if associated with sodium citrate in the presence of which it is more easily assimilated.

Histamine does not appear in the urine but is

destroyed in the tissues by deamination and oxidation.

Toxicity to Herbivora: Histamine is exceptionally toxic to herbivorous animals but not to such a great extent to carnivora. It must be conceded that the majority of the subjects in this Colony ought to be considered vegetarian (or cereal eating) people and a change to a diet richer in meat with consequent higher protein value may help to reduce the incidence of the disease. The success of this factor was demonstrated by Mr.Biddle (1919) when, during a short epidemic, increased meat rations were issued with considerable benefit to the patients and diminution in the number of fresh cases, although no change was made in the rice supplied.

Relation to Ergotism: Taken at face value, Epidemic Dropsy does not appear to have any obvious relation to the chronic poisoning of ergotism, or to dry gangrene with peripheral neuritis. Both, however, appear to be vaso-motor disturbances of varying degree (extreme on one hand and less severe on the other) and they appear, also, to be due to products of decomposition. Tyramine and histamine are commonly associated with this condition and are found in ergot. They are held to be produced by the same type of chemical change, namely, decarboxylation, allied with decomposition.

Melanin: It may be interesting to note one line of decomposition of tyrosin, a substance allied to histidine.

Instead of by decarboxylation to phenylethylamine or tyramine, tyrosin is oxidised in the presence of the enzyme tyrosinase, Bourquelot and Bertrand (64), to the black pigment melanin via a red coloured substance, having the nature of a phenylalanine, which, in turn, can give rise to phenylethylamine. Fungi and the larvae of meal worms are rich in the enzyme tyrosinase, Raper and Speakman (65), so that further comment on the presence of these organisms may be considered superfluous, when regard is taken of the discolouration process in the rice grains. In the experiments on fermenting rice, colour changes are produced the red brown pericarp becoming black and it will be recalled that from the black grain the most toxic extracts were derived. It is thus possible to base the degree of toxicity of the fungoid rice on the proportion of these black and discoloured grains, as an index of the state of decomposition and of the danger following its consumption.

Moist Storage: The disease most commonly puts in an appearance when old and new rice crops have been mixed, and it has been noticed that the disease breaks out in the year succeeding that of a bumper crop, with large stocks of old rice left in the dealer's hands after the new crop comes in. The new crop contains a much greater proportion of moisture. In these circumstances, mixing appears to favour decomposition. Fungi and the dormant spores of fungi have improved facilities for growth on account of the increased moisture content of the mixed

mass and of the heat engendered, as in some cases of so called spontaneous combustion by the fermentative changes in a moist heap. Storage during a rainy season appears to be ideal for such organismal activity because of the heat and the high relative humidity. These, it is maintained, are the attributes that make the problem serious in this Colony. It is held that the rice becomes highly toxic if it is a mixture of old and new crops and is stored in conditions that encourage destructive attacks by fungoid and other organisms. If mixing of crops is permitted there is absolutely no guarantee but that these outbreaks of fatal epidemic dropsy will be repeated and I make bold to assert that this is one of the essential factors determining the control of the disease.

In addition to the effect of mixing old and new crops, there is accumulating evidence that similar and rapid destruction occurs when new season's crop is kept in wet storage, or stored in an imperfectly dried condition.

It has been observed, as in other tropical and subtropical countries, that the disease appears when grain is eaten after prolonged storage under moist warm conditions. Famine conditions, with shortage of new crops, may readily be simulated when a sword of Damocles is held over a community forced to accept and to use old rice that has been kept under faulty conditions. Again, although no such obvious state may exist, it is simple to produce an artificial famine by market

manipulations in a commodity which, in the tropics, is liable to rapid destruction on account of the entire absence of supervision, or proper control of store-houses and granaries.

Conclusion.

I am convinced, therefore, that oedema at the Freetown Prison, Wilberforce Barracks, and Kissy Asylum is not that of Beriberi (avitaminosis) but that it is akin to epidemic dropsy. It is not associated with any lack of or diminution of accessory food substances, as vitamin "B", which has been supplied in copious amounts to the inmates of these institutions, nor is it allied with protein starvation. The disease is essentially one of auto-intoxication or food poisoning due to absorption of highly poisonous nitrogenous putrefactive products, engendered in old rice by the activity of organisms acting in hot and moist conditions and producing bodies of a nature allied to the histamine group. The toxic substances are water soluble, especially in hot water, and they are capable of withstanding boiling water, without considerable alteration of their poisonous principles. This last observation is important, as recommendations have been made in former epidemics that the rice water should be saved and added to the soup. The rice water derived from such diseased grain must be rejected to obviate any chance of contracting the food poisoning.

That there are changes in the intimate chemical

structure of the rice is seen from the change in soluble nitrogen and phosphorus content. These are associated with putrefactive changes. With an increasing value in the soluble nitrogen content, there is found evidence of increasing destructive changes. That the destructive change results in the production of soluble toxic substances has, I think, been established clinically, biochemically and physiologically, when extracts of this rice are made and utilised either for animal inoculation or for chemical study. Apart from the observations made on human subjects and in the field of clinical medicine, there are the concomitant results of the biological experimentation of which recapitulation is unnecessary. It has been shown that the soluble nitrogen factor in relation to total nitrogen may be considered a reasonably good index of the toxicity of the foodstuff.

The disease-producing grain has a musty odour and, generally with discolouration, displays the presence of decomposition and of fungoid activity. Consumption of such foodstuff is fraught with great danger, resulting, inter alia, in the rapid onset of oedema of an extremely fatal nature.

When new rice is given to patients suffering from the oedema under review, the disease rapidly clears. In a way this may be the outcome of several factors. There is the resistant state of the living rice germ to disease, associated with the nondestruction of the protein aleurone layer and there is the

factor of time, as new season's rice has not been subjected to prolonged bacterial and fungoid activity. Consequently, one expects even from this last aspect little, if any, putrefactive changes.

When considered purely as a disease due to the lack of vitamin B, it is difficult to understand why, with the superabundant diet issued at the Freetown Prison, Beriberi should continue to be present and also, if its nature is essentially one of "avitaminosis", why the disease should be of so protracted a type, when additional accessory food substances almost to excess are exhibited. On the other hand, the aspect that this disease of oedema is due to toxic absorption finds support on a number of points.

Rice forms the staple food of the Colony and owing to a rapid extension of swamp-rice farming during the past three years an export trade in it is anticipated. Oedema, therefore, becomes a matter of serious concern, especially, where it is known that apart from its incapacitating effects this condition is attended by a very high mortality among consumers of rice which has been permitted to become decomposed.

I am, therefore, of the opinion that the disease which constitutes the subject matter of this thesis is Epidemic Dropsy and that, although confounded with the wet form of beriberi due to avitaminosis, it is essentially of the nature of a food poisoning, rather than a disease of deficiency judged by the

accepted standards of such conditions.

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CENSUS OF WILBERFORCE BARRACKS COMPOUND.

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
1	1-2	O	M	D.P		
	3	O	FF	H5	1	
	4	K				
	5	U				
	6-7-8	O			1	
2	1	O	M F CF	D	1 1	
	2	S U		P		
	3	O	M F		1 1	
	4	S O	S		1	
	5	S U				
	6	O	M F		2	
	7	O	M F		1 1	
	8	S		P		
3	1	O	M	D	1 1	
	2	O	M F		2	
	3	O	M F	D	1 1	
	4	O	M F		1 1	
	5	O			1	
	6	O	M F	D P	1	
	7	O	M F CF	D	1 1	
	8	O	M CF		1	
4	1	O	M F CM	D P	1	
	2	O	M F	D	1	M
	3	O	M F		1	
	4	O	M F	D	1	M F
	5	S				
	6	O	F		1	
	7	O	M		1	
	8	O	M F	D	1	
5	1	O	M F CF	D	1 1	
	2	O	M F		1	M
	3	O	M F		1	
	4	O	SS		2	
	5	S O	F CF	D2	1	
	6	O	M F		1	
	7	O	M F		1	M
	8	S O	S		1	
6	1	S		P		
	2	O	M F		1 1	
	3	O	M F		1	
	4	S O	S		1	

(Ctd.)

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
6	5	S O	S		1	
(Ctd.)	6	O	M		1	
	7	S				
	8	O	M F		1 1	
7	1	U				
	2	O	M F		1 1	M
	3	U	M			M
	4	O	M F	D	1 1	M
	5	O	M F CM		1 1	M
	6	O	M		1 1	
	7	O	M F	D	1 1	
	8	S		H	1	
8	1	O	M F CF	D	1 1	M
	2	O	M F CM		1	
	3	O	M F CM		1	M CM
	4	O	M F	D	1 1	F
	5	O	M		1	
	6	O	M F	D	1	M
	7	O	M F	P	1	F
	8	O	M F CF		2	
9	1	S O	SS		2	S
	2	O	M F		1 1	
	3	O	M F		1 1	F
	4	O	M F CF		1 1	
	5	O	M F	D	1	F
	6	O	M F CF	D	2	M
	7	O	M		1	M
	8	O	M		1	M
10	1	S		P		
	2	O	M S		1 1	M
	3	O	M F	D	2	
	4	O	M CF		2	
	5	O	M F		1	
	6	S				
	7	O	M F		1 1	M(Kissy)
	8	O	M		1	
11	1	U		P		
	2	O	M F		1 1	
	3	O	M F		1 1	
	4	O	M F CM		1 1	
	5	S		P		
	6	U				
	7	O	M F		1 1	
	8	O	M F		1 1	

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
12	1	S				
	2	O	M F		1 1	
	3	O	M F		1	
	4	O	M F CF		1	
	5	S		H		
	6	O	M F	D	1	
	7	O	M F		1 2	
	8	S O	SS		2	
13	1	O	M F CF	D	1 1	
	2	O	M	D	1 1	
	3	O	M		1	M
	4	O	M F		1	M F
	5	S				
	6	O	M S		1 1	
	7	O	M F CM	D P	1	
	8	O	M F S	P	1 1	
14	1	O	M F		1 1	M
	2	O	M F		1 1	F
	3	O	M F		1	
	4	O	M F		2	M F
	5	O	M F		1 1	
	6	O	M F		1 1	
	7	S O	SS		2	S
	8	O	M F		1 1	
15	1	S				
	2	O	M F		2	M F
	3	O	M F CF	D P	1 1	
	4	O	M F		1	
	5	O	M		1 1	
	6	O	M S		1	
	7	O	M F		1 1	
	8	O	M F CF	D	1 1	M
16	1	O				
	2	O				
	3	O				
	4	O				
	5	S				
	6	O	M		1	
	7	O	M F CM CF	P	1 1	F
	8	O	M F		1 1	M
17	1	O	M F CM		1 1	
	2	S O	S		1	
	3	O	M F		1	F
	4	O	M F		1 1	

(Ctd.)

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
17	5	S				
(Ctd.)	6	S				
	7	O	F CM		2	M(Kissy)
	8	O	M F CF		2	M
18	1	S				
	2	O	M F	D	1 1	
	3	O	M F		1	
	4	S O	S		1	
	5	O	M F		1 1	M
	6	O	M F		1 1	
	7	O	M F		1	
	8	O	M F CF	D	2	
19	derelict.					
20	1	O	M F	D	1 1	F
	2	O	M F		1	
	3	O			1 1	
	4	O	M F		1	M
	5	O	M F CM		1	
	6	O	M		1	
	7	O	M F CF CF		1 1	
	8	O	M F CM		1 1	
21	1	O	M F		1	M
	2	O	M		1	
	3	O	M F		1	
	4	O	M F		1	
	5	S O	S		1	
	6	O	M		1 1	
	7	O	M F	D	1	
	8	O	M		1 1	M
22	1-4	O	M FF CM S	D	1 2	
	5-6	O	M	D	2	
	7-8	U				
23	1	O	M F		1	
	2	O	S		1	
	3	O	M F		1	
	4	S				
	5	O	M	D		
	6	S O	F CF		1	
	7	O	S		1	
	8	S O	S		1	
24	1	O	M	D		
	2	O	FFF	P	2	
	3	O	M F		1	
	4	U				
(Ctd.)						

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
24						
(Ctd.)	5	O	SS		2	
	6	O	M		1	
	7	O	F S		1	
	8	O	S		1	
25	1	U				
	2	O	M		2	
	3	O	F CF	D	1	
	4	S				
	5	O	S		1	
	6	O	S	H	1	
	7	O	S		1	
	8	O	F S		1	
26	1	O	S		1	
	2	O	M		1	
	3	O	M S		1	
	4	O	M S		1	
	5	S		H	1	
	6	O	F CF CF		2	
	7	O	F CM	P	1	
	8	S O	M		1	
27	1	O	S		1 1	
	2	O				
	3	O	S		1	S
	4	O	S	D	1	
	5	O	SS		2	
	6	O	S		1	
	7	O	M S		1	F
	8	O	F SSS		1	S
28	1	O	M F	D	1	
	2	O				
	3	O	M		1	
	4	O	F		1	
	5	O	M F CF		1 1	
	6	O	FFF		1	FF
	7	S O	M F		1	
	8	O	CF	D	1	
29	1	O	M F S		1	
	2	O			1	
	3	O	M		1	
	4	O	S		1	
	5	O	S		1	
	6	O	M F	D	1 1	
	7	O	M F CF	P	1	
	8	S				

(Ctd.)

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
30	1	O	M		1	
	2	O	M		1	
	3	O	M F CM CF S	D	1	M
	4	O	F		1	
	5	S				
	6	O	F		1	
	7	O	M F		2	
	8	O			1	
31						
32	1	U S				
	2	U K				
	3	U				
	4	U				
	5	O	S	DP	1	
	6	O	M	P	1	
	7	O	M		3	
	8	S		H		
33	1	O	M		1	
	2	O	F CM		1	
	3	U				
	4	K				
	5	O	M F		3	F
	6	O				
	7	O	M			M
	8	O				
34	1	O				
	2	O			1	
	3	O			1	
	4	O	M	D	1	
	5	O	M F		1	
	6	O	M F		1	
	7	O	M F		1	
	8	O				
35	1	O	M F S	D	1	
	2	O				
	3	O	M F		1	
	4	S				
	5	O	M F		1	F
	6	O	M F		1	
	7	O	FF		1	
	8	O	M		1	
36	1	S			1	
	2	S				
	3	O	M		2	
	4	O	M F CM	P	1	

(Ctd.)

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
36	5	O	M S		2	
(Ctd.)	6	O	M F	P	1	
	7	O	F CM		1	
	8	O	M	D	1	
37	1	S				
	2	O	M F		1 1	F
	3	O	F	D	1	
	4	O	M		1	
	5	O	M F CM		1	
	6	O			1	
	7	O	M	D	1	
	8	O	F		1	
38	1	O	M F		1	
	2	O	M F		1	
	3	O	M F		1 1	
	4	O	M F CF		1	
	5	O	M F		1	
	6	O	M F		2	
	7	O	M F		1 1	
	8	O	M F		2	
39	1-8	O	M F CF S			F
	2-7				2	
	3-6	O			1 1	
	4-5	O	M M		2	
40	1	O			1	
	2	O	M F CF	P	1	
	3	O	M F		1	M
	4	S		P		
	5	S				
	6	O	M CM CM		1	
	7	O	M F CM		1	
	8	O	M F		1	
41	1	U				
	2	U				
	3	U				
	4	U				
	5	S				
	6	O	M F CM		1	
	7	S	M			
	8	O	M		1	
42	1	U		P		
	2	O	M		1	
	3	U				
	4	U				

(Ctd.)

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
42	5	U		H		
(Ctd.)	6	S O			1	
	7	O	M F	P	1	
	8	U			1	
43	1	U				
	2	U				
	3	U				
	4-5-8	O	M CM S		1 1	
44	1-6	U		H		
45	1	U				
	2	O	M		1	
	3	O	M F CF		1 1	
	4	O	M F CF		1 1	
	5	O	M		1	
	6	O			1	
	7	O	M CF CF S		1	
	8	O	M CF CF		2	
46	1	O			1 1	
	2	O	M F CF CF CF	P	1	
	3	U				
	4	S O	S		1	
	5	O			1	
	6	O	M		1	
	7	O	M F		1	
	8	O	M F		1	
47	1	U				
	2	O	M F		1 1	M
	3	O	M S		1 1	
	4	S				
	5	O	M F		1	
	6	O	SS		1	
	7	O	M			
	8	O	M F CM		1	
48	1	O	M		1 1	
	2	O	M F		1 1	
	3	O	M F CF		1 1	
	4	O	M F CM CM S		1	
	5	O	M F		1	
	6	O				
	7	O	M		1	
	8	O	M		1	
49	K					
50	1-4	U				
	5-8	O	M F CM CM S		2	

Hut.	Room.	Defin.	Occupants.	Animals.	Beds.	Oedema.
					U.S.	
51	1	O	M		1	
	2	O	M F		1 1	
	3	O	M			
	4	O	M F		1	
	5-8	U				
52	1	O	M F		1	
	2	O	M		1	
	3	O	M		1	
	4	O	M F CF		1 1	
	5	U				
	6	O	M F		1 1	
	7	O	M F		2	
	8	U				
53	1	O	SS		1	
	2	O	M		2	
	3	O	M CF CF	H	1 1	
	4	O	M		1	
	5	K		D		
	6	O	M	P	1	
	7	O	F CF CF		1	
	8	O			1	
54	1	O			1	
	2	O	M CM S		1 1	
	3	O	M S		1	
	4	O	M F CM	D	2	
	5	O	M F		1 1	
	6	O	M F		1	
	7	O	M		1	
	8	O	F CF CF CF	H3	1	

KEY

Defin. - Use to which hut is put.
O = Occupied. U = Unoccupied.
S = Store. K = Kitchen.

Occupants - M = Adult Male. F = Adult Female.
CM = Child Male. CF = Child Female.
S = Servant.

Animals - H = Guinea Pigs. D = Dogs.
P = Poultry.

Beds - S = Screened. U = Unscreened.

Oedema - Number of Oedema cases in hut.