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BY

OFFICERS OF THE MEDICAL AND SANITARY DEPARTMENTS

OF THE

GOVERNMENT OF INDIA

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BEING THE FINAL REPORT OF AN ENQUIRY CARRIED OUT

BY

MAJOR E. D. W. GREIG, M.D., D.Sc., I.M.S.,
Under the Direction of the Director, Central Research Institute, Kasauli

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DESCRIPTION OF ILLUSTRATIONS.

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INTRODUCTION.

HAVING completed my epidemiological enquiries at Calcutta and as no fresh cases of the disease were occurring I proceeded on 11th December 1910 to Kasauli to officiate (for three months) as Director of the Central Research Institute and also to continue my experimental investigations in relation to the etiology of Epidemic Dropsy. On my leaving Calcutta the services of Assistant Surgeons Taraknath Sur and Charu Chandra Bose were replaced at the disposal of the Inspector General, Civil Hospitals, Bengal. Assistant Surgeon J. G. Mukerji assisted me in the experimental investigations at Kasauli.

This is the final report so far as the present enquiry is concerned; there are, however, interesting problems arising out of the investigations deserving of further study: these problems are connected with the important question of diet.

In recent years, especially in connection with the study of tropical diseases, a great deal of attention has been directed to the parasitic origin of disease, and deservedly so, because it is a subject of very great importance; this has, however, somewhat overshadowed the question of the relation of defects of dietary to the causation of disease in the tropics. The time has now come when the older methods of determining the nutritive value of food materials require reconsideration, and further investigation is wanted on this important subject. Defects in dietary not only require careful attention from the point of view of diseases which result directly from them, but they are of equal importance as affecting the course of certain diseases occasioned by parasites, as well as the general health of communities.

The conclusions arrived at in my first report[1] have been confirmed by my subsequent investigations.

It may be desirable to summarise shortly the facts connected with the etiology of Epidemic Dropsy as determined by my enquiry at Calcutta. In the first place it will be seen that the two severe epidemics, in 1878-79 and 1908-09, in Calcutta have commenced and declined with a rise and a fall in the price of food grains. During the periods of both the above-mentioned

[1] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

epidemics there was a very high and sustained rise in the price of food grains. In the interval between these severe outbreaks the price curve did not show such a change, and associated with this there was no severe outbreak of the disease. Further, conditions of dietary remaining the same as at present, an outbreak of Epidemic Dropsy may be expected in the future when the curve of the price of food grains again assumes the characters met with during the two previous outbreaks in Calcutta. Hence it will be evident that a study of this curve is a very important matter, and the curve may be used as an indicator for forecasting the occurrence or non-occurrence of conditions favourable or unfavourable to the development of so-callel Epidemic Dropsy amongst the population. The *modus operandi* of this factor in the production of Epidemic Dropsy will be understood from a consideration of the following facts which have been scientifically demonstrated. The signs and symptoms of this disease are liable to develop when a diet, largely composed of polished rice or poor in certain constituents, is consumed. In a dietary largely composed of polished rice these essential constituents, which are required to meet the physiological demands of the body, and especially of the peripheral nervous system, are not present in sufficient quantity; but the necessary constitutents can be supplied by supplementing the dietary by suitable articles of food containing them; a full discussion regarding the nature of these essential constituents will be found in the chapter devoted to experimental investigations in this report, page 49. When the price of food grains is low, it is possible to purchase these supplementary articles, but when the price of food grains rises and remains high the capacity for purchasing additional suitable articles of diet diminishes and the diet becomes dangerously "One-sided." Enquiry showed that the section of the population in Calcutta, amongst whom the disease was most prevalent, was the class with small fixed incomes, *vide* page 10 of this report; the reason for this is obvious, seeing that the purchasing power of this class is definitely limited, and therefore a rise in the price of food grains affects them most severely, because they become unable to purchase the additions necessary to render the diet safe.

In this research it has been shown that a most valuable portion of the rice, namely, the Koorah or polishings, is not being utilised, this could be properly cleaned and sifted, and made available as an article of diet. If an adequate percentage of rice bran is consumed daily, scientific investigation shows that considerable protection will be afforded against the accidents classed under the heading Epidemic Dropsy. In this report the subject of rice bran is fully discussed in its various aspects. The question of the addition of rice bran to the diet and other questions dealing with the removal of defects in dietary considered in my reports on Epidemic Dropsy should

receive careful attention from those responsible for the administration of Jails, Asylums, etc., etc., in India. Further, in regard to ships, especially those carrying Indian crews and other rice-eating peoples, the responsible authorities should have their attention specially directed to this and other matters dealt with in my reports as they are of very considerable importance to shipping communities.

CHAPTER I.

Study of the Outbreak of Epidemic Dropsy in Calcutta in 1909.

In the first place I shall deal with the complete study of the outbreak of Epidemic Dropsy in Calcutta in 1909. Before proceeding to give a detailed account of the investigations it may be well to record a few facts regarding the city of Calcutta. The notes have been taken from the Gazetteer of India.[1] Calcutta, the capital of the Indian Empire, is situated 22° 34″ N., 88° 22″ E., on the east bank of the Hooghly river, within the 24-Parganas district, Bengal. The city lies about 86 miles from the sea and is only about 18 to 21 feet above mean sea level. It covers an area of 20,547 acres of which only 1,792 are rural, and 1,113 acres form the maidan. The city is bounded on all sides by suburban municipalities which have been excluded from Calcutta for the purpose of municipal administration. These are Cossipore Chitpore on the north, Maniktala on the east, Garden Reach on the south-west, Howrah on the west bank of the Hooghly river. If these be included Calcutta has a population of 1,106,738, which is greater than any European city except London, Constantinople, Paris, and Berlin, and of any city in America, except New York, Chicago, and Philadelphia. Excluding China, the population of whose cities is uncertain, the only city in Asia with more inhabitants than Calcutta is Tokio: and next to London is the most populous city in the British Empire.

In the centre of the town stands Fort William, surrounded by the noble expanse of park known as the Maidan. North of this are the shops and business houses of the Europeans, whose residential quarter bounds it on the east. Surrounding the European quarter is Burra Bazar, the chief centre of native business: the buildings are mainly one-storeyed masonry shops, and it is only here and in the adjoining quarters of Joraabagan and Bow Bazar that brick buildings are more numerous than tiled huts. Three-fifths of the whole population live in the latter which have mud or wattle walls and are known as kachcha houses. The native town is traversed by three main roads from north to south, and by five or six roads from east to west, but with these exceptions it is extremely ill-arranged. The lanes are tortuous and badly lit; the dwellings are overcrowded and insanitary; and the overwhelming proportion of one-storeyed houses gives this portion of the town a peculiarly squalid appearance.

[1] Vol. IX, 1908.

The soil on which Calcutta has been built has been formed at a comparatively recent date by the alluvial deposit of the Gangetic delta; excavations made for tanks and foundations disclose alternate layers of sand and clay. The climate is hot and moist. The mean temperature averages 79° F., the mean maximum being 102° F. in May, and the mean minimum 48° F. in January. The average temperature in the hot season is 85° F., in the rains 83° F., and in the cold season 72° F. Humidity averages 78 per cent. of saturation, ranging from 69 per cent. in March to 89 per cent. in August. The annual rainfall averages 60 inches, and the average number of rainy days in the year is 118. The population of Calcutta in 1901 was 847,796, the mean density being 41 persons per acre for the whole city, and 68 in Calcutta proper. Judged by European standards the city is seriously overcrowded: more than half the population have less than half a room per head, and 90 per cent. have three-quarters of a room or less.

In the whole population there are only half as many women as men. This is due to the large number of immigrants, among whom there are only 279 females to 1,000 males; the majority of these are temporary settlers who leave their families at home. Another result of the large volume of immigration is that 44 per cent. of the entire population are adult males, which is double the proportion of the whole of Bengal.

Nearly a third of the inhabitants of Calcutta are engaged in manufactures and nearly a fourth in trade, while personal service accounts for a sixth.

The city has been divided into four municipal districts, each with its own staff for conservancy, roads, and buildings.

The drinking water supply is derived from the Hooghly river at Palta, 17 miles north of Calcutta, where it is pumped up into settling tanks and filtered. The pure water is conveyed by gravitation through iron mains to masonry reservoirs at the north end of the city. Thence it is pumped into distributing mains and three other reservoirs in different quarters of the city, and from these it is again pumped into distributing pipes. The scheme was inaugurated in 1860, and it was then intended to supply 6,000,000 gallons per diem or 15 gallons per head. In recent years the works have been greatly extended, and the Corporation has now three pumping stations at Palta and four in the city; there are 1,997 standposts and 5,904 ground hydrants, and the number of filtered water connections exceeds 26,000. These give to Calcutta and the adjacent towns of Barrackpore, Dum-Dum, Cossipore Chitpore, Maniktala, and Garden Reach a daily supply of over 7,624,000,000 gallons of filtered water, or 21½ gallons per head.

The streets are watered and the drains flushed with unfiltered water pumped up in Calcutta, and for these purposes there are more than 3,500 connections.

The scheme of underground drainage, by which the city is freed of surplus water and of filth, which water will carry, was inaugurated half a century ago. The drainage is carried eastwards by a series of five parallel conduits which discharge into an intercepting sewer, and thence into a large well at Tangra in the eastern suburbs. There it is raised by steam pumps into a high level sewer, which carries it to the salt water lakes east of the city, there to undergo oxidation. The original project was commenced in 1859 and took sixteen years to complete; but meanwhile fresh additions had been found necessary, these are still incomplete so far as the "added area" is concerned.

(i) Method of collecting Information regarding the Epidemic in Calcutta.

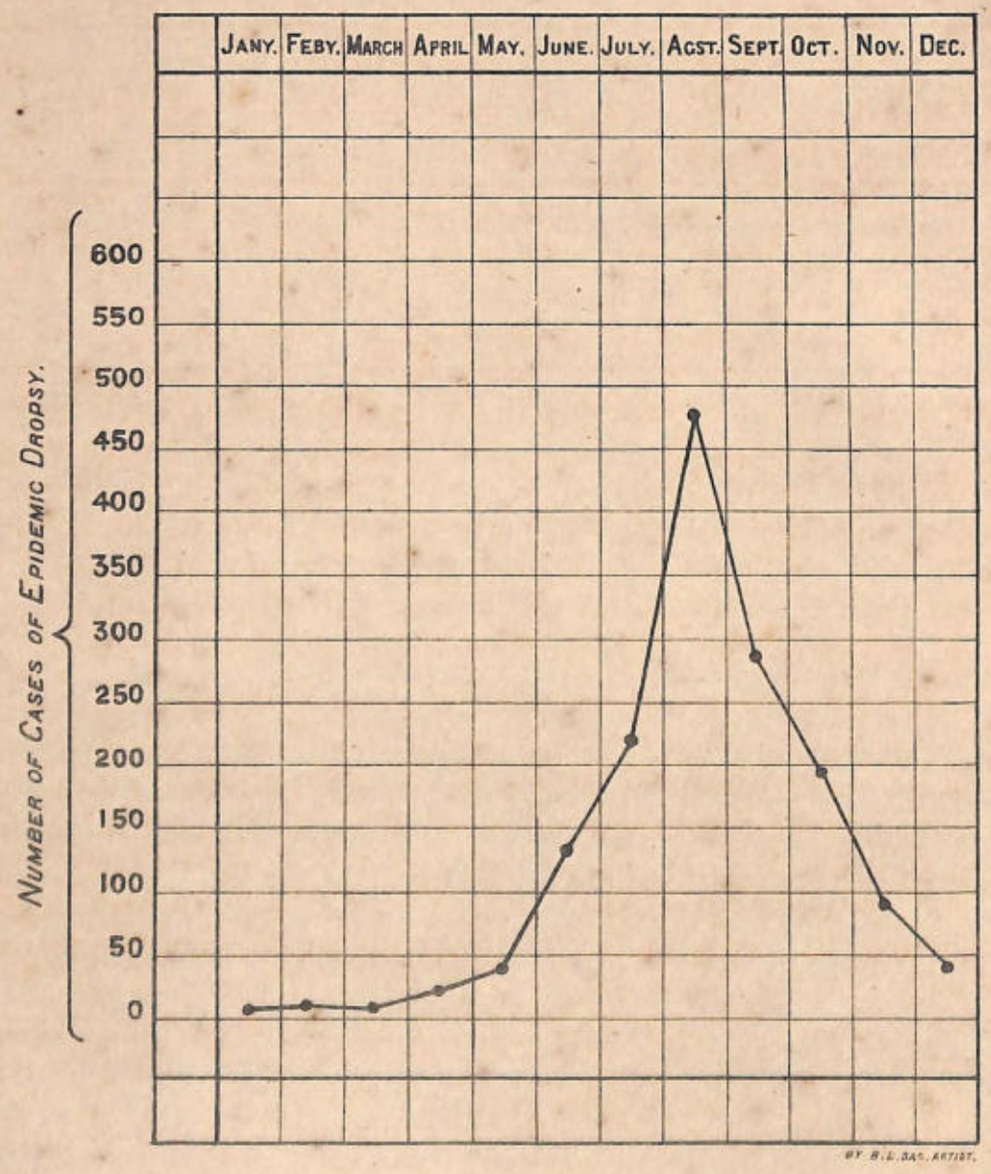
As the cases of Epidemic Dropsy were not notified to the Health Department, Calcutta, it was necessary to seek out as many of these cases as possible and make full enquiry regarding them. From the inspection of bodies at the burning Ghaut, Calcutta, a rough estimate of the cause of death is made, and the name and address of the deceased is taken. From this source, information regarding the deaths stated to be due to Epidemic Dropsy was obtained, and formed the starting point for further investigations at the house of the deceased, where it was found, as a rule, that other cases of Epidemic Dropsy were present among the family, or there was a history of previous cases or deaths. From the Health Officer, Calcutta, I obtained a complete list of the names and addresses of all fatal cases of Epidemic Dropsy reported from the burning Ghaut, and the houses and inhabitants were carefully investigated by myself or my assistants and the information obtained was recorded on two forms which I had prepared specially for the purpose, see appendix to my first report[1] on Epidemic Dropsy in Calcutta.

During the year, 1909-10, I was engaged on the enquiry at Calcutta, I investigated 321 houses with a total of 4,637 inhabitants among whom were 1,581 cases of Epidemic Dropsy. In this way a large amount of valuable information regarding the epidemic was recorded. In my first report[1] some of the facts obtained were dealt with and in this report the remainder are given in full. In dealing with the information collected it has been divided into Epidemiological, Symptomatological, and Dietetic.

[1] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

I.

CHART SHOWING THE MONTHLY INCIDENCE OF EPIDEMIC DROPSY DURING 1909.



(ii) Epidemiological Investigations.

1. Annual Incidence of Cases.

The following table shows the number of cases of Epidemic Dropsy investigated which occurred in Calcutta in 1907-08-09-10 :—

Number of cases of Epidemic Dropsy in			
1907.	1908.	1909.	1910.
6	30	1,528	17

2. Monthly Incidence of Epidemic Dropsy in 1909.

The following table shows the number of cases of Epidemic Dropsy which occurred in each month in 1909 :—

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
6	8	7	18	41	129	214	481	289	199	90	46

From this it will be seen that in the present outbreak the majority of cases occurred in the monsoon period of the year, but in the previous epidemic in Calcutta, 1878-79, the disease was most prevalent in the cold season and died down in the hot weather. It cannot, therefore, be stated that the occurrence of Epidemic Dropsy is limited to a particular period of the year.

The chart No. I at the end of this report shows in graphic form the monthly incidence of Epidemic Dropsy in Calcutta for the year 1909.

3. Geographical Distribution of Cases of Epidemic Dropsy in Calcutta.

As has been already mentioned, Calcutta is divided into four districts, and these are again subdivided into Wards. In my first report[1] a map of Calcutta was given showing the distribution of the fatal cases of Epidemic Dropsy up to date.

The following table shows the number of houses investigated in which cases were ascertained to have occurred in the four districts of Calcutta in 1909 :—

Number of houses investigated in which cases of Epidemic Dropsy occurred.			
District I.	District II.	District III.	District IV.
143	108	27	43

[1] *Ibid.*

The following table shows the number of houses investigated in which cases of Epidemic Dropsy were ascertained to have occurred in the various Wards in Calcutta in 1909 :—

Number of houses investigated in which Epidemic Dropsy occurred.								
Ward 1.	Ward 2.	Ward 3.	Ward 4.	Ward 5.	Ward 6.	Ward 7.	Ward 8.	Ward 9.
24	13	41	19	10	36	4	33	45
Ward 10.	Ward 11.	Ward 12.	Ward 13.	Ward 14.	Ward 15.	Ward 16.	Ward 17.	
7	19	0	3	9	0	0	0	
Ward 18.	Ward 19.	Ward 20.	Ward 21.	Ward 22.	Ward 23.	Ward 24.	Ward 25.	
0	11	4	17	11	3	1	11	

The significance of the geographical distribution has been considered in my previous report.[1] It may be mentioned that the noteworthy features were the small number of cases in Wards 5 and 7, inhabited chiefly by Marwaris, as compared with Wards adjoining 6 and 8, inhabited chiefly by Bengalis, and further the fatal cases of Epidemic Dropsy recorded in these Wards, 5, and 7, did not occur among the Marwaris, but among the Bengalis, who inhabit these Wards in small numbers; and further, Wards 15, 16, 17 populated by the better class European community did not show any fatal cases of Epidemic Dropsy. It will be thus seen that the distribution of the disease in Calcutta afforded important information.

4. General Incidence of Epidemic Dropsy in Inhabitants of Houses investigated.

The following table shows the total number of houses investigated in which cases of Epidemic Dropsy occurred, the total number of inhabitants of these houses and the total number of cases of Epidemic Dropsy amongst the inhabitants of the houses :—

Total number of houses investigated in which cases of Epidemic Dropsy occurred.	Total number of inhabitants of houses.						Total number of cases of Epidemic Dropsy amongst inhabitants of houses.					
	Adults.		Children.*		Servants.		Adults.		Children.*		Servants.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
321	1,349	1,339	692	627	302	328	543 40·2%	621 46·4%	166 24%	115 18·5%	73 24%	63 19%

[1] *Ibid.*

* Under 12 years.

5. General Mortality amongst Cases of Epidemic Dropsy investigated.

The following table shows the total number of cases of Epidemic Dropsy investigated and the total number of deaths amongst these cases :—

Total number of cases of Epidemic Dropsy.				Total number of deaths amongst these cases.			
Adults.		Children.*		Adults.		Children.*	
Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
616	684	166	115	102	223	19	24
				16·5%	32·6%	11·4%	20·8%

* Under 12 years.

6. Incidence of Epidemic Dropsy amongst Castes or Religions.

The following table shows the total number of cases of Epidemic Dropsy investigated, the number of Hindus, Mohamedans, Indian Christians, Eurasians amongst them :—

Total cases of Epidemic Dropsy investigated.	Hindus.		Mohamedans.		Indian Christians.		Eurasians.
	Bengalis.	Others.	Bengalis.	Others.	Bengalis.	Others.	
630	534	4	56	4	27	...	5

From this table it will be seen that the large majority of cases of Epidemic Dropsy occurred amongst Hindus (Bengalis).

7. Age Incidence of Epidemic Dropsy amongst Cases investigated at Calcutta.

The following table shows the total number of cases of Epidemic Dropsy investigated, and the number of cases which occurred at various age periods amongst males and females :—

Total number of cases of Epidemic Dropsy.	The number of cases of Epidemic Dropsy in each of the following age periods amongst males and females.															
	Up to 12 years.		13—20.		21—30.		31—40.		41—50.		51—60.		61—70.		Over 70.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
630	25	24	47	60	75	90	50	70	57	48	25	27	8	14	6	4

8. Mortality from Epidemic Dropsy at different Age Periods.

The following table shows the total number of fatal cases of Epidemic Dropsy investigated, the number of deaths from Epidemic Dropsy in each of the following age periods amongst males and females :—

Total number of fatal cases of Epidemic Dropsy.	The number of deaths from Epidemic Dropsy in each of the following age periods amongst males and females.															
	Up to 12 years.		13—20.		21—30.		31—40.		41—50.		51—60.		61—70.		Over 70.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
228	8	12	11	31	11	36	6	33	15	19	11	16	6	9	1	3

Chart No. 2 shows the age composition of the population of Calcutta. Chart No. 3 shows the age incidence of cases of Epidemic Dropsy in the male and female population of Calcutta. Chart No. 4 shows the mortality from Epidemic Dropsy at different age periods amongst the male and female population in Calcutta.

These Charts are of considerable interest. In the first place it will be seen from the Chart showing the age distribution of the population of Calcutta that the bulk of the inhabitants are between the ages of 20 and 40 years. Further, although, as we have seen, in the whole population of Calcutta there are only half as many women as men, yet the number of fatal cases of Epidemic Dropsy is higher at each age period in females than in males. In my first report[1] and in the present one this problem is discussed, and the explanation of the greater mortality amongst female Hindus lies in the fact that their diet, and especially amongst widows, is, in ordinary circumstances, distinctly "One-sided," and, consequently, any factor which increases this "One-sidedness" of diet, as rise in price of food grains, affects most severely the adult female population.

9. Occupations of Persons attacked by Epidemic Dropsy.

1.—Males.

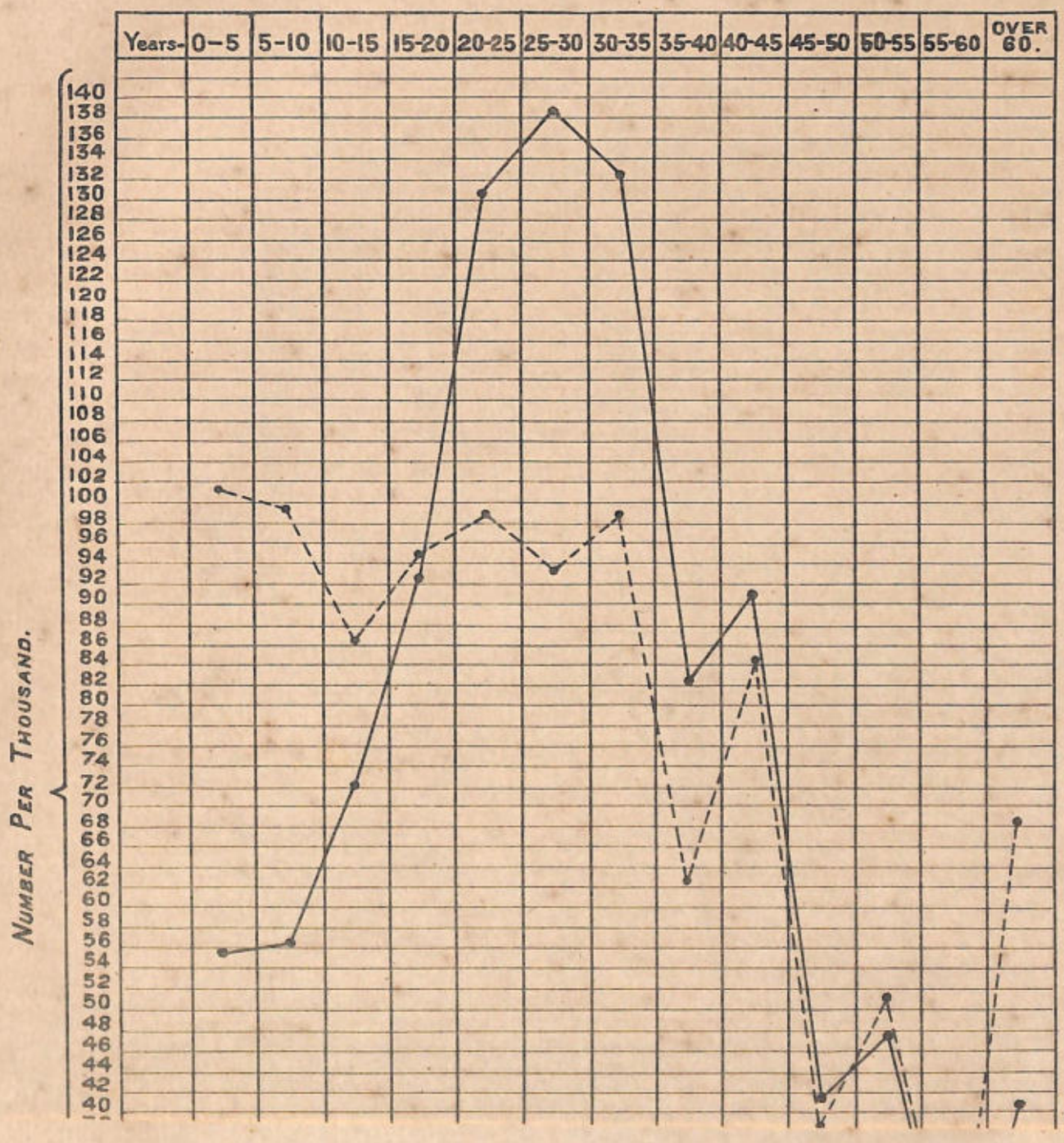
Total number of Epidemic Dropsy cases investigated.	Clerks.	Petty traders.	Artisans.	Press hands.	Landholders.	Merchants.	Medical practitioners.	Brokers.	Musicians.	Priests.	Teachers.	Pleaders.	Engineers.	Bankers	Mill-owners.	Menials, domestic servants, etc.	Mill hands.	Lascars.	Pensioners.	Students.	No occupation.
293	104	29	26	13	10	7	10	5	2	1	1	2	1	1	1	3	2	1	6	36	31

[1] *Ibid.*

II.

AGE DISTRIBUTION OF 1000 OF EACH SEX IN CALCUTTA

(CENSUS OF INDIA, 1901. Vol. VII. PART IV.)



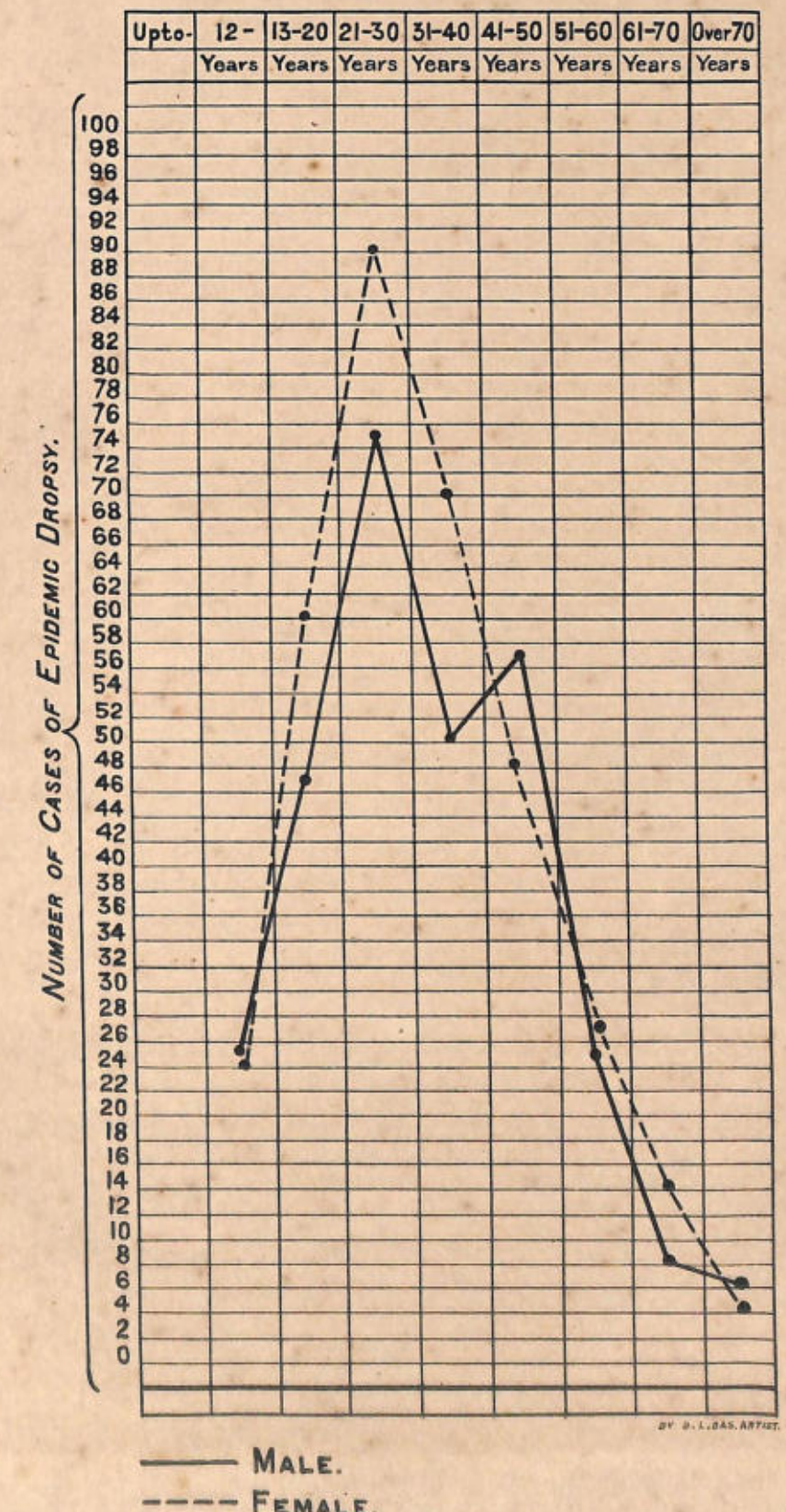
——— MALE.

– – – – FEMALE.

III.

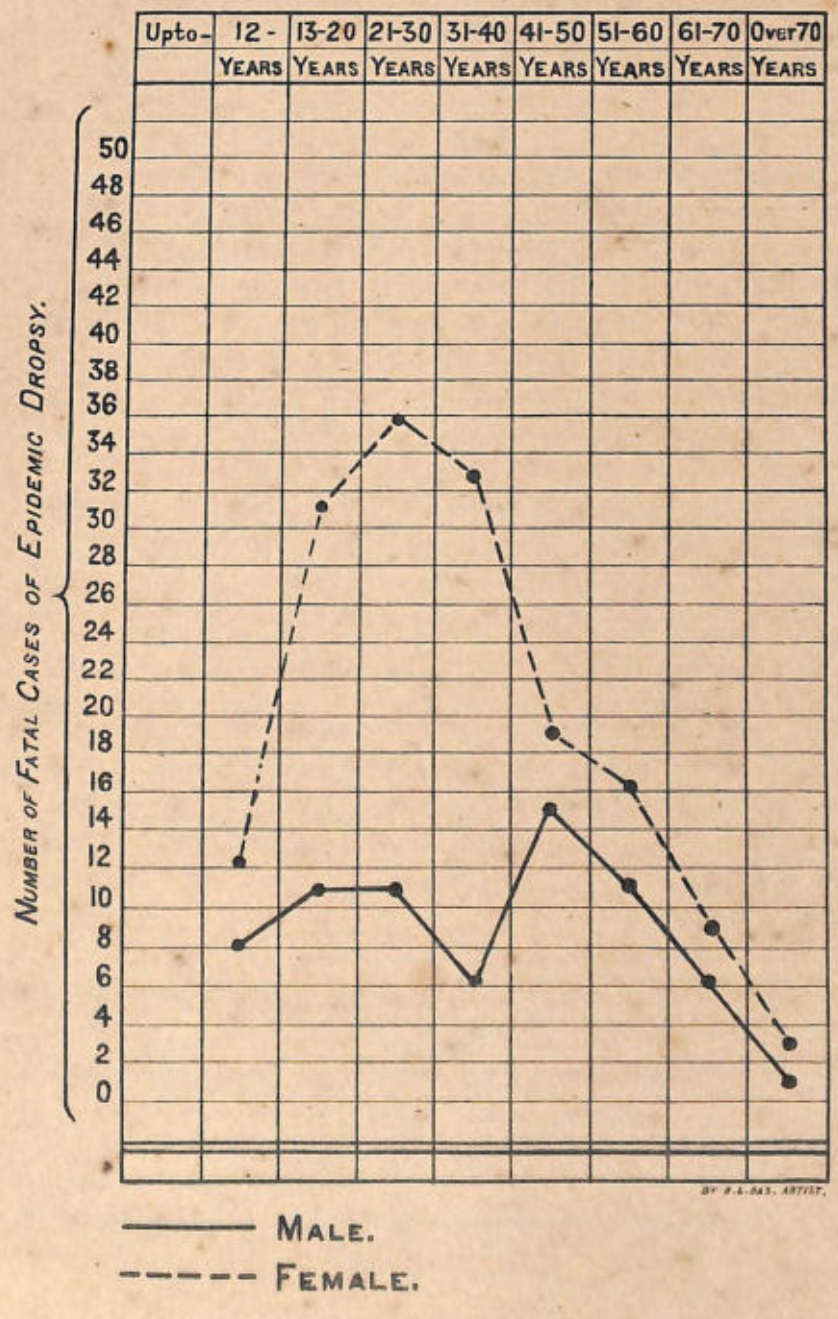
Age Incidence of Epidemic Dropsy.

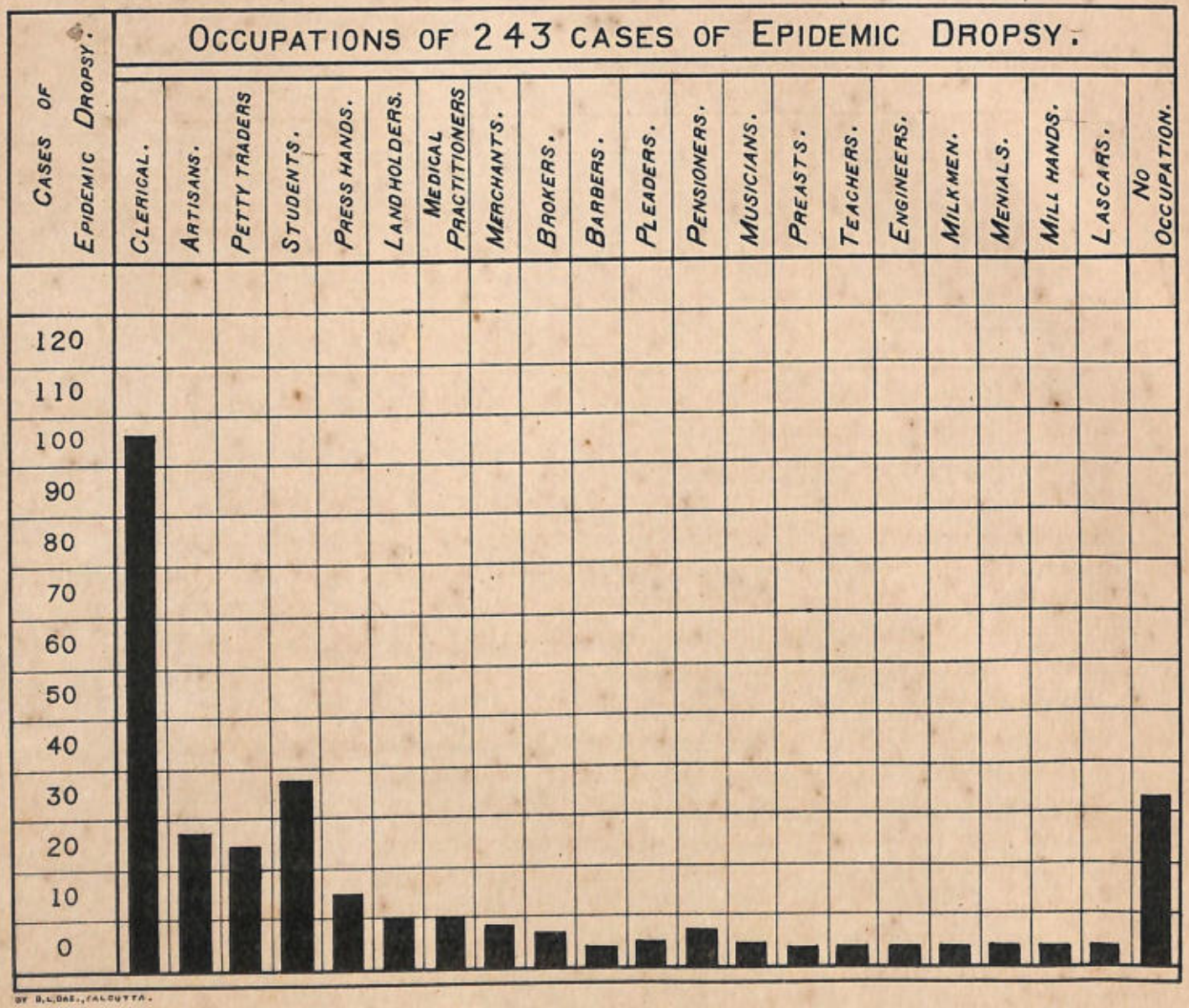
Male and Female.



IV.

Chart showing Mortality from Epidemic Dropsy at various Age Periods.
Male and Female





BY B.L.DAS., CALCUTTA.

2.—Females.

Total number of Epidemic Dropsy cases investigated.	Workers.				Dependent on												
	Schoolmistresses.	Maidservants, etc.	Hawkers, etc.	Prostitutes.	Clerks.	Traders.	Artisans.	Merchants.	Landholders.	Brokers.	Pleaders.	Medical practitioners.	Teachers.	Press hands.	Menials.	Priests.	Musicians.	Christian schools.
337	3	6	14	10	15	32	24	10	29	6	5	11	5	4	6	1	1	11

Chart No. 5 shows in graphic form the occupations of 293 persons attacked by Epidemic Dropsy.

From a study of the two tables and Chart it will be seen that of the 630 cases of Epidemic Dropsy investigated, 205 males and 215 female dependents belonged to the Clerical, Artisan, Student, or Petty trader classes, that is to say, they belonged to the classes with small fixed incomes. This is a very important point because as I have shown in my first report[1] the factor which determines the extensive outbreaks of Epidemic Dropsy is a sustained high price of food grains, and, consequently, it is just those persons with small fixed incomes who would be most severely affected. In times of prosperity and low price of food grains these persons can purchase additional articles of diet and so compensate the defects in their staple food, and in this way maintain nutritional equilibrium, but when the price of their staple article of food rises and remains high, then their power of purchasing additional articles of food is gone, and their diet, accordingly, becomes more and more "One-sided"; and the longer this condition lasts, the more severe will be the manifestations of a nutritional breakdown: when the price of food grains falls to normal and they are again able to supplement their dietary by additional articles of food the "One-sidedness" of their dietary ceases, and with it the epidemic as occurred in Calcutta in 1879-80, and again in 1909-10.

10. Incidence of Epidemic Dropsy amongst Hindu Females (Married, Unmarried, and Widows).

The following table shows the total number of adult female inhabitants in 130 houses investigated and the total number of cases of Epidemic Dropsy amongst them:—

Total number of adult female inhabitants in 130 houses investigated.		Total number of cases of Epidemic Dropsy amongst them.	
Married and single.	Widows.	Married and single.	Widows.
398	151	201 50·5 %	85 56·2 %

[1] *Ibid.*

11. Case Mortality amongst Hindu Females (Married, Unmarried, and Widows).

The following table shows the case mortality from Epidemic Dropsy amongst female Hindus in Calcutta :—

Total number of cases of Epidemic Dropsy amongst adult female Hindus in 130 houses.		Total number of deaths from Epidemic Dropsy amongst these cases.	
Married and single.	Widows.	Married and single.	Widows.
201	85	62 30·89 %	45 52·9 %

A study of these tables brings out the interesting fact which was dealt with in my first report,[1] namely, that the mortality from Epidemic Dropsy is higher amongst female Hindus (Bengalis) than amongst male Hindus, and particularly amongst widows. As I have already pointed out, this fact has an important bearing in connection with the etiology of Epidemic Dropsy, because female Hindus consume less fresh meat than adult male Hindus, and widows, for religious reasons, do not partake of meat at all and are pure rice-eaters. If this fact is examined in the light of the working hypothesis, that Epidemic Dropsy is dependent on defects in dietary whereby it is rendered "One-sided," is correct, then Hindu widows, whose diet is a typical example of "One-sidedness," ought to have suffered most, and this is exactly in accordance with the facts brought out in my reports of the investigation.

Incidence of Cases of Epidemic Dropsy in Families.

(*1*) *Households of two families.*

Total number of households investigated.	Number of households in which	
	One family attacked.	Two families attacked.
26	24	2

(*2*) *Households of three families.*

Total number of households investigated.	Number of households in which		
	One family attacked.	Two families attacked.	Three families attacked.
21	15	2	4

[1] *Ibid.*

(3) *Households of four families.*

Total number of households investigated.	Number of households in which			
	One family attacked.	Two families attacked.	Three families attacked.	Four families attacked.
16	10	4	2	0

(4) *Households of five families.*

Total number of households investigated.	Number of households in which				
	One family attacked.	Two families attacked.	Three families attacked.	Four families attacked.	Five families attacked.
1	1	0	0	0	0

(5) *Households of six families.*

Total number of households investigated.	Number of households in which					
	One family attacked.	Two families attacked.	Three families attacked.	Four families attacked.	Five families attacked.	Six families attacked.
2	1	0	1	0	0	0

(6) *Households of more than six families.*

Number of families in household.	Total number of such households investigated.	Number of households in which	
		One family attacked.	More than one attacked.
7	1	1	0
9	2	2	0
10	1	1	0
11	1	1	0
12	1	1	0

In the above tables some of the households investigated have been classified into those with 2, 3, 4, 5, and 6 families, and the results of the enquiry as to the number of families in each household which was attacked by Epidemic Dropsy stated. It is interesting to note that in the great majority of instances

1 family only in these various sized households was attacked. This limitation of the disease to single families in households is important in regard to the question of infectivity of the disease. That is to say, that amongst the healthy inhabitants there were foci of persons attacked by Epidemic Dropsy and the disease did not spread from these foci to the unaffected population. The question of the infectivity of Epidemic Dropsy has been discussed fully in my previous report,[1] and reference to it should be made in this connection.

13. Degree of Communication between Families in Households affected by Epidemic Dropsy.

The following table shows the degree of communication between families in households affected by Epidemic Dropsy, the food and cooking arrangements of these families, and the occurrence or non-occurrence of Epidemic Dropsy in unaffected families :—

HOUSEHOLDS COMPOSED OF TWO OR MORE FAMILIES IN WHICH CASES OF EPIDEMIC DROPSY OCCURRED.

Number of such households investigated.	Number of households in which communication between families was		Number of households in which cooking arrangements are		Number of households in which Epidemic Dropsy	
	Intimate.	Slight.	Same.	Different.	Occurred in unaffected families.	Did not occur in unaffected families.
72	33	39	72	0	0	66
	In 6 households all the families were affected simultaneously.					

In this table the interesting fact comes out that in 66 out of 72 households cases of Epidemic Dropsy were not recorded in the families *originally unaffected by the disease*, and in the remaining 6 households all the families were affected simultaneously. This is further evidence that the disease remains limited to the family originally attacked although communication may be intimate with other families of the household.

14. Movements of Families in Relation to Epidemic Dropsy.

The following table shows the number of households free from Epidemic Dropsy into which cases were imported and the number of these households which recorded cases of Epidemic Dropsy after importation :—

Number of Epidemic Dropsy free households into which cases were imported.	Number of these households which recorded cases of Epidemic Dropsy after the importation.
31	2

[1] *Ibid.*

This table was referred to in my first report.[1] It very clearly demonstrates the fact that the spread of the disease does not follow the importation of cases into households previously free from infection; and taken along with the other evidence supports the contention that Epidemic Dropsy is non-infectious.

15. Incidence of Epidemic Dropsy amongst Servants.

The following table shows the number of servants in households in which cases of Epidemic Dropsy occurred, and the number of servants attacked by Epidemic Dropsy :—

Total number of servants in households in which cases of Epidemic Dropsy occurred.		Number of servants attacked by Epidemic Dropsy.	
Male.	Female.	Male.	Female.
302	328	73 24·1 %	63 19·2 %

The following table shows the number of servants having the same food as, and number of servants having different food from, the affected families and the incidence of Epidemic Dropsy in both cases :—

Number of servants attacked by Epidemic Dropsy having same food and cooking arrangements as affected family.		Number of servants attacked by Epidemic Dropsy having different food and cooking arrangements.	
Male.	Female.	Male.	Female.
55	44	18	19

From these tables it will be seen that the incidence of Epidemic Dropsy amongst servants is lower than amongst their employers. A further important fact emerges, namely, that a larger proportion of servants were attacked by the disease amongst those who had partaken of the same kind of food as their masters, than amongst those who had consumed their own food, which, though cheaper, has not been so highly polished, and is, therefore, more nutritious.

16. Single Cases of Epidemic Dropsy recorded in Households.

Total number of houses where a history was available in which cases of Epidemic Dropsy occurred.	Total number of these houses reporting single cases of Epidemic Dropsy.	Number of such cases which proved on enquiry to be Epidemic Dropsy.
404	163	79

[1] *Ibid.*

It is noteworthy that when single cases of Epidemic Dropsy were reported from a house it was found, on investigation, that either the disease was not Epidemic Dropsy, or that the case had been imported. It was rare for a single individual to be attacked in a household; generally a whole family.

17. Sanitation of Houses in which Cases of Epidemic Dropsy occurred.

The following table shows the number of houses investigated, in which cases of Epidemic Dropsy occurred, and the condition of the sanitation of these houses :—

Number of houses investigated in which cases of Epidemic Dropsy occurred.	Number of houses in which sanitation was			
	Poor.	Fair.	Good.	Excellent.
321	66 (including 29 *kachcha huts).	151	93	1

* Built of mud and wattle.

During the house to house enquiry a note was made of the general state of the sanitation and the above table sets forth the results. It will be observed that in the majority of cases the sanitation is reported to be fair.

(iii) Symptomatology of Epidemic Dropsy.

In this section the frequency of the various signs and symptoms associated with Epidemic Dropsy are set forth. As most of the cases were seen in their houses it was not possible to enter into an elaborate clinical study of the phenomena of each case. The detailed results of the examination of the blood, excreta, etc., of such cases as were seen by me in hospitals have been recorded in my first report.[1] In the present report the histories of a large number of cases have been analysed and the signs and symptoms classified.

1. Duration of Illness.

The following table shows the total number of cases of Epidemic Dropsy examined and the duration of illness of these cases :—

Total number of cases of Epidemic Dropsy investigated.	Duration of illness of these cases of Epidemic Dropsy.										
	Under 1 month.	1—2 months.	3—4 months.	5—6 months.	7—8 months.	9—10 months.	11—12 months.	13—14 months.	15—16 months.	17—18 months.	19 and over.
630	21	88	255	157	63	24	9	7	1	2	3
	3·3%	14%	40·4%	24·9%	10%	3·8%	1·4%	1·1%	·1%	·3%	·4%

[1] *Ibid.*

From this table it will be observed that from 3 to 4 months was the duration of the disease in 40·4 per cent. of the total number of cases examined and 5 to 6 months in 24·9 per cent. It will be seen from these figures that the duration of the disease is prolonged. In many cases certain symptoms, *e.g.*, cardiac disturbance, slight œdema, may persist for long periods giving rise to partial or complete incapacity for work.

2. Relapses in Epidemic Dropsy.

The following table shows the frequency of relapses in Epidemic Dropsy :—

Total number of cases of Epidemic Dropsy investigated.	Number of these cases which had		
	1 relapse.	2 relapses.	3 relapses.
630	26	2	3

3. Fever in Epidemic Dropsy.

The following table shows the frequency of the occurrence of fever in cases of Epidemic Dropsy examined :—

Total number of cases of Epidemic Dropsy investigated.	Number of cases in which fever has been recorded.
630	322

From this table it will be seen that fever is not a constant symptom in Epidemic Dropsy.

4. Gastro-intestinal Symptoms in Epidemic Dropsy.

The following table shows the frequency of these symptoms :—

Total number of cases of Epidemic Dropsy investigated.	Number of cases showing gastro-intestinal symptoms.	Number of cases in which gastro-intestinal symptoms were		
		Severe.	Moderate.	Slight.
630	382	35	294	53

Severe = profuse diarrhœa, vomiting, etc.
Moderate = diarrhœa moderate, occasional vomiting, want of appetite.
Slight = dyspepsia, liquid stools twice or thrice daily, want of appetite.
Profuse vomiting was noted in three cases only.

5. Œdema in Epidemic Dropsy.

The following table shows the position and frequency of occurrence of the œdema occurred in Epidemic Dropsy :—

Total number of Epidemic Dropsy cases investigated.	Number of cases in which œdema was present in						
	Feet alone.	Feet and legs.	Lower extremities.	Legs and hands.	Face alone.	Hand and face.	Whole body.
630	8	400	42	37	0	5	129

It will be seen from this table that in the great majority of cases the œdema occurred in the feet and legs.

6. Cardiac Symptoms in Epidemic Dropsy.

The following table shows the frequency of cardiac symptoms in Epidemic Dropsy :—

Total number of cases of Epidemic Dropsy investigated.	Number of cases in which the following symptoms and signs were noted.			
	Precordial pain alone.	Palpitation alone.	Pain and palpitation.	Dyspnœa.
630	0	102	4	364

7. Condition of the Knee Jerk in Epidemic Dropsy.

Total number of cases of Epidemic Dropsy investigated.	Number of cases in which knee jerks were			Number of cases in which tenderness of calf muscle was noted.
	Normal.	Increased.	Diminished.	
181	153	12	6	54

As the majority of the cases were examined towards the end of the disease or when convalescence was advanced, it is probable that the number of instances in which the knee jerk was found normal is higher than it would have been if it had been possible to examine the cases at an earlier period in the illness.

8. Eye Symptoms in Epidemic Dropsy.

Total number of cases of Epidemic Dropsy investigated.	Number of cases of increased intraocular tension with disturbance of vision.
630	15

Maynard[1] contributes an interesting note on increased intraocular tension met with in cases of Epidemic Dropsy in Calcutta. He states, "On examining them one usually finds the cornea a little steamy; the anterior chamber normal or deep, pupils small or moderately dilated and acting but sluggishly to light; there is sometimes complaint of pain, but rarely is there any injection of the vessels. The tension of the eyeball is usually distinctly increased; sometimes it is normal, in one case it was diminished. Halos, generally rainbow-like, are spontaneously complained of by those not complaining of dimness of vision; it will often be found that they have had halos at some time or another during the attack of dropsy. These halos are sometimes seen early in the morning, but more often later in the day and lasting only a few hours, sometimes recurring again in the evening. They are not due to conjunctival secretion. Usually the failure of the vision follows the dropsy, but in some cases it is noticed at the same time and in two cases it preceded the dropsical signs by a short interval.

"Two-thirds of the cases showed pathological cupping of the disc from 2 to 6 D in depth, a few showed only physiological cupping, though usually of considerable extent, and a few showed no cupping at all. The retinal veins are usually engorged and both they and the arteries show marked pressure pulsation in several cases. Priestly Smith's scotometer frequently gave negative results, Bijerrum's sign being absent. The fields were generally contracted, especially on the nasal side. In none was the eyeball enlarged. None had R. P. or signs of iritis, past or present. None of the patients had markedly small corneæ. Two were myopes. Two-thirds were men and one-third women. The ages of all except 2 were under 36. Eight were under 28, and there was no family history of Glaucoma forthcoming."

9. Skin Lesions in Epidemic Dropsy.

The following table shows the kind and frequency of occurrence of skin lesions in Epidemic Dropsy :—

Total number of cases of Epidemic Dropsy investigated.	NUMBER OF CASES IN WHICH THE FOLLOWING LESIONS WERE NOTED.		
	Mottling over the œdematous parts and petechiæ.	Other lesions.	
		Ulceration of cheek.	Bleeding nævi.
630	180	3	4

[1] *Indian Medical Gazette*, October 1909.

The petechiæ were quite distinct from the mottling and their distribution was different, being found on the back, chest and other places, whilst the mottling was confined to the œdematous parts. The petechiæ were apparently small cutaneous hæmorrhages.

10. Emaciation in Epidemic Dropsy.

The following table shows the total number of cases of Epidemic Dropsy investigated and the presence or absence of emaciation amongst them :—

Total number of cases of Epidemic Dropsy investigated.	NUMBER OF CASES IN WHICH EMACIATION WAS		
	PRESENT.		ABSENT.
	Slight.	Well marked.	
630	85	67	478

11. Complication in Epidemic Dropsy.

The following table shows the kind and frequency of occurrence of complications in Epidemic Dropsy :—

Total number of cases of Epidemic Dropsy investigated.	Scorbutus.*	Piles.	Hæmoptysis.	Septic infections.†	Pneumonia.	Jaundice.	Ascites.	Dysentery.
630	52	43	3	12	1	3	10	4

* Includes stomatitis, bleeding from the gums, hæmorrhage from the bowel.
† Includes brawny induration, cancrum oris, necrosis of jaw.

12. Analysis of Urine and Blood in Beriberi and "Ship Beriberi."

In a recent paper Breaudat[1] contributes a note on the urine and blood in Beriberi and a short account of his results is given.

He finds on examining the urine of Beriberi cases at an early stage the following :—

(1) The constant absence of important pahological elements in salution (Nucleo-albumin, albumin, sugars, alkaptone blood or bile pigments, urobiline, acetone, oxybutyric acid). Peptone is hardly ever found and only in traces.

(2) Few anatomical elements in suspension, but the most frequent are castes, hyaline castes with or without leucocytes.

(3) Extreme poverty of physiological elements, especially in organic material.

[1] Bull. Soc. Path. Exotique, Tome III, No. 9, Seance, Nov. 9, 1910.

In severe cases with generalised œdema he observed that the urine had a specific gravity of 1,003, and giving in the 24 hours 24·74 grammes of soluble material, 1·73 gram. of ash, 0·82 gram. phosphoric acid, and 9·50 gram. Urea. In cases of moderate severity these numbers are somewhat increased.

The following table gives the results of the analysis in 15 cases of Beriberi, typical and comparable. For comparison, the results of the analysis of the urine of natives (Annamite) and Europeans are given :—

Urine of 24 hours.	Annamites Beriberi.	Annamites healthy.	European.
Volume	1,100 c. c.	1,097 c. c.	14 to 1,500
Reaction	Slightly acid	Slightly acid	Acid
Specific gravity	1,008·6	1,011·8	1,018 to 1,022
Water	1,082·1	1,080·4	1,350 to 1,450
Elements dissolved	27·4%	20·4%	48 to 52
Organic matter	18·9	18·6	36 to 38
Urea	11·5	9·6	25 to 38
Sodium chloride	5·2	8·7	10 to 12
Phosphoric acid. P_2O_5	0·9	0·8	2·50
Total nitrogen	...	5·8	...

Breaudat has made an analysis also of the blood of 6 cases of Beriberi. 4 to 6 c. c. of blood were taken from a vein at the bend of the elbow. These cases were amongst the 15 recorded above in which an analysis of the urine was made.

The following table shows the results of the examination per 100 gram. of blood :—

Elements determined.	Beriberi cases 6 examined.	Annamites 2 examined.	Blood of Europeans.
Water	81·12	79·90	78·80
Dry extract	19·17	20·09	21·15
Organic matter	18·04	19·17	20·23
Ash	1·10	0·92	0·96

Breaudat concludes that the blood of a Beriberi patient is markedly poor in organic matter, 1·13 per cent. less than a healthy native and 2·19 per cent. less than a European. As the quantity of mineral matter varies little, it

follows that the blood of a Beriberi case is much richer in water than a healthy person.

Schaumann[1] gives the results of his analyses of the urine and fæces of cases of "Ship Beriberi" at Hamburg.

The following table from his monograph shows the results of his analysis of urine and fæces before treatment and after treatment :—

TABLE IV.—SCHAUMANN.

Urine and fæces examination.

3 Patients from sailing ship "P. R.".

1. Patient T. admitted to Seaman's Hospital on 22nd December 1909.

Diet.—Mixed.

Treatment.—First day after admission 15 drops of digitalis twice daily. Sweated once. In addition 4 times daily 1 gram. Testikulin.

2. Patient L. admitted to Seaman's Hospital on 23rd December 1909.

Diet.—Mixed.

Treatment.—For three days twice daily 15 drops of digitalis. In addition 4 times daily 1 gram. Testikulin.

3. Patient S. admitted to Seaman's Hospital on 23rd December 1909.

Diet.—Mixed.

Treatment.—For two days twice daily 15 drops of digitalis. In addition 4 times daily 1 gram. Testikulin.

Patient.	Date 1909.	OUTPUT IN 24 HOURS.					
		URINE.				FÆCES.	URINE AND FÆCES.
		Quantity of urine.	Reaction.	Specific gravity at 15 C.	P_2O_5 gram.	P_2O_5 gram.	P_2O_5 gram.
		c. c.					
T.	22nd—23rd December	760	Acid	1·027	1·6032	0·7395	1·7427
	29th—30th „	1,100	„	1·0200	1·9470	2·0254	3·9724
L.	23rd—24th December	790	Acid	1·0218	2·0145	0·6670	2·6815
	29th—30th „	1,850	„	1·0190	2·9970	3·1095	6·1065
S.	23rd—24th December	1,310	Acid	1·0208	2·0798	1·5234	3·6032
	29th—30th „	2,290	„	1·0155	3·8243	2·8078	6·6321

[1] Archiv. f. Schiffs und Tropenhygiene, Beiheft, No. 8, Bd. XIV, Dec. 1910.

Patient.	INCREASE OF P_2O_5 IN 6—7 DAYS					
	In Urine.		In Fæces.		In Urine and Fæces.	
	Absolute increase.	Relative increase.	Absolute increase.	Relative increase.	Absolute increase.	Relative increase.
	Gram.	Per cent.	Gram.	Per cent.	Gram.	Per cent.
T. . . .	0·9438	94·08	1·2859	305·5	2·2297	127·9
L. . . .	0·9825	48·77	2·4425	91·1	3·4250	127·7
S. . . .	1·7445	83·88	1·2844	84·3	3·0289	119·0
Average .	1·2236	75·57	1·6709	160·3	2·8945	124·9

Durham[1] carefully studied the composition of the urine in a number of cases of tropical Beriberi in the Federated Malay States.

The following table shows the average output in 24 hours of his 14 cases as regards the quantity of urine, Urea, P_2O_5, SO_3 and the relation of the output to normal :—

—	Output in 24 hours.			
	Urine.	Urea.	P_2O_5.	SO_3
Average of Durham's cases .	c.c. 1·716	Gram. 11·261	Gram. 1·036	Gram. 0·6579
Relation to normal . . .	Per cent. 98·06	Per cent. 37·54	Per cent. 29·60	Per cent. 29·29

Durham states, " That the metabolism in Beriberi is seriously diminished. The amounts of Urea, Phosphoric, and Sulphuric acids may be greatly reduced."

Schaumann[2] gives the results of the analysis of the urine in 24 cases of tropical Beriberi.

—	Output in 24 hours.					
	Urine.	Reaction.	Specific gravity.	Urea.	SO_3.	P_2O_5.
Average	c. c. 1·113	Acid	1·021	Gram. 17·40	Gram. 1·4065	Gram. 1·7399
Relation to normal . .	Per cent. 63·60	...	Per cent. 100·0	Per cent. 58·00	Per cent. 62·51	Per cent. 49·71

[1] Brit. Med. Journ., Feb. 27, 1904.

[2] Archiv. f. Schiffs und Tropenhygiene, Beiheft, No. 8, Bd. XIV, Dec. 1910.

Schaumann[1] also gives the following table :—

Combined estimation of Phosphoric Acid in Urine and Fæces in Beriberi.

Patient (Beriberi).	Urine of 24 hours.		Fæces of 24 hours.		P_2O_5 content in Fæces of 24 hours.	
	Quantity.	P_2O_5.	Quantity.	P_2O_5.	Absolute amount.	Relation to normal.
	c. c.	Gram.	Gram.	Gram.	Gram.	Per cent.
22	231	0·9558	82	0·2839	1·2397	22·54
23	800	0·4560	88	0·6020	1·0580	19·24
24*a* *	2,110	1·8146	83	0·3321	2·1467	39·03
24*b* *	860	1·9436	305	0·7210	2·6646	48·45
Average .	750	1·2925	139	0·4847	1·7772	32·31

* Urine and fæces of same patient estimated on different days.

Urine Analysis (Schaumann).

Beriberi.

Food.—Hospital diet.

No treatment with Phosphorus.

Without Phosphorus treatment.	Output in the urine of 24 hours					
	On the first day after admission.			After 12 days in hospital.		
	Patient 2.	Patient 3.	Patient 4.	Patient 2.	Patient 3.	Patient 4.
1. Quantity of urine . .	680 c. c.	1,360	1,400	425	1,160	750
2. Reaction . . .	Slightly acid	Slightly acid	Acid	Acid	Acid	Acid
3. Specific gravity . .	1·023	1·017	1·022	1·031	1·011	1·024
4. Calcium oxide (CaO)	0·1849 gram.	0·2258	0·4102	0·2074	0·1508	0·1325
5. Sodium chloride (NaCl) .	5·1320 gram.	8·5130	15·8060	3·9780	8·4146	6·9322
6. Total sulphuric acid (SO_3)	1·2603 gram.	2·2624	2·3464	1·3213	1·1380	1·7962
7. Phosphoric acid (P_2O_5) .	1·7476 gram.	2·6792	2·7720	2·0612	1·7516	2·1875
8. Urea	15·96	29·67	31·36	8·81	24·77	17·61

[1] *Ibid.*

Without Phosphorus treatment.	Average output in 24 hours.						
	Quantity.	Specific gravity.	Calcium oxide.	Sodium chloride.	Sulphuric acid.	Phosphoric acid.	Urea.
	c. c.		Gram.	Gram.	Gram.	Gram.	
On first day . . .	1,147	1·021	0·2736	9·8170	1·9563	2·3996	25·66
After 12 days . . .	778	1·022	0·1636	6·4416	1·4185	2·3334	17·06
Difference .	−369	−0·001	−0·1100	−3·3754	−0·5378	−0·0662	−8·60
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Relative increase or diminution	−32·17	−0·001	−40·20	−34·38	−27·49	−2·76	33·52

Urine Analysis (Schaumann).

Food.—Hospital diet—160 gram. Phaseolus daily.

Phaseolus radiatus (Mung dal) treatment.

Hospital diet—160 gr. Mung dal. Patient 5 after 12 days. Patient 9 after 3 days.	Output in the urine in 24 hours						
	On 1st day after admission.			After 3 and 12 days' feeding on hospital diet—Mung dal.			
	Patient 5.	Patient 9.	Average.	Patient 5.	Patient 9.	Average.	Average increase.
							Per cent.
1. Quantity of urine .	1,805 c. c.	410	1,107	1,850	1,460	1,655	49·50
2. Reaction . . .	Neutral	Acid		Acid	Acid	...	...
3 Specific gravity . .	1·010	1·026	1·018	1·018	1·020	...	...
4. Sulphuric acid (SO_3) .	1·4223 gram.	1·1480	1·2851	2·7195	2·8180	2·7687	115·4
5. Phosphoric acid (P_2O_5).	1·1191 gram.	1·1480	1·1335	4·3105	4·0730	4·1917	270·6
6. Urea	13·014 gram.	12·660	12·837	37·09	44·97	41·03	219·5

These tables show clearly the effect of the addition of Mung dal to the ordinary hospital diet on the output of P_2O_5 in the urine.

Schaumann tested the effect of the addition of various other phosphorus containing substances to the diet on the output of phosphorus in the urine. He found that the greatest increase in the output was given with Mung dal and the least with yeast.

The beneficial action of Mung dal in the preventive and curative treatment of Epidemic Dropsy is fully discussed in this report, page 49.

(iv) Diet in Epidemic Dropsy.

As it became early evident in the course of the enquiry that there was a relationship between the causation of Epidemic Dropsy and the kind of food consumed, detailed notes of the diet in each case of Epidemic Dropsy investigated were made, and these records were analysed with the following results :—

1. Rice.

The following shows the total number of cases investigated with special reference to diet, and the number of those cases whose staple food was rice :—

Number of cases of Epidemic Dropsy investigated.	Number of those cases whose staple food was rice.
594	594

The following table shows the number of cases of Epidemic Dropsy investigated, and the quantity of rice they consumed daily :—

1 CHITTAK.*				2 CHITTAKS.				3 CHITTAKS.				4 CHITTAKS.			
ADULT.		CHILD.		ADULT.		CHILD.		ADULT.		CHILD.		ADULT.		CHILD.	
M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
3	1	8	3	36	24	17	20	106	170	...	...	37	38	...	...
5 CHITTAKS.				**6 CHITTAKS.**				**7 CHITTAKS.**				**8 CHITTAKS.**			
ADULT.		CHILD.		ADULT.		CHILD.		ADULT.		CHILD.		ADULT.		CHILD.	
M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
8	6	...	...	55	46	...	...	...	...	...	...	12	2	...	...

* 1 Chittak = $2\frac{3}{16}$ oz. Avoir.

2. Dal.

The following table shows the total number of cases investigated with special reference to diet, and the number of those consuming dal :—

Total number of cases investigated.	Number consuming dal.
594	594

The following table shows the number of cases of Epidemic Dropsy investigated, and the quantity of dal they consume daily :—

½ CHITTAK AND UNDER.				½ TO 1 CHITTAK.				1 TO 1½ CHITTAKS.			
ADULTS.		CHILDREN.		ADULTS.		CHILDREN.		ADULTS.		CHILDREN.	
Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.
40	32	25	23	175	221	...	...	42	36	...	...

3. Ata.

The following table shows the number of cases of Epidemic Dropsy investigated with special reference to diet, and the number of cases consuming fine and coarse ata :—

Total number of cases of Epidemic Dropsy investigated.	NUMBER OF CASES CONSUMING	
	Fine ata.	Coarse ata.
594	505	3

4. Fish.

The following table shows the total number of cases investigated with special reference to diet, and the number of cases consuming fish :—

	TOTAL NUMBER OF CASES OF EPIDEMIC DROPSY.					NUMBER TAKING FISH.				
	ADULTS.			CHILDREN.		ADULTS.			CHILDREN.	
	Males.	Females.*	Widows.	Males.	Females.	Males.	Females.*	Widows.	Males.	Females.
Hindus . .	222	161	84	22	18	209	160	13	22	18
Others . .	35	39	5	3	5	33	38	3	3	5

* Excluding widows.

It will be seen from this table that the quantity of fish consumed was not large.

5. Meat.

The following table shows the total number of cases of Epidemic Dropsy investigated with special reference to diet, and the number of cases consuming meat :—

	TOTAL NUMBER OF CASES OF EPIDEMIC DROPSY.					NUMBER OF MEAT-EATERS.				
	ADULTS.			CHILDREN.		ADULTS.			CHILDREN.	
	Males.	Females.*	Widows.	Males.	Females.	Males.	Females.*	Widows.	Males.	Females.
Hindus . .	222	161	84	22	18	184 82·8%	18 13%	0	14 63·6%	11 61%
Others . .	35	39	5	3	5	35	39	5	3	5

* Excluding widows.

6. Milk.

The following table shows the total number of cases investigated in reference to diet, and the number of cases consuming milk :—

	TOTAL NUMBER OF CASES OF EPIDEMIC DROPSY INVESTIGATED.					NUMBER TAKING MILK.				
	ADULTS.			CHILDREN.		ADULTS.			CHILDREN.	
	Males.	Females.	Widows.	Males.	Females.	Males.	Females.	Widows.	Males.	Females.
Hindus . .	222	161	84	22	18	141	177	60	17	15
Others . .	35	39	5	3	5	21	13	2	1	3

7. Mustard Oil.

The following table shows the total number of cases investigated in reference to diet, and the number of cases consuming mill oil, and the number of cases taking oil from other sources :—

TOTAL NUMBER OF CASES OF EPIDEMIC DROPSY INVESTIGATED.				NUMBER TAKING MILL OIL.								NUMBER TAKING OIL FROM OTHER SOURCES.			
ADULTS.		CHILDREN.		ADULTS.				CHILDREN.				ADULTS.		CHILDREN.	
				M.		F.		M.		F.					
M.	F.	M.	F.	Calcutta Mill.	Cawnpore Mill.	Calcutta Mill.	Cawnpore Mill.	Calcutta Mill.	Cawnpore Mill.	Calcutta Mill.	Cawnpore Mill.	M.	F.	M.	F.
257	289	25	23	154	49	185	37	17	3	15	3	54	67	5	5

Several interesting facts emerge from a study of the above tables giving details of the diet of cases of Epidemic Dropsy in Calcutta.

In the first place it will be seen that every one of the persons attacked consumed rice, and this was their staple food. Further, it will be observed that the amount of rice consumed daily varied from 1 Chittak to 8 Chittaks (1 Chittak equals 2 $\frac{2}{3\frac{1}{5}}$ oz. Avoir.). In my first report[1] I dealt very fully with the question of rice as an etiologic factor in Epidemic Dropsy, and in the present report, in the chapter dealing with experimental investigations, further particulars are given. It may be recalled, however, that the rice consumed by persons attacked by Epidemic Dropsy had undergone a process of polishing which deprived it of certain constituents essential for the physiological requirements of the body.

Since the last report was written an interesting paper on "The bran of paddy in the prevention and cure of Beriberi," by Breaudat and Dernier,[2] has been published. They studied an epidemic of Beriberi in 1909-10 at Cape St. Jacques. The disease was of moderate severity with a marked predominance of cardiac troubles. Preventive treatment was attempted in the 5th Regiment of Artillery from 1st July 1909 to 1st March 1910; among the Rifles from the 23rd June to the end of January 1910. 290 men were given rice bran, and 471 were kept as controls. Different doses of bran were administered. From the 23rd June to the 9th August the men took 20 gram. bran. They furnished 17 cases per thousand, the controls 34. From 9th August to the 15th September the men took 30 gram. bran. They supplied 5 cases per thousand, the controls 45 per thousand. From the 15th September to 1st February 1910 the batch of men treated was reduced to 165, and the controls to 189. The men took 40 gram. bran. There was not a single case of Beriberi amongst the treated, but there were 174 cases among the controls. The experiments on the curative treatment lasted at the Hospital at St. Jacques from 15th September 1909 to 5th April 1910. There were 119 cases during this period. In the first month all the patients without exception were supplied with bran. From the 15th October every alternate case was treated, there was thus a batch of treated and a batch of controls. The doses of bran varied from 40 to 350 gram. The patients of this series had the ordinary diet without medicine. The control batch was treated on the usual therapeutic lines; absolute milk diet, cardiac medication (Caffeine and Digitalis), purgatives, Brandy, Cod liver oil, Potassium Iodide, Cocodylate of Soda, Fowler's solution, Quinine. From the milk dietary they passed on to ordinary food through soups, meat juice, bread and grilled meat. A meat ration entered

[1] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

[2] Bull. de la Soc. Path. Exot. Seance. Nov. 9, 1910, Tome III, No. 9.

into the diet of these patients. In both batches the progress of the disease was the same. The œdema generally disappeared rapidly, and the nervous symptoms cleared up. The cardiac symptoms are very tenacious, and often persist after the patient has left Hospital. This was also noted in the recent Calcutta outbreak by me. Relapses were : 25·75 per cent. among the treated, and 31·25 per cent. among the controls. One death among the treated, and two among the controls.

The authors reach the following conclusions :—

(1) The bran of paddy even if given in large doses does not produce digestive disturbance.

(2) Employed as a prophylactic, especially among the men of the Rifles, in doses of 40 gram. daily, it had a distinct protective influence. On the contrary when given in this dose to men already affected its action appeared to be *nil*, but larger doses were not administered.

(3) From the curative point of view when given in doses of 40 gram. and over, the bran employed as the only means of treatment without in *any way changing the ordinary native dietary* has given the same results as the numerous therapeutic measures mentioned until it was associated with a European diet.

This interesting paper demonstrates the value of rice bran as prophylactic in polyneuritis, and also in the cure of Beriberi when the native dietary is simultaneously improved and approaches the European standard. Rice bran has the advantages over other therapeutic measures in being infinitely simpler, less costly, and always available.

An interesting note by Theze,[1] on the relation of rice to Beriberi, has been published recently. He states that the Penitentiary at Poulo Condore (Cochin China) for a long time has been a focus of Beriberi : in 1906 this disease caused 116 out of the total 130 deaths and this mortality did not exceed the average in this establishment.

In the epidemic of 1906 the substitution of incompletely decorticated rice (red rice) for white rice mechanically decorticated has produced remarkable results when disinfection of the locality and intestinal disinfection did no good. This measure commenced towards the middle of August completely arrested the epidemic; and the patients already affected, who were submitted to the new *régime*, rapidly improved; after the 22nd August there was not a single case.

[1] Ann. d'hyg. et de med., col. 1910, p. 16, referred to in Archiv. Schiffs u. Trop. Hyg., Bd. XIV, Heft. 21, p. 678, 1910.

The analysis of the ration distributed to the prisoners at Poulo Condore leads the author to believe that the symptoms are due to an insufficient quantity of phosphorus in the diet. Contagion does not appear to play any part at all.

In a note, appended to the report of M. Theze, the Editor of the *Annales d'hygiene de medicine coloniales* gives an interesting account of the results obtained in the prison at Saigon by excluding polished rice; the orders were given by M. Grall in November 1903.

The following table gives the results :—

Saigon Prison.

Year.	Average number of prisoners.	Deaths from Beriberi.
1899	615	80
1900	628	78
1901	507	93
1902	464	85
1903	584	76
1904	746	3
1905	779	6
1906	860	15
1907	762	5

The following table shows the results of substituting partially husked (red rice) for white rice in 1906 at the Penitentiary at Poulo Condore :—

Year.	Average number of prisoners.	Deaths from Beriberi.
		Percentage.
1901	295	27·45
1902	375	13·60
1903	489	57·46
1904	534	7·67
1906 From 1st January to 15th August	363	31·99
1906 From 15th August to 31st December	249	0
1907	703	0
1908 From 1st January to 1st September	909	0

The above table illustrates in a very striking manner the effect on the mortality from Beriberi of altering the diet from polished to unpolished rice.

Gilmore Ellis,[1] Medical Superintendent, and Medical Officer, Beriberi Hospital, Singapore, brings forward evidence from his own investigations, which have been carried on since 1901, showing the causal connection between polished rice and Beriberi.

It is interesting to note that, in his report on the Medical Department of the Straits Settlements for 1909, Dr. Ellis[2] states that no case of Beriberi originated in the Singapore Jail; this is the third year in succession in which this immunity has occurred. In the same report it is stated that parboiled rice is now used in various Government institutions of the Malacca Province. One fatal case of Beriberi occurred at a police depôt; the victim, a sub-inspector, had been warned against Siam rice, but refused to alter his diet.

It will be observed from my tables that the quantity of dal taken by the Bengalis in Calcutta is small; in the great majority of cases under 1 Chittak a day is consumed. This is an important point, because I have shown in my previous report[3] that dal, especially the Mung dal, *Phaseolus radiatus*, has valuable prophylactic and curative properties when administered in suitable doses; it supplies the essential constituents which are deficient in a polished rice diet. In the chapter of this report dealing with the results of the experimental investigations the prophylactic and curative properties of the Indian Mung dal in relation to the neuritis of birds are clearly demonstrated.

In regard to the consumption of ata a very interesting fact is brought out, namely, that practically all cases of Epidemic Dropsy amongst Bengalis in Calcutta partook of fine or sifted ata, and this, as was shown in my first report,[4] is remarkably poor in certain essential constituents necessary to meet the physiological requirements of the body. Consequently, a diet composed of polished rice and sifted ata is very deficient in respect of these constituents.

It will be noted that Hindu widows partake of very little fish and no meat at all. Thus of 84 widows suffering from Epidemic Dropsy, only 13 took fish, and none consumed meat.

By reference to the tables giving the mortality it will be observed that the death rate from Epidemic Dropsy amongst the Hindu females in Calcutta is very high.

Considerable importance has been attached to mustard oil in connection with the etiology of Epidemic Dropsy, and consequently enquiries were made

[1] Brit. Med. Journal, Oct. 2, 1909.

[2] Lancet, Feb. 4, 1911.

[3] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

[4] *Ibid.*

regarding it. It was thought that the causation of Epidemic Dropsy was dependent on certain impurities, mineral oils ("Batch and Bloomless oils"), in the mustard oil, and this hypothesis received a considerable amount of popular attention in Calcutta. The results of the experimental study of this question are recorded in the chapter dealing with experimental investigations in this report. Neither the epidemiological nor the experimental studies, made in connection with the present enquiry, support the above hypothesis, and there is no scientific evidence in favour of it.

CHAPTER II.

Note on an Outbreak of Epidemic Dropsy in Basti Jail, United Provinces.

As some interesting facts regarding the relationship of rice diet to Epidemic Dropsy were brought out in the course of this enquiry, a record of it may be appropriately inserted at this point.

In December 1907 I was directed to proceed to Basti Jail to enquire into an outbreak of a disease resembling Beriberi. I was only able to devote a short time to the enquiry as I was officiating as Director of the Central Research Institute at the time. From the evidence I was able to collect I expressed the opinion, tentatively, that defects in dietary were playing an important part in the causation of the disease.

The general features of the condition very closely resembled those of Epidemic Dropsy in Calcutta. In this jail rice was consumed, and it is of interest to note that this was the only jail in the United Provinces in which rice was generally consumed by all the prisoners, and it is the only jail in the United Provinces which has recorded an outbreak of this disease.

The Honourable Lieutenant-Colonel C. Mactaggart, I.M.S., Inspector-General of Prisons, United Provinces, in answer to a recent query by me kindly supplied me with further notes regarding the epidemic at Basti Jail. He writes under date 23rd February 1910, "So far as I am aware no cases of Beriberi or Epidemic Dropsy have occurred in our jails except those you investigated at Basti. I was on the Factory Commission when the epidemic in Basti Jail occurred, and you yourself know far more about the epidemic than I do. Rice is never given in our jails as an article of diet except to a few toothless old prisoners and infirms. The only exception to this rule was the Basti Jail, where for some years rice was given as a forenoon meal, because some Superintendent of that jail considered it was more in harmony with the diet of the free population of the district, and the prisoners did better on it than wheat. I stopped the issue of rice in the Basti Jail in October 1907 owing to the occurrence of some cases of cholera, and it must have been about the same time that the cases of Beriberi occurred although the disease was not recognised till November. Whether the disease was due to the rice diet or not I cannot say, but it is peculiar that the disease should have occurred in the only jail where rice was issued generally as an article of diet. The epidemic in Basti came to an end in January 1908 I believe. Rice diet has not been reverted to in the jail and so far as I know there have been no cases of Beriberi in the jail since January 1908.

"Mustard oil is issued to all prisoners in our jails daily and the oil issued is made in the jail. I do not think it is at all likely that adulteration with petroleum could occur. I believe there were some cases of Epidemic Dropsy in Gorakhpur city and a few in Cawnpore city some time ago, but otherwise I have never heard of the disease in these Provinces. Cases may occasionally occur but they are certainly rare."

The study of this outbreak at Basti Jail presents several interesting features. In the first place it will be noted that the disease occurred in the only jail in the United Provinces in which rice is consumed generally, and this in itself is a significant fact in the light of our recent knowledge of this disease. Nextly, with the cessation of the rice and the replacement of it by wheat the epidemic stopped and no fresh cases occurred. Further, the mustard oil consumed could not have been adulterated with petroleum, as will be seen from the letter of the Inspector General. Hence in this case the etiological connection between adulterated oil and Epidemic Dropsy could be excluded. Evacuation was not carried out. Had it taken place the cessation of the outbreak might have been attributed erroneously to this measure.

As my report on the epidemic at Basti Jail to the Sanitary Commissioner with the Government of India has not been published before, I include it in the present one, because, it has important relationships to the Calcutta epidemic.

A Report on an Epidemic resembling Beriberi at Basti Jail, United Provinces, by Captain E. D. W. Greig, M.D., I.M.S.

Forwarded to the Sanitary Commissioner with the Government of India on 14th January 1908.

I have the honour to state that in accordance with your telegram No. 53, dated the 22nd December 1907, I proceeded to Lucknow on December 26th, and arrived there next day and had an interview with Lieutenant-Colonel S. H. Henderson, I.M.S., Officiating Inspector General of Prisons, United Provinces, who gave me particulars of a disease resembling Beriberi in the Basti Jail. I reached Basti next day and remained there till 31st December. This report contains the result of the enquiry which I conducted with the Superintendent, Basti Jail, Dr. N. S. Harvey, who facilitated my work there in every way.

2. The first official intimation of the occurrence of cases of a disease resembling Beriberi in Basti Jail was made by Dr. Harvey, who reported on 2nd December 1907 that, "I took over the jail from Dr. MacLeod on the 19th November 1907, he handed over to me two convicts in the Jail Hospital who

were suffering from œdema of the legs, lassitude and cardiac irritability, but nothing abnormal was discovered in any of their organs; their urine, although repeatedly examined, was found normal, they had no rise of temperature; in addition to these two cases there were 14 to 16 convicts who were suffering from slight œdema of the feet; as this did not inconvenience them to any great extent they were not admitted into Hospital." " These have steadily increased, so that to-day I have 48 male and 2 female prisoners and 1 warder suffering from the above symptoms." " I am of opinion that the disease is Beriberi in mild form, although the insidious nature of the disease showed itself in two convicts, who had very slight œdema of the feet and no other symptoms; suddenly they complained of dyspnœa and violent palpitation, they gasped and struggled for breath and died in 6 hours, one on the 29th November, and the other on the 30th November; they developed, what is styled an acute Pernicious Cardiac attack of Beriberi." On December 7th, 1907, Lieutenant-Colonel S. H. Henderson, I.M.S., Officiating Inspector General, United Provinces, paid a special visit to Basti Jail and reported, " The Jail population is at present 329, of whom there are 50 men and 2 women in Hospital suffering from symptoms of this disease. The symptoms are, briefly, œdema of the feet and legs, and sometimes of the body and face, pain and oppression over the heart, anæmia and a generally debilitated condition." " Three cases have already died in which practically the only symptom was severe precordial oppression, dyspnœa and cardiac pain coming on suddenly in men who otherwise had shown no sign of the disease."

3. On enquiry it was found that some of the cases admitted into the Jail Hospital, had been suffering from œdematous swelling of the feet—the most constant sign of the disease—for a considerable period, in one case, for at least 90 days before admission to Hospital on 8th December 1907. Hence we see that the disease was existent in the jail early in September last.[1] Many of the cases present very few signs and might easily have escaped detection, or slight significance might have been attached to them. However, the occurrence of two fatal cases at the end of November forcibly directed attention to the malady, and in December all cases showing any signs of the disease were admitted to Hospital. Thus, during the month of December 1907 a high admission rate for this disease occurred.

4. In considering the general facts connected with this outbreak of disease in Basti Jail, it is important, in the first place, to bear in mind that the disease is not confined to the jail; cases are also occurring in the district round the jail. As regards the jail itself, which has a population of between

[1] This is important in regard to the question of the connection between rice dietary and this disease. The rice was not stopped until October, *vide* paragraph 8 of this report, and the epidemic died down in December and January.

320 and 350, cases have been admitted into hospital from practically every part of it. Cases have been received from the female ward; here the female prisoners are completely shut off from all communication with the male prisoners. Also, cases have occurred in the families of the jailors, who never mix with the prisoners. A feature of interest is that the disease was first detected amongst the prisoners employed as cooks, and the incidence of the disease was high amongst them. 38·5 per cent. of the prisoners employed as cooks contracted the disease.

5. The etiology of Beriberi and its allies has not yet been scientifically determined.[1] Hence in investigating a disease of this class the most profitable course to adopt is to proceed to analyse systematically, on scientific lines, the bearing of each conceivable factor in the production of the disease. In this particular epidemic, the factor common to all effected individuals, is the food supply, and this factor is, also, common to the population of this district, in which the disease is prevailing. The food supply of the jail, therefore, requires, in the first place, to be carefully studied in its possible causal relation to the disease.

6. By the following observation it could be ascertained whether or not the food supply (grain) of the district, which is partly used in Basti Jail, can produce the train of symptoms associated with this disease. The prisoners in Basti Jail might be equally divided into two groups A and B for the purpose of this observation. A roll of prisoners in A and B groups respectively would be made out. The food of the prisoners in A group would be exactly the same as they are getting at present whilst all the grain for B group would be got from a district free from the disease, preferably, the same kind of grain as is being used in the jail of the selected district. The quantities and kind of grain would be exactly the same for A and B, the only difference being the source. Should, therefore, the disease continue, it would be possible to determine whether or not the grain of Basti district is producing the train of symptoms at present met with amongst the prisoners in the jail.[2]

7. On my arrival at the Basti Jail the great majority of the cases of the disease resembling Beriberi were already convalescent; so I had not an opportunity of observing the clinical phenomena of the acute phase of the malady. In Table No. 11 an analysis of the signs and symptoms of all cases of this disease at present in hospital is given; the most constant objective feature of these cases is œdematous swelling of the feet and lower limbs. The knee

[1] This was written in January 1908. Since that date our scientific knowledge of the etiology of these diseases has been materially advanced.

[2] The Superintendent informed me that no fresh cases occur after January 1910. Observations were not undertaken therefore to test the etiological relationship of the different kinds of food grains to the disease. However in this case the cessation of the epidemic was probably due to the stopping of the rice diet.

jerks were absent in a number of cases, but they showed no signs of paralysis or paresis.[1] In one of the more severe cases there was distinct tenderness on pressure over the nerves. In a certain percentage of cases cardiac signs and symptoms were present. Examination of the urine by Dr. Harvey had shown it to be normal. Apart from the nervous and circulatory, the systems of the body presented no noteworthy alteration.

8. The daily diet of the prisoners at present is: Wheat (1st Class 12 Chittaks; 2nd Class 10 Chittaks); Gram (1st Class 2 Chittaks; 2nd Class 2 Chittaks); Dal (1 Chittak); Vegetables (3 Chittaks). Mustard oil 2 seers oil per 100 diets. Up to 2nd October the prisoners were receiving Rice (1st Class 7 Chittaks; 2nd Class 6 Chittaks) in addition to a smaller quantity of Wheat (1st Class 7 Chittaks; 2nd Class 6 Chittaks) and Gram (1 Chittak for both classes). On this date owing to cholera the rice was stopped and the amount of wheat and gram increased as before.[2]

9. In this district I am informed by Dr. Harvey that although actual famine conditions do not exist there is a scarcity at present.[3]

[1] In this respect they closely resemble the cases of Epidemic Dropsy in Calcutta.

[2] This is a very important point, because shortly after the rice was stopped and the wheat increased the acute phase of the epidemic ceased. The part played by diet in the production of this disease has been more clearly demonstrated by recent research.

[3] This is an interesting point, because in this outbreak the conditions of scarcity would operate by bringing about a "One-sidedness" in dietary of the population outside the jail, amongst whom cases of the disease were occurring, in the same way as I have shown the high price of food operated in the Calcutta epidemic.

TABLE I.

Showing population of Basti Jail in December 1907, the number of cases, and the number of deaths from Epidemic Dropsy which occurred there.

Population of Jail.	Total number of cases of Epidemic Dropsy.	Total number of deaths from Epidemic Dropsy.
329	81	4

TABLE II.

Showing an analysis of the signs of Epidemic Dropsy as observed in 63 prisoners at Basti Jail.

Total number of cases investigated.	ŒDEMA OF FEET.		CARDIAC SIGNS.						NERVOUS SYSTEM.				
			PRECORDIAL PAIN.		HEART.				KNEE JERKS.			SENSATION FEET.	
					Action.			Heart sounds.					
	Present in	Absent in	Present in	Absent in	Normal in	Rapid in	Weak in	Alteration of, Murmurs in	Normal.	Diminished.	Absent.	Present in	Absent in
63	63	0	55	8	45	4	6	8	22	6	35	51	12

CHAPTER III.

Epidemic Dropsy and Ship Beriberi.

In my first report[1] I referred to the similarity of the features of Epidemic Dropsy and Ship Beriberi as described by Axel Holst and the Norwegian Ship Beriberi Committee. Since my last report I have obtained furher information on this important question.

Fleet Surgeon R. C. Munday, R.N., P.M.O., of the ships in the Persian Gulf, writes under date 28th November 1910 to me[2] that, "Last year we had a number of cases of Beriberi amongst the natives in the crews of these ships and there was a high mortality. I advised the Admiral to allow none but cured (parboiled) rice on board any ship. Since then although the number of lascars have enormously increased no Beriberi has occurred. On the other hand although there has been no Beriberi amongst the natives, we have had a running dropping fire of cases of peripheral neuritis closely resembling Beriberi occurring solely amongst Europeans and having no mortality. There was in nearly every case some slight œdema of the legs. The heart was either not affected at all or only very slightly. None of these men had eaten rice in any but very small quantities and that was cured rice. Suspecting that this was a form of scurvy due to the poverty of the food obtainable in the Persian Gulf Ports, I advised the Admiral to issue a special ration of fruit which was to be obtained from Bombay or Karachi. Once a week chickens were to be issued in lieu of beef and mutton to be supplied as live stock from Bombay or Karachi. As soon as this improved dietary came into force the cases of peripheral neuritis diminished and have now ceased. This may be due to the cessation of the hot weather." He adds also, "I am anxious to acquire all the knowledge I can about Beriberi, its diagnosis, and preventive treatment as it has become an important factor in the campaign we are carrying on against the Afghan gun-runners in the Persian Gulf."

In this interesting note of Fleet Surgeon Munday it will be seen that cases with slight œdema of the feet as the most prominent sympton occurred amongst the Europeans of the squadron resembling the milder cases of Epidemic Dropsy in Calcutta. As soon as the European dietary was rendered less "One-sided" and monotonous by the supply of fresh fruit and chickens, the latter being obtained as live stock, and fresh meat could thus be partaken of, the outbreak ceased. The association between the diet and the disease was demonstrated in this case. The beneficial effect of fresh flesh in

[1] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

[2] Also in paper read before United Services Society. Brit Med. Jour., Mar. 4, 1911.

this outbreak is clearly shown, and in this relation the table from Schaumann's monograph given on page 46 showing the phosphorus content of fresh and preserved meat should be studied as it affords an explanation of the amelioration of the symptoms as noted by the P. M. O.

The following interesting report regarding an outbreak of Beriberi which occurred on the S. S. "Clan Urquhart" was submitted by Dr. N. N. Chowdhury, Port Health Officer, Chittagong, and forwarded to me.

He reports, "that the S. S. 'Clan Urquhart' arrived at this port from the United Kingdom on 17th September 1910; there had been an outbreak amongst the Indian crew during the voyage. This particular voyage consisted of nearly 4½ months in all and commenced from Colombo on the 30th April 1910, from where the crew were recruited and terminated at Chittagong on the 17th September 1910.

In all she had 68 Indian crew :—

Deck crew	26
Saloon crew	8
Engine room crew	34

During her voyage from Colombo she touched the following ports noted below till it reached Glasgow on 21st June 1910 :—

From Colombo to—

1. Suez.
2. Port Said.
3. Algiers.
4. Havre.
5. Glasgow.

Arrival 21st June 1910.

Departure 2nd July 1910.

The first manifestation of the outbreak was noticed by the master of the ship at Glasgow where two cases occurred, just 52 days after her voyage from Colombo. The chief complaints were swelling of the legs, inability to stand on legs, and their tenderness, difficulty of breathing and palpitation, and in one case the initial symptom was vomiting.

This number increased up to 24 on her way to Durban. She touched the following places noted below till she reached Chittagong :—

From Glasgow to—

1. Birkenhead.
2. Durban.
3. Lorenzo Marques.
4. Biera.
5. Chittagong.

During the period 6 died and three were left at Durban Hospital and the rest improved their health on their way to this port."

Dr. Chowdhury also gives a table, given below, which shows the distribution of the disease amongst the crew and he directs attention to the fact that the engine room crew were most affected :—

	Total number of crew.	Affected with Beriberi.	Death.
Engine room crew	34	17	5
Deck crew	26	7	1
Saloon	8	0	0

Dr. Chowdhury forwarded to me at Calcutta a sample of the rice used by the crew. It was Burma rice, ordinarily known as Rangoon rice, and was very highly polished. There was not sufficient rice for an animal experiment, but the chemical and histological examination of the rice showed that the pericarp had been very completely removed and that the phosphorus content was low.

The following table shows the result of the chemical analysis of the rice used by the crew of the " Clan Urquhart " :—

Weight of 100 grains in grammes.	Water.	Ash.	P_2O_5
	Per cent.	Per cent.	Per cent.
2·04	13·13	·53	0·26

The following particulars regarding the diet of the crew during the voyage were supplied to me by the Health Officer, Chittagong :—

Daily scale of provisions for lascars and other native seamen.

(*a*) *For foreign going ships.*

	Lb.	Oz.	Dram.
Rice	1	6	0
Flour	0	10	0
Dal	0	6	0
Ghee	0	2	0
Salt	0	0	8
Curry stuff	0	1	0
At sea. On five days of the week dry fish . . .	0	4	0
At sea. On two days of the week meat . . .	0	4	0
In harbour fresh meat every day	0	4	0

	Lb.	Oz.	Dram.
Vegetables—			
Dry at sea	0	6	0
Fresh in harbour	0	6	0
Tamarind	0	1	0
Tea	0	0	4
Sugar	0	1	8
Lime juice	0	1	0
Oil	0	0	12

In bad weather when unable to cook 6½ ozs. biscuits and 2 ozs. sugar in addition to the quantity provided in the above scale may be substituted in the place of dal and rice.

When a lascar is ill and off duty, biscuits, tea and sugar should be given to him with arrowroot or sago as needed.

The daily allowance of lime juice shall be served out to the crew as soon as they have been at sea for ten days and during the remainder of the voyage, except during such time as they are in harbour and are supplied with fresh provisions.

Change of diet made on the 25th July 1910.

8 A.M. Lime juice one tumbler three parts full to each man.

9 A.M. Curry and rice one plateful to each man. The " rice " consists of 7 parts of rice, 3 parts barley. The curry consists of fresh mutton, potatoes, onions and green peas.

11 A.M. 20 drops tincture of steel in a wine-glassful of water to each man.

1 P.M. Tea with sugar and milk, bread and butter to each man.

5-30 P.M. Curry and rice one plateful to each man. The " rice " consists of 7 parts rice and 3 parts barley. The curry consists of tinned fish, beans, potatoes and onions.

8 P.M. Milk with port wine or brandy.

These observations are of very considerable importance; as was pointed out in my first report[1] the features of Epidemic Dropsy as met with in Calcutta closely resemble those of " Ship Beriberi." In the above outbreak, the history of which is very clearly given in the report of the Health Officer, Chittagong, we have an example of " Ship Beriberi." The " Clan Urquhart " had an Indian crew of 68, whose staple food was highly polished Rangoon rice with a low phosphorus content, and the vessel made a prolonged voyage starting from Colombo on 30th April 1910, she arrived at Glasgow on 21st

[1] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoi No. 45.

June 1910 and it was at the latter port that the master observed the first manifestations of the disease. It is interesting to note, therefore, that the early cases did not occur in a tropical port. Further, the period elapsing between the commencement of the Rangoon or polished rice dietary and the development of the first case was about two months, and this interval corresponds closely to that required for the experimental production of neuritis in pigeons and fowls fed on polished rices. As will be seen from the report a change of diet was made on July 25th, 1910, additional articles were given and the dietary became much less "One-sided;" after the change no further cases of the disease occurred.

Schaumann[1] in his important monograph on the etiology of Beriberi states that in his opinion, "Ship Beriberi" is the pathological expression of a rapidly brought about deficit through a great want of organic phosphorus components, whilst tropical Beriberi is a gradually produced deficit occasioned by a slight, and indeed, sometimes, without a failure of these substances." And he concludes further, "'Ship Beriberi' is a disease of metabolism, which is produced by a poverty of organic phosphorus compounds in the dietary."

A consideration of these facts shows that this disease presents an important problem in connection with shipping. In the case of the "Clan Urquhart" the outbreak was brought about by the consumption of very highly polished rice which had been deprived of constituents essential for nutrition, especially of the peripheral nerves. Consequently ships undertaking prolonged voyages should be careful to avoid the use of polished rice and increase the supply of Mung dal. The question of adding rice bran to the diet should be carefully considered.

[1] Archiv. Schiffs u. Tropenhygiene, Bd. XIV, Beiheft. Dec. 8, 1910.

CHAPTER IV.

Epidemic Dropsy and Scurvy.

In my former Report I discussed at some length the relationship of Scurvy to Epidemic Dropsy, and quoted the opinions of the old Indian observers on the subject, namely, Chevers, Morehead, Waddell, etc. Since the report was written Couvy, a French investigator, has recorded some interesting observations on this problem. Couvy[1] observed an epidemic of Scurvy and Beriberi amongst the garrison of Akjoucht. The Garrison consisted of 11 Europeans and 150 Natives.

PROGRESS OF EPIDEMIC.

Natives.

On 23rd May	4 cases	amongst	the	150
„ 4th June	20 „	„		„
„ 5th „	44 „	„		„
„ 17th „	124 „	„		„
„ 20th July	142 „	„		„
„ 15th August	144 „	„	the	149 (1 died).

The first 40 cases presented no difficulties in diagnosis as they had all the symptoms of typical Beriberi. From 5th June onwards the question of the occurrence of Scurvy presented itself, indeed towards the 20th June the pathognomonic lesions of Scurvy were observed. From this date we saw the evolution of the two diseases side by side, but more frequently superposed, and, as a rule, the symptoms of Beriberi start suddenly threatening the life of the patients already presenting the clinical signs of Scurvy.

Europeans.

8th June	4 cases.
15th July	6 „
21st „	9 „
15th August	11 „

The Europeans were attacked by Scurvy but have never presented signs of Beriberi. This is an interesting point: amongst the better class European population of Calcutta cases of Epidemic Dropsy were not observed. When the diagnosis was established on 23rd May the patients were given biscuits in place of rice. Without other treatment the symptoms improved and disappeared in a few days. On the 20th June the biscuits being exhausted the 124 patients under treatment were placed again on rice; from the 22nd a relapse occurred amongst 30 of the cases, one case of fainting for 12 hours with

[1] Bull. de la Soc. de Path. Exot. T. 111 No. 10, Seance, Dec. 14, 1910.

paralytic symptoms occurred. On the 23rd aggravation of symptoms showed itself in 88 cases. This relapse occurred in men already quite convalescent. On June 23rd millet intended for the horses of the post was distributed to the worst cases. Improvement was noted on the 29th and 30th June. From 1st July, after the millet was exhausted, it was necessary to give rice; since the 3rd 17 cases of aggravation of the condition with cardio-respiratory trouble occurred. On the 6th the number of relapses reached 66, some days later 83. Before these occurrences a ration of 350 grammes of meal flour was substituted for rice in the case of the more severely affected patients. The poor state of the provisions never permitted of continuing the appropriate diet until the cure was complete; when a patient improved and was no longer in danger it was necessary to put him on a rice diet which was followed by a fatal relapse. Finally on 23rd August a convoy arrived with millet and biscuits; since then all the beriberi cases have been able to consume without interruption their ration of biscuit in place of rice. This absolute suppression of rice has corresponded with a rapid amelioration without relapse, and on 15th September all the symptoms of severe beriberi had disappeared in all the cases.

They had 5 deaths on 9th, 17th, 22nd August, that is during the period they failed to have suitable provisions. Two deaths occurred on 1st September from cardiac disorder, the symptoms commenced on 20th August.

Suppression of rice and substitution of biscuit had always a beneficial and rapid effect on the cardiac disorders. This influence was so distinct that it was possible to obtain an improvement even in the most severe cases by stopping rice for 2 to 6 days. On the contrary the absorption of 1 to 2 kilogrammes of rice in 2 to 4 days sufficed in the majority of cases to produce a severe relapse.

This interesting paper brings out the point that there is a relationship between Scurvy and Beriberi, and further, it demonstrates how the symptoms may be modified by change of diet.

Monteith,[1] whilst in North-West Australia during 1890-91 and 1892, as Medical Officer to Messrs. Streeters, Pearling Fleet, observed an epidemic of Beriberi with symptoms which pointed very strongly to a Scorbutic origin. The disease affected chiefly the lugger boys shipped from Koepang, F. M. S. The cooks, Chinamen generally, the West Australian aboriginals, and the white men who lived aft in the schooners, seemed exempt from the disease The disease manifested itself when the men had been many months at sea. The prominent symptoms were :—The ankles and legs were greatly swollen and œdematous, and pitted on pressure, especially over the tibiæ, and were

[1] Lancet, Oct. 3, 1908.

painful, especially at night. A bronzing or pigmentation was visible in the buccal mucous membrane and the gums were redish and spongy and in some cases overgrown. In a case of fatal termination the symptoms would be obstinate constipation and vomiting and dyspnœa. Then anasarca developed and the abdomen became prominent. The face and eyes were puffy and in this stage the pupils were contracted. Later, when the patient could scarcely stand, the dyspnœa increased to such an extent as to cause almost continuous moaning and groaning. *Post mortem* examination, showed the heart to be dilated and fatty degeneration to a marked degree was present.

The provisions, which were taken aboard when the ship put into port for unloading the pearl, consisted chiefly of rice and tinned meat. When the dietary of the sick was altered and included fresh meat, bullocks or kangaroo flesh, and fresh raw lime juice the majority soon showed signs of improvement and were able to return to sea again. Dr. Monteith observed that those who did not improve complained of a pain or subjective suffocative sensation referable to the epigastric or midsternal regions to which regions they pointed with their finger. Dr. Monteith came to regard this as the finger of death for it foreboded with absolute certainty death in a few days.

This outbreak is an example of "Ship Beriberi" and its well marked association with scurvy is interesting.

Macrae[1] in an account of Scurvy in South Africa states, "Scurvy is still met with in South Africa, notably in Johannesburg and its environments, and different opinions have prevailed as to its real nature. Some have spoken of it as associated with a form of Beriberi."

In relation to "Ship Beriberi" and Scurvy it is of interest to note the

Distribution of Phosphorus in fresh and salted meat.

The following table is from Schaumann's monograph[2]:—

Food material dried at 100 C. (In the dried substance).	100 GRAM. OF FOOD MATERIAL CONTAIN						
	Total P_2O_5.		Phosphatid P_2O_5.	Water soluble Ester P_2O_5.	Nuclein and Proteid P_2O_5.	Water soluble Phosphates P_2O_5.	
	Estimated direct.	Calculated.				In gram. of substance.	In per cent. of total P_2O_5.
	Gram.	Gram.	Gram.	Gram.	Gram.		
1. Fresh fat free horse flesh .	1·995	2·031	0·246	0·499	0·330	0·956	47·92
2. Fresh fat free beef . .	1·937	1·946	0·193	0·168	0·215	1·370	70·73

[1] Lancet, June 27, 1908.
[2] Archiv. Schiffs u. Tropenhygiene, Bd. XIV, Beiheft, Dec. 8, 1910.

Food material dried at 100 C. (In the dried substance).	100 GRAM. OF FOOD MATERIAL CONTAIN						
	Total P_2O_5.		Phosphatid P_2O_5.	Water soluble Ester P_2O_5.	Nuclein and Proteid P_2O_5.	Water soluble Phosphates P_2O_5.	
	Estimated direct.	Calculated.				In gram. of substance.	In per cent. of total P_2O_5.
	Gram.	Gram.	Gram.	Gram.	Gram.		
3. Salt meat (beef) fat free from ship M. K. . .	0·241	0·219	0·053	0·048	0·094	0·024	9·96
4. Salt meat (beef) fat free from ship L. P. . .	0·139	0·161	0·040	0·055	0·048	0·018	12·96
5. Salt meat (beef) fat free from ship H. . . .	0·386	0·378	0·066	0·079	0·160	0·073	22·12
6. Preserved meat (boiled beef) fat free from ship C. H. .	1·179	1·063	0·214	0·198	0·124	0·527	44·70
7. Dried fish from ship H. fat free.	1·823	1·625	0·144	0·125	0·148	1·208	66·26
8. Fat free preparation of Testicles.	3·550	3·477	0·382	1·050	0·977	1·068	30·08

Phosphorus in fresh vegetables.

Vageler,[1] states that, "The fresh vegetables, which in spring and summer are always available, and whose advantages are generally recognised, are especially rich in Phosphatides. One will not go far wrong if one ascribes in great part the excellent physiological action of these substances to the alcohol soluble phosphatides." Schaumann agrees with this and adds, "The salad is frequently considered to be a specially active vegetable, this is explained not only by the high Phosphatide content, but also by the fact that it is eaten raw, hence all loss and alteration of phosphorus containing substances by cooking is avoided."

The above facts afford an explanation of the improvement of the symptoms in the cases of Epidemic Dropsy amongst the Europeans of the ships of the Squadron in the Persian Gulf, page 40 of this Report. As noted by Staff Surgeon Munday as soon as fresh fruit and meat were added to the dietary cases of peripheral neuritis diminished and finally ceased.

These questions, therefore, should be carefully noted by authorities responsible for the maintenance of health on board ship.

[1] Biochem. Zeitschr. 1909 Bd. XVII, p. 189 (quoted by Schaumann).

Effect of Pickling on Phosphorus Content of Meat.

The observations of Nothwang[1] on the effects of pickling beef are of interest.

The following table shows the loss of Proteid and Phosphoric acid which results from pickling :—

Duration of Pickling.	Pickled flesh in the Lake.		Pickled flesh in dry Brine.	
	Loss of Proteid.	Loss of P_2O_5.	Loss of Proteid.	Loss of P_2O_5.
	Per cent.	Per cent.	Per cent.	Per cent.
One week	1·53	35·5	0·99	31·7
Two weeks	1·86	44·9	1·43	27·0
Three „	2·08	48·5	1·32	31·2
Four „	2·14	50·1	1·23	32·8

Nothwang[1] compares also the loss from fresh meat by cooking with that of pickling.

	Loss by pickling.	Loss by cooking and steaming pickled flesh.	Total Loss.
	Per cent.	Per cent.	Per cent.
Extractive (meat bases)	42·2—47·3	20·6—23·4	65·6—67·9
P_2O_5	20·2—25·4	19·1—19·3	39·5—44·8

[1] Archiv. f. Hygiene, 1892, Bd. XVI. p. 269 (quoted by Schaumann).

CHAPTER V.

Experimental Investigations.

In my first Report a number of experiments with fowls and pigeons are recorded. It was shown that progressive loss of weight and neuritis resulted from feeding pigeons on polished Bengal and Rangoon rice, whereas when fed on a mixture of wheat and pulses no neuritis developed and the animals remained in perfect health. The observations were carried on over several months.

In the present Report the results of further experimental researches are given.

In December 1810 Fraser and Stanton[1] published the results of their recent investigations on the etiology of Beriberi in the F. M. S. Schaumann[2] in the same month published an important monograph on the etiology of Beriberi including "Ship Beriberi" in which he gives the results of his chemical and experimental investigations on this subject. As these results are very interesting and important a full summary of the two works is given here before proceeding to describe the details of my further experimental investigations.

Fraser and Stanton during the past year have directed their attention towards the determination of the nature of the substances present in the subpericarpal layers of the original rice grain which are removed in the milling process and which it would appear are of such high physiological importance in maintaining the normal nutrition when a diet largely composed of white, polished rice is consumed.

As in the previous experiments Fraser and Stanton employed fowls for testing the value of the various materials. In the present investigation all the products employed, unpolished rice, polished rice, polishings, etc., were derived from the same lot of paddy.

The following table shows the results of their analyses :—

	Protein.	Fats.	Carbohydrates.	Ash.	Moisture.	P_2O_5.
	Per cent.	Per cent.	Per cent.	Per cent	Per cent	Per cent.
Polishings (sifted) . . .	13·7	14·16	52·77	7·54	11·83	4·1
Unpolished rice . . .	9·0	1·65	75·52	1·08	12·75	0·56
Polished rice	8·6	0·22	76·23	0·6	14·35	0·26

[1] Lancet, Dec. 17, 1910.

[2] Archiv. Schiffs. u. Tropenhygiene, Bd. XIV, Beiheft, Dec. 8, 1910.

They also give the following table which shows the composition of these articles calculated on dried materials which renders differences more striking and accurate, and also the composition of a diet composed of 60 gram. of polished rice and 5 gram. of polishings calculated in the same manner and shows how closely this diet approximates to one of polished rice :—

Calculated on Dried materials.

	Protein.	Fats.	Carbohydrates.	Ash.	P_2O_5.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Polishings (sifted) . . .	15·5	16·0	59·8	8·5	4·65
Unpolished rice	10·3	1·89	86·5	1·23	0·64
Polished rice	10·0	0·25	89·0	0·7	0·3
Ration 60 grammes rice *plus* 5 grammes polishings contains per cent.	10·4	1·5	86·6	1·31	0·64

The polishings have been stored for months without impairing their efficiency, nor is the value affected by the ordinary cooking process.

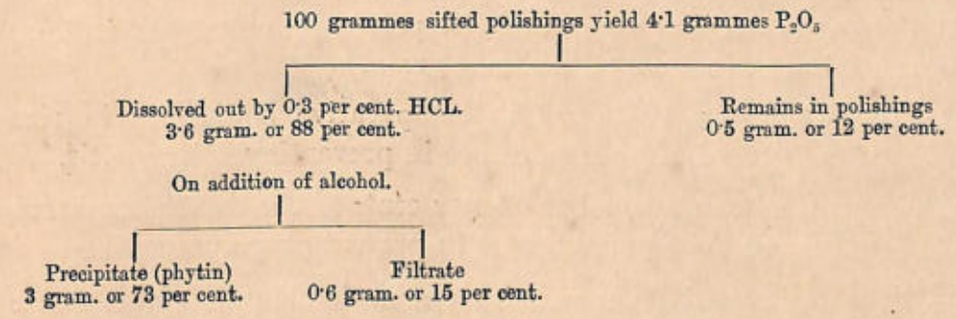
1. Fat.—The polishings contain a high percentage of fat. In my first Report,[1] Mr. Hooper's analyses show that in the samples of polishings from Bengal rice mills examined, a high percentage of fat was present. Fraser and Stanton fed 12 fowls on polished rice and 4·5 gram. fat free polishings. The fowls maintained their weight and remained in good health. From these experiments the non-importance of fat was established.

2. Phytin.—Estimations of the phosphorus pentoxide in rices had consistently shown their value as indicators of their liability or otherwise to produce polyneuritis. This question is discussed also in my first Report.[1] This suggested the probability that the essential substance was one containing phosphorus and Dr. Hans Aron stated that the substance was phytin, the Calcium magnesium salt of an organic acid containing phosphorus. Fraser and Stanton determined that unpolished rice contained 1·07 per cent. phytin, the sifted polishings contain 8·8 per cent., washed and dried rice contained none. Fraser and Stanton prepared phytin from sifted polishings. A fowl consuming 60 gram. of unpolished rice daily would be receiving 0·66 gram. of phytin so that this amount of phytin would require to be added to a diet of washed

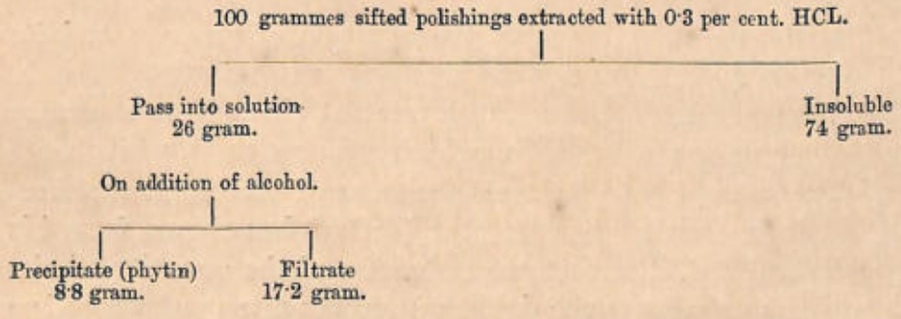
[1] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

polished rice alone. Fraser and Stanton disproved the importance of phytin by their experiments.

3. Substance soluble in 0·3 per cent. hydrochloric acid.—Experiments were carried out to ascertain if the essential substance or substances passed into solution when macerated in 0·3 per cent. HCL. This solvent was chosen because it was employed in the extraction of phytin. By experiments on fowls it was shown that the essential material was removed uninjured by the process of extraction and subsequent treatment. It is also shown that 85 per cent. phosphorus pentoxide is unimportant.



4. Alcohol (proof spirit) soluble fraction of the substances originally soluble in 0·3 per cent. HCL.



It was found that fowls fed on polished rice plus the alcoholic filtrate did not develop neuritis and remained healthy.

This experiment proves that of the 5 gram. of sifted polishings required daily for the maintenance of weight and health in a fowl on a polished rice diet, no less than 4·2 gram. are unimportant and of the 0·8 gram. probably only a part is essential.

Fraser and Stanton reach the following conclusions :—

1. White polished rice when forming the staple of the diet in man has been shown to cause Beriberi.

2. Such white polished rice when fed to fowls produces in them a disease closely analogous to Beriberi in man. This reaction has been taken in this

and previous researches as a test of Beriberi producing power of a rice when it forms the staple of a diet in man.

3. The addition of rice polishings to a diet of white rice is an effective preventive of the development of polyneuritis in fowls. Rice polishings comprise from 8 to 10 per cent. by weight of the original grain.

4. The substances contained in polishings which are effective in preventing polyneuritis are soluble in 0·3 per cent. HCL. and are not precipitated from the solution on the addition of 95 per cent. alcohol, in quantity sufficient to make the resulting mixture of proof spirit strength. These substances comprise 16 per cent. or less by weight of rice polishings or 1·6 per cent. or less by weight of the original unpolished rice grain.

5. The fats, which are contained in comparative abundance in rice polishings, have been proved of no importance in preventing polyneuritis.

6. Phosphorus compounds equal to 85 per cent. of the total phosphorus content have been proved to be unimportant in preventing polyneuritis.

Breaudat[1] has extracted from rice bran a nucleoalbumin or vegetable casein, a gluten, which is present in the rice to the amount of 12 to 13 per cent. and which he found protected pigeons fed on white polished rice from polyneuritis.

In my previous Report[2] the effect of the addition of meat to and its absence from the dietary in cases of Epidemic Dropsy was recorded. Hindu widows, for religious reasons, do not consume meat at all and the mortality from Epidemic Dropsy was shown to be very high amongst them, whilst male Hindus (Bengalis) pertake of a considerable amount of meat and the mortality was low. It is interesting to note that McCay[3] has shown from his investigations on Bengal Jail diet that the reduction of the quantity of rice and the addition of fish or meat to the dietary improves nitrogen metabolism as the following table from his Report shows :—

Ordinary diet.	Per cent. of protein absorbed.	Grammes nitrogen per man daily.
26 ozs. rice, 7 ozs. gram dal	49·20	7·35
13 ozs. rice, 7 ozs. gram dal . { 3 ozs. fish . . / 2½ ozs. goat flesh . }	78·68	11·30

[1] Bull. Soc. Path. Exot., Tome 111, No. 1, Seance, Jan. 12, 1910.

[2] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

[3] Scientific Memoirs of the Govt. of India, No. 37, p. 84.

The following is a fairly full summary of a recently published Monograph by Dr. H. Schaumann[1] on the etiology of Beriberi including "Ship Beriberi." The monograph contains a very complete, up to date bibliography on the subject.

Schaumann has exhaustively examined possible factors as causal agents in Beriberi and particularly "Ship Beriberi." The following are extracts from his important monograph :—

1. Toxines and Oxalic acid as possible pathogenic factors.—He investigated this problem by (1) Animal experiments, (2) Mycological studies of provisions from Beriberi ships, (3) By chemical researches undertaken for the purpose, which included, (*a*) the examination of the provisions from a Beriberi ship, (*b*) the urine from cases of ship beriberi, (*c*) the contents of the crop, the stomach, and the intestine of pigeons which died of polyneuritis for oxalic acid. He concludes, "The results of the above described experiments and investigations permit the conclusion that they afford no grounds for supporting the view of there being one or more specific poisons for the production of Beriberi or 'Ship Beriberi.' This especially applies to oxalic acid, the quantities of which in the urines examined was only very small, and indeed were far below the normal limits (0·029 in 24 hours), whilst this acid could not be found in the intestines of fowls who had died of experimental neuritis."

2. Poverty of enzymes in the food material as a possible pathogenic factor.—This question he studied by (*a*) Animal experiments, (*b*) Chemical investigations. He concluded that poverty of autolytic enzymes in the food material as a pathogenic factor of Beriberi cannot be considered.

3. Poverty in protein material (albumin) as a possible pathogenic factor.—From his observations and that of others which he quotes, he is of opinion that his experiments prove that the addition of albumin to a diet which can produce neuritis in rabbits and pigeons, does not protect these animals from the disease.

4. Poverty in mineral constituents in the diet as a possible pathogenic factor.—He added various mineral constituents in different quantities to polished rice on which 5 pigeons were being fed. The minerals were, Potass. Carbonate, 30 gram., Sodium Chloride, 3 gram., Anhydrous Sodium Sulphate, 2 gram., Calcium Carbonate, 3 gram., Magnes. Carb. 4 gram., Dyalised oxide of Iron, 3 gram. In this combination all the constituents in vegetable ash are found, with the exception of phosphates and silicates. Silicates were not added, because it is known that pigeons pick up these themselves (sand, etc.). All the pigeons developed neuritis and died. Schaumann concludes that,

[1] Archiv. Schiffs u. Tropenhygiene, Bd. XIV, Beiheft, Dec. 8, 1910.

"A protective action of the mineral constituents added to the food was excluded."

5. Phosphorus and its relation to Beriberi.—Schaumann deals very completely with this question.

A. The combinations of Phosphorus in diet.

The phosphorus content of food varies greatly from 0·2 per cent. in polished rice and egg albumin to 19 per cent. in cow milk and egg yolk.

He discusses the following phosphorus combinations :—

1. Phosphatide (Lecithane)—

(*a*) Lecithin.
(*b*) Kephalin.
(*c*) Jecorin.
(*d*) Kuorin.

Falk[1] gives the amount of phosphatides in

Non-medullated fibres.		Medullated fibres.	
	Per cent.		Per cent.
Total extract	11·51	Total extract	46·59
Percentages of total extract—		Percentage of total extract—	
Kephalin . . .	23·7	Kephalin . . .	12·4
Lecithin . . .	9·8	Lecithin . . .	2·9

This would correspond to phosphatides in the original nerve substances :—

In non-medullated fibres 3·85 per cent. In medullated fibres 7·13 per cent.

2. Nucleoproteids (Nucleic Acid).

(*a*) Nucleoproteid.
(*b*) Nucleic acid.

Nucleic acid; constant and characteristic constituents of all nucleic acids are organically combined phosphoric acid and Purin as well as Pyrimidin bases. The molecule of phosphorus in nucleic acid is probably not as orthophosphoric acid, H_3PO_4, but as anhydride.

Schaumann thinks it is probable that the phosphoric acid is present in nucleic acid as Metaphosphoric acid, so it is theoretically possible to increase

[1] Biochem. Zeitschr, 1908, Bd. XIII, p. 153.

the number of these combinations to an extraordinary extent, since according to the investigations of Tanmann[1] the metaphosphates as concerns their richness in Isomeres and Polymeres, are unique.

3. Paranucleoproteids (Nucleo-albumin).

Kasein.

4. Phytin.—As will be seen from the work of Fraser and Stanton referred to in this Report the relation of phytin to the causation of Beriberi has been excluded. This substance was discussed in my first Report.[2]

5. Protagon.

6. Nucleon.

7. Inorganic phosphates.

8. Phosphorus combinations of unknown composition.

The following table from Schaumann's Monograph shows the distribution of phosphorus in the dry substance of various food materials :—

The results give the amounts of phosphorus in 100 parts of dry substance of food material.

Substance.	Dry substance.	Total Phosphorus.		P. as phosphatide.	P. as soluble phosphate.	P. as soluble ester.	P. as Nuclein and P. alumin.
		Estimated direct.	Calculated.				
1. Horse flesh . . .	26·0	0·74	0·73	0·150	0·440	0·04	0·10
2. Cow milk . . .	12·6	0·84	0·80	0·050	0·250	0·05	0·45
3. Egg Alb. . . .	12·6	0·12	0·11	0·000	0·020	0·02	0·07
4. Bread	70·1	0·14	0·13	0·010	0·050	0·00	0·07
5. Rice	87·8	0·11	0·11	0·005	0·0050	0·00	0·10
6. Gluten	98·8	1·47	1·29	0·020	0·250	0·35	0·67
7. Yellow turnips . .	13·6	0·40	0·38	0·030	0·200	0·11	0·04
8. Sweet turnips . .	14·6	0·19	0·19	0·040	0·080	0·05	0·02
9. Green cabbage . .	12·3	0·48		0·070	0·220	0·09	0·10
10. White cabbage . .	8·3	0·31		0·060	0·140	0·017	0·04

[1] Jour. F. prakt. Chemie. neue folge, 1892, Bd. XVII, pp. 417 and 120.

[2] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

Schaumann gives the following table which shows the distribution of P_2O_5 in the organs of the human body :—

Substance (organs, etc.).	Total P_2O_5 in the material.	
	In original substance.	In the ash.
	Per cent.	Per cent.
1. Human body	4·35	38·90
2. Bones	26·76	40·09
3. Teeth	31·61	
4. Cartilage	0·41	9·05
5. Muscle	0·40	42·00
6. Brain	1·11	49·00
7. Liver	4·65	46·46
8. Spleen	3·02	38·64
9. Lungs	0·20	44·60
10. Heart	2·75	
11. Kidneys	3·22	
12. Bile	0·84	
13. Blood (corpuscles)	0·11	
14. Blood (serum)	0·007	
15. Blood (serum and corpuscles) . .	0·078	10·23
16. Lymph		1·09
17. Milk (human)	0·049	20·74
18. Fæces	0·710	26·90
19. Urine	0·230	11·21

Schaumann states that the phosphorus requirements of adult men of average weight on mixed dietary and moderate physical exercise amounts to 1·96 to 2·18 gram. phosphorus or 4·5 to 5 gram. P_2O_5 per day.

He also discusses the metabolism of all the phosphorus combinations mentioned above, Phosphatide, Nucleic Acid, etc.

Schaumann considers it probable that the absence of the different phosphorus combinations in the organism will be expressed specifically in various ways, that it will produce different kinds of morbid phenomena, *e.g.*, Scurvy, Beriberi, Ship Beriberi, etc. He admits, however, that the subject is a very complex one.

As a result of his experimental studies in animals he comes to the following conclusions :—

1. The food material, which after a long period of feeding in certain animals can produce neuritis, is characterised by either a poverty in phosphorus or certain organic phosphorus combinations. The poverty in the latter may be either naturally present or brought about by artificial means.

2. The addition of albumin, inorganic salts (including phosphate and Calcium biphosphoricum) as well as the artificially produced organic phosphoric acid combinations (Albumin-phosphate Calcium glycerophosphoric acid) to a diet which produces polyneuritis does not prevent its occurrence.

3. The addition of certain substances which contain much organically combined phosphorus (yeast, rice bran, white gluten, Testikulin, Mung dal, pulses) to a diet, by long exclusive feeding on which, polyneuritis is produced, exercises even in small quantities complete prophylactic and curative action.

4. Vegetarians (pigeons) and carnivora (dogs) respond to these protective substances (Bull's testicles preparation, Testikulin) differently. Whilst Testikulin protects the latter completely, in the former it does so only in a limited number of cases. Yeast protects both completely.

5. The organic phosphorus combinations (phytin from rice bran, phytin like bodies from Mung dal, Nucleic acid of yeast, and probably also certain phosphatides), which have been obtained from these protective substances, and whose action has been tested, exert only a limited prophylactic and a temporary curative action. The inorganic phosphates alone afford no protection.

6. It is very probable that the above named protective substances (yeasts, rice bran, white gluten, Testikulin, Mung dal, pulses) owe their peculiar prophylactic and curative properties to a collective effect of a number of phosphorus containing substances found in them, amongst which the organic phosphorus combinations are essential. The inorganic phosphates in the food serve to maintain the phosphorus metabolism of the body; they are not, however, in a position to support or replace the organic phosphorus combinations in the food. It may be accepted on good grounds that the animal body does not possess the power of forming by suitable transformations organic phosphorus combinations from inorganic phosphates; it is very probable that this

is the case, as has been proved in plants, and as is the case in other food stuffs (albumins and carbohydrates).

7. Nitrogen and Phosphorus metabolism, as has been shown by former experiment and confirmed by my own observations, stand in close relationship. If the content in organic phosphorus combinations sinks below a certain amount in the food, then nitrogen transformation is simultaneously depressed.

8. The polyneuritis, which occurs in animals, dependent on an alimentary origin or produced intentionally, is a disease of metabolism, which in the latter case is dependent on the poverty of the food in certain organic phosphorus combinations, which require to be more closely defined.

Schaumann comes to the following final conclusions on the etiology of Beriberi including " Ship Beriberi " :—

1. Beriberi is a disease of metabolism, which is caused by insufficient intake of organic phosphorus combinations into the general circulation of the body.

2. This deficiency is occasioned in a great number of cases, by too small a content of organic phosphorus combinations in the food consumed.

3. In others but apparently in a very small minority of cases, this condition is brought about by an insufficient absorption of organic phosphorus combinations although their content in the food consumed is sufficient.

Apparently this insufficient phosphorus absorption may be brought about by—

(*a*) Injury of the intestinal tract by micro-organisms or their metabolic products by which the preparation of organic phosphorus combinations for absorption is affected, or pathologically by micro-organisms producing alterations of the intestinal mucus membrane by which an adequate absorption becomes impossible.

(*b*) The destruction of the organic phosphorus combinations in the chyme by organisms as well as by their enzymes.

(*c*) A combined action of (*a*) and (*b*).

It is noteworthy that Schaumann inclines to the opinion that deficiency of certain organic phosphorus combinations brings about the following diseases in addition to Beriberi and " Ship Beriberi " :—

1. Scorbutus.
2. Barlow's disease.
3. Rickets.

4. Osteomalacia.[1]
5. Pellagra perhaps.

He considers that the explanation of the difference in the features of the above diseases is dependent on the absence of different kinds of combinations of organic phosphorus : each combination plays a specific part in the function of metabolism of the human body; and their absence is expressed by disease processes, which are as specifically different from one another, as are the organic phosphorus combinations, the absence of which produces them.

Heubner & Reeb[2] give as the result of their analysis the following distribution of Phosphorus in polished rice :—

	In 100 grammes dry substance.	Relationship to the total P_2O_5.
	Gram.	Percentage.
1. P_2O_5 as phosphatide	0·011	4·38
2. „ „ sol. phosphates	0·011	4·38
3. „ „ „ ester	0·000	0·000
Total P_2O_5 content .	0·251	100·00

Schaumann's results are :—

	For 100 grammes rice.	Relationship to the total P_2O_5.
	Gram.	Percentage.
1. P_2O_5 as phosphatide	0·043	16·41
2. „ „ sol. phosphates	0·062	23·66
3. „ „ „ ester	traces	0·00
4. „ „ Nuclein and Albumin . . .	0·157	59·93
Total P_2O_5 .	0·262	100·00

[1] Hœnicke E. Zur Theorie der Osteomalacie, Berlin, Klin, Woch. 1904, No. 44.
[2] Archiv. s. Exper. Path. u. Pharmak, 1908, Suppl. Schmiedeberg Festschrife S. 265 (quoted by Schaumann).

Having discussed the literature of the most recent and important experimental investigations on the etiology of Beriberi including "Ship Beriberi" I now proceed to detail the results of my own experimental enquiry on the etiology of Epidemic Dropsy in Calcutta.

The animal experiments referred to in my previous Report[1] have been continued and a large number of feeding experiments with pigeons and fowls to test the nutritive value of the various kinds of food grains have been carried out by me. As already pointed out these animals form very delicate indicators of the food value of the different grains. When fed on polished grains they lose weight progressively and develop neuritis. A symptom, which was frequently noted in pigeons and fowls, which showed signs of neuritis, was a recurving of the neck, the head being drawn over towards the animal's back. *Post mortem* the peripheral nerves of pigeons and fowls dying with symptoms above noted show well marked degeneration changes, and a plate is given in my first Report[1] which depicts these changes in the nerves of the animals.

I have carried out a large number of experiments with pigeons and fowls fed on different kinds of polished grains with the result that progressive loss of weight and neuritis with death invariably occurred. The symptoms developed whether the rice was boiled or unboiled; indeed a more rapid course was taken by the disease in the case of animals fed on boiled rice. The rice was also placed in the autoclav for one hour before giving it to the pigeons, in this way any organisms, moulds, bacteria, etc., and, probably, enzymes, present in the rice would be destroyed; yet loss of weight and neuritis invariably resulted when pigeons were fed on polished rice so heated.

An account of the experimental work is given below and Charts No. 6 to 9 and Photographs 10-14 illustrate certain experiments.

The details of the conditions under which the experiments were conducted are given in my first Report.[1]

1. Experiments with polished grains.

Bengal (Khulna) rice polished (unboiled).

This variety of Bengal rice was used because a sample was sent in to the Medical College from Khulna district, where Epidemic Dropsy was prevailing at the time, to be examined.

Six pigeons were fed on 30 gram. of this rice daily. No other grain was given.

[1] First Report on Epidemic Dropsy in Calcutta by Major E. D. W. Greig, M.D., D.Sc., I.M.S., Scientific Memoir No. 45.

The chemical analysis of these grains gave the following results :—

Weight of 100 grains in gram.	Moisture.	Ash.	Nitrogen.	Protein.	P_2O_5.
	Per cent.	Per cent.			
2·43	10·2	0·82	1·45	9·06	·43

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of experiment, the percentage loss of weight, and the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	18	420	260	—38·1	Neuritis.
2	26	320	200	—37·5	„
3	32	270	120	—55·5	„
4	51	300	130	—56·6	„
5	59	280	160	—59·9	„
6	61	280	190	—37·1	„

Remarks.—It will be noted that the average percentage loss of weight in these pigeons was 50·8 per cent. In all cases neuritis developed. The animals were killed when the symptoms became well marked in order to obtain fresh specimens of the nerves. Examination of the peripheral nerves showed well marked degenerative changes.

Rangoon rice polished (unboiled).

Experiment 22.—Eight pigeons were fed on 30 grammes of this rice daily.

No other grains were given.

The chemical analysis of these grains gave the following results :—

Weight of 100 grains in grammes.	Moisture.	Ash.	Nitrogen.	Protein.	P_2O_5.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
2·06	10·2	0·82	1·45	9·06	0·43

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of experiment, the percentage loss of weight, and the occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	26	310	170	—45·5	Neuritis.
2	37	270	140	—48·1	„
3	33	280	190	—32·1	„
4	44	210	130	—38·1	„
5	25	230	130	—43·4	„
6	53	250	120	—52	„
7	46	260	100	—61·5	„
8	59	270	120	—55·5	„

Remarks.—In this experiment the results were very similar to the last; the average percentage loss of weight was 45·8 per cent. All the animals developed neuritis which was verified by microscopic examination.

The above two experiments illustrate very clearly the effects of feeding pigeons on polished grain, one Bengal, the other Rangoon rice. They show that constituents necessary to meet the physiological demands of the body, particularly of the nervous system are wanting from these polished grains.

Rangoon rice polished (boiled).

Experiment 31.—Six pigeons were fed on 30 grammes of this rice daily, but before administration it was boiled in the autoclav for 1 hour, then dried in the sun.

The chemical analysis is the same as given under Experiment 22.

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of the experiment, the

percentage loss of weight, and the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	25	290	180	—37·9	Neuritis.
2	36	250	120	—52·0	„
3	40	310	190	—38·7	„
4	50	240	130	—45·8	„
5	51	350	190	—45·7	„
6	50	290	200	—31·03	„

Remarks.—In this experiment the grains were placed first in the autoclav by which treatment all moulds, bacteria, etc., would be destroyed, but nevertheless the symptoms produced were exactly the same as in pigeons fed on unboiled rice. The average percentage loss of weight was 40·8 per cent.

Polished Rangoon rice (boiled).

Experiment 51.—Six pigeons received 30 grammes of this rice daily; the rice was treated as in Experiment 22.

The chemical analysis is the same as given under Experiment 22.

The following table shows the number of pigeons fed on boiled polished Rangoon rice, the duration of the experiment, the weight at the beginning and end of the experiment, the percentage loss of weight and the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	105	320	170	—46·8	Neuritis.
2	94	320	230	—56·2	„
3	36	310	200	—35·4	„
4	32	400	230	—42·5	„
5	105	350	260	—25·7	„
6	28	330	200	—39·3	„

Remarks.—This experiment corresponds in all respects to the previous one and the results are similar.

Polished Rangoon rice (boiled).

Experiment 53.—Six pigeons received 30 grammes of this rice daily; the rice was treated as in Experiments 22 and 51.

The chemical analysis is same as that given under Experiment 22.

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of the experiment, the percentage loss of weight, the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	90	210	250	+19·0	Healthy.
2	81	280	220	—21·4	Neuritis.
3	80	260	160	—38·4	„
4	73	310	240	—22·5	„
5	80	230	210	—8·6	„
6	13	290	240	—17·3	„

Remarks.—In this experiment one pigeon out of six remained healthy, whilst the remaining five succumbed to neuritis. This is of interest as showing there may be individual peculiarities in certain pigeons by which they can exist on a diet which is insufficient for the majority of pigeons.

Polished Rangoon rice (boiled).

Experiment 54.—Six pigeons received 30 grammes of this rice daily; the rice was treated as in Experiments 22 and 51.

The chemical analysis is the same as that given under Experiment 22.

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of the experiment, the percentage loss of weight, and the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	20	240	190	—12·5	Neuritis.
2	20	280	210	—25·0	„
3	68	250	170	—32·0	„
4	80	270	180	—33·0	„
5	79	290	210	—27·5	„
6	71	270	260	—3·7	„

Remarks.—In this experiment all six pigeons developed neuritis.

Polished Rangoon rice (boiled).

Experiment 55.—Six pigeons received 30 grammes of this rice daily; the rice was treated as in Experiment 22.

The chemical analysis is the same as that given under Experiment 22.

The following table shows the number of pigeons fed on polished boiled Rangoon rice, the duration of the experiment, the weight at the beginning and end of the experiment, the percentage loss of weight, and the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	79	250	210	—16·0	Neuritis.
2	83	290	170	—41·3	„
3	74	250	160	—36·0	„
4	83	290	200	—31·0	„
5	83	320	210	—34·7	„
6	90	250	190	—24·0	„

From a study of these experiments it will be seen that pigeons fed on polished rice invariably develop neuritis and show progressive loss of weight, proving that certain essential constituents necessary for the physiological requirements of the body are absent from the polished rice grains. The question arises, what are these essential constituents? The researches of Fraser and Stanton, and Schaumann, which have been already fully referred to in this report, throw light on this problem.

Having seen that polished rice invariably produces neuritis, further investigations have been made to show how this may be (*a*) prevented, (*b*) cured by altering the diet.

In the first place we will consider the experimental investigations dealing with—

The prevention of neuritis in pigeons.

This may be done in the following ways :—

(1) By substituting another grain diet for the polished rice.

(2) By substituting unpolished for polished rice or by adding the polishings of rice (Koorah) in a certain percentage to the polished rice diet.

The following table gives the results of the analysis of the various ingredients of the mixture :—

1. Substitution of diet of other grains for polished rice.

Experiment 28.—Eleven pigeons received 30 grammes daily of the following mixture :—

Wheat	82·0	parts.
Pulses	13·0	„
Stones	3·1	„
Barley	1·9	„
TOTAL	100	

The other conditions of the experiment were the same as in the polished rice ones.

The following table gives the results of the analysis of the mixture :—

Moisture.	Ash.	P_2O_5.
12·8	2·7	0·76

The following table gives the results of the analysis of the various ingredients of the mixture :—

Name of ingredient.	Moisture.	Ash.	P_2O_5.
	Per cent.	Per cent.	Per cent.
Wheat, large	13·7	2·1	0·74
„ small	14·1	2·0	0·80
Barley, husked	13·4	1·3	0·65
Pigeon pea, Arhar	13·6	4·0	0·86
Green Mung	11·3	4·3	1·17

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of the experiment, the

percentage gain or loss of weight, and the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	208	280	310	−7·2	Well.
2	208	250	350	+40·0	„
3	208	290	310	+6·8	„
4	103	260	280	+7·6	Flew away.
5	89	300	290	−3·3	Well.
6	159	270	310	+14·8	„
7	15	195	180	−7·6	Killed, no neuritis.
8	99	330	320	−3·03	Well.
9	15	230	250	+8·4	„
10	92	310	310	...	„
11	92	270	320	+18·5	„

Remarks.—From this table it will be seen that none of the pigeons developed neuritis. No. 7 showed signs of suppurative ophthalmia and was destroyed. The majority of the pigeons gained weight during the experiment. No. 10 has remained stationary. Nos. 5 and 8 have lost a very little weight. They are all healthy. It will thus be seen that this diet meets the physiological requirements of the body.

2. Substitution of unpolished for polished rice diet.

Six fowls received 30 grammes daily of unpolished Bengal rice. The other conditions of the experiment were the same as in the polished rice diet.

The following table gives the results of the analysis of the unpolished rice :—

Moisture.	Ash.	P_2O_5.	Percentage of P_2O_5 in ash.
Per cent.	Per cent.	Per cent.	
11·10	1·7	0·80	47·0

The following table shows the number of fowls fed, the duration of the experiment, the percentage gain or loss of weight, and the occurrence or non-occurrence of neuritis :—

No. of fowls.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	113	950	980	+3·4	Healthy.
2	113	900	1,000	+11·1	„
3	120	1,000	1,360	+36·0	„
4	120	900	1,060	17·7	„
5	113	900	1,020	+13·3	„
6	113	920	990	+7·6	„

Remarks.—This experiment demonstrates clearly the advantages of a diet of unpolished rice as compared with polished rice. All the fowls remained well and a gain of weight occurred in each case, whereas in the polished rice experiments the pigeons developed neuritis with progressive loss of weight.

3. By replacing one-third of the polished rice by Mung dal.

It was interesting to determine whether by adding a small proportion of a grain which is recognised to be of value in the prevention of Beriberi to a polished rice diet the animals could be maintained in good health and the occurrence of neuritis prevented. The grain selected for this purpose was the green Mung dal of India, *Phaseolus radiatus*.

Experiment 47.—Six pigeons received 20 grammes of polished rice and 10 grammes of Mung dal daily instead of 30 grammes of polished rice, but the other conditions of the experiment were the same as in the polished rice alone.

The following table shows the result of the analysis of the Mung dal :—

Moisture.	Ash.	Albuminoids.	P_2O_5.
Per cent.	Per cent.	Per cent.	Per cent.
14·6	3·2	22·2	0·95

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of the experiment, the

percentage gain or loss of weight and the occurrence or non-occurrence of neuritis :—

No. of pigeons.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	64	260	200	—23	Died, no neuritis.
2	161	270	310	+14·8	Healthy.
3	161	260	300	+15·3	„
4	161	280	270	—3·5	„
5	161	230	280	+21·3	„
6	161	260	280	+7·6	„

Remarks.—This experiment is a very interesting one. It will be seen that five out of the six pigeons remained healthy. One pigeon died with loss of weight but there was no neuritis. Of the remaining healthy pigeons one showed a slight loss of weight, 3·5 per cent., all the others showed a gain. This experiment, therefore, proves that the development of neuritis and loss of weight which occurs in pigeons fed on a pure polished rice diet can be prevented by the addition of a suitable quantity of Mung dal of India. This is an important observation and deserves special attention in regard to the problem of the prevention of Epidemic Dropsy in India.

Curative treatment of neuritis by change of diet.

Having seen that pigeons develop neuritis with progressive loss of weight when fed on polished rice, it became an important point to determine whether the signs of neuritis would disappear and the pigeons regain weight by simple change of diet without other treatment. Accordingly after the signs of neuritis had developed the diet was changed from polished rice to a mixture of wheat and pulses, which I have shown keeps the animals in good health.

Five pigeons received 30 grammes of polished rice daily until signs of neuritis had become well marked; it was then stopped entirely and 30 grammes of wheat pulse diet was given daily.

The other conditions of experiment remained the same.

The analysis of the mixture has already been given on page 66.

The following table shows the number of pigeons fed on polished rice and subsequently on the wheat pulse mixture, the duration of the experiment

on the polished rice and on the wheat pulse mixture, the weight at the beginning and end of the periods of experiment on polished rice and on wheat pulses, the percentage gain and loss of weight during both periods, the occurrence or non-occurrence of neuritis during these periods :—

Period on polished rice (Rangoon).

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	28	330	200	—39·3	Neuritis.
2	13	290	240	—17·3	„
3	20	240	190	—12·5	„
4	20	280	210	—25·0	„
5	36	310	200	—35·4	„

Period on wheat pulse diet.

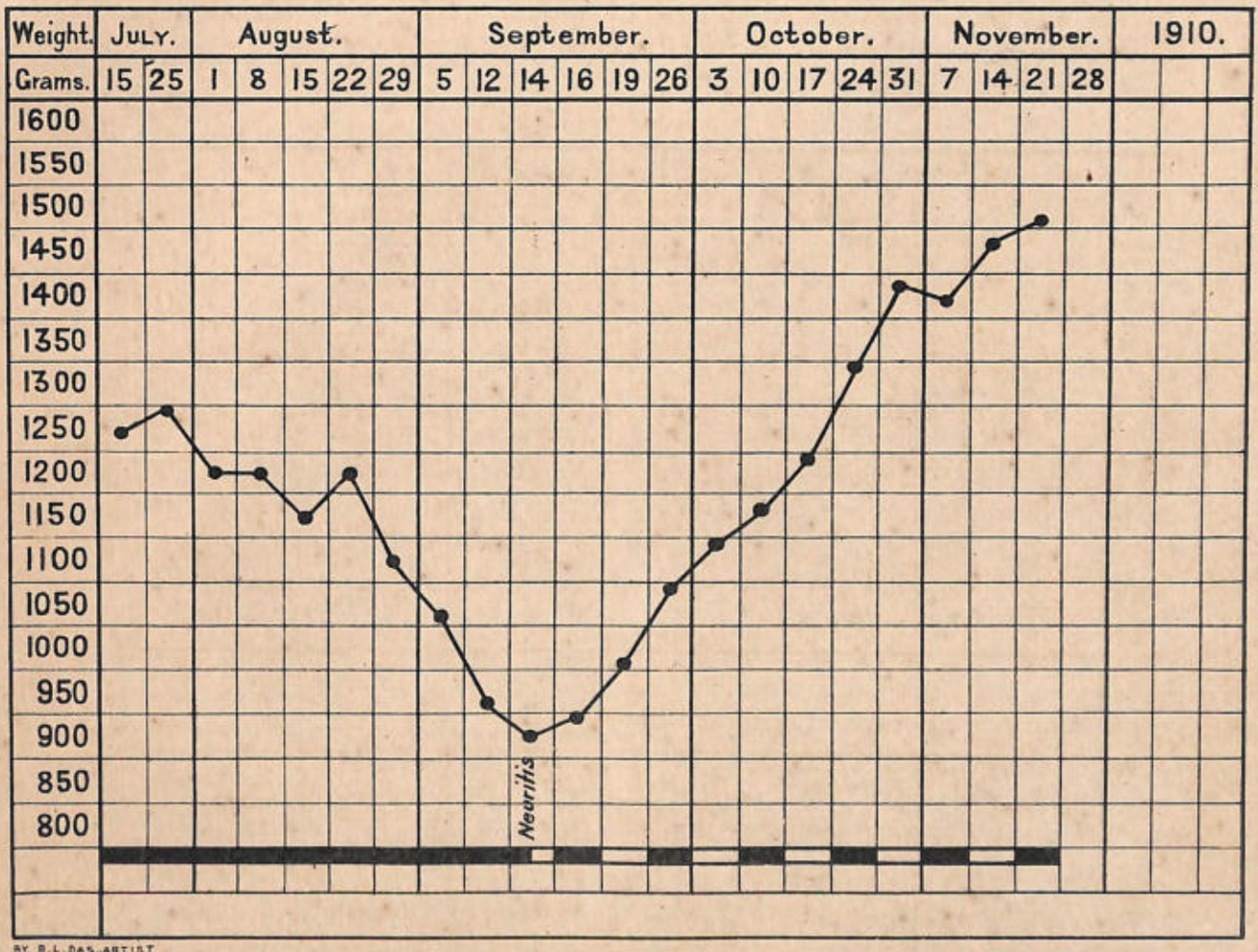
No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	78	200	320	+60·0	Healthy.
2	78	240	330	+37·5	„
3	71	190	240	+26·3	„
4	71	210	300	+42·8	„
5	49	200	270	+35·0	„

Remarks.—This is a very interesting experiment. If the pigeons had been allowed to continue on polished rice diet after the neuritis had developed then all five would have succumbed, as we have seen from the many experi-

VIII.

Ex. XXXV.

Fowl, No 1.

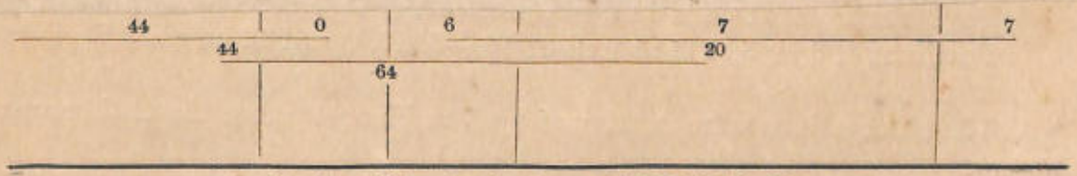


Period during which the fowl is fed on Barley.

Period during which the fowl is fed on Mūng dal, wheat and pulses.

From 14.9.10. Animal showed distinct signs of Neuritis.

" Diet changed from Barley to Mūng dal and wheat, pulses.



[1] Archiv. Schiff. u. Tropehygiene, Bd. XIV, Beiheft, 3, 1910.

5	49	200	270	+35°0	„

Remarks.—This is a very interesting experiment. If the pigeons had been allowed to continue on polished rice diet after the neuritis had developed then all five would have succumbed, as we have seen from the many experi-

ments already made. By stopping the rice dietary completely and substituting wheat and pulses I was able to save all five pigeons. The symptoms of neuritis gradually disappear. In one animal the gait remained altered for some weeks, but gradually improved. All five pigeons regained the weight which they had lost.

The experiment is of very considerable importance and throws light on the treatment of this condition. If the structural alterations are too advanced then, of course, change of diet will not be so likely to effect an improvement. Hence in the case of human beings the early recognition of the disease is of great importance in order that the change of diet may be made at the earliest opportunity before the anatomical lesions are too pronounced.

In regard to the above experiments on the prophylactic and curative treatment of Epidemic Dropsy a recent publication of Hulshoff Pol[1] in which he communicates the results of his researches on Beriberi in the Dutch East India Colonies with special reference to its prophylactic and curative treatment is of interest and a full summary of this important paper is given.

He conducted an investigation on the curative action of *Phaseolus radiatus*, the Mung dal of India, on Beriberi cases occurring in his Lunatic Asylum. The observation lasted from August 1901 to end of April 1902. He added to the usual dietary of half the Beriberi patients, *Phaseolus radiatus* 50 grammes thrice daily. The other articles of diet were 500 gram. rice daily; in the morning, rice and flesh or fish. Abundance of vegetables and spices were given also. Later when he became convinced of the curative value of the bean one meal of rice was withdrawn and replaced by 150 grammes beans. The beans were cooked as porridge, and sweetened with sugar. It was definitely determined that the beans were eaten, by the observations of himself or his European attendants.

The following table gives the results of his observations :—

NUMBER OF BERIBERI PATIENTS.

Received *Phaseolus radiatus*.		Received no Phaseolus.		
A	B	C	D	E
Cured or improved.	Died.	Cured or improved.	Received Phaseolus after their condition had become so bad that their life was despaired of. A rapid improvement set in.	
44	0	6	7	7
44		20		
64				

[1] Archiv. Schiff. u. Tropehygiene, Bd. XIV, Beiheft, 3, 1910.

The following observations were made by him on the prophylactic value of Phaseolus in Beriberi :—

There were 300 lunatics in 12 pavilions. The inhabitants of Pavilions Nos. 1, 5 and 9 received daily instead of a meal of rice 130 grammes Phaseolus.

The inhabitants of Nos. 2, 6, and 10 Pavilions received daily 300 grammes of various vegetables, more than the usual amount. These were partly cooked, partly raw.

The inhabitants of Nos. 3, 7, 11 Pavilions acted as controls and received the usual diet.

The inhabitants of Nos. 4, 8, 12 Pavilions received the usual daily food, but the pavilions were all disinfected with 3 per cent. solution Sapocarbol. A complete spraying took place weekly with this solution. At first dead beetles, lizards and other vermin were found, but later not a single animal was found.

The following table shows the results of his observations for nine months :—

—	Number of persons.	Developed Beriberi.
Pavilions Nos. 1, 5, 9 received Phaseolus . . .	78	1
Pavilions Nos. 2, 6, 10 extra vegetables . . .	86	16
Pavilions Nos. 3, 7, 11 controls	78	33
Pavilions Nos. 4, 8, 12 disinfected	58	19

The above experiment shows that *Phaseolus radiatus* has a powerful prophylactic action in Beriberi.

He took Pavilions Nos. 2 and 7, where Beriberi cases were numerous, and put them on a diet of Phaseolus, whilst he stopped the bean diet in Nos. 1 and 5.

The diet of Pavilions Nos. 3, 4, 6, 8 was not altered. This second experiment lasted from May 1902 to February 1904, namely, 21 months. The results were as follows :—

Pavilions 2 and 7, bean diet,—no Beriberi.

Pavilions 1, 3, 4, 5, 6, 8 as well as 10,—5, 19, 6 and 10 cases of Beriberi occurred.

The observations were continued by Von Hengel[1] when the author was absent.

[1] Hulshoff Pol. Geneesh. Tijdschr. Van. N. I., 1906 (Ll. 490 proven van van Hengel).

The following table shows the complete results of his prophylactic experiments with Phaseolus which extended over three years :—

—	Number of Beriberi cases.	
Pavilion 1—		
May to July 1901, only rice	.....	5
August 1901 to April 1902, rice and beans . .	0	.....
May 1902 to January 1904, only rice . . .	.....	10
February to June 1904, only rice . . .	.....	12
	0	27
During rice and beans :—		
9 months . . no cases.		
During rice alone :—		
27 months . . 27 cases.		
Pavilion 2—		
May to July 1901, only rice	.....	4
August 1901 to July 1902, only rice . . .	.....	5
August 1902 to January 1904, rice and beans .	0	.....
February to June 1904, only rice . . .	.....	9
	0	18
During rice and beans :—		
19 months . . 0 cases.		
During rice alone :—		
19 months . . 18 cases.		
Pavilion 3—		
May 1901 to January 1904, only rice . . .	.....	23
Pavilion 4—		
May 1901 to January 1904, only rice . . .	.....	26
Pavilion 5—		
May 1901 to January 1904, only rice . . .	.....	3
August 1901 to May 1902, rice and beans . .	0	.....
June 1902 to June 1904, only rice . . .	.....	20
	0	23
During rice and beans :—		
10 months . . 0 cases.		
During rice alone :—		
28 months . . 23 cases.		

—	Number of Beriberi cases.	
Pavilion 6—		
May 1901 to June 1904, only rice . . .	.....	42
Pavilion 7—		
May to July 1901, only rice	.....	3
August 1901 to May 1902, only rice . . .	.....	18
June 1902 to January 1904, rice and beans . .	0	.....
February 1904 to June 1904, rice only . .	.....	6
	0	27
During rice and beans :—		
20 months . . 0 cases.		
18 months . . 27 cases.		
Pavilion 8—		
May 1901 to June 1904, only rice . . .	.....	25

Kiewiet de Jonge[1] repeated and confirmed these observations. Hulshoff Pol also tried the use of decoction of the beans. He had already investigated this question in 1903.[2] He made a decoction of 500 grammes of the beans and he considered this quantity given daily was sufficient for the cure of a case of Beriberi.

He carried out the observations for two months, the results of which are given in the following table :—

A. Control without decoction.

21 Beriberi cases.

(*a*) Cured	1
(*b*) Only improved	0
(*c*) Remained stationary	8
(*d*) Became worse	7
(These improved on receiving the decoction.)	
(*e*) Severely ill	3
(The life despaired of. Received bean diet and improved.)	
(*f*) Died	2
TOTAL .	21

[1] Kiewiet de Jonge. Onderzoekingen over Beriberi. Geneesk. Tijdschr. Van N. I., 1909.

[2] Hulshoff Pol. Beriberi. Voorkoming en genezing door Ketjong-Hidjoi (*Phaseolus radiatus*). Amsterdam, 1904, de Bany.

B. Experiment with decoction.

18 Beriberi cases.

(*a*)	Recovered	13
	Became better	5
(*c*)	Remained stationary	0
(*d*)	Became worse	0
(*e*)	Became very ill	0
(*f*)	Died	
	TOTAL	18

Kiewiet de Jonge confirmed the curative action of the decoction of Phaseolus.

Hulshoff Pol isolated chemically from the decoction of beans an active ingredient, and he calls it X. acid.

He reaches the following conclusions as a result of his investigations :—

1. In investigations on Beriberi a distinction must be drawn between the disease itself and the paralysis resulting from the degeneration of the neurones.

2. The disease can be cured by the exhibition of the remedy referred to under 3, 4 and 6; the paralysis due to degeneration can only be cured by regeneration.

3. Beriberi can be obviated by daily administration of at least 150 grammes of boiled Phaseolus beans sweetened with sugar. The beans can be taken in addition to the regular food or instead of a meal.

4. Beriberi may be cured by the daily administration of at least 150 grammes of boiled beans. The paralysis due to degeneration remains and will only be cured after regeneration.

5. Phaseolus has little influence on old cases because the symptoms depend on degeneration of the neurones.

6. Beriberi can be cured by a decoction of not less than 500 grammes of the beans daily.

7. The active ingredient of the bean for the treatment of Beriberi is soluble in water.

8. The chemically purified Phaseolus decoction in which there is no nuclein, vegetable mucin, etc., as well as the decoction, has valuable curative properties for Beriberi.

9. By evaporating the chemically purified decoction crystals are obtained which belong to an unknown vegetable acid. This acid is provisionally called X. acid.

10. The practitioner must regularly determine that the patients are taking the remedy, because a few of them oppose it after long use.

11. The poor results which Japanese practitioners have had in treating Beriberi with Phaseolus (Aduki) are partly due to the fact that they have attempted to treat the degeneration of the neurones with Aduki.

12. The Japanese Aduki and the Dutch East Indian Katjong hidjoe belong to the same plant family : *Phaseolus radiatus*, L., but they are different varieties. The Japanese beans are red to black, the Dutch East Indian are green. The Japanese variety can thrive in the Dutch East Indian Colonies, but not well.

13. The Katjong hidjoe has no direct specific action on the kidneys. The disappearance of the œdema is only a general sign of the cure of the disease.

14. The beans protect against Beriberi only so long as they are taken.

15. It is recommended to suspend the supply of beans, as soon as the disease is cured or the epidemic has ceased.

16. A considerable increase of vegetables, raw or cooked, does not obviate Beriberi.

17. Indian corn, given in similar amounts and in the same way as Katjong hidjoe, is not able to prevent Beriberi.

18. Disinfection of the pavilions, whereby all beetles and lizards and such vermin were killed, does not prevent Beriberi.

19. The polyneuritis of fowls, which pathologically closely resembles Beriberi, can be cured either by the administration of the bean or a decoction of it.

20. The polyneuritis of fowls is not favourably influenced by the administration of nucleins obtained from Katjong hidjoe.

The remarks of Hulshoff Pol regarding the attempt to treat cases where the neurones are markedly degenerated should receive careful attention; because as he points out in cases where the signs are dependent on extensive degeneration of the neurones amelioration can only be expected when the regeneration commences. Hence it would be obviously unfair in judging the effect of a change from an unsuitable to a suitable diet not to bear this in mind, and make due allowance for it.

Effect of contaminating Grains with Bloomless Oil.

A theory in regard to the etiology of Epidemic Dropsy in Calcutta which obtained considerable notoriety was based on the alleged fact that the mustard oil consumed was being largely adulterated with mineral oils. Accordingly a certain quantity of a mineral oil (" Bloomless oil ") was added to the food of pigeons and the effects noted. The form of oil was said to have been added to

mustard oil consumed by Bengalis attacked by Epidemic Dropsy during the last Calcutta outbreak.

Experiment 33.—Six pigeons received *30* grammes of wheat pulse mixture daily and to this was added 0·75 c. c. of " Bloomless oil."

The following table shows the number of pigeons fed, the duration of the experiment, the weight at the beginning and end of the experiment, the percentage loss or gain of weight and the occurrence or non-occurrence of neuritis :—

No. of pigeon.	Duration of experiment.	Weight at beginning of experiment.	Weight at end of experiment.	Gain or loss of weight.	Result.
	Days.	Gram.	Gram.	Per cent.	
1	161	290	310	+6·8	Healthy. No signs of paralysis.
2	105	300	330	+10·0	"
3	105	270	300	+11·1	"
4	105	350	350	...	"
5	105	305	310	+1·6	"
6	97	320	350	+9·3	"

Remarks.—This experiment shows that the addition of " Bloomless oil " to the diet of pigeons over a very long period has no deleterious effect : the pigeons did not show neuritis or loss of weight. Similar experiments were done with other animals with like results. The results of these experiments are in agreement with the epidemiological findings. There is no evidence in favour of the consumption of mustard oil contaminated by mineral oils being an etiological factor in Epidemic Dropsy.

CHAPTER VI.

General Conclusions.

As will be seen from a study of this report, the two main factors which have determined the recent outbreak of Epidemic Dropsy in Calcutta are :—

(1) The high and sustained rise in the price of food grains.

(2) Certain defects in dietary.

During the period of high price in Calcutta the conditions brought about, amongst individuals with small fixed incomes, is broadly speaking analogous, as regards dietary, to the conditions met with on board ships which touch ports at prolonged intervals. In both the diet becomes "One-sided" and monotonous, and in both cases a morbid condition may result, called in the one case "Ship Beriberi" and in the other "Epidemic Dropsy," and the features of these conditions very closely resemble each other and bear a relationship to scurvy.

For the eradication of this disease it would be necessary to deal with both conditions. The questions, however, connected with (1) are, as has been pointed out by me already, outside the scope of my enquiry, but they are being investigated by an Expert Committee under the Finance Department of the Government of India.

In regard to (2) the defects in dietary which have been demonstrated should receive attention. Also further investigation on diet with special reference to this disease should be carried out.

The addition of rice bran to the dietary of persons consuming polished rice is likely to prove of value not only in the prevention, but, also, in the cure of this disease, and it has the advantage of being a simple and economical means of dealing with the disease.

Jauducheau[1] who confirms the opinion of Breaudat regarding the value of rice bran in the prophylactic treatment of Beriberi, gives the following combination :—

Common sugar (native)	300 gram.
Sifted rice bran	300 „
Salicylic acid	3 „
Water	60 „

The problem of the prevention of Beriberi or Epidemic Dropsy has a very important relationship to the dieting of large bodies of persons whose staple food is rice, *e.g.*, troops, prisoners, lunatics, etc., etc.

[1] Bull. Soc. Path. Exot., Tome 111, No. 8, Oct. 12, 1910.

It has also an important bearing on the maintenance of the health of crews of ships undertaking prolonged voyages, particularly those ships carrying rice-eating crews. Consequently the accounts of recent researches on this subject should be brought to the notice of all concerned with a view to preventing outbreaks of this disease.

An Indian food grain, which I have shown has valuable prophylactic curative properties in this disease, is the green Mung dal of India, which corresponds to the Katjong hidjoe of the Far East and the Aduki of Japan and its technical name is *Phaseolus radiatus*. Green Mung or Mung dal is cultivated in India, chiefly at Bijapur,[1] North Canara,[2] Kathiawar,[3] Poona,[4] Satara,[5] Sirsi, North Canara.[6]

Van Andel,[7] in the treatment of Beriberi patients, " Forbids rice, tobacco, tea, and coffee for a time, and allows the Katjong hidjoe (Mung dal of India) prepared in various ways along with fresh meat or fish, vegetables and fruit. Under this regimen one finds an apparently hopeless paraplegic, and the most advanced cases of Beriberi, improve rapidly. Eating of rice surrepticiously was scrupulously guarded against." He also warns against malingering in connection with this disease and notes that the induction of cardiac irregularities suggesting Beriberi in areas where the disease prevails, by the use of drugs, is a possibility to be borne in mind by Medical Officers under whose care native soldiers and workmen are being dealt with.

The value of the addition of fresh meat to the dietary has been already discussed, and it should be borne in mind in the prophylactic and curative treatment of Epidemic Dropsy.

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[1] Imperial Gazetteer, India, Vol. VIII.
[2] " " " " XIV.
[3] " " " " XV.
[4] " " " " XX.
[5] " " " " XXII.
[6] " " " " XXIII.
[7] Jour. Trop. Med. & Hygiene, No. 5, Vol. XII, March 1909.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
8, HASTINGS STREET

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta. 1911

PIGEON No. 1.

NEURITIS EARLY.

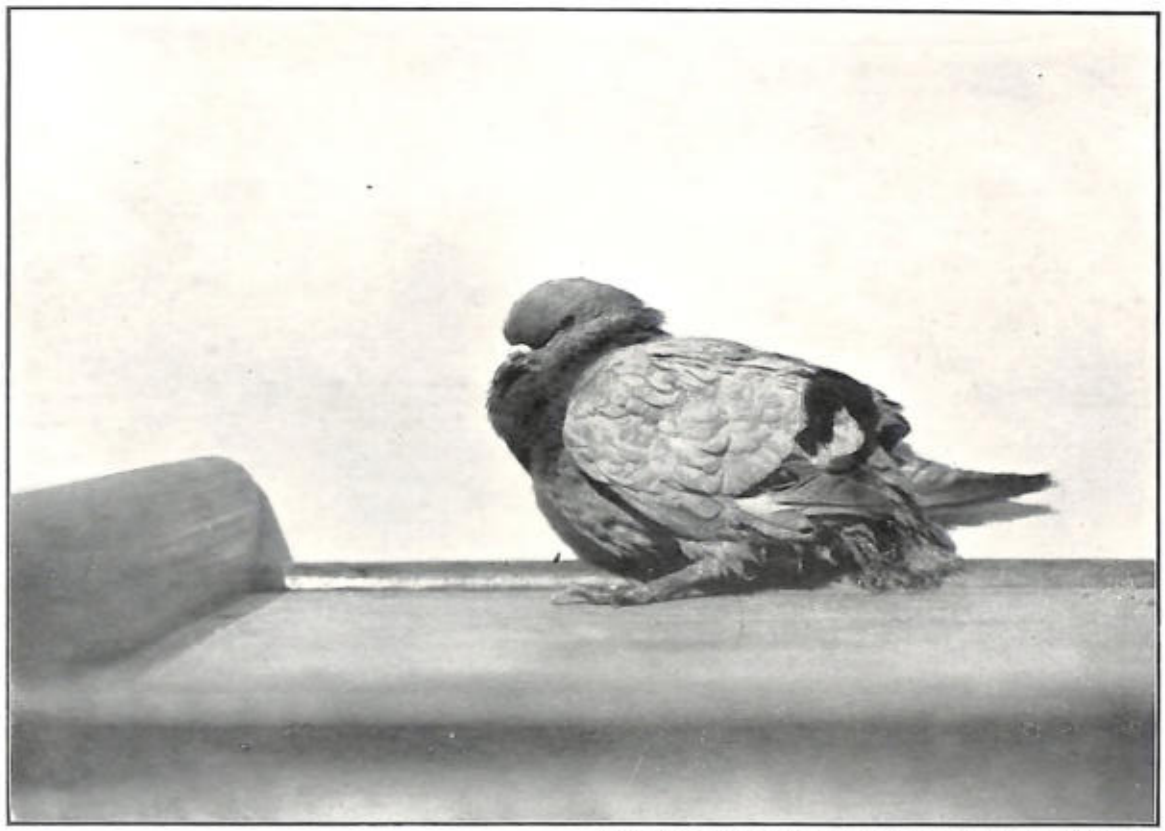

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1913

PIGEON No. 2.

NEURITIS MODERATLY ADVANCED.

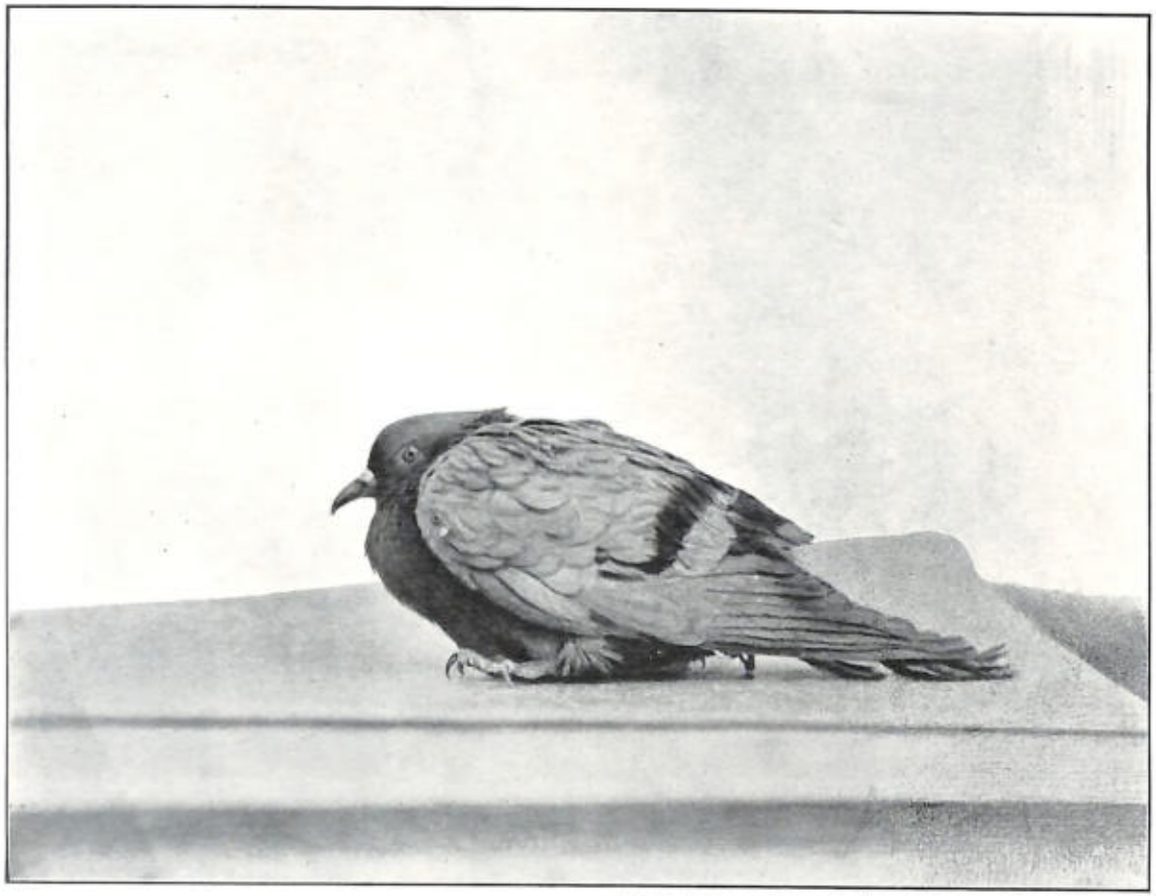

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1911.

PIGEON No. 3.

NEURITIS ADVANCED.

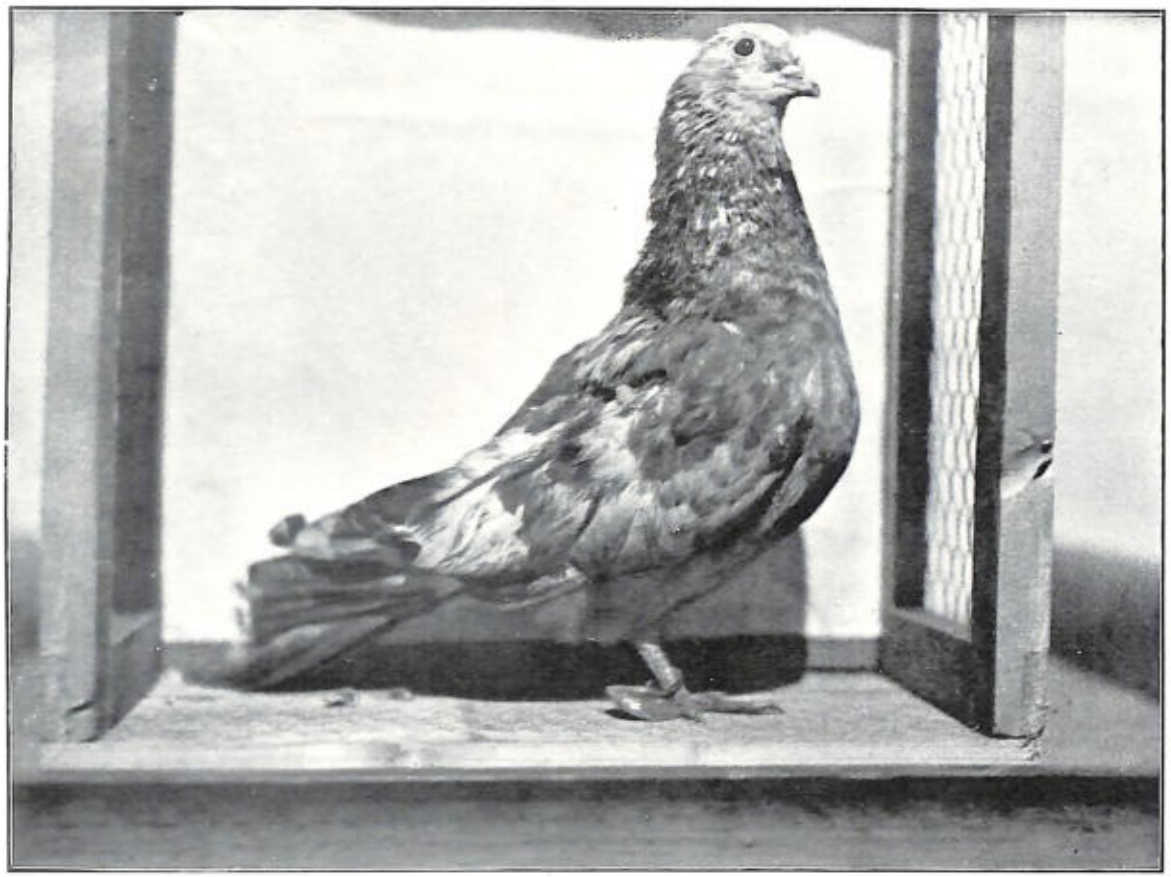

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1911.

PIGEON No. 4, HEALTHY.

NEURITIS CURED BY MUNG DAL & PULSES.

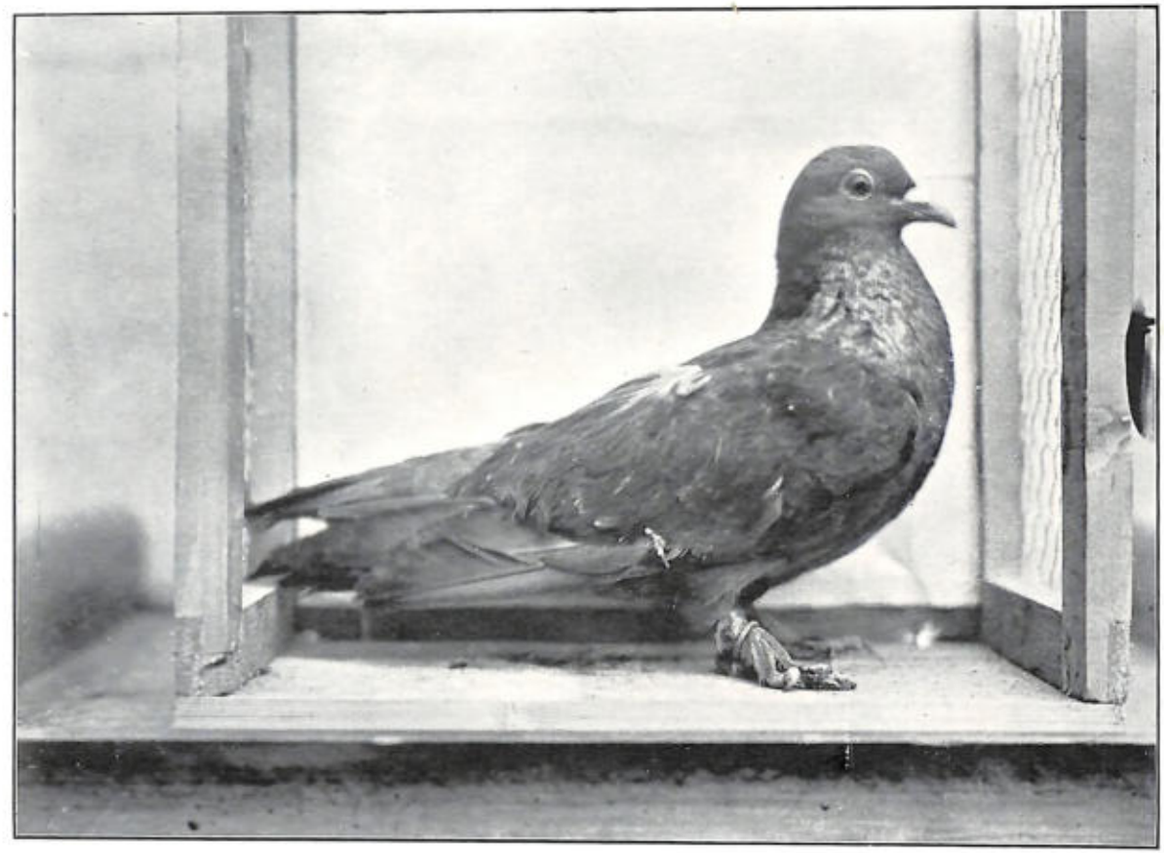

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta 1911.

PIGEON No. 5, HEALTHY.
POLISHED RICE & MUNG DAL DIET.