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BY

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OF THE

GOVERNMENT OF INDIA

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BEING THE FIRST 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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CONTENTS.

Illustrations at the end of the Report.

First Report on Epidemic Dropsy in Calcutta.

CHAPTER I.

Introduction.

IN accordance with instructions received from the Director, Central Research Institute, Kasauli, I proceeded to Calcutta to enquire into the causation of an outbreak of Epidemic Dropsy or beri-beri there. I arrived in Calcutta on December 13th, 1909. Assistant Surgeon Taraknath Sur and Assistant Surgeon Charu Chandra Bose were detailed for duty in connection with the enquiry and joined on 14th and 15th January 1910, respectively.

The Government of India appointed Mr. D. Hooper, F.C.S., officiating Reporter on Economic Products to the Government of India, on the 24th May 1910, to conduct the analytical portion of the enquiry. All the chemical analyses referred to in this Report have been made by Mr. Hooper.

When I reached Calcutta the acute phase of the outbreak of Epidemic Dropsy was over. However I took every opportunity of seeing cases of the disorder immediately after my arrival: in addition to the various Hospitals, I visited a large number of private houses, schools, etc. In this way I was able to observe and investigate a fair number of cases. After the Assistants arrived and the organization for the enquiry was complete, the investigations proceeded along the following lines :—

(1) The complete investigation of each fresh case of Epidemic Dropsy as it occurred, including examination of blood, excreta, etc.

(2) House to house enquiry.—A list of all houses in which cases of Epidemic Dropsy had occurred was obtained from the Health Officer, Calcutta. Two forms were drawn up (Appendix I), and on these all details connected with the house and its inhabitants are recorded. This portion of the enquiry is still in progress, but many records have already been made.

(3) Experimental research.—A large number of feeding experiments are being carried on with various animals, especially pigeons and fowls.

(4) Chemical investigation of food grains.—This is being undertaken by Mr. D. Hooper at his laboratory in the Indian Museum.

(5) In addition to the work on the Calcutta epidemic a number of outbreaks have been reported to me by the Government of Eastern Bengal and Assam in accordance with the orders of the Government of India.

I have received the Reports of the several outbreaks and have issued instructions for the transmission of food grains from the affected areas, which were investigated experimentally by me and chemically by Mr. D. Hooper.

Through the kindness of Lieutenant-Colonel Drury, I.M.S., Principal, and Major L. Rogers, I.M.S., Professor of Pathology, Medical College, Calcutta, accommodation for the enquiry was provided at the Medical College, which, from its proximity to the large hospitals, was very convenient for the purpose.

The investigation is still in progress and some months more will be required for its completion. In the meantime, however, certain important results have been obtained, and in this Report it is proposed to deal with these, leaving the other aspects of the investigation for a final Report.

It may be well to clear the way for the discussion which follows by explaining one or two points which, if misunderstood, may lead to confusion and misconception of the problems which will be considered in this Report. In the first place it is necessary to bear in mind that the prominent features of epidemic dropsy, *viz.*, swelling of the feet and breathlessness, may be produced by other conditions, which may be confused with it by the ordinary, and even by the skilled observer. These features may be produced by, over-indulgence in alcohol,[1] by ankylostomiasis, which for years was placed under the heading "Beri-beri of Ceylon" in Government returns, and by other causes. Hence it is necessary to eliminate in the first place these various conditions by a careful examination of each patient, and opinion on cases, cited as "Epidemic Dropsy," must be suspended until the required evidence is forthcoming. In the second place as the narrative of this Report proceeds certain questions regarding rice and wheat and their preparation in steam and other mills will be discussed in detail: but it must be remembered that this treatment of grains and the removal of portions containing physiologically important constituents only forms part of a general problem, namely, that of 'one-sidedness' in dietary. In the present outbreak and probably in many others 'polishing' of food grains plays an important part in bringing about such a 'one-sidedness' in the diet, but it can be brought about also, by the habitual consumption of other articles, *e.g.*, meat, which has been exposed to a high temperature, sago, etc., or in other words, deficiency of diet in certain essential constituents necessary for the physiological requirements, is the underlying principle, the mechanism of the production of this 'one-sidedness' of dietary will vary in different races and peoples with the staples of their food, in one case it may be 'polished' rice, in another a starchy flour, and so on. Indeed if Bengalis replaced entirely the 'polished' rice by the 'fine ata,' which many of them consume, the 'one-sidedness' of their dietary would be more accentuated than at present. I have stressed

[1] McGill, Bombay Medical Congress Trans., 1909.

these points here as I know from experience that their correct meaning is frequently not clearly understood, and it is a common error to consider that the present special case represents the general problem of defective dietary, whereas it is only one aspect of it. The question is an extensive one, involving as it does the influence of nourishment upon general health.

As the subjects discussed in this Report are complex and highly technical it may be well to pick out the main conclusions arrived at regarding the recent outbreak of Epidemic Dropsy in Calcutta. The evidence available appears to warrant the following :—

(1) That no causa morbi is to be found in the blood, œdematous fluid, excreta, etc., of Epidemic Dropsy cases.

(2) That the features of Epidemic Dropsy very closely resemble those of 'Ship Beri-beri.'

(3) That the evidence points to Epidemic Dropsy being non-infectious.

(4) That there is evidence to show that Epidemic Dropsy is a nutritional disease, and is brought about by a 'one-sided' dietary.

(5) That a community (Marwaris), living in the heart of the affected portion of Calcutta, practically entirely escaped Epidemic Dropsy. A careful chemical analysis of their dietary, which differs materially from that of the Bengalis, shows that it is much richer in some important constituents,—phosphorus, etc., than a rice dietary, and, therefore, the quantity of these constituents taken by the Marwaris, amongst whom no fatal cases of Epidemic Dropsy have been recorded, is greater than that consumed by Bengalis, whose staple is rice, and who were very severely affected by Epidemic Dropsy in the recent outbreak. The better class European community in Calcutta, living on a 'mixed dietary,' and not consuming large quantities of rice continuously, have escaped.

(6) That chemical analysis and histological examination show that by the process of 'polishing,' as carried out in the steam and other mills at Calcutta and elsewhere, constituents essential for nutrition are removed from the rice, and that the ata (wheat) which many Bengalis consume habitually, had been so finely 'sifted' that it is deprived of these ingredients to an even greater extent than rice.

(7) That the chemical examination of samples of the kind of rice consumed habitually by patients affected by Epidemic Dropsy shows that the samples had undergone a process of 'polishing' by steam milling and that important constituents had been removed to a considerable extent; that wheat consumed by patients affected by Epidemic

Dropsy had undergone a considerable loss of phosphates in the preparation of ata.

(8) That pigeons show, when fed on 'polished' rices, both boiled and unboiled, a progressive loss of weight with characteristic polyneuritis. Chemical analyses of these samples of rice show them to have a low phosphorus content.

(9) That control pigeons when fed on a mixture of wheat and pulses show no loss of weight, but rather a gain, and they have remained for months in good health. Chemical analysis of this food shows that it contains double the quantity of phosphorus contained in the sample of rice used for feeding the pigeons.

(10) That the two severe outbreaks of Epidemic Dropsy in Calcutta and Bengal, namely in 1877-78-79 and 1907-08-09, have been correlated with a sustained high price of food grains during the period and the cessation of these epidemics has synchronised with the fall in price of food.

CHAPTER II.

Features of Epidemic Dropsy.

The various signs and symptoms of this disease will be discussed in full in a later Report after the observations which are being recorded on the subject at present are completed, but it may be well to refer at the present stage to certain broad features of the disease which have a bearing on the problem of etiology.

The "symptom complex" of this disorder deviates fairly widely from that observed in Chinese patients in Calcutta suffering from beri-beri. It approximates much more closely to the condition described under the name "Ship Beri-beri." The symptoms of the latter condition consist [1] "In the great majority of cases in weakness and a prominent dropsy of the lower limbs, extending often to other parts of the body. There, also, exists shortness of breath and other symptoms of a weak heart, causing often sudden death from acute paralysis of the heart. But as Nocht [2] in Hamburg and the Norwegian 'Ship Beri-beri' Committee [3] have shown, symptoms of neuritis of the limbs are comparatively rare. For instance, Nocht was only able to ascertain neuritis in cases from four of his thirty-four beri-beri ships: and though the investigations of the Committee extended to fifty-seven affected ships, the neuritis was only found in men from four of them." "The great majority of patients suffering from the ordinary, *i.e.*, dropsical ship disease, recover as soon as they are able to change their food." These symptoms and signs of "Ship Beri-beri" agree very closely with those of Epidemic Dropsy as seen in Calcutta. Bradon [4] states, "There is not, according to the Report of the Norwegian Commission and later of Holst, who especially investigated both this disorder and true beri-beri, in pelagic dropsy (Ship Beri-beri), any constant or definite implication of the nervous system any more than there is in Epidemic Dropsy, which it indeed more closely resembles." Munro [5] who investigated Epidemic Dropsy in the Darjeeling District in 1907 states, "There are certain facts in support of a theory that the disease is due to under-feeding on certain of the constituents of a physiological diet." As in "Ship Beri-beri" the records of the occurrence of neuritis in Epidemic Dropsy are variable some authorities [6] consider that it is not a feature in the latter disease; others hold that it does occur: thus Megaw,[7] in a careful study of cases of Epidemic Dropsy in Eurasians and poor Europeans in the European General Hospital, Calcutta, notes that neuritis is invariably a marked

[1] Holst, Axel. Experimental studies relating to "Ship Beri-beri and Scurvy." *Journal of Hygiene*, Vol. VII, Part II, 1907.

[2] Festschrift zum sechzigsten Geburtstage Von Robert Koch. Jena, 1903.

[3] Indstilling fra Beri-beri Komiteen (Report of the Beri-beri Committee). Christiania, 1902.

[4] Trans. Bombay Medical Congress, 1909.

[5] Munro, Captain, I.M.S., on the prevalence in the Darjeeling District of a disease resembling Beri-beri. Report to Government of Bengal, February 1908.

[6] Rogers. Fevers in the Tropics, 1910.

[7] Megaw, J. W. D., Captain, I.M.S., Volume XLV, No. 4, April 1910. *Indian Medical Gazette.*

feature of the disease. He states, however, "That there is a marked difference in type between Epidemic Dropsy and beri-beri as seen among Chinese patients in Calcutta;" but he inclines to the opinion that the two diseases are not essentially different. Authorities, who have studied Epidemic Dropsy recently in India, record the fact that alteration of the dietary plays an important part in the cure of this disease; thus Neil Campbell[1] in considering of treatment of Epidemic Dropsy states, "The first thing is absolute rest, knock off every form of labour and permit the patient to be in the recumbent posture as much as possible, the next is good and nourishing diet." Megaw[2] also observes, in the treatment of his cases of Epidemic Dropsy, "That tendency towards recovery within a short time after the patient has been placed on a liberal diet free from rice is strongly in favour of the dietetic theory." These observations are in agreement with those of Axel Holst, Nocht, and others, in regard to the treatment of "Ship Beri-beri." Holst[3] states "That 'Ship beri-beri' is, in accordance with the opinion of Nocht, a food disease, showing a marked congruence with scurvy." In this connection it is interesting to record that a certain proportion of the patients during the recent Calcutta outbreak of Epidemic Dropsy showed sponginess of the gums, which bled readily, also a certain number had hæmorrhage from the bowel, etc. The following table shows the number of cases of Epidemic Dropsy which presented on examination spongy gums :—

NO. OF CASES EXAMINED.				NO. OF CASES SHOWING BLEEDING FROM GUMS AND HÆMORRHAGE FROM BOWELS.			
ADULTS.		CHILDREN.		ADULTS.		CHILDREN.	
Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
249	241	23	15	27	18	3	1

In his description of scurvy as seen amongst the troops after the occupation

1 Campbell, Neil, Lt.-Col., I.M.S., Report on outbreak of Epidemic Dropsy in the Lunatic Asylum, Dacca, in March 1908.

2 *Ibid.*

3 *Journal of Hygiene*, Vol. VII, Part II, 1907.

of Rangoon, Waddell [1] in 1826 states, " In all the worst cases the feet became œdematous : and however apparently mild the other symptoms might have been this affection was an almost certain prognostic of approaching anasarca, hydrothorax and death." He, also, mentions, " To those affections (Scorbutic) were associated, in many instances, diarrhœa and œdematous swellings of the feet."

Norman Chevers [2] in his chapter on beri-beri fever, in which he describes the last severe outbreak of Epidemic Dropsy in Calcutta, 1877-78-79, states, " Marked evidences of scorbutus are so often noticeable as prominent symptoms in cases of beri-beri that at least one of our best Indian observers has considered that beri-beri is essentially a form of scurvy." Morehead [3] considered, " That beri-beri, more particularly in its acute form, occurs usually in persons favourably circumstanced for the development of a scorbutic taint, and subsequently exposed to cold, dry or moist winds, or to lying on the ground wet with rain or dew." Chevers [4] expresses his own opinion on this point as follows, " I think that, when we state the fact that, wherever beri-beri prevails it specially selects the scurvied, we are free from the error of supposing that acute beri-beri is an expression of scorbutic cachexia, although scorbutus should be looked for in all cases of beri-beri, and be treated when present, as a grave complication." It will be seen from the above that the occurrence of scurvy in relation to previous outbreaks of Epidemic Dropsy in India had been observed and commented on. It is interesting in this relation to note that Chevers [5] lays down the following : " One of the most valid maxims which an old Indian physician can offer to a young one is : Never treat a case of any severe disease in India, whether the patient be European or Native—landsman or sailor—without taking at least a glance at the question—Is scorbutus possibly a factor in the causation of this malady."

It is possible that Epidemic Dropsy is one phase or expression of a general condition long ago recognised by Chevers and called by him Morbus Bengalensis,[6] although he himself did not associate the two conditions ; Chevers gives the following account of this disease : " It appears to be an arrest of nutrition resulting from chronic starvation. I have never seen this condition in a European or East Indian, or in a native gentlemen who lived generously ; but wealthy orthodox Hindus of the old school, whose diet is very poor and deficient in nitrogenous

[1] Waddell G. (M. D.) (Assistant Surgeon, Bengal Establishment) on the Diseases of Rangoon. Trans. Medical and Physical Society, Calcutta, Vol. III, page 240, 1827.

[2] Chevers Norman, C.I.E., M.D. (Deputy Surgeon-General, H. M.'s Indian Army, Late Principal and Professor of Medicine in the Medical College, Calcutta). A Commentary on the Diseases of India, 1886.

[3] Morehead C., M.D., Late Principal and Professor of Medicine, Grant Medical College, Bombay. Researches on Diseases of India, Churchill, 1860.

[4] Chevers, Norman, C.I.E., M.D., Deputy Surgeon-General, H. M.'s Indian Army, late Principal and Professor of Medicine in the Medical College, Calcutta.

[5] *Ibid*, page 347.

[6] *Ibid.*

ingredients sometimes die in this manner. In teaching I put aside the name Diarrhœa Hectica[1], and called the malady 'Morbus Bengalensis.' Throughout his daily work, the powerful influence of this condition of chronic semi-starvation not merely in the poor Bengali himself but throughout his entire race and generation, is constantly obtruding itself upon the physician, who says 'This man's constitutional malady is mal-nutrition, anæmia, asthenia, complicated with fever, dysentery, or what not.' 'Consequently the first indication of treatment is a proper and nourishing diet.'" If we replace Chevers' 'what not,' with the symptoms, swelling of the feet and breathlessness, a fairly complete description of the features of Epidemic Dropsy results.

McLeod[2] in his account of Epidemic Dropsy as met with in Calcutta during 1877-78-79 states, "There can be no question that, in consequence of the Madras famine, the price of food in Calcutta, throughout Bengal and Assam, was unprecedently high in the years 1877-78-79. Rice sold at double its usual rate, and the lower classes were undoubtedly underfed. There was also an influx into Calcutta of half-starved folk from the famine district. This circumstance may perhaps explain the amount of scurvy and general ill health observed in many of the Calcutta cases." These are important observations, and it is evident that in former outbreaks of Epidemic Dropsy symptoms of scurvy were noted also, and at the same time famine-rates for food were being charged. McLeod, also, notes that symptoms of Epidemic Dropsy occurred in persons showing no scorbutic symptoms, which is in agreement with Holst's observation in "Ship Beri-beri."

A disease very closely resembling Epidemic Dropsy has been observed in the prisons of Europe and America during the early part of the 19th century. Thus, "Besides typhoid fever and consumption, this 'Prison Dropsy' (Wassersucht der Gelängnisse) is stated, in 1847, to have been the most prevalent cause of death in 41 prisons in England, France and North America.[3] In 1857 it caused one half of the deaths in a prison in Breslau,[4] and if it were not that nothing is said about the occurrence of neuritis, some reports from those days recall the descriptions of the Asiatic beri-beri prisons of our own time."[5]

Schauman[6] has endeavoured to show that "Ship Beri-beri" is caused by a lack of nucleophosphoric acid which is extracted or destroyed by certain sterilization processes, and further he contends that a similar lack of organic phosphorus (nucleoproteins) in the food, especially in white rice, may produce tropical beri-

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1 Tytler J., Trans. Medical and Physical Society of Bengal, Volume III, Page 1826.

2 *Indian Medical Gazette*, January 1894.

3 Wald. Vierteljahrchr. für. gericht. Med. 1857, Vol. IX (quoted by Holst).

4 Bær. Weyls Handbuch der Hygiene, Hygine des Gef "ängnisswesens," pp. 42-43 (quoted by Holst).

5 Kersandt, quoted by Bær, Vierteljahrchr. f. offent. Gesundheitspflege, 1876.

6 Arch. f. Schiffs. Und. Trop. Hyg. Beiheft (1908, 12 and 37).

beri. Schauman[1] recently has published a second paper on the same subject giving the results of animal nutritional experiments.

The examination of the blood in cases of Epidemic Dropsy in India by different observers shows that the most marked feature is a reduction of the red corpuscles and hæmoglobin during the course of the disease, and as the case progresses towards recovery there is a gradual return to normal of the condition of the blood. This change in the blood picture is significant in relation to the nutritional origin of the disease. Neil Campbell[2] gives the result of the enumeration of the R. B. C. and W. B. C., at the onset, during the course, and in convalescence of five well marked cases of Epidemic Dropsy.

The following table gives the average of his results :—

Onset.			Course.			Convalescence.		
R. B. C.	W. B. C.	Proportion.	R. B. C.	W. B. C.	Proportion.	R. B. C.	W. B. C.	Proportion.
4,030,000	9,800	1-481	3,442,200	10,500	1-328	4,087,500	6,925	1-530

Neil Campbell[3] states, "I am inclined to conclude from careful clinical observation that progressive anæmia is a very interesting feature of the disease."

Rogers[4] gives the result of the examination of the blood in eight typical cases of Epidemic Dropsy in natives. The following table shows the average of his results :—

Hb.	Hb value.	R. B. C.	W. B. C.	Proportion.	P. N.	S. M.	L. M.	E.
37·5	·69	2,608,000	8,719	1-325	60·3	25·2	8·6	5·9

[1] Arch. f. Schiffs Und. Trop. Hyg. Beiheft (1909, 82-90).

[2] Campbell, Neil, Lt.-Col., I.M.S., Report on outbreak of Epidemic Dropsy in the Lunatic Asylum, Dacca, in March 1908.

[3] *Ibid.*

[4] Fevers in the Tropics, 1910.

Megaw,[1] as a result of his examination of the blood of six of his cases at the European General Hospital, Calcutta, states, " That the red cells were from two and a half to five millions, the hæmoglobin from 45 to 80 per cent., the rule being a moderate reduction in the red cells and a more marked reduction in the hæmoglobin. The leucocyte count showed an increase, both total and relative, in the lymphocytes and an increase in the eosinophiles in most of the cases." The results of the examination of the blood in Epidemic Dropsy, which I have obtained in my investigations in Calcutta, are in general agreement with the above quoted observations.

The following table shows the results of the enumeration of the R. B. C. and W. B. C., the percentage of Hb, the total, and the differential counts of the leucocytes in cases of Epidemic Dropsy :—

No.	Age.	Sex.	Race.	Stage of disease.	Date of examination.	R. B. C.	Hb%	W.B.C.	Percentages.			
									P.N.	S.M.	L.M.	E.
1	15	F	I. Ch.	Chronic (relapse)	1st February 1910 .	3,540,000	48	4,500	56	31	12	1
2	14	F	,,	,,	1st February 1910 .	3,580,000	48	4,000	41	50	8	1
3	15	F	,,	,,	2nd February 1910 .	4,590,000	56	5,000	50	32	18	0
4	15	F	,,	,,	3rd February 1910 .	4,020,000	57	5,000	50	44	5	0
5	14	F	,,	,,	2nd February 1910 .	4,670,000	60	5,000	63	29	8	0
6	15	F	,,	,,	2nd February 1910 .	4,780,000	65	9,000	71	21	9	0
7	24	F	,,	,,	3rd February 1910 .	4,990,000	62	8,000	52	39	7	0
8	15	F	,,	,,	2nd February 1910 .	4,590,000	56	5,000	50	32	12	0
9	33	M	,,	,,	17th January 1910 .	3,200,000	55	8,000	65	21	14	0
10	35	M	B	,,	20th January 1910 .	3,740,000	40	5,500	58	34	17	1
11	28	M	B	,,	25th January 1910 .	3,650,000	55	9,000	52	36	12	0
12	24	F	I. Ch.	Acute . .	18th December 1909	2,200,000	32	7,812	72	13	15	0
13	25	F	,,	,, . .	4th January 1910 .	3,910,000	60	9,000	58	30	12	0
14	19	F	,,	Chronic . .	10th February 1910	5,350,000	50	12,000	78	8	14	0
15	15	M	B. H.	,, . .	16th February 1910	4,000,000	42	5,000	65	26	8	1
16	55	M	,,	,, . .	16th February 1910	3,040,000	35	12,000	62	25	12	1
17	29	M	,,	Acute . .	20th September 1909	2,100,000	14	6,700	..	..	..	..
18	22	M	M	Chronic . .	23rd April 1910 .	3,800,000	60	5,600	60	34	6	0
19	45	F	I. Ch.	Convalescent .	5th February 1910 .	5,020,000	80	7,000	65	27	8	0
20	16	F	,,	,,	5th February 1910 .	4,850,000	70	6,000	43	48	5	2
21	16	F	Brahmo .	,,	8th February 1910 .	5,110,000	78	7,000	57	38	5	0
22	22	F	,, .	,,	8th February 1910 .	4,420,000	75	5,000	37	48	13	2

The coagulation time of the blood was determined in a number of cases of Epidemic Dropsy. In none of them was it abnormally prolonged when controlled by observations on the presumably healthy.

[1] Megaw : Fevers in the Tropics, 1910.

The following table shows the records of the coagulation time of the blood in cases of Epidemic Dropsy :—

Serial No.	Age.	Sex.	Race.	Stage of disease.	Date of examination.	Coagulation time.
1	15	F	I. Ch. B.	Chronic	1st February 1910	4′—50″
2	14	F	,,	,,	1st February 1910	3′—45″
3	15	F	,,	,,	2nd February 1910	2′—25″
4	15	F	,,	,,	3rd February 1910	3′—40″
5	14	F	,,	,,	2nd February 1910	4′—20″
6	15	F	,,	,,	2nd February 1910	3′—0″
7	24	F	,,	,,	3rd February 1910	4′—30″
8	15	F	,,	,,	2nd February 1910	4′—47″
9	19	F	,,	,,	10th February 1910	3′—30″
10	15	M	H	,,	16th February 1910	3′—30″
11	55	M	H	,,	16th February 1910	2′—50″
12	22	M	M	,,	23rd April 1910	2′—45″

I. Ch. B.=Indian Christian (Bengali).
H.=Hindu.
B.=Bengali.
M.=Mahomedan.

CHAPTER III.

Infectivity of Epidemic Dropsy.

An important question to determine in the first place was, whether or not an organism exists in the tissues of patients suffering from Epidemic Dropsy. A careful examination of the blood of cases of Epidemic Dropsy, which came under observation, was made, both by cultivation in various media and direct microscopic examination.

The following table shows the presence or absence of bacteria in the blood of patients suffering from Epidemic Dropsy :—

No. of case.	Date of examination.	Age.	Sex.	Race.	Stage of disease.	Quantity of blood.	Nutrose broth.	Nutrose Agar.	Serum.
39	18th December 1909 . .	24	F	I. Ch.	Early	5 c.c. .	Sterile	Sterile	Sterile.
40	4th January 1910 . .	25	F	,,	,,	5 c.c. .	,,	,,	,,
41	10th January 1910 . .	35	M	Panjabi	,,	5 c.c. .	,,	,,	,,
42	8th January 1910 . .	30	M	I. Ch.	,,	5 c.c. .	,,	,,	,,
44	16th February 1910 . .	15	M	H	Chronic	5 c.c. .	,,	,,	,,
45	16th February 1910 . .	55	M	H	,,	5 c.c. .	,,	,,	,,
53	22nd February 1910 . .	18	M	H	,,	5 c.c. .	,,	,,	,,
54	19th March 1910 . .	22	M	H	,,	5 c.c. .	,,	,,	,,
62	23rd April 1910	22	M	M	,,	5 c.c. .	,,	,,	,,
63	4th May 1910 .	22	M	M	,,	5 c.c. .	,,	,,	,,
68	10th June 1910	15	M	Eura-sian.	,,	5 c.c. .	,,	,,	,,

I. Ch. = Indian Christian.
H. = Hindu.

Remarks.—The blood, which was removed with the usual precautions from a vein at the bend of the elbow, was placed at once in a considerable quantity of nutrose broth ; the blood was found invariably to be sterile. The blood was planted, also, on nutrose agar and serum, but with like result. Therefore as far as the blood is concerned there is no evidence of bacterial invasion in Epidemic Dropsy.

Careful microscopic examination of films of blood taken from the cases of Epidemic Dropsy and stained in various ways gave negative results as regards the presence of parasites. Also 5 c.c. of blood were taken from a vein and mixed with a little sodium citrate to prevent coagulation and then centrifuged; the clear plasma was pipetted off and again centrifuged: then the supernatant fluid was poured off and the residue which remained was examined fresh for parasites. The result was negative in each case.

In this connection it is interesting to note that Megaw[1] drew 3 c.c. of blood from an early typical acute case of Epidemic Dropsy and having allowed the blood to clot he inoculated himself with the serum subcutaneously without ill effects.

I have inoculated subcutaneously several monkeys with blood taken from typical cases of Epidemic Dropsy, an interval of a few minutes only elapsing between the time of taking blood from the patient and the injection into the monkey. For the purpose 5 c.c. of blood were removed from the vein at the bend of the elbow of early cases of Epidemic Dropsy, and mixed with a little Sodium Citrate to prevent coagulation. No noteworthy sign or symptom was observed in the monkeys, which remain free from disease after the injection.

In several instances the skin of the œdematous limb of early cases of Epidemic Dropsy was disinfected carefully with carbolic 1-20, and afterwards washed with alcohol and ether: a sterile hypodermic needle was then introduced under the skin and some of the fluid was sucked up into the syringe. This fluid was planted on various media. It was examined, also, microscopically, both before and after centrifuging, but no parasite was detected in any case; and the fluid remained sterile in the various culture media, *viz.*, nutrose broth, nutrose agar, serum, etc.

The fæces and urine were examined microscopically and culturally in several typical acute cases, but no specific organism was determined.

It will be seen that the results of the search for a causa morbi in the tissues of cases of Epidemic Dropsy have been uniformly negative. Whilst these results do not prove a non-microbic origin of the disease they increase considerably its probability. Recent work on beri-beri in the Far East has given similar results. De Haan states,[2] "My own very numerous attempts to find the causa morbi in the blood, the organs, or the excreta of persons suffering from beri-beri, also. have never succeeded."

Apart from the results of the examination of the blood, etc., of the patient, there is other evidence in support of the non-microbic origin of the disease. Epidemiological investigations do not support the view that the disease is infectious from person to person. Thus in Calcutta there is a large community of Marwaris (Hindus) living in the heart of the affected portion of Calcutta, and the sanitary

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[1] Megaw: Fevers in the Tropics, 1910.

[2] De Haan. *Philippine Journal of Science*, Vol. V., No. 1, February 1910.

conditions under which many of them are living are not especially favourable. In Wards 5 and 7, in which they chiefly live, comparatively few fatal cases of Epidemic Dropsy occurred, and a careful investigation of those fatal cases in Wards 5 and 7 showed that all of them were Bengalis, not Marwaris ; none of the fatal cases were traced to the latter. Hence we see that in these two Wards in Calcutta two communities, Marwaris and Bengalis, the former largely predominating, were living under the same environmental conditions, yet fatal cases are recorded from the one, and not from the other. The reason for this will be evident when the question of geographical distribution of the disease in Calcutta is described ; this example indicates the absence of infective power of the disease. Further, no authentic case of Epidemic Dropsy has been recorded amongst the better class European community in Calcutta. The latter have no such immunity from ordinary infectious disease, *e.g.*, cholera, small-pox, etc., or from such diseases as malaria, seven-day fever, etc. The reason for their immunity will be discussed later.

During the course of the enquiry I have directed special attention to the study of the movements of persons and households affected by Epidemic Dropsy. Records of persons at all stages of the disease, who came into households in which no disease existed previously, and the subsequent history of these households, have been and are being obtained. In practically all these instances the imported case has recovered or died, but no spread of the disease to healthy members has occurred.

The following table shows the number of Epidemic Dropsy free houses into which persons suffering from Epidemic Dropsy at various stages came, and the occurrence or non-occurrence of Epidemic Dropsy in the houses thereafter.

No. of Epidemic Dropsy free households into which cases were imported.	No. of these households which recorded cases of Epidemic Dropsy after the importation.
28	2

From this it will be seen that the movement of affected persons was not followed by a spread of the disease. The cases coming to the houses were in all stages of the malady, from the early initial phase to convalescence. In only two examples did the disease occur in households, apparently, after the entry of cases, but on careful enquiry these instances were explainable on other grounds.

Evidence was obtained in many cases of one out of several families living in the same house being affected with Epidemic Dropsy, the remaining unattacked families keeping free from the disease, although the sick and healthy mixed intimately. In the majority of instances the only difference being that the food

was not the same, or procured from separate sources. Further, in some of the schools in Calcutta (which I investigated), after cases of Epidemic Dropsy had occurred no attempt was made to isolate the scholars. The children suffering from the disease mixed freely with the healthy ones, and the disease did not spread.

The cases of Epidemic Dropsy treated in the Hospitals in Calcutta have not been isolated and no dissemination of the disease has taken place. On this point Neil Campbell[1] in dealing with the Dacca Asylum outbreak of Epidemic Dropsy states that, "Removal of the insanes from the asylum, or segregation of the affected, was considered unnecessary." Megaw[2] also observes, "Against the disease (Epidemic Dropsy) being an infection is also the fact that all the cases were treated in the open wards without any attempt at segregation being considered necessary, and that no case of infection occurred among the other patients." Assistant Surgeon Rammay Ray,[3] who saw many cases of Epidemic Dropsy in Madras and Calcutta, during the previous outbreak, 1877-78-79, concludes as follows:—"From all the facts mentioned above, I believe that beri-beri (Epidemic Dropsy) is not communicable from person to person." McLeod[4] states regarding the same outbreak of Epidemic Dropsy, "The general opinion among natives was that the disease was not infectious." Lovell[5] writes regarding the Epidemic Dropsy in Mauritius (1879) that the majority of medical men at Mauritius were opposed to the view that the disease was contagious.

Dr. de Haan, Director of the Government Medical Laboratory at Waltevreden, Java, who has made a prolonged study of beri-beri at Waltevreden, states,[6] regarding the infectivity of that disease: "No one hitherto has succeeded in proving beri-beri to be caused by a specific microbe, or shown that it should be classed among infectious diseases." He further gives this important warning on the point: "Neither its epidemic nor endemic dissemination, nor the few cases mentioned in literature indicating the possibility of infection from one person to another, should be considered as proof of its microbic origin, since the clinical symptoms of beri-beri—polyneuritis with all its sequels—may be caused by many other factors."

Dr. Hans Aron of the Philippine Medical School, observes[7], "In spite of the claims of various investigators who have described a number of so-called beri-beri organisms which all, more or less have been proved not to be the specific cause

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[1] Campbell, Neil, Lt.-Col., I.M.S., Report on outbreak of Epidemic Dropsy in the Lunatic Asylum, Dacca, in March 1805.

[2] Megaw: Fevers in the Tropics, 1910.

[3] *Indian Medical Gazette*, May 1st, 1880.

[4] *Indian Medical Gazette*, March 1st, 1880.

[5] *Indian Medical Gazette*, page 222, August 1880.

[6] *Philippine Journal of Science*, Vol. V, No. 1, February 1910.

[7] *Philippine Journal of Science*, Vol. V, No. 1, 1910.

of the disease, we can to-day regard it as proved that beri-beri is not an infectious disease.''

Further, Dr. Grijns[1] in his observations on polyneuritis gallinarum, a disease closely related to beri-beri of man, and which can be produced experimentally by feeding birds on polished rice, records the following results to show that the injection of the blood and nerves of fowls suffering from polyneuritis into healthy fowls was not followed by the disease :—

'' He injected into the peritoneal cavity of healthy fowls the blood of diseased birds (a minimum of 57 c.c. in 12 injections and a maximum of 220 c.c. in 23), but without result. The nerves of diseased fowls, either free or inclosed in collodion sacks, and introduced into the peritoneal cavity of healthy birds, did not give rise to polyneuritis. The feeding of healthy fowls on the flesh of diseased birds had no effect, neither did the injection of the blood of the former into the latter accelerate the appearance of polyneuritis in the case of fowls fed on cleaned rice.''

By Fraser and Stanton's carefully controlled observations,[2] on 300 Javanese indentured labourers employed in the work of road construction in a remote part of Jelebu District in the State of Negri Sombilan, it was clearly shown that beriberi was not infectious and was not conveyed from person to person. ''Systematic examinations were made of the blood and urine of patients suffering from beriberi. Various methods of examination were employed, but in no instance were any organisms found except those well known as the causative agents of other diseases.'' '' The results of observations made on such occasions furnished evidence that the disease is not a directly communicable one.''

It will be seen that the results obtained on the question of the infectivity of Epidemic Dropsy during the enquiry at Calcutta are in agreement with those of a number of competent observers. The importance of this aspect of the investigation requires no comment.

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[1] Over Polyneuritis gallinarum I en II, Genees Tyds. V. Ned. Ind., 1900, 41 and 1909, 49.

[2] Studies from the Institute for Medical Research, F. M. S., No. 10, 1909.

CHAPTER IV.

Geographical Distribution of Epidemic Dropsy in Calcutta.

In studying the epidemiology of disease valuable information may be obtained from observing the geographical distribution of the cases. Accordingly the records of all fatal cases of Epidemic Dropsy reported to the Health Officer, Calcutta, during the outbreak of 1909 were obtained and investigated. In the first place a map showing the geographical distribution of fatal cases of Epidemic Dropsy in Calcutta was constructed in the following manner: If after enquiry into the case the diagnosis of Epidemic Dropsy was confirmed, a dot was placed on a blank map of Calcutta on the locality where the death occurred. This was done for every fatal cases of Epidemic Dropsy in Calcutta and suburbs up to the end of 1909. In this way it was possible to study the distribution of the outbreak of Epidemic Dropsy in Calcutta. The skeleton map made from the original shows the geographical distribution of Epidemic Dropsy in Calcutta during 1909.

A glance at this map shows at once that certain populous Wards in Calcutta have to a large extent escaped the disease. These wards are 5 and 7, and 15, 16, 17. Can the immunity of these wards from Epidemic Dropsy be accounted for, or can it be correlated with any particular feature of these Wards or the inhabitants of them ? On further enquiry into these points several interesting and significant facts emerge. Wards 5 and 7 are very largely inhabited by a community of Hindu merchants, Marwaris, whilst Wards 15, 16, 17 are populated almost entirely by the better class European community, and form the European quarter of Calcutta. Proceeding further with the investigation of this problem it is found that the dietary of the Marwaris is entirely different from their Bengali neighbours in adjoining Wards, who have suffered so severely from the disorder. As is well known the staple article of diet of the Bengali is rice, which they consume in large quantities daily. The Marwaris on the other hand consume much less rice and only a small proportion take it habitually. They replace the rice by coarse ata (wheat), mung dal, and other pulses to a large extent. The chemical analysis of the Marwari and Bengali diet will be discussed shortly. In the map, Wards 5 and 7, the inhabitants of which are chiefly Marwaris, with a sprinkling of Bengalis, have been enclosed in a thick continuous line. When compared with adjoining Wards it will be seen the number of fatal cases of Epidemic Dropsy recorded within this line is small. A most careful and special enquiry was made into each case, and it was ascertained in every instance that the person who had died of Epidemic Dropsy was a Bengali, not a Marwari. This is a very significant fact, because from this it will be seen that the foci of disease existed in these Wards and the sanitary conditions are

certainly no better, possibly not so good as those in adjoining Wards ; yet notwithstanding these circumstances no fatal cases of Epidemic Dropsy were recorded from the Marwari population. This fact points strongly to Epidemic Dropsy being a nutritional rather than an infectious disorder. The portion of the map enclosed within the thick continuous line (Marwari Wards, 5 and 7) stands out in marked contrast to its neighbours (Bengali Wards, 9 and 8) as regards the number of fatal cases of Epidemic Dropsy recorded. These Wards are all under the same environmental conditions, etc., the populations inhabiting them vary only in regard to the dietary habitually consumed.

Chart No. 1 shows the number of fatal cases of Epidemic Dropsy in Wards 5 and 7, and Wards 9 and 8, the population of the Wards, and their inhabitants.

The better class European quarter of Calcutta has been enclosed within a thick broken line. Here again it will be seen that the enclosed space is distinguished in a remarkable manner by the complete absence of dots. It is interesting to note that in the outbreak of Epidemic Dropsy in Calcutta, 1877—79, no Europeans were attacked then also.[1] As is well known rice is consumed in small quantity only, at irregular intervals, and forms only a trivial portion of the dietary of the European. That Europeans do not possess any peculiar immunity from the disorder is shown from the fact that, when their dietary approximates to the diet of the Bengali, and they consume a large quantity of rice habitually, they may fall victims to the disorder ; this has been shown by Megaw[2] in his observations on cases of Epidemic Dropsy amongst poor Europeans in the General Hospital, Calcutta. He says, "The conditions under which Epidemic Dropsy occurs among European patients in Calcutta are very significant in this connection. All the cases were in persons who had been in the habit of consuming considerable quantities of rice, and on the whole the severity of the cases seemed to be proportional to the amount of rice taken. There is the remarkable fact that among Europeans who do not take rice, except in very small quantities, Epidemic Dropsy is unknown, whilst amongst those who take a moderate amount the disease occasionally appears, usually in the mild form." Hence it will be seen that much valuable information has been obtained by the study of the geographical distribution of the disease. This information has formed the starting point for further research on the etiology of the disease.

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[1] McLeod, K. *Indian Medical Gazette*, Vol. XXIX, 1894.

[2] Megaw : Fevers in the Tropics, 1910.

CHAPTER V.

Polishing of Food Grains in relation to Epidemic Dropsy.

From a study of the foregoing it will be seen that the evidence points to Epidemic Dropsy being a disorder of nutrition. It will now be necessary to enquire into the presence or absence of defects in the dietary habitually consumed by the race attacked by Epidemic Dropsy. The views of the Professor Axel Holst[1] on the etiology of 'Ship Beri-beri' have been discussed already. He regards it as a food disease. In concluding his paper he states, "Several chemical questions arise. For instance, which are, properly speaking, the nutritive constituents, the presence of which prevent, and conversely the absence of which produce the disease? That such elements exist has been suggested by Grijns, and seems to be proved by Eijkman[2] who was able to cure the malady by adding to the injurious food an aqueous extract of rice bran." Whilst the present enquiry was in progress an important paper has been published by Fraser and Stanton on the Etiology of Beri-beri.[3] In this investigation they show that the polishing of rice in steam mills removes substances which are essential for the maintenance of the normal nutrition of nervous tissue. These substances exist in adequate amount in the original grain and in superabundant amount in the polishings of white rice. They state further that, "The estimation in terms of phosphorus pentoxide of the total phosphorus present in the given rice may be used as an indicator of the beri-beri producing power of such rice when forming the staple diet in man." At the first biennial meeting of the Far Eastern Association of Tropical Medicine held at Manila, March 5 to 14,[4] the question was fully discussed and the results of several important original investigations on the subject were communicated. The views of Fraser and Stanton were confirmed, and further valuable additions to our knowledge of the subject were made; as a result of these far-reaching discoveries the following important resolution was passed by the Association:—

"Resolved, that in the opinion of this Association sufficient evidence has now been produced in support of the view that beri-beri is associated with the continuous consumption of white (polished) rice as the staple article of diet, and the Association accordingly desires to bring this matter to the notice of the various Governments concerned."

Since the evidence obtained in regard to Epidemic Dropsy in Calcutta pointed to its causation being associated with a particular kind of dietary it was necessary to enquire very carefully into the composition of the articles making up this diet,

[1] Holst, Axel. Experimental studies relating to "Ship Beri-beri" and Scurvy. *Journal of Hygiene*, Vol. VII, Part II, 1907.

[2] Arch. f. Hyg., 1906, Vol. LVIII.

[3] Studies from the Institute for Medical Research, F. M. S., 1909, Kuala Lumpur.

[4] *Philippine Journal of Science*, Vol. V, No. 1, February 1910.

and to determine whether or not they contained certain essential ingredients required to meet the physiological requirements. In the Bengali diet, rice and to a less extent ata (wheat) are the staple articles, and as these are consumed after polishing and milling, obviously it became necessary to determine the effect on the nutritive value of these articles of these processes in the light of recent researches. Accordingly Mr. Hooper made a very careful chemical analysis of the rice and wheat with special reference to the phosphorus content.

Samples of rice were obtained from a representative steam mill, *viz.*, the Ram Kristopore Mill, Howrah, at every stage of the process of preparation.

The samples were described as follows :—

(1) Anchata or unpolished rice.
(2) Kolchata or polished rice, first process.
(3) Polished rice after the second process.
(4) Koorah (polishings) removed by first polish.
(5) Koorah (polishings) removed by second polish.

The weight of a 100 of the rice grains was respectively 1·79, 1·74, 1·61 grammes.

They contained the following constituents :—

—	Water. %	Ash. %	P_2O_5 %	Percentage of P_2O_5 in ash.
1	11·10	1·7	·58	34·1
2	11·0	·9	·45	50·0
3	11·0	1·0	·38	38·0
4	7·6	16·5	3·39	20·5
5	8·3	13·8	3·27	23·7

The process of polishing has removed the layers containing the phosphated compounds. The phosphoric acid in the first polished rice is reduced by 22·4 per cent. compared with the unpolished rice. The phosphoric acid is further reduced by the second polishing, but the ash remains about the same.

The analysis of another series of samples of rice gave the following results :—

The samples were described thus :—

(1) Rice husked, before polishing.
(2) Rice after first polishing.
(3) Rice after second polishing.
(4) Koorah after first polishing.
(5) Koorah after second polishing.

The weight of a 100 of the rice grains was respectively 2·02, 1·81, 1·74 grammes. They contained the following constituents :—

—	Ash. %	P_2O_5 %	S_1O_2 %	Percentage of P_2O_5 in ash.
1	1·7	·80	..	47·0
2	1·0	·50	..	50·0
3	1·0	·45	..	45·0
4	15·0	3·10	9·3	20·67
5	15·0	3·60	9·1	24·0

Considering that a different kind of rice is represented in this series, the results compared with the first series are very similar.

As regards the fat content of rices—

Unpolished rice has 2 to 2·5 per cent. of oil.

Polished rice has ·5 per cent. or less of oil.

Rice bran (koorah) has 22 to 24 per cent. of oil.

The determination of the amount of nitrogen in polished and unpolished rice gave the following results :—

Unpolished rice contained 1·23 per cent. of nitrogen, which equals 7·68 per cent. albuminoids.

Polished rice contained 1·0 per cent. of nitrogen, which equals 6·25 per cent. albuminoids.

It will be seen from this analysis that nitrogen is not concentrated in the outer layers in the same proportion as the phosphorus and oil, but it is distributed throughout the rice grain.

In addition to the chemical analysis the samples of rice at each stage of the process were submitted to histological examination.

The drawing of sections of rice (*vide*) grains shows the results of the histological examination of the rice grains at the different stages of preparation.

Paddy, that is the grains of the rice plant, consists of the fruit enclosed in the paleæ, which constitute the husk. The fruit possesses a thin pericarp firmly adherent to the seed and is either silver-like or varying from dark red to black in colour. At the base of the dorsal edge may be seen the embryo lying in a depression.

After preliminary polishing the whole of the pericarp, much of the aleurone layer, and some starch cells are removed; and after final polishing almost the whole of the aleurone layer with some of the exterior starch cells are removed. The aleurone layers contain nitrogen, phosphoric anhydride, and fat.

Experimental observations on pigeons were made, the animals being fed with different kinds of ' polished ' rice. The results of these experiments will be described shortly.

It will be seen from a consideration of the above results that valuable nutrient constituents are removed from the rice in the process of polishing: and races who depend on rice, as the main source of these food constituents, which are of high physiological importance, must be in a state of unstable nutritional equilibrium; disturbing factors, which will be discussed later may precipitate the phenomena associated with ' starvation ' in respect of these constituents. Amongst the obvious signs of such ' starvation ' are, swelling of the feet and heart trouble, anæmia, polyneuritis, etc. Alteration of the dietary to meet the physiological needs restores the nutritional balance and brings about a disappearance of the phenomena of the disorder and a return to normal.

During the course of the present enquiry a very important fact emerged, namely, that the wheat (ata) consumed by Bengalis is very poor, even poorer than ' polished ' rice in its nutritive constituents. During the course of our house to house enquiry in regard to Epidemic Dropsy we have ascertained that it is the custom to consume a particular kind of fine wheat (ata), and an analysis of this by Mr. Hooper showed that it has a remarkably low phosphorus content. Accordingly samples of wheat were obtained from a well known representative steam mill in Calcutta at every stage of the process of preparation, and these were analysed by Mr. Hooper with the following results:—

Calcutta Mill.	Moisture. %	Ash. %	Phosphoric anhydride. %
Ata (wheat) No. 4 entire grain	11·86	1·13	·59
Ata (wheat) No. 2	11·93	·60	·32
Ata (wheat) B	12·53	·33	·21
Wheat bran	13·33	4·20	2·02
Soojee, small	13·06	·66	·26
„ large	13·00	·60	·22
Flour 3	12·33	·53	·22
„ 2	12·93	·53	·21
„ 1	11·46	·53	·20

It will be seen from this series that in the process of milling in Calcutta the

ata (wheat) is deprived of a large amount of phosphates. The flours, which appear to be fairly constant in composition, contain only $\frac{1}{3}$ of the phosphoric anhydride present in the entire grain.

It is well to bear in mind that the same phenomena may be produced by the habitual consumption of other articles poor in these constituents. Thus Aron and Hocson [1] record their occurrence in a man who was fed on bread and water for 41 and $\frac{2}{3}$ days. Schaumann[2] has produced the lesions in pigs, cats, and rats by feeding them on horse flesh which had been heated in a 20 per cent. solution of sodium carbonate for three hours.

We see, therefore, that the question is an interesting but complex one, and involves difficult problems in metabolism. In the present instance the food, habitually consumed by the person presenting the phenomena of the disorder, is 'polished' rice and to a less extent 'sifted' wheaten flour, and to these attention has to be directed. It is interesting to note in this connection that the number of steam mills for polishing rice have increased in India, especially in Madras, in recent years. It is difficult to obtain exact figures on this point as no note is taken of mills of less than 20 hands in official records.

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[1] *Philippine Journal of Science*, Vol. V, No. 1, February 1910.

[2] Arch. f. Schiffs. U. Trop. Hyg. Beiheft (1909), 13, 82—90.

CHAPTER VI.

Chemical and Histological Examination of samples of Food Grains of the kind consumed by patients suffering from Epidemic Dropsy.

Having seen that by the process of manufacture (milling) rice and wheat are deprived of certain constituents of high physiological value, it became a matter of importance to determine to what extent the rice and wheat partaken of by families who had been affected by Epidemic Dropsy during the recent outbreak in Calcutta had lost these constituents in the process of milling. It may be mentioned the more it has been polished the more elegant the preparation of the rice appears, and it commands a higher price in the market. A beautifully milled sample of rice prepared in England was examined recently chemically and histologically, and was found to have had all the aleurone layer with its constituents removed. Since Epidemic Dropsy presents the features of a nutritional disorder, at first sight it might be thought that it would not attack well-to-do persons, yet as a matter of fact it has affected this class also during the recent outbreak. The explanation of this largely lies in the fact that in paying a higher price for elegant preparations of rice and wheat, articles containing the essential physiological constituents in sufficient quantity are not obtained, and if this deficiency is not compensated for by an adequate addition of suitable ingredients to the dietary a condition of defective nutrition results. It may be stated in general terms that the higher the polishing of the rice the lower will be its content in the essential constituents. Hence in this respect the high-priced, highly-polished rice is more dangerous than the cheap coarser varieties.

During the course of the enquiry houses in which cases of Epidemic Dropsy have occurred are being visited daily to record certain information, and during these visits samples of rice and wheat have been obtained from the inhabitants of the houses. The rice was of the same kind as that used by them during the outbreak of Epidemic Dropsy last year. In this way a number of samples are being collected and submitted to chemical and histological examination. The

results of the analysis of some of these samples of rice are given in the following table :—

No. of sample.	Kind of rice.	Weight of 100 grains.	Moisture. %	Ash. %	Phosphoric acid. %
281	Balam . . .	1·27	12·3	1·1	·43
287	Atap . . .	2·07	13·2	·6	·33
287	Desi . . .	1·69	13·1	·9	·45
296	Balam . . .	1·44	12·8	·7	·43
320	Desi . . .	1·52	13·0	·7	·29
	Barisal . . .	1·82	11·3	1·1	·46
327	Balam . . .	1·42	12·3	1·0	·40
340	Desi . . .	1·41	12·2	·9	·39
348	Desi Pubna . .	1·57	12·2	·9	·34
349	Balam . . .	1·40	12·1	1·0	·42
356	Balam . . .	1·50	12·1	1·0	·46
359	Desi . . .	1·64	12·0	1·0	·45
362	Balam . . .	1·61	12·3	1·3	·46
363	Balam . . .	1·19	12·4	1·0	·44
370	Balam . . .	1·52	11·8	1·0	·48
From Bangalore.	Patna . . .	2·09	13·2	·9	·21

At the same time a histological examination of the grains showed that the phosphorus content varied directly with the amount of removal of the aleurone layers, that is to say, if the chemical analysis of the grain showed a low phosphorus content, as in the last sample of rice in the table, the aleurone layers were found to have been very completely removed, whereas if the phosphorus content was higher it was found that the process of polishing had been less complete. Hence the estimation of the phosphorus serves as a useful indicator of the amount of polishing which the grain has undergone, and, therefore, will have a special value in determining the dietetic value of rices. In addition to the (1) chemical, and (2) histological investigations, (3) the polished rice has been used for feeding pigeons

and fowls experimentally ; the results of these experiments are of great importance and will be dealt with later. It is seen, therefore, that the highly-priced, highly-polished and elegant-looking preparations are largely deprived of essential constituents of high physiologic importance—some samples to a greater, others to a lesser degree. The rice bran (or polishings), called in Bengali koorah, which is removed in the manufacture, contains the necessary constituents in superabundance, and is thus a very valuable food material. This koorah is sold at a comparatively very low price ; a considerable proportion of it being exported from India, and is used as a cheap source of oil. It is also employed for feeding animals.

In addition to rice many of those who were attacked by Epidemic Dropsy consumed ata, wheaten flour, generally at the evening meal. Samples of this fine ata were obtained from the inhabitants of houses in which Epidemic Dropsy had occurred ; the ata was of the same kind as that consumed by them habitually. The samples of ata were very white and highly screened.

The following table gives the results of the analysis of the samples of ata :—

No. of samples of ata.	Moisture. %	Ash. %	Phosphoric anhydride. %
396	12·5	·70	·26
410	13·2	·73	·24
431	12·0	·73	·23
437	13·2	·73	·25
439	12·6	·80	·37
441 (flour) . . .	12·8	·53	·26
441 (ata) . . .	12·8	·53	·22
442 (ata) . . .	12·2	·65	·23
		Average .	·25

Remarks.—It will be seen that the wheaten flour is very starchy and the phosphorus content is remarkably low, even less than the average of the rice (0·40). Such flour is incapable of supplying the nutrient constituents which are defective in the rice.

The composition of the bran (polishings) from rice and wheat has only recently received serious consideration. Jordan, Hart and Patten,[1] Hart, Andrews[2] and

[1] Amer. Journal Physiology (1906), 16, 268. Amer. Chem. Jour. (1904), 37, 564.

[2] Bull. New York. Exp. Stat. (1903), No. 238.

others, have shown that an organic substance containing phosphorus, termed phytin, the calcium magnesium salt of phytic acid, is found therein. Phytic acid or anhydroxymethylendiphosphoric acid was discovered by Postemak[1] as a constituent of green plants. Suzaki, Yoshimura and Takaishi[2] proved that 85 per cent. of the phosphorus in the bran of rice is in the form of phytin. The phosphorus of phytic acid being readily absorbed is a valuable compound to supply phosphorus in a form which can be readily assimilated. Aron[3] has shown that if 100 grams of white rice were extracted with 0·5 per cent. hydrochloric acid a yield of 0·123 grams of soluable P_2O_5 was obtained, whilst if 100 grams red rice were extracted with 0·5 per cent. hydrochloric acid a yield of 0·330 gram of P_2O_5 was obtained. This if equal quantities of rice (unpolished) and white rice (polished) be consumed by different persons the former will ingest nearly three times the quantity of soluable phosphorus compounds that the latter does. Aron[4] is inclined to consider that the important constituent in bran, the non-consumption of which is liable to produce disease, is an organic compound of phosphorus.* It is important to remember in this connection that the metabolism experiments of Clerk and Cook[5] and Aron and Hocson[6] have shown that the addition of organic phosphorus to the diet increases the retention of nitrogen, showing that there is a close connection between nitrogen and phosphorus metabolism in general.[7] Hence this important fact emerges that a diet poor in phosphorus is not only detrimental by depriving the human system of this constituent, but it also operates by reducing the power of retaining nitrogen. Aron and Hocson[8] have brought out a further very interesting point, namely, that a patient suffering from beri-beri in a fairly advanced stage has his capability of utilizing the nitrogen and phosphorus in his food reduced. He, therefore, demands a higher intake of nitrogen and phosphorus than a normal person to attain nitrogen and phosphorus equilibrium. Hence it will be seen that the non-consumption of rice and wheat bran or its equivalent by a normal individual probably brings about the following events :—In the first place the want of bran constituents occasions a disorder of metabolism, one of the signs of which is the inability of the patient to utilize these constituents when supplied,

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[1] Compt. rend. Soc. Biol. (1906), 55, 1190.

[2] Bull. Coll. Agric. Tokyo (1907), 7,495—572.

[3] *Philippine Journal of Science*, Vol. V, No. 1, February 1910.

[4] *Ibid.*

[5] Jour. Biol. Chem. (1909), 59, 405—491.

[6] *Ibid.*

[7] Tunnicliffe. Arch. int. D. Pharm. U. Therap. 12. 1907.

[8] *Ibid.*

* Whilst this Report was passing through the press Fraser and Stanton (*Lancet*, December 17th, 1910) have published important results regarding the essential constituents of rice bran, and by their experiments have disproved the importance of phytin in connection with the production of beri-beri. This paper will be referred to more fully in my second Report.

and the starvation of the tissues is still further accentuated, and this prevents the patient from recovering his nutritional equilibrium.

The Japanese investigators[1] in their study of beri-beri show that nitrogen destruction in that disease is increased. However these problems of metabolism are by no means solved and require further research for their complete elucidation. It must be remembered that although starvation in regard to phosphorus and nitrogen is taking place it may not be sufficient to bring about obvious signs of ill-health, such persons may be merely weak and easily tired. It would be possible to construct a scale, at the one end of which are the slight cases, unrecognisable to the ordinary observer, and at the other, the severe examples of the disorder, with pronounced œdema, heart troubles, etc., which frequently end fatally. Between these extremes all varieties of clinical manifestations occur and the scale of transition between them is extensive. Indeed the complex problem of the influence of nourishment upon general health and muscular power is involved in this consideration. It is certain that the present method of estimating the nutritional value of diet from the amount of proteins, fats, carbohydrates and ash contained in them will require reconsideration, and probably readjustment, in the light of recent research, because this method has been shown to be crude and incapable of showing differences which may be of vital importance to the physiological requirements of the individuals. The action of food poor in phosphorus on young animals has been studied recently by Hart McCallum and Fuller[2] and by Heubner[3] and Lipschutz.[4] The latter has observed nervous symptoms in one of the dogs, and mentions the possible connection of this problem and beri-beri. Aron and Hocson[5] quoting from Tigerstedt,[6] Ehrstrohm,[7] Renvall state that the minimum amount of phosphorus required by the average man in his daily allowance of food is about 3·4 grams P_2O_5 or 0·06 gram per kilo of body weight. It would be interesting to determine for particular races how far this amount of phosphorus can be lowered without detrimental results to the health. Hans Aron, Aron and Hoscon[8] have gone into this question for the Filipinos and they find that, "a diet consisting of bread and rice (both poor in phosphorus), and some fat (bacon) and sugar, furnishing 40 calories, 0·15 gram nitrogen and 0·025 P_2O_5 per kilo body weight does not cover the demands of the body for nitrogen and P_2O_5 and therefore leads to nitrogen and P_2O_5 loss from body." They, also, arrive at the following important conclusions from their metabolism experiments: "(1) It is highly probable

[1] Beri-beri or Kakke. Miura. Ergeb. d. inn. Med. u. kinderheilk (1910. 4. 282—318).

[2] Amer. Jour. Phys., 1908, 23. 246—277.

[3] & [4] Verhandl. 26. Vers. Gesellsch. f. Kinderheilk (1909), 146—161.

[5] *Ibid.*

[6] Handbuch d. Phys. Braunsweig, 1908.

[7] Skand. Arch. f. Phys. (1903), 14·91.

[8] *Ibid.*

that living for an extended period on a one-sided almost exclusively vegetable diet, which is characterised by its poverty in phosphorus and protein, may result in beri-beri. (2) The process of polishing rice removes a fine skin and the outer layers (bran); this rice bran is rich in phosphorus, especially in its organic, soluble form (phytin); the content of phosphorus of the rice is considerably reduced by the removal of the bran. (3) Polished rice, poor in phosphorus, may cause beri-beri in man if it is the main constituent of the food; but it is harmless if sufficient other nourishment, rich in phosphorus and protein is taken. The same polished rice causes a polyneuritis in chickens. White bread, a food of similar chemical composition as regards phosphorus and protein, cannot sustain monkeys in normal health if it forms the entire diet."

CHAPTER VII.

Observations on the effect of Variations in Diet on the mortality from Epidemic Dropsy in Calcutta.

If Epidemic Dropsy has an origin in certain defects in dietary, obviously a very important method of testing the truth of this view would be to place certain groups of individuals on different dietaries, other conditions being constant, the only varying factor being diet. In practice, however, it is almost impossible in a large civil population like that in Calcutta to deliberately arrange such an investigation and enforce its being carried out with the rigor necessary for a scientific observation. Fortunately a careful analysis of the data showed that the population of Calcutta was divided up in a manner very useful for epidemiological observations and provided material for working out the problem; the general conditions approximated closely to the requirements of a definitely planned scientific experiment. The first set of observations to be considered is :—

1. The effect of the addition of meat to a staple rice dietary.

In the course of my enquiry the details of the dietary of cases of Epidemic Dropsy which occurred in the outbreak of 1909 are being recorded. As a large number of cases have been examined daily, a considerable amount of material is at hand for analysis. A careful study of the above data enables us to appreciate the effect on the mortality from Epidemic Dropsy of the addition or non-addition to the diet of certain important articles. Obviously one of the most important is meat.

It is a well known fact that Bengali males take meat fairly frequently : whereas Bengali females seldom consume it; and Bengali widows are not permitted, for religious reasons, to partake of it at all. Hence it will be obvious that these three groups of Bengalis furnished valuable information to enable us to ascertain the effect on the mortality from Epidemic Dropsy amongst Bengalis in Calcutta of the addition or non-addition of meat to the diet.

The results of this investigation have been set out in Chart No. II. The dark portion of the upper columns represents the percentage of meat eaters amongst the cases of Epidemic Dropsy in Bengalis (adult and children). The unshaded portion of the upper column represents the percentage of non-meat eaters amongst cases of Epidemic Dropsy in the same classes. The lower columns represent the percentage of fatal cases of Epidemic Dropsy in these groups.

The exact percentage of Bengalis, males and females, affected with Epidemic Dropsy, who took meat at all, was ascertained. It was known, and was confirmed by our enquiry in each case, that Bengali widows took no meat, their dietary being practically pure rice and ata At the same time the percentage of fatal cases of Epidemic Dropsy amongst those affected was ascertained, also, from our records for all three groups of individuals. The results are given in graphic form in the above Chart. A glance at it will show at once the strikingly close connection be-

tween the death rate from Epidemic Dropsy and the quantity of meat consumed. In the case of the Hindu widows attacked by Epidemic Dropsy who do not consume meat at all the mortality is very high. The females (excluding widows) attacked, who consumed only a little meat, stand next, whilst the male Bengalis who consumed a larger quantity of meat show the lowest mortality from Epidemic Dropsy.

If we turn to the mortality from Epidemic Dropsy in Bengali children under 12 years, male and female, it will be noted that the death rate is approximately the same, and low compared to the death rate amongst females (adult); and this is correlated with the observation made in the course of our investigations that the percentage of meat eaters amongst male and female Bengali children under 12 years is high, and practically equal. This affords further proof of the close relationship between the death rate from Epidemic Dropsy and the quantity of meat consumed, and that sex, *per se*, does not appear to play any part in influencing the mortality.

In Chart No. II the mortality from Epidemic Dropsy amongst male and female Bengali children, and the percentage of these male and female Bengali children, under 12 years, who consumed meat in their dietary, are shown.

The above records are very instructive and indicate clearly the effect on the mortality from Epidemic Dropsy of the addition of meat to a diet. The more ' one-sided ' the diet, as in the case of the Hindu widows, the more severe is the disease. The consumption of the rice and ata is harmful in the case of the widows, because they are the predominating articles of the dietary, the chief sources of supply from which constituents, required to meet the physiological demands of the human system, can be obtained. As we have seen these particular sources cannot meet the demands and hence ' starvation ' with its various manifestations, results. The harmfulness of polished rice is rendered proportionately less, as additional satisfactory sources of supply are added to the dietary. We see, therefore, that the danger in this connection of polished rice and wheaten flour depends on the extent to which they enter into the dietary. In other words the more " one sided" the dietary, the higher the death rate and, *vice versâ*. It is this " one sidedness " of the dietary which plays a very important part in the etiology of Epidemic Dropsy. The problem is a complex one as will be readily understood. It is not easy to say, for example, what precise degree of ' one-sidedness ' of dietary will produce recognisable morbid signs in a previously healthy person. Further, the personal factor will come in also; some individuals will be able to live without showing very obvious signs of disease on a degree of ' one-sidedness ' of dietary, which would cause manifest and perhaps severe symptoms in others: certain factors, *e.g.*, economic conditions, price of food, etc., may expose a larger number of individuals to ' one-sidedness ' in dietary. This problem will be referred to later, in section 9.

The second set of observations, which remains to be discussed, is :—

2. Supplementing and replacing rice by other suitable kinds of grain in the diet.

In the geographical distribution of Epidemic Dropsy in Calcutta we have referred to the interesting and important observation that a group of Hindus (Marwaris) living in the heart of the portion of Calcutta affected by Epidemic Dropsy returned no fatal cases. Obviously, therefore, it was necessary to make careful enquiry regarding the dietary of the Marwaris to see in what respects it differed from that consumed by the Bengalis. This was done, and a chemical analysis of the various articles was made by Mr. Hooper. It was ascertained that the quantity of rice consumed by Marwaris is small, in fact 75 per cent. of them do not take it at all. It is supplemented and replaced by the following articles :—

Ata—Wheat (*Triticum sativum*) } Coarse.
„ —Bajri (*Pennisetum typhoidenm*) }
Besan—Pea flour (*Pisum sativum*)
Dal—Mung (*Phaseolus radiatus*)
Papar prepared from dal.
Kair—Fruit of Capparis aphylla.
Sangar—Pods of Prosopis spicigera.
Gourfali—Cyamopsis psoralicides.
Motha-ka-fali—Pods of Phaseolus.

The last four fruits are obtained from Bikanir and are not ordinarily met with in Calcutta, and these and the Sangar fruits are often eaten in times of scarcity as these trees grow in arid regions. The young pods of Cyamopsis and Phaseolus are particularly nourishing.

The following is the result of the analysis :—

	Moisture. %	Ash. %	Albuminoids. %	Phosphoric acid. %
Wheat	13·7	1·7	12·1	·73
Bajri	11·5	2·5	10·4	·78
Basan	13·8	3·2	23·6	·84
Dal	14·6	3·2	22·2	·95
Papar	18·8	6·5	21·9	·85
Kair	18·5	4·2	16·8	·57
Sangar	16·0	4·1	17·1	·54
Gourfali	18·0	8·1	17·1	·76
Motha-ka-fali	16·0	5·5	20·1	1·10

From the quantity of the articles consumed in the diet the amount of phosphorus taken per day by Marwaris has been calculated as follows :—

		Grains Phosphoric Anhydride.		
Rice	½ to 1 chittak . .	1·8	to	3·6
Wheat ata . . .	7 to 8 „ . .	46	to	52·5
Bajri flour . . .	3 to 4 „ . .	21	to	28
Dal	½ to 2 „ . .	4·3	to	28
Besan	½ chittak . .	3·75	to	3·75
		76·85		115·85

In the same way the amount of phosphorus taken per day by Bengalis has been calculated :—

Diet I.			Phosphoric Anhydride. Grains.
Morning meal . .	Rice . . .	3½ chittaks . .	13·54
	Dal . . .	½ chittak . .	2·49
Evening meal . .	Rice . . .	3 chittaks . .	11·61
	Dal . . .	½ chittak . .	2·49
		Total .	30·13

Diet II.			Phosphoric Anhydride. Grains.
Morning meal . .	Rice . . .	3½ chittaks . .	13·54
	Dal . . .	½ chittak . .	2·49
Evening meal . .	Ata . . .	3 chittaks . .	7·02
	Dal . . .	½ chittak . .	2·49
		Total .	25·54

Diet II is very commonly consumed by Bengalis in Calcutta ; the rice being replaced by ata in the evening meal. It is evident from the above that the total phosphorus content of the food grains composing the Marwari dietary is much higher than that of the Bengalis.

In addition Bengali adult males and children consume meat occasionally, and the beneficial effect of this addition to the dietary has been discussed. The Bengalis, with the exception of widows, partake of a small quantity of fish and vegetables, and sometimes milk.

CHAPTER VIII.

Experimental Researches to note the effect of Feeding Pigeons on various kinds of Rice and Grain.

In 1888 Eijkman[1] observed the occurrence of an epidemic of polyneuritis in Laboratory fowls which resembled beri-beri in many respects. The clinical signs noted were—staggering, often followed by total paralysis, paresis of the wings, dyspnœa and cyanosis, followed by death. The *post-mortem* examination revealed wasting of the muscles and subcutaneous tissue, fluid in the pericardium, degeneration of nerve fibres, but no microscopic nor macroscopic alterations of the brain or of the spinal cord. This was not a microbic disease, but was closely associated with the food of the fowls. The disease always appeared after an incubation period of varying duration (ranging from twenty to thirty days, sometimes more). The polyneuritis could not be caused by a poison present in the rice, because fowls sickened much sooner when fed on boiled rice than when the same variety of grain was given unboiled. Eijkman showed that when the diet consists of rice alone, the appearance of the disease depends on whether the pericarp has been removed. Fowls fed on starch (cakes made of sago meal, pearl tapioca, or the starch of palm tree " *Arenga saccharifera*. Labill ") also suffered from polyneuritis, but they soon recovered exactly as fowls did which had fallen ill by being fed on cleaned rice alone, when subsequently given raw meat.[1] Grijns[2] has carried out feeding experiments on fowls. So, also has Axel Holst.[3] These observers have confirmed the results of Eijkman. Although Eijkman considered that the polyneuritis was due to a definite poison in the rice; Grijns[4] and Holst[5] are of opinion that it is due to the non-consumption of certain essential constituents necessary for physiological requirements. Fraser and Stanton[6] fed some fowls on paddy and some on polished rice. All the former remained healthy whilst six out of 12 in the latter series developed polyneuritis in five weeks. Aron[7] investigated the relationship of the non-consumption of Phytin* to beri-beri by feeding experiments.

It will thus be seen that fowls are very useful experimental animals for the demonstration of the food value of certain grains. Early in my enquiry I commenced feeding experiments on a number of different kinds of animals to ascertain

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[1] Polyneuritis by hœnderen. Genees. Tyds. V. Ned. Ind. (1890), 30 : (1893) 32 and (1896) 36.

[1] De Haan. *Philippine Journal of Science*, Vol. V, No. I, February 1910.

[2] Over Polyneuritis gallinarum I en II. Genees. Tyds. V. Ned. Ind. (1900). 41 and (1909) 49.

[3] Journal. Hyg. (1907)

[4] *Ibid.*

[5] *Ibid.*

[6] Studies from Institute for Medical Research, F. M. S., 1909.

[7] *Philippine Journal of Science*, Vol. V., No. I, February 1910.

* *Vide* footnote, page 11.

which would be most suitable for my purpose. After testing a number, *e.g.*, rabbits, guinea pigs, cats, rats, monkeys, pigeons and fowls, I decide to use pigeons and fowls for the experimental investigations. I had large cages constructed consisting of a wooden frame closed by wire netting. The floor is of wood. The cages are cleaned out; carefully washed with a solution of Lysol ; and fresh, clean sand sprinkled on the floor daily. The cages are placed in an open veranda. The birds have plenty of space and fresh air. Thus during the experiment they are placed under the best hygienic conditions. A measured quantity of the particular grain is given to the birds twice daily. They are supplied with water. Each bird is weighed weekly. The precautions taken are necessary to avoid complicating factors entering into the observations and so rendering the results uncertain.

Feeding Experiments (Bengal Rice).

The Bengal rice selected for experiment was a sample received from Khulna. It was chosen because it had been sent to the Medical College for examination on account of Epidemic Dropsy being prevalent at the time in the district. This rice was given raw to healthy pigeons, 30 grms. per pigeon daily. No other food was allowed.

The weekly weight of the pigeons, the duration of the feeding experiments, and the presence or absence of neuritis are shown in graphic form in Chart No. III.

It will be seen from this experiment that all the pigeons fed on this rice lost weight. They developed signs of polyneuritis : when this occurred the animal was killed to obtain the nerves in a fresh condition. Both sciatic nerves were carefully dissected out to their finest terminations and placed in a solution of Osmic acid,—pressure and stretching being avoided. The nerves were passed through alcohol and clove oil, in which they were carefully teased out and examined under the microscope.

In each case we conclusively proved by microscopic examination that the bird had polyneuritis.

The chemical analysis of the rice on which these pigeons were fed gave the following results :—

Water.	Ash.	P O	N.	Protein.	Weight of 100 grains of the rice in grammes.
10·2	·85	·43	1·45	9·06	2·45

The histological examination of the rice grains showed that they had been polished.

Feeding Experiments (Rangoon Rice).

(1). *Unboiled rice.*—The Rangoon (Burmah) rice selected for experiment was purchased in Calcutta. This rice was given unboiled in this experiment to healthy pigeons, 30 grms. per pigeon daily. No other food was allowed.

The weekly weight of the pigeons fed on Burmah rice, the duration of the feeding experiments, and the presence or absence of neuritis are shown in graphic form in Chart No. III.

The drawing at the end of this report shows a well marked degeneration of the fibres of the sciatic nerve of one of these pigeons.

The chemical analysis of the rice on which these pigeons were fed gave the following results :—

Water.	Ash.	P_2O_5	N.	Protein.	Weight of 100 grains of the rice in grammes.
10·2	·63	·36	1·23	7·68	2·06

A histological examination of the rice showed that it had been polished, the pericarp and sub-pericarp layers having been completely removed.

Feeding Experiments (Rangoon Rice).

(2). *Boiled rice.*—In order to determine whether or not the neuritis could be prevented by submitting the rice to high temperature, the same Burmah rice as was used in the above experiment was submitted to a temperature of 100°C for one hour. This boiled rice was given to healthy pigeons, 30 grammes per pigeon daily. No other food was allowed.

The weekly weight of the pigeons fed on boiled Burmah rice, the duration of the feeding experiment, and the presence or absence of neuritis are shown in graphic form in Chart No. III.

For chemical analysis of the rice see the previous experiment.

It will be seen from these experiments that boiling has no effect at all in preventing the occurrence of neuritis in pigeons. This is an important point because the prolonged heating would destroy moulds, poisons in the rice, etc., which have been erroneously assumed to be the cause of the neuritis of fowls.

Feeding Experiment (Control).

Wheat, Pulses, Barley.—In order to observe the effect of feeding pigeons on other grains than rice an experiment was carried out with the following mixture :—

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

The pulses were—Pigeon pea, Ahrar (*Cajanus indicus*), Green mung (*Phaseolus radiatus*). 30 grammes of this mixture were given to each pigeon daily. No additional food was allowed. The conditions otherwise were precisely the same as in the rice experiment.

The weekly weight of the pigeons, the duration of the feeding experiments, and the presence or absence of neuritis are shown in graphic form in Chart No. III.

The chemical analysis of the ingredients of the mixture on which these pigeons were fed gave the following results :—

Constituent of diet.	Water. %	Ash. %	Phosphoric acid. %
1. Wheat, large	13·7	2·1	·74
2. Wheat, small	14·1	2·0	·85
3. Barley, husked	13·4	1·3	·67
4. Pigeon pea, Arhar.	16·6	4·0	·80
5. Green mung dal	11·3	4·3	1·16

The analysis of the mixture used for feeding gave the following results on analysis :—

Water. %	Ash. %	Phosphoric acid. %
12·8	2·7	·76

The above feeding experiments are very instructive and throw a considerable amount of light on the problem. In the rice feeding experiments all the pigeons lost weight progressively, and all developed signs of polyneuritis and were killed in order to obtain a fresh undecomposed preparation of the nerves for histological examination, as *post-mortem* changes in the nerves set in very rapidly in this climate, and to avoid this the animals were killed when the signs of polyneuritis were marked, and the nerves were removed with as little delay as possible. The analysis of the rice shows that the phosphorus content is about the same as that in the milled rice partaken of by the Bengalis attacked with Epidemic Dropsy. In striking contrast to the rice experiments are the feeding experiments with wheat, and pulses; none of the pigeons on wheat-pulses have lost weight, in fact they have rather gained, and none of them have developed neuritis. The wheat and pulse experiments, as will be seen, have been going on for some months, and the pigeons are quite healthy. Further, the results of the chemical analysis of

the rice and wheat-pulse diets are very interesting and important. The wheat-pulse diet shows a high phosphorus content, in fact about double that of the rice diets. It will be seen that one of its constituents, Mung dal, is particularly rich in phosphorus, containing 1·17 of phosphoric anhydride, whilst Burma rice contained only 0·36. The chemical and experimental results therefore agree. These diets imitate approximately the food consumed by the Bengalis and Marwaris, respectively. In the former rice is the staple, whilst in the latter, as already described, wheat-pulses largely supplement or entirely replace rice. As we have observed the Marwaris had immunity from Epidemic Dropsy during the outbreak in Calcutta in 1909, and we have an experimental explanation of this immunity from the feeding experiments on pigeons.

These feeding experiments prove that an exclusive diet of polished rice, which is poor in essential constituents, is unable to meet the physiological requirements, and signs of starvation result, but that a diet of wheat and pulses, containing these constituents in abundance, is capable of meeting all the physiological demands, and the animals remain well.

CHAPTER IX.

The Causation of Periodicity in Outbreaks of Epidemic Dropsy.

A noteworthy feature in the history of this disease in Bengal and other places has been a certain periodicity. Thus the outbreak of the disease in 1877-78-79 in Calcutta and Bengal was followed by an interval of quiescence and the next severe recurrence was the recent epidemic of 1907-08-09. The disorder is probably never entirely absent during the interval. Rogers[1] observed a few cases of Epidemic Dropsy in Calcutta in 1901. Delany[2] in his Report on Epidemic Dropsy in Eastern Bengal and Assam considers that it is quite probable that the disease has remained in the Sylhet District for 30 years, since the epidemic of 1878-79. In 1902 in Bombay I observed a limited number of cases of this disease.

The problem to settle, however, is the cause of the occurrence of severe outbreaks at particular periods. I am engaged at present in collecting evidence to ascertain the factor or factors likely to bring about this periodicity. I may state that so far as my researches go I have observed that there is a remarkably close relationship between the price of food grains and the prevalence of Epidemic Dropsy. Thus the severe and extensive outbreak of 1877-78-79 was preceded by the great famine of 1876—1878, which was, "In respect of the area and population affected and the duration and intensity of the distress, the most grievous calamity of its kind experienced by British India since the beginning of the century."[3] The price of food was very high in Madras,[4] Bengal[5] and elsewhere during this period. With the drop in price in 1880 the epidemic disappeared.

A study of the price of food grains in India shows that in 1906 a sharp rise in the price of rice and other grains in Bengal occurred, the point touched being higher than in any previous year since 1880. In 1907 the price of rice in Bengal was still higher, and in 1908, the highest level so far recorded in the present series was reached.[6] The commencement of this rise is followed by the recent (1907-08-09) extensive and severe outbreak of Epidemic Dropsy in Bengal. It is noteworthy that no severe epidemic of the disease has been reported so far (October 1910) this year, and this became more significant when it was observed that it was correlated with a decided drop in the price of food grains in 1909, and in the present year 1910 a further lowering of prices may be expected. These facts are of considerable importance in relation to the explanation of the occurrence of periodic extensive

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[1] Fevers in the Tropics, 1910.

[2] Report on the investigation into the causation of Beri-beri in jails of Eastern Bengal and Assam.

[3] Report of the Indian Famine Commission, Pt. I, 1880.

[4] Madras Administration Report, 1878-79.

[5] McLeod, *Indian Medical Gazette*, 1894.

[6] *Prices and Wages*, compiled in office of Director-General, Commercial Intelligence, India, 26th issue, 1909.

outbreaks of Epidemic Dropsy affecting wide areas. When taken in conjunction with the fact that all the evidence obtained points to Epidemic Dropsy being a nutritional disease dependent on defects in dietary, the relationship becomes all the more striking. It would appear, therefore, that economic factors, *e.g.*, price of food grains, play an important part in determining the periodic character of the severe outbreaks of Epidemic Dropsy. It will be readily understood that such a far-reaching factor as the price of food grains must affect directly or indirectly a very considerable number of people, some more, some less, severely.

Chart No. IV at the end of this Report[1] shows the variations from the mean of the average retail price of rice in Bengal for each year from 1885 to 1909, and the occurrence or non-occurrence of extensive outbreaks of Epidemic Dropsy from 1885 to 1909 in Bengal.

Through the kindness of the Director-General of Commercial Intelligence I have obtained the necessary figures and have prepared a chart showing the fluctuations in the price of rice from 1875 to 1883, that is to say, a period before, during, and after the severe and extensive outbreak of Epidemic Dropsy in 1877-78-79 in Calcutta and Bengal.

Chart No. V shows the variations from the mean of the average retail price of rice in Bengal for each year from 1875 to 1883, and the occurrence or non-occurrence of extensive outbreaks of Epidemic Dropsy in Calcutta and Bengal during that period.

From a study of Charts Nos. IV and V it will be seen that the two occasions, in a space of thirty years, on which Calcutta and Bengal were affected by severe outbreaks of Epidemic Dropsy, *viz.*, in 1877-78-79, and 1907-08-09, synchronised with a period of high price of food. The fact that this has occurred twice in the history of this disease in Calcutta strengthens the view that the occurrence of extensive outbreaks of Epidemic Dropsy in Calcutta and Bengal is determined by an increase of the price of food grains.

The cessation of the epidemic phase of the malady is observed to be associated with a fall in the price of food grains, and during the period of quiescence the price is at or below the mean. It is interesting to read in an editorial note in the *Indian Medical Gazette* of May 1st, 1880, that, " Beri-beri has died out in Calcutta as the hot weather advanced. It is feared that it will re-appear at the close of the next rains as in the three preceding years, most probably extending its area of prevalence." Fortunately this forecast by the Editor (Colonel McLeod) did not prove correct. The interest of the above statement, however, lies in the fact that in 1880 a marked drop in the price of food grains occurred in Bengal as Chart No. VI shows.

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[1] Figures obtained for the preparation of this Chart from *Prices and Wages* compiled in office of Director-General of Commercial Intelligence, India, 20th issue, 1909.

Chart No. VI shows the variations from the mean of the average retail prices of rice in Bengal for 1878-79-80 and the occurrence or non-occurrence of extensive outbreaks of Epidemic Dropsy from 1878 to 1881 in Bengal.

From the foregoing it will be seen that the probable explanation of the cause of the periodic recurrences in Bengal of Epidemic Dropsy is, that, from the nature of the Bengali dietary, a condition of 'nutritional instability,' if the phrase be permitted, exists in those consuming it, and, in ordinary conditions, no very obvious signs are apparent by which it can be recognised; but when a severe strain, *e. g.*, famine prices for food grains, which is far-reaching in its effect, is superadded the 'nutritional balance' of a varying percentage of the population is upset and this breakdown manifests itself amongst the 'nutritionally unstable,' by various unmistakable signs, which from their severe character, direct attention forcibly to the condition. When the strain is removed by the drop in price of food grains the nutritional balance adjusts itself more or less correctly and the epidemic ceases; this is illustrated by the course of the two severe outbreaks of Epidemic Dropsy in Bengal.

There are many interesting points connected with this question. For example the amount of rise in price of food grains necessary to determine these outbreaks. From a study of the Chart No. IV the character of this rise during the last outbreak is illustrated. It is high and sustained over several years. It is probable that it is the combination of these two conditions, *viz.*, the high level and the maintenance of this elevation for two or more years which is the determining factor in causing the outbreak. It is probable that a rise for a single year is insufficient to produce an epidemic: thus it will be observed that there was a sharp rise in price of food grains in 1897, but in the next year a fall below the mean occurred. It will be noted that the character of the price curve for 1906-07-08-09 is a sustained high level for a considerable period, a similar character of the curve has not been observed since the last severe famine of 1877—1879; no severe outbreaks of Epidemic Dropsy were recorded between these periods.

By studying such a curve of food prices a forecast of the possibility of Epidemic Dropsy occurring amongst the 'nutritionally unstable' at a particular period might be made with fair accuracy.

CHAPTER X.

The Prevention and Treatment of Epidemic Dropsy.

In the present Report it is proposed only to mention shortly the lines on which preventive measures should proceed. When the work, which is now in progress, is complete, further details may be available. It will be already obvious from the results of the investigation that as the disease is brought about by a 'one-sidedness' in dietary, the aim of prevention should be to remove this defect. In the Bengali diet the researches have shown that this 'one-sidedness' is due to the habitual consumption of articles of food, *viz.*, 'polished' rice and wheaten flour deficient in essential constituents,—the latter being more defective than the former. The following indicate in general terms the possible methods of improving the nutritional value of the dietary, (1) by using unpolished food grains, (2) by the addition to the dietary of the rice and wheat bran removed in the cleaning process, (3) by diminishing considerably the quantity of polished grains consumed and supplementing or replacing them by an adequate quantity of other suitable food grains rich in the required constituents. Of food grains the Mung dal (*Phaseolus radiatus*) is the richest in the ingredients. The addition of fresh meat to the dietary is clearly shown to be of high value as a prophylactic: even when consumed occasionally it had the effect of greatly reducing the mortality from the disease. If consumed more regularly still better results might be expected.

It may be interesting to record the views of that careful observer Chevers in regard to the prevention of the disease which he named "Morbus Bengalensis," and to which reference has already been made. In his Presidential address to the Bengal Social Science Association on February 1870 he says: "I consider that the only valid remedy for the Morbus Bengalensis, as well as the only means of enabling the Bengali to withstand the marsh poison of his country until he shall have driven out the malaria by bringing his rice-swamps into dry cultivation, is *the introduction into Bengal of a higher staple of food.*"[1]

In the treatment of persons actually suffering from Epidemic Dropsy it has to be remembered that probably their capability of utilising the essential constituents in the food is reduced, and the patients, therefore, demand a higher intake of these constituents to attain physiological equilibrium. Hence in the treatment of cases it is necessary to bear this in mind. It is possible that at certain stages of the disease the capability of utilizing the essential ingredients may be lost entirely.

Probably success in treatment would be attained by the addition of a considerable quantity of fresh meat to the diet. Also the addition of the *Phaseolus radiatus*, especially in the pods, would be clearly indicated. At the same time the quantity of polished food grains should be very considerably restricted or

[1] Chevers: Diseases of India. Page 569, Churchill 1886.

withheld altogether. The sifted rice bran which has been shown to prevent the disease in animals should be given. It is an inexpensive preparation which could be generally used, and would be most valuable both in the treatment and prevention of Epidemic Dropsy.

The present method of estimating diets will require further investigation and research. It is doubtful whether the determination of the quantity of proteins, fats, carbohydrates and ash gives sufficient information to enable us to distinguish differences in diets which may be of extreme importance for the physiological requirements.

A much larger problem in the prevention of Epidemic Dropsy opens out, namely, how to obviate a continued rise in in the price of food grains. If this factor could be eliminated probably the extensive and severe outbreaks of the disease might be prevented. This question is, of course, beyond the scope of my investigation. I understand, however, that a special investigation on the subject of *prices* is being held at present under the Finance Department of the Government of India, and the Report of this enquiry will be looked forward to with interest in connection with the eradication of Epidemic Dropsy.

APPENDIX.

Forms on which information obtained in the house to house enquiry is recorded.

Epidemic Dropsy Enquiry Form $\frac{A.}{No.}$

GENERAL.

Record of examination of inmates and house No.——— in———————
———————————Street———Ward———District.

Date of examination———————————

Reference $\frac{B}{Nos.}$———————

Total No. of inmates (*a*) adults (male and female)———————————
(*b*) children (male and female)————————No. of servants (male and female)
———————————No. of families in house————Food and cooking
arrangements of families (separate or common)———————————Food and
cooking arrangements of servants (separate or common, nature of food taken)
———————————————————————————————

Inmates recently arrived, number, date, previous address, ———————————
———————————————————————————————

Communication between families (intimate or slight) ———————————

Total No. of cases of Epidemic Dropsy in house (*a*) adults (male and female)
———————————(*b*) children (male and female up to 12)————
No. of cases of Epidemic Dropsy in house at present (*a*) adults (male and female)
———————————(*b*) children (male and female)———————Fatal
cases———————— No. of cases of Epidemic Dropsy which have left house
(*a*) adults (male and female)———————(*b*) children (male and female)——
————Present address———————————————Fatal cases—
———————No. of cases among servants———————— No. of cases
among recently arrived ———————————————————————
If more than one family in house state incidence of cases in each————
———————————————————————————————

Month and year of onset of first case and month or months in which subsequent
cases occurred and in which fatal cases occurred———————————
———————————————————————————————
———————————————————————————————
———————————————————————————————
———————————————————————————————

General sanitation (poor, fair, good or excellent)———————————
Additional notes ———————————.

Epidemic Dropsy Enquiry Form $\frac{B.}{No.}$

SPECIAL.

Record of examination of case in No. ———————————————
———————————————Street———— Ward———— District

Date of examination———————————

Reference $\frac{V.}{Nos.}$ ———————

Name———————age———————sex————Married, single, widow or widower———————Occupation———————Caste, religion, habits ———————————Date of onset of disease————Date of recovery or death———————— Still suffering————————

Symptoms and date of onset

Gastro-intestinal disturbance (diarrhœa, etc.)———————————

Œdema (position)———————————————————

Fever (temperature)———————————

Eruptions (mottling over œdematous parts, petechiæ, etc.)———————————

Cardiac (pain, palpitation dyspnœa, bruit, etc.)———————————————

Nervous system (K. J., tenderness of calf, muscles, etc.) ———————————
———————————————Relapses (No. and date) ————
———————————Emaciation ———————————————

Diet—

Rice————kind————new or old———— Quantity taken per day (*a*) before illness———————(*b*) during illness ———————

Where purchased———————Do other inmates of the house take this rice (*a*) healthy———————(*b*) sick ————Do servants take this rice———————

Mustard oil———————quantity per day (*a*) before illness———————
———————(*b*) during illness———————Where purchased ———————————Do other inmates of the house take this oil (*a*) healthy ———————(*b*) sick———————Do servants take it———————

Fish————kind————quantity per day (*a*) before illness ————(*b*) during illness———————

Other articles of diet ———————————————————

Cooking arrangements (common or separate) ———————————

Additional remarks and notes———————————————

Result of Examination.

Date.

ŒDEMATOUS.

Specimen taken of _____	BLOOD.						URINE.	FÆCES.
	R.B.C.	H.B. %	W.B.C.	P.N.	S.M.	L.M.E.	culture.	
_____								
_____								
_____								

47

Map of Calcutta.

Showing.

Distribution of Fatal Cases of Epidemic Dropsy in 1909.

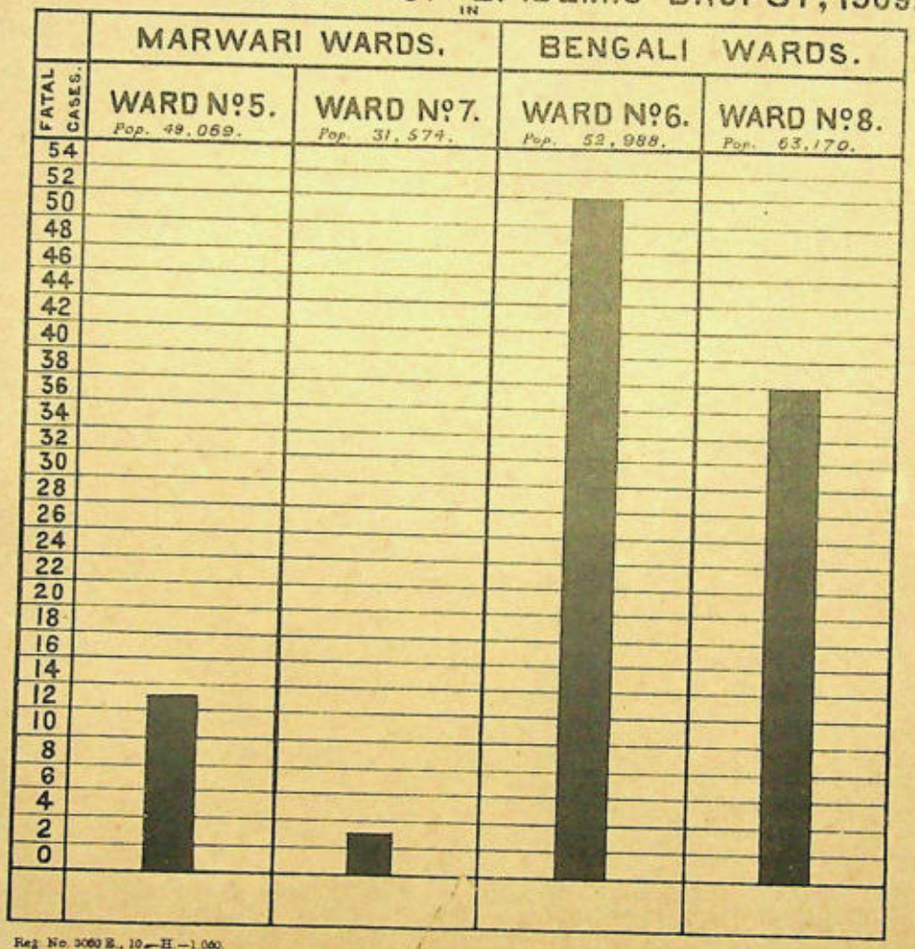
Thick line encloses Wards No 5 and 7 = Marwari Quarter.

Interrupted thick line encloses Wards No 15, 16, and 17 = European Quarter.

Each black dot represents a fatal case of Epidemic Dropsy.

CHART I.

FATAL CASES OF EPIDEMIC DROPSY, 1909. IN



Reg. No. 3060 E., 10.—H.—1,000.

Sections of Rice Grains.

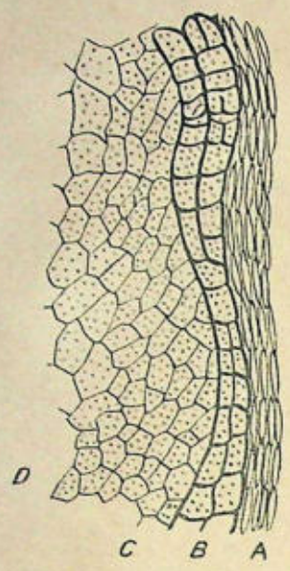


Fig. I.

Section of a Rice grain (caryopsis) before Polishing with only husk removed.

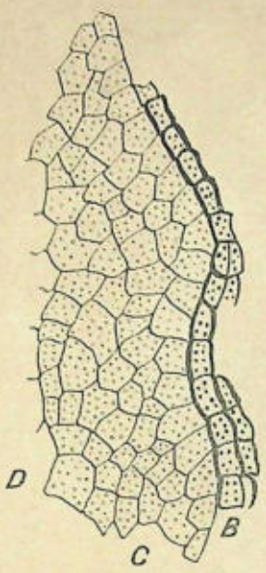


Fig. II.

Section of a Rice grain after first Polishing.

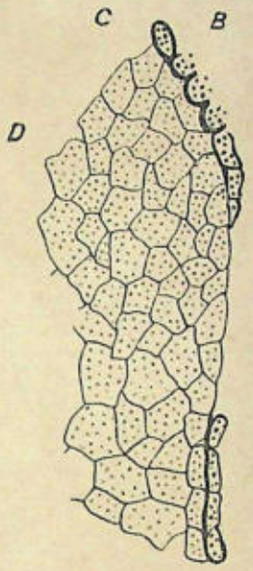


Fig. III.

Section of a Rice grain after final Polishing.

A.— Pericarp and Seed-coat composed of tabular cells.

B.— Fat and aleurone layers.

C.— Starch-cells at the periphery containing starch granules and a little proteid.

D.— Starch-cells in the interior containing starch granules but hardly any proteid (as indicated by the Xanthoproteic test).

B, C and D = Endosperm.

CHART II.

SHOWING THE PERCENTAGE OF MEAT EATERS AMONGST BENGALI ADULTS .E AND FEMALE), WIDOWS, CHILDREN (MALE AND FEMALE) AND MORTALITY FROM .DEMIC DROPSY IN EACH CASE.

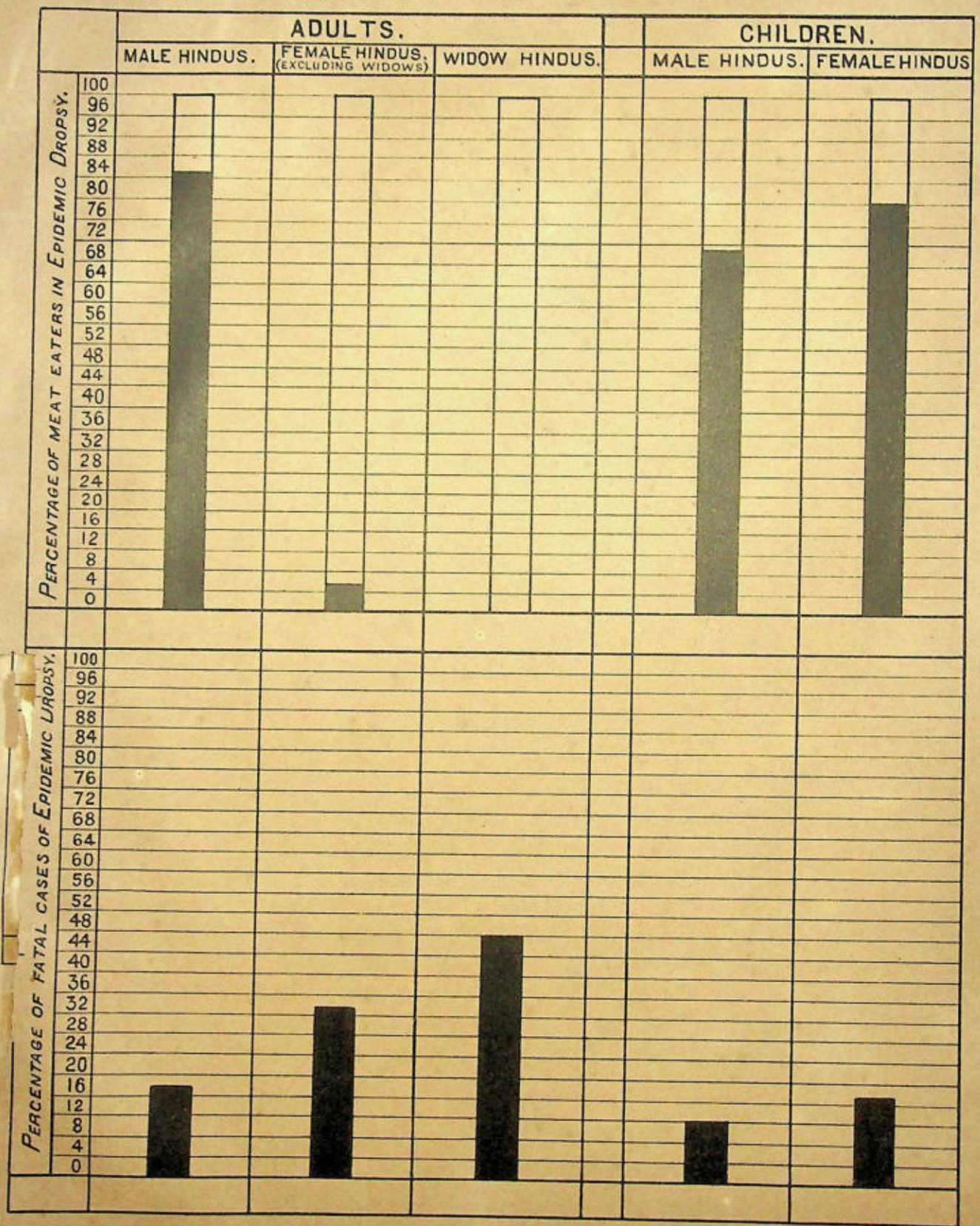
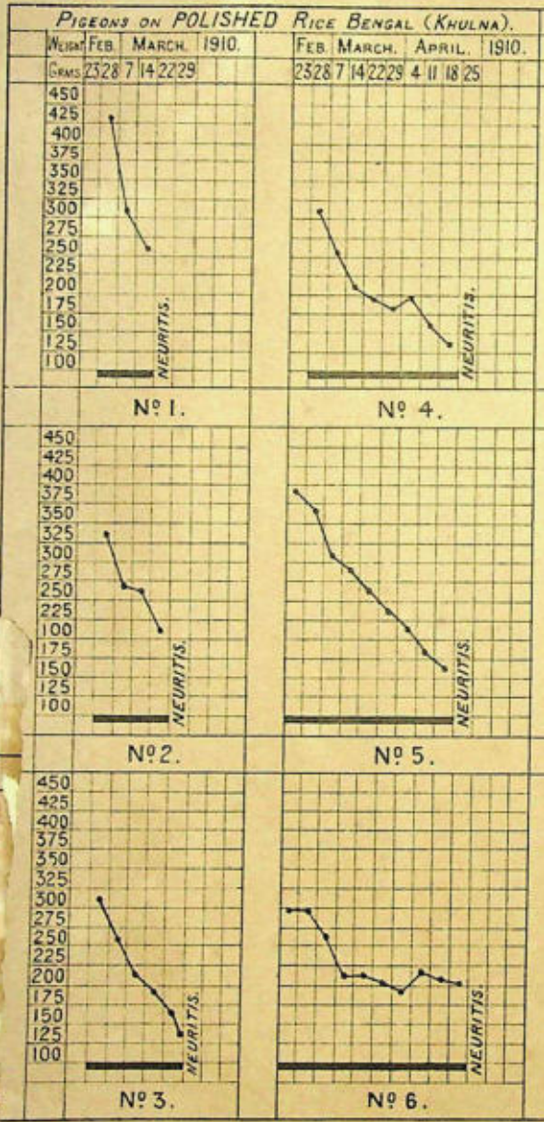


CHART III.

1

EXPERIMENT II.

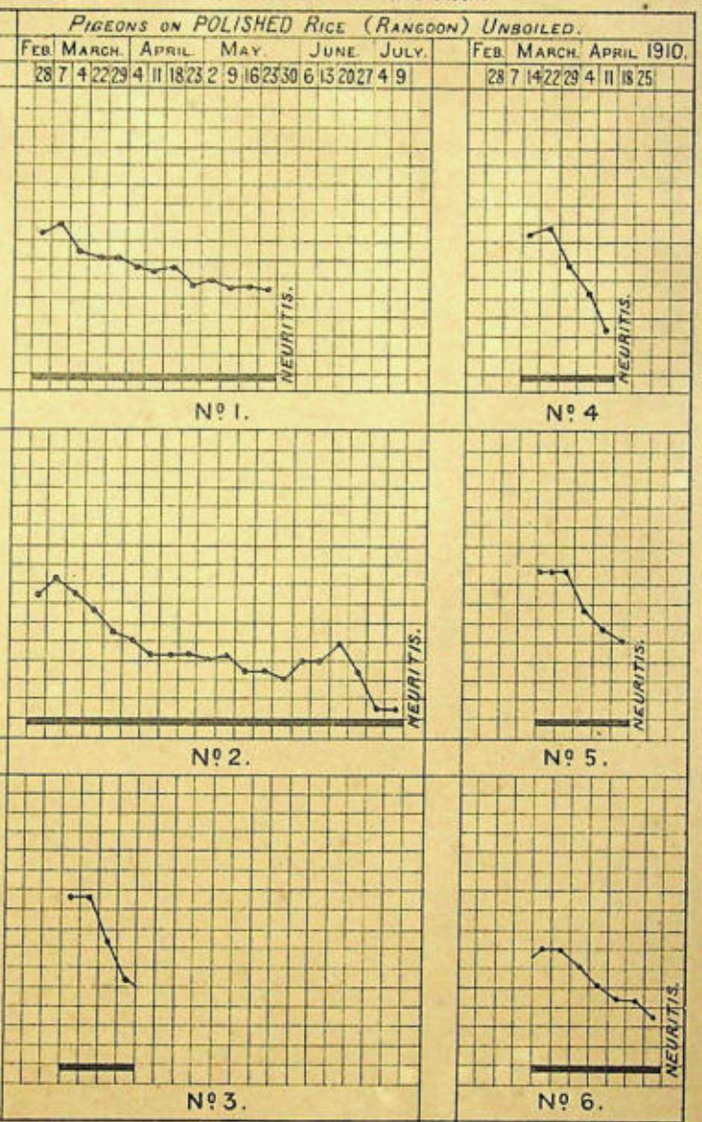
PIGEONS ON POLISHED RICE BENGAL (KHULNA).



2.

EXPERIMENT XI AND XXII.

PIGEONS ON POLISHED RICE (RANGOON) UNBOILED.



——— THIN CONTINUOUS LINES SHOW THE WEIGHT OF PIGEONS IN GRAMMES FED ON POLISHED RICE.

------ " DOTTED " " " " " WHEAT & PULSES (CONTROLS).

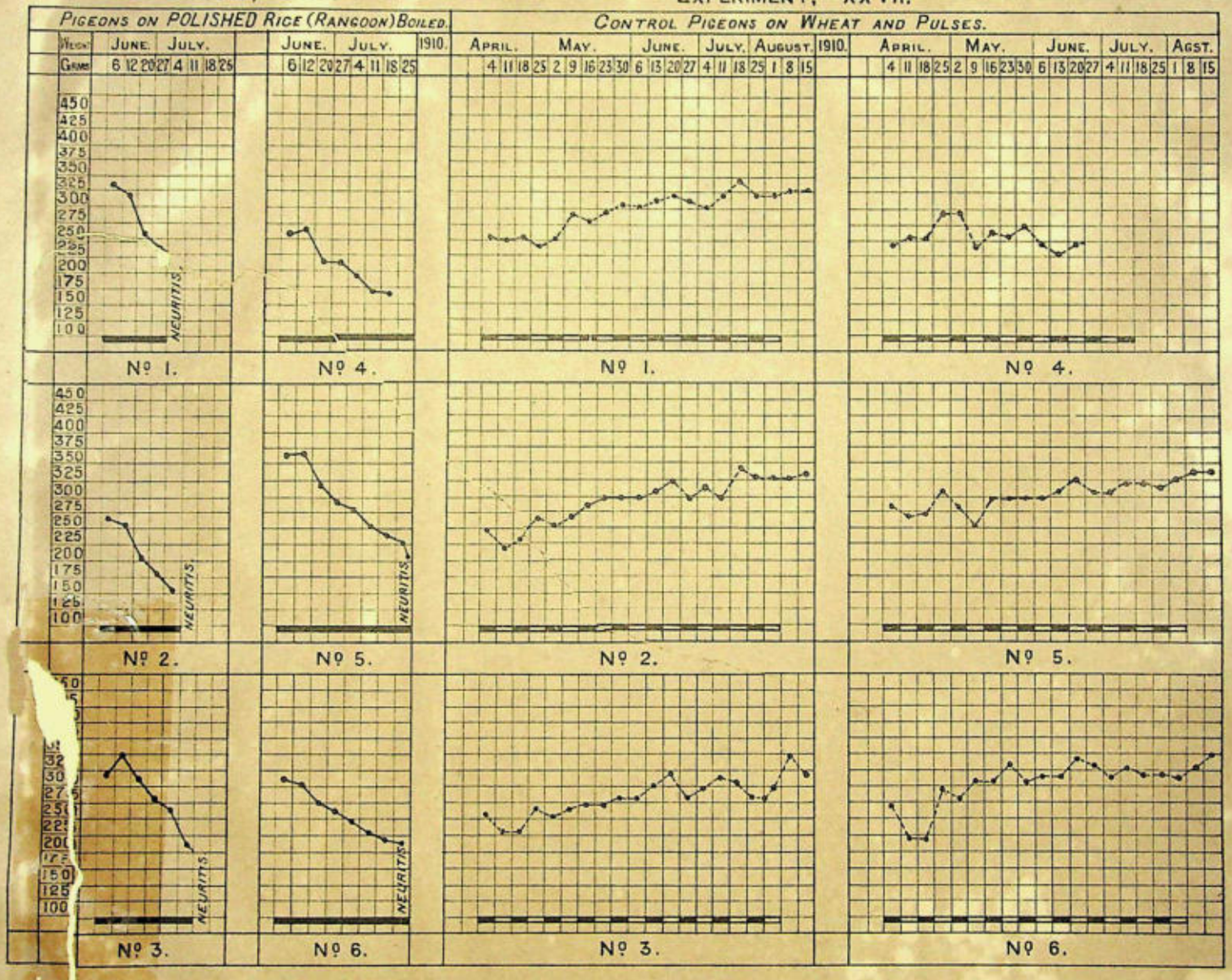
▬▬ THICK COTINUOUS LINES SHOW THE PERIOD THE PIGEONS WERE FED ON POLISHED RICE.

▬ ▬ " DOTTED " " " " " WHEAT & PULSES (CONTROLS).

CHART III. CONTINUED.

3. EXPERIMENT, XXII.

4. EXPERIMENT, XXVII.



——— THIN CONTINUOUS LINES SHOW THE WEIGHT OF PIGEONS IN GRAMMES FED ON POLISHED RICE.

- - - - - - THIN DOTTED " " " " " " " " " " WHEAT AND PULSES (CONTROLS).

▬▬▬ THICK CONTINUOUS LINES SHOW THE PERIOD THE PIGEONS WERE FED ON POLISHED RICE.

▬ ▬ ▬ " DOTTED " " " " " " " " " " WHEAT AND PULSES (CONTROLS).

Experiment XXII.

Pigeon Fed On Polished Rangoon Rice.
Sciatic Nerve Showing Degenerative Changes in Fibres.

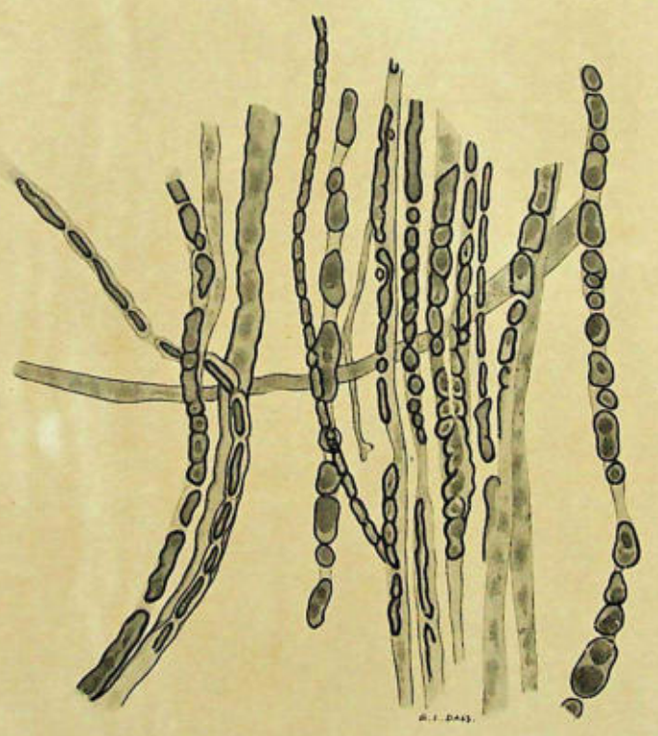
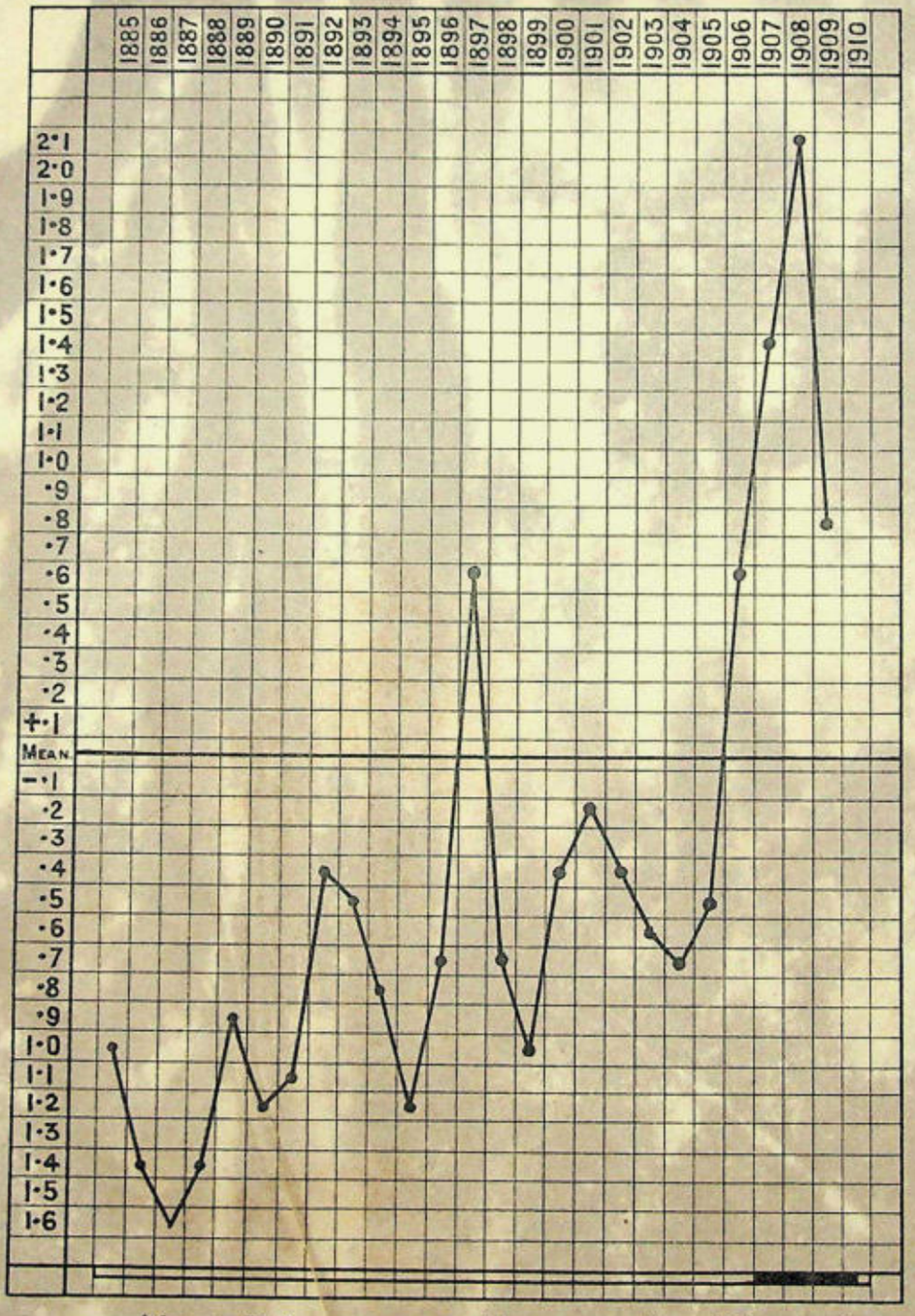


Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta. 1911.

CHART IV.

Shows the variations from the mean of the average retail price of Rice in Bengal during the period from 1885–1909 and its relation to Epidemic Dropsy in Bengal.



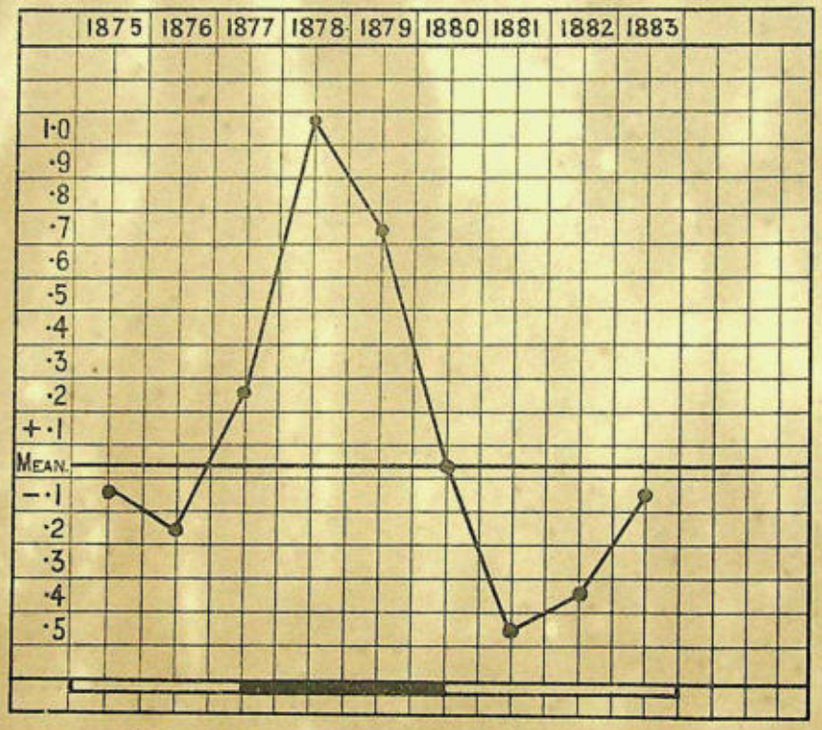
Mean = 3·5 rupees per Maund of Rice (Common).

▭ *Period during which no Extensive out-break of Epidemic Dropsy occurred in Bengal.*

▬ *Period during which Extensive out-break of Epidemic Dropsy occurred in Bengal.*

CHART V.

Shows the variations from the mean average retail price of Rice in Bengal during the period from 1875-1883, and its relation to Epidemic Dropsy in Bengal.



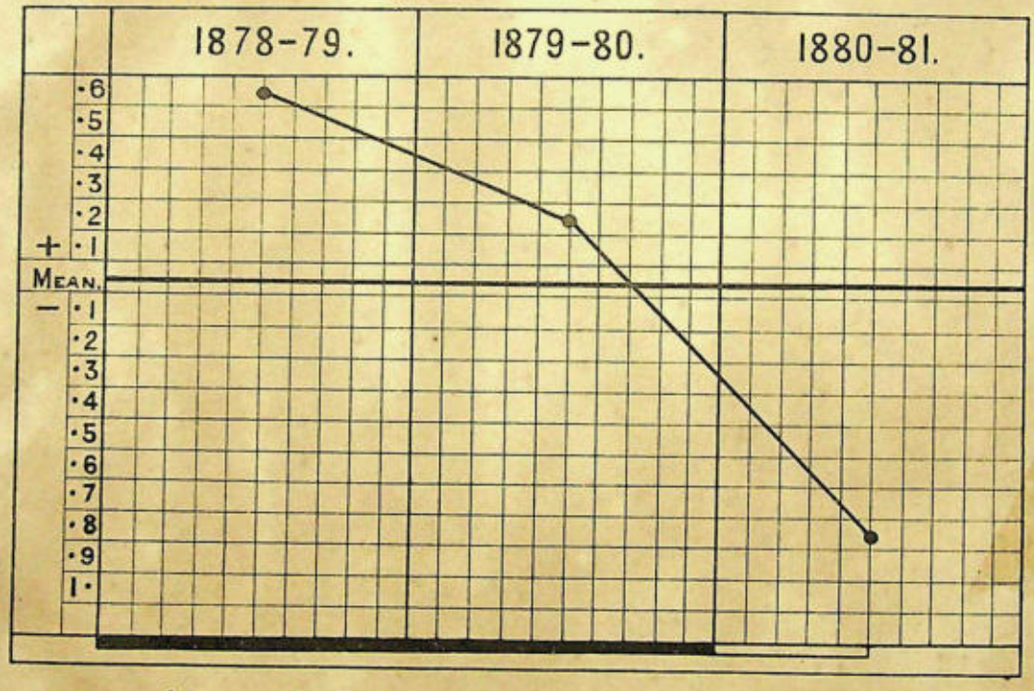
Mean 2·0 Rupees per Maund of Rice.

Period during which no extensive out-break of Epidemic Dropsy occurred in Bengal.

Period during which extensive out-break of Epidemic Dropsy occurred in Bengal.

CHART VI.

SHOWS THE VARIATIONS FROM THE MEAN AVERAGE RETAIL PRICE OF RICE IN BENGAL DURING THE PERIOD FROM 1878–80, AND ITS RELATION TO EPIDEMIC DROPSY IN BENGAL.



MEAN = 2·5 RUPEE PER MAUND OF RICE (COMMON).

PERIOD DURING WHICH EXTENSIVE OUT-BREAK OF EPIDEMIC DROPSY OCCURRED IN BENGAL.

" " " NO " " " " " "