

THE NATURE OF BERI-BERI.

AN ETIOLOGICAL STUDY AMONG CHINESE PRISONERS
IN SHANGHAI.

(One Figure.)

BY ARTHUR STANLEY, M.D., B.S. (LOND.), D.P.H.

Health Officer of Shanghai.

SHANGHAI is situate in the sub-tropical zone and has a climate of wide variation of temperature, but is broadly tropical during the summer quarter and temperate for the rest of the year. Lying on the alluvial flat of the Yangke delta the conditions of soil and sub-soil are uniform in all parts of the Settlement. The ground water-level is about five feet below the surface.

As a rule beri-beri becomes prevalent at the end of the summer, and is in Shanghai an autumn disease, though a few cases may occur throughout the year (see chart of seasonal prevalence).

The following observations extend from 1898 until the present time, and include 500 cases of beri-beri under my own care at the Shanghai Municipal Isolation Hospital. The cases were furnished by the Chinese prisoners under municipal supervision, incarcerated in the Gaol and in cells at three police-stations completely isolated from each other as regards situation and staff. Each of these places furnished numerous cases of beri-beri, the incidence being of approximately the same degree but greatest where the length of incarceration of the prisoners was most prolonged, namely, at the Gaol. The cases were furnished almost entirely by prisoners undergoing sentences of one month and over: of these 14% developed the disease, and broadly the tendency to acquire it was greater in proportion to the length of sentence. In many of the prisoners with sentences of two or more years the disease recurred each autumn. Each of the prisons is separated by a wall from a dense native population, but in this respect the isolation of one of them—the Gaol—is more complete than that of the others.

The conditions under which the prisoners live as regards ventilation, cleanliness, exercise, and food, are as a rule better than prior to incarceration. In the Gaol two prisoners sleep in a cell, and at the police-stations about a dozen sleep together in a much larger cell. Notwithstanding this propinquity whereby disease could easily be

CASES OF BERI-BERI ADMITTED INTO MUNICIPAL ISOLATION HOSPITAL.

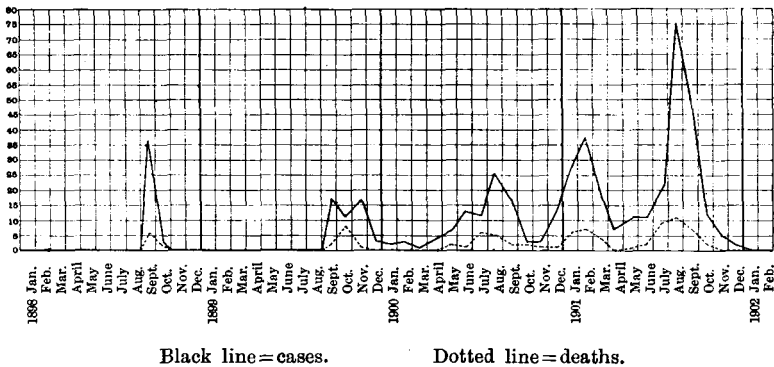


CHART SHOWING SEASONAL INCIDENCE WITH MAXIMUM AT END OF SUMMER.

propagated by contagion, beri-beri has been the only prevalent disease, and, with the exception of contagious impetigo due to lice, there was remarkably little disease other than beri-beri. Signs of beri-beri were rarely detected among the prisoners on admission, and the majority of cases developed the disease a month or more after incarceration.

GENERAL INCIDENCE OF BERI-BERI AMONG MUNICIPAL PRISONERS, 1898—1901

Total municipal prisoners	50,000
Prisoners with sentence of one month and over (these prisoners furnished all the cases of beri-beri)	3,430
Cases of beri-beri	480
Incidence of beri-beri on all prisoners	1 ⁰ / ₁₀₀
Incidence of beri-beri on long sentence prisoners (<i>i.e.</i> with sentence of one month and upward)	14 ⁰ / ₁₀₀
Deaths from beri-beri	98
Case-fatality	20 ⁰ / ₁₀₀

DISTRIBUTION OF BERI-BERI AMONG PRISONERS

		Gaol	Station No. 1	Station No. 2	Station No. 3	Total
1898	Prisoners undergoing sentence of one month and over	Not yet opened	346	187	188	721
	Cases of beri-beri		15	19	6	40
	Deaths from beri-beri		2	6	2	10
1899	Prisoners undergoing sentence of one month and over	235	342	266	403	1,246
	Cases of beri-beri	27	3	5	13	48
	Deaths from beri-beri	7	1	2	1	11
1900	Prisoners undergoing sentence of one month and over	210	313	221	179	923
	Cases of beri-beri	34	53	55	7	149
	Deaths from beri-beri	12	12	10	0	34
1901	Prisoners undergoing sentence of one month and over	192	170	91	87	540
	Cases of beri-beri	134	60	30	19	243
	Deaths from beri-beri	18	11	13	1	43
Total prisoners furnishing cases		637	1,171	765	857	3,430
Total cases of beri-beri		195	131	109	45	480
Total deaths from beri-beri		37	26	31	4	98

PREVIOUS OCCUPATION OF PRISONERS SUFFERING FROM BERI-BERI

Coolies	158	Grocers	4	Ginseng seller	1
Boatmen	56	Coppersmiths	4	Merchant	1
Ricscha men	16	Masons	4	Tea-shop keeper	1
Carpenters	15	Fish sellers	4	Tin maker	1
Tailors	15	Sailors	3	Pawnshop broker	1
Soldiers	11	Wine sellers	3	News reporter	1
Barbers	10	Police constables	3	Farmer	1
Mafoos	10	Quartermasters	2	Hotel-man	1
Cooks	10	Tea merchants	2	Goldsmith	1
Blacksmiths	9	Teachers	2	Earthenware dealer	1
Painters	8	Tobacco dealers	2	Fish congee seller	1
'Boys'	8	Yamen runners	2	Gardener	1
Rice dealers	8	Chinese doctors	2	Filature coolie	1
Opium merchants	7	Meat sellers	2	Silk dealer	1
Professional thieves	7	Detectives	2	Scholar	1
Shroffs	5	Servants	2	Hot water seller	1
Shoemakers	5	Washermen	2	Lime maker	1
Detectives	5	Money-changers	2	Bookseller	1
Medicine sellers	4	Shopkeepers	2	Type picker	1
Brass smiths	4	Cotton-mill worker	1	Fan dealer	1
Bankers	4	Earthenware maker	1		

This table tends to show that beri-beri is not associated with any particular trade or occupation.

Comparative Prevalence in Gaols etc. outside Shanghai.

In the Singapore Gaols⁽¹⁾ in 1900 the incidence of beri-beri among a total number of 4,390 prisoners was 5·1%. In the Straits Lunatic Asylum half the total mortality was caused by beri-beri. In the Japanese Navy and in Japanese Gaols⁽²⁾ the percentage of cases of beri-beri varied from 10 to 30% previous to 1884. At the Hong Kong Gaol⁽³⁾ during 1900 out of a total number of 5,432 prisoners there were but 5 cases of beri-beri. Among the 110,016 prisoners in the whole of the Gaols of India⁽⁴⁾ during 1900 there were but 18 cases of beri-beri and 2 deaths. The maximum incidence of beri-beri is in Japan, but it is also very prevalent in the Malay Archipelago, and the Dutch East Indies. There is no beri-beri in the Gaols of England, though it has been claimed that an isolated outbreak has occurred at the Richmond Lunatic Asylum in Ireland.

Prevalence of Beri-beri in Shanghai, especially in other Institutions where Chinese are aggregated.

That the incidence of beri-beri among the Chinese public in Shanghai is not so great as among municipal prisoners is clear. Were the outside public to die from beri-beri at the same rate as the muni-

cipal prisoners do, there would be 17,500 deaths annually from this cause alone, while the total number of deaths for the year is under 5,000 from all causes. There is therefore an exceptional incidence of the disease among the municipal prisoners. The total number of deaths from beri-beri among the Chinese population in Shanghai from January to August 1901 given by the Chinese Death Register was 58, but little reliance can be placed on the accuracy of these figures. To determine the actual general prevalence of the disease the native institutions of Shanghai, where Chinese are aggregated, were visited.

Gaol under control of the Chinese authorities in the walled city of Shanghai. There were 70 prisoners here at the end of August, 9 of whom presented obvious signs of beri-beri. The prisoners lived under comparatively healthy conditions; each prisoner occupying one cell with windows of paper, which in the summer was allowed to wear away, so that day and night were spent in the open air. There was no deficiency of ventilation or light, and the prisoners looked comfortable. In fine weather they worked outside, making match-boxes. The food given in no way differed from that of an ordinary Chinese coolie, consisting of about 1½ lbs. of rice daily, with cooked vegetables, fish, and seasonings.

Refuge under Chinese management for sick and aged. Here was an aggregation of some 300 starvelings, maniacs, lepers, and aged of both sexes. About 10% showed obvious signs of beri-beri. Ventilation and light were ample and the inmates were comfortably cared for.

Orphanage for Chinese, under control of Catholic Mission. This was visited in the autumn of 1900 and a large number of severe cases of beri-beri were found among the Chinese girls educated in it. The girls appeared to have every care and were provided with good food, but their bedrooms were overcrowded and badly ventilated.

Licensed Chinese prostitutes. No case of beri-beri was met with among some 250 licensed Chinese prostitutes who have been examined weekly for three years. These women may be taken as affording an instance of life among the general population, *i.e.* non-institutional life.

Medical men in practice locally among the Chinese rarely see cases of beri-beri among the better class of the general population. Cases however occasionally present themselves at the two native hospitals, but the prevalence is manifestly very much less among the Chinese public than among those aggregated in institutions.

Beri-beri therefore is chiefly found in Shanghai where the natives are aggregated together for long periods of time.

*The Causation of Beri-beri.**General Considerations.*

The essential to prevention is a knowledge of the cause. With regard to beri-beri this knowledge is still conspicuously absent. Cantlie (1901) in the article on beri-beri in *Allchin's Medicine*, says: 'The cause of beri-beri has not yet been ascertained.' My own work up to the present time has been to some extent disappointing; the conclusions arrived at rather eliminating negative than establishing positive points. It is however of considerable value to discover with certainty what is not the cause, both for conserving energy in preventive measures, and as a means of being finally led into the way of truth. In spite of the fact that the cause of beri-beri may be considered to be as yet unknown, the question may still be asked—What determines the exceptional incidence of the disease among municipal prisoners in Shanghai? Why should beri-beri be more common in native institutions than among the general population?

Possible Infection in Beri-beri.

If the disease were communicable it would have every opportunity for spreading among the prisoners in the Gaol and police cells. But practically all observers of beri-beri are at one in considering infection a negligible danger. There can be no doubt, however, that beri-beri is apt to be an institutional disease, which favours the conclusion that infection may after all play a part in its spread. In this respect it may be regarded as analogous to diphtheria, which may be limited to individual houses; but when there is aggregation of susceptible units, as in a school, the disease may spread rapidly. The infection here only becomes obvious where there is aggregation of susceptible units.

The Gaol and Police-stations are inhabited by a series of individuals any one of whom may introduce the cause. The criminal class is more likely to be infected than any other. There is therefore a greater probability of these places becoming infected than any ordinary dwelling-house inhabited by one family, which is a unit more or less isolated. This applies to all similar institutions where there is an aggregation of changing units. The length of sojourn of the prisoners, especially the longer term prisoners of the Gaol, is also in favour of development of a disease like beri-beri, which has a prolonged incubation period.

The evidence usually adduced of the absence of infection in beri-beri is afforded chiefly by the fact that hospital assistants do not contract the disease from the patients. The infection may however require intimate and prolonged contact or the infection may be conveyed by parasites—bugs, fleas and lice—which are most common among the criminal class.

The Isolation Hospital furnishes strong evidence against mosquitoes propagating the disease. No case of beri-beri has arisen among the sick prostitutes, who are kept in wards contiguous to the beri-beri wards. Moreover mosquitoes, especially *Culex fatigans* and also *Anopheles sinensis*, are very numerous at the Isolation Hospital.

With regard to lice it is the rule to find the pigmentation of the skin and pustular impetigo, which is associated with body lice—so called 'Vagrant's disease.' Here therefore is an adequate means of conveying infection from one to another, especially when more than one prisoner sleeps in the same cell.

Beri-beri and Locality.

The Gaol and the three Police-stations, more or less widely separated from each other, were nearly equally affected with beri-beri. The fact that these were nearly equally affected by the disease practically eliminates the idea of miasma of limited localisation. Moreover at the Police-stations numbers of European and Indian police reside, among whom no case of beri-beri has arisen. The cause of the disease therefore does not directly arise either from the site or its immediate surroundings. It does not therefore arise directly from the soil.

Beri-beri and Food.

Rice was found to be the only food common to all the Police-stations. The Gaol source was however a different one. The remaining articles of food—fresh and salt vegetables, fish, pork and oil—were obtained from different sources.

Rice was the suspected article of food inasmuch as other cereals, e.g. rye and maize, when infected by a fungus, may cause symptoms of poisoning analogous to beri-beri,—ergotism or pellagra. The rice used at the various stations was examined and found to be of very poor quality, weevilly, and with a distinct mouldy smell.

In order to ascertain whether this inferior rice was a cause of the

disease it was recommended that a common supply of rice of a recognised good quality be obtained. With this object an excellent quality of rice was obtained from Annam—long-grained rice—at \$5³⁰ a picul. The mouldy rice then in use cost \$4⁶⁰ a picul. 100 piculs of this Annam rice was purchased and stored at the Central Station in a concrete cell, which is sometimes used for foreign prisoners. All openings of this cell were closed and the atmosphere was kept dry and pure by means of numerous open jars of chloride of lime, round which the sacks of rice were piled. This supply of rice was distributed every three days to the Gaol and Police-stations from the beginning of August until well into November. In view of the long incubation period however no diminution of cases was expected or occurred in August. Toward the end of September however the cases diminished markedly in number, and in October the disease almost ceased. But this may also be explained by seasonal diminution, beri-beri in Shanghai being essentially a disease of late summer and early autumn. (See chart of seasonal incidence.) The results of the rice experiment were therefore probably negative. Annam rice was used rather because its long grains were easy to identify and one could make certain that it was actually being used. Annam is by no means free from beri-beri. In fact, in practically all rice-producing countries beri-beri is prevalent, so that the possibility of rice carrying the infection can with difficulty be eliminated. The conditions of the experiment therefore preclude any definite conclusions.

The history of beri-beri in the Japanese Navy, Army, and Prisons, is interesting, inasmuch as in Japan it is firmly believed that the nature of the diet rather than any definite infective agent is the cause of beri-beri. The Japanese claim to have reduced the prevalence of beri-beri from 20% to 1% by a change of diet from almost exclusively rice to one containing rice in a comparatively small quantity; the deficit being made up by wheat, barley, beans, and meat, *i.e.*, by a diet of more albuminous and fatty character⁽²⁾.

In the prisons of Japan the daily allowance of rice was 750 grammes with some poor auxiliary food, costing 1 to 1.5 sen per head per day. In 1875 the prisoners were allowed barley also, and in 1881 the proportion of barley to rice was as 6:4. Since this change was made beri-beri is said to have become rare. The experiment was repeated in the Japanese Army, with the result that the number of cases occurring there was reduced to 1%.

On account of a short crop in Japan in 1899 rice imported from China was used for the prisoners of Nugata, and from January to

March 400 out of 1000 prisoners had beri-beri. It is said that those supplied with 'white Chinese rice' were more affected than those supplied with 'red Chinese rice.'

In Corea, where the Japanese and Coreans live side by side, the Japanese commonly have beri-beri, while it occurs only very rarely among Coreans. The Corean houses are small, dark and dirty, but the inhabitants feed chiefly on peas and do not eat rice as the Japanese do. Beri-beri is common in Brazil, where rice is the staple food.

It is held by the Japanese that beri-beri always prevails where rice is the principal food of the nation. Beri-beri however is very much less prevalent in India than in Japan.

In the Straits Settlements the Tamils are very slightly affected by beri-beri, while the incidence among the Chinese and Malays is marked. Rice is the staple food of each, but the Tamil decorticates his rice after cooking, while the Chinese and Malays eat rice which has been husked up to a year or more previous to use⁽⁸⁾.

The theory that beri-beri is due to the use of food, insufficient or unsuitable, but not specifically contaminated does not explain the seasonal variation of the disease. Nor is it likely that beri-beri, which is essentially a peripheral neuritis, a pathological condition usually associated with toxæmia, would be caused merely by insufficiency of food were this in itself wholesome. Should however the rice be specifically contaminated it is conceivable that the replacement by uncontaminated food, whether of another variety or not, would stop the disease.

The Japanese explain the excessive prevalence in summer by the appetite desiring the plainer foods, such as rice, to the exclusion of more albuminous and fatty foods. The excessive prevalence in barracks, gaols and other crowded places they assign to the food being given regardless of the choice of the individual with a consequent increase in the quantity of rice. The Japanese view regarding the causation of beri-beri is not generally accepted. Still it is quite probable that a diminution in the rice consumed may actually be the cause of a diminution of beri-beri: the reason being that rice, although unable of itself to produce the disease may yet carry its specific contagium. Beri-beri is quite prominently a Japanese disease. This being so it has been thought proper to adopt the Japanese method of stopping it, and it is at the present time being applied at the Municipal Gaol. About half the ration of rice is replaced by beans and crushed wheat or barley. Inasmuch as the change was instituted when cases of beri-beri naturally decline in number, another year must elapse before any conclusion can

be drawn. It may be said however that since the change of diet was made no fresh cases of beri-beri have arisen.

BERI-BERI IN THE JAPANESE NAVY.

Year	Cases of beri-beri per 100 of Navy		Grammes
1878	32.8	Food ration during these years was	Rice 782
1879	38.9		Fish 96
1880	34.8		Beef 73
1881	25.0		Pickled vegetables 145
1882	40.4		Fresh vegetables 215
1883	23.1		Sugar 18
1884	12.74		Bean sauce 60

The ration was here changed for a more albuminous and fatty one.

1885	0.59	Food ration during these years was	Rice (or 600 bread or 490 biscuits) 648
1886	0.04		Fish 150
1887	0.0		Fresh vegetables 450
1888	0.0		Milk 45
1889	0.03		Sugar 75
1890	0.04		Meat 300
1891	0.01		Bean sauce 50
1892	0.03		Flour (wheat) 75
1893	0.01		Beans 15
1894	0.26		Pickled vegetables 75
1895	0.13		Fat 15
1896	0.08		Salt 8
1897	0.14		Tea and vinegar
1898	0.08	Saké 90	

Experimental Work.

Bacteriological Examination of the Blood in Beri-beri.—Thirty cases, where the symptoms were well-marked and in stages both before and after loss of knee-jerks, were examined. A band being placed round the arm to distend the veins, the bend of the elbow was sterilised by 10% lysol in strong alcohol repeatedly rubbed in for half-an-hour and then washed with ether. The needle of a sterile all-metal syringe was plunged into the median cephalic vein and 1 c.c. of blood withdrawn. This blood was examined under the microscope directly and also stained with methylene blue with a negative result. Tubes of peptone bouillon, gelatin, agar and blood serum were inoculated with two or three drops of blood in each: deep stabs in glucose-agar were also made. Beyond the adventitious inoculation by *Staphylococcus aureus* and *M. tetragenus* respectively, of two out of 150 tubes incubated all remained sterile.

Six rabbits were injected subcutaneously with 1 c.c. of blood from six well-marked cases of beri-beri but nothing resulted.

Diet experiments.—We have seen (p. 376) that the exclusive use of

Annam rice for three months by all the prisoners caused no reduction of cases other than would be explained by seasonal variation.

Storage of rice.—The grain in the husk keeps for two or three years with comparatively little care, but when decorticated greater delicacy is necessary to preserve the grain intact. Granaries for decorticated rice are usually raised well above ground, the rice being stored in large hollow baskets so as to avoid damp, and sometimes the ash of the burnt husk is used to scatter among the grains as an antiseptic. Before being sold in the market the rice undergoes, besides decortication, a pounding with wooden hammers, which makes it white by bruising the outer coat of the grain, fracturing also the pointed end: by this process the outside of the grain becomes coated with floury matter, and it is this which is washed away during the process of 'washing the rice,' which is invariably done immediately before cooking by placing the rice in a fine wicker basket and immersing and rinsing it several times in water. There is apparently no definite reason why this should be done, for good starch in large quantities is thus wasted; and this among a wonderfully thrifty people like the Chinese is remarkable. It is interesting to trace the evolution of these methods of treating rice. The processes of preserving and treating the rice grain, which in China have been arrived at through a period of domestic evolution of some thousands of years, point to the use of methods now recognised to be antiseptic and having for their object the preservation of the grain from vegetable parasites, e.g. retention of the husk as long as possible, dry storage, use of ash as an antiseptic, detrition of the outer layer of the decorticated grain and subsequent washing away of the detritus, and finally sterilising by prolonged boiling during cooking. In this way the rice is preserved from parasites and their products, and before being consumed it is thoroughly sterilised. It is therefore possible only to introduce with the rice into the human body the products of an organism which may have established itself in the grain, much as ergot of rye or maize infected with *pellagra* or beans with *lupinosis*.

Rice used by Chinese prisoners furnishing the present series of cases.—The rice was found to be old rice of a cheap quality with a distinct mouldy smell. There were the usual proportions present of red and blue grains found in most local samples of rice. Rough bacteriological examination yielded nothing distinctive as to flora.

Five mice were fed with the unboiled rice for a period of two months without effect.

Six guinea-pigs were fed with the boiled rice for two months without result.

An aqueous extract, made by boiling and concentrating to small bulk, was injected weekly for three weeks into four rabbits with no ultimate result.

Alcoholic and glycerin extracts were also made and injected into rabbits without anything noteworthy happening.

CONCLUSIONS.

1. The incidence of beri-beri in Shanghai on Chinese prisoners under municipal police supervision is markedly greater than on the general public.

2. The incidence in four widely separated prisons completely isolated in every respect was of approximately the same degree. In none of these places were the European and Indian staff affected though they resided in the same compound with the prisoners. The cause of the disease therefore does not arise either from the soil or its immediate surroundings.

3. The simultaneous incidence at the Gaol and Police-stations would point rather to a general cause than to place infection; but would also be explained by diffuse infection among the native community generally; a case admitted to aggregations of susceptible units as in Gaol and police cells spreading by contagion (intimate contact).

4. The figures show a progressive development of infectivity of beri-beri on all the four places where municipal prisoners are aggregated.

5. The fact that beri-beri mainly occurs among natives aggregated for periods of over one month favours the idea of its propagation by contagion. Given the presence of the infective agent, whether conveyed in food or by parasites or by contagion, its operation would be favoured by aggregation of potentially infective units.

6. Inasmuch as, apart from rice, the food supply of three out of the four prisons was from different sources and a change of rice for all the prisons to one of recognised good quality produced no well-marked effect on the prevalence of the disease in two months, food infection would appear not to be a factor in the cause.

7. Beri-beri being a peripheral neuritis, which is a pathological condition usually associated with toxæmia, food would in the absence of a primary lesion (as in diphtheria) seem specially indicated as a cause. For the same reason the cause would be met with in specifically contaminated food rather than in either qualitative or quantitative changes in diet.

8. The marked and apparently primary degenerative action of beri-

beri on heart muscle like that produced by diphtheria⁽⁶⁾ and to a less degree by influenza and alcohol and arsenic poisoning, all of which may also cause peripheral neuritis, and the remarkable clinical resemblance of beri-beri to diphtheria in the frequency of death from sudden heart failure would indicate a form of chronic poisoning⁽⁶⁾.

9. The identity of the pathological changes in beri-beri, diphtheria, and arsenic and alcohol poisoning and the grouping of alcoholic poisoning with ergotism, pellagra, and lathyrism, which are caused by poisons produced by parasites in vegetable foods, suggest the possibility of the cause of beri-beri being a toxine derived from an extraneous parasite of some article of food.

10. In the outbreak in Richmond Asylum, Ireland, which is held to disprove the rice origin of the disease, it is impossible to eliminate from the diet such articles as rice, tapioca, sago, etc. which may have been derived from countries in which beri-beri is prevalent. Beri-beri appears to be markedly prevalent only in countries where rice is the staple food.

11. The oft-repeated statement that a beri-beri patient recovers quickly when removed to a fresh locality may not indicate that this disease is a place infection, but rather that the source of the toxine may be removed by change of residence.

12. Beri-beri does not appear to be associated with any particular trade or occupation.

13. Something more is required for the prevention of beri-beri than attention to the general rules of sanitation, such as ventilation, cleanliness and diet. Moreover isolation of cases as they arise, followed by disinfection, does not suffice to limit the disease.

14. The maximum incidence of beri-beri in Shanghai being at the end of the tropical summer (the remainder of the year being quite temperate) the liability to recurrence yearly at this season in the same patient would be compatible with the elaboration of a toxine favoured in its origin by the period of maximum atmospheric heat and moisture.

15. The blood in beri-beri is sterile.

16. The bacteria found by Pekelharing and Winkler⁽⁷⁾ associated with beri-beri bear no causal relation to the disease.

REFERENCES. (1) Ann. Rep. Health Officer of Singapore, 1900. (2) *Sei. I. Kawai*, Vol. xx., Nos. 4 and 5. (3) Ann. San. Rep. Hong Kong, 1900. (4) Ann. Rep. San. Comm. India, 1900. (5) *Metrop. Asylums Bd. Rep.*, 1897, p. 180. (6) *Journ. Trop. Med.*, Sept. 1st, 1901. (7) PEKELHARING AND WINKLER. 'Beri-beri,' 1888. (8) BRADDON. *Med. Arch. Fed. Malay States*, 1900.