"SIAM RICE"
as a factor in the EtiologyofBERI-BERI.

Thesis for the degree of M.D.

by

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CHAPTER I.

INTRODUCTION.

Beri-Beri is a disease of world wide distribution; its great endemic centre being in the Malay Peninsula, the Malay Archipelago, and the adjacent countries of Burma and Siam.

In the native medical literature of Siam, Beri-Beri as a sporadic disease has been recognised for over a 100 years, some of the symptoms described and various forms of treatment advised. It is there called by the name "Nep Char", ("Nep" meaning tingling and "Char" numbness.)

It is only within the last thirty years, however, that Beri-Beri has spread through the whole tropical and subtropical world in epidemic form till it has now become one of the most important hygienic problems to the various Governments in those parts of the Globe.

The specific cause and method of propagation have caused endless discussion and each year some new theory is published accounting for this disease.

Many different varieties of Parasites have been impeached; from the lowest forms/
forms of Schizomycetes and Blastomycetes ascending through the scale of animal life as high as the Hexapoda or insects, including the orders, Siphunculata, Hemiptera and Pediculi. Some observers state that Beri-Beri is due to the absence of some essential chemical component required by the body for the performance of its natural functions, such as, fats, nitrogen, organic phosphorus and nucleo-proteids. But none of these theories have as yet been generally recognised as the cause of this most puzzling disease.

The theories most prominent in the last three years and which have gained most acceptance are those which start from the initial standpoint that the consumption of rice is an important if not an essential factor in the causation of Beri-Beri. For the disease is to all intents and purposes limited to those countries where rice is the staple form of diet, though a few cases are very occasionally reported from various parts of the world in which rice is not eaten.

It has been noticed by many observers among whom may be mentioned Braddon, Fraser and Stanton; Eijkmann and Vorderman in Java and Hans Aron and Felix Hocson in Manilla that, given a rice eating people/
people and Beri-Beri prevalent - this disease does not occur equally amongst all classes of the community - Tamils who only eat parboiled rice are totally exempted and also those natives such as Malays who hand-mill their own rice. That there is no racial immunity amongst Tamils or Malays is proved by their getting Beri-Beri when in gaol and so placed on the same food as other natives, such as Chinese; and yet the Tamils are the worst paid members of the community so cannot afford to augment their diet with more expensive forms of meat to any marked degree.

In Siam, I have noticed the same class immunity holds good, and that Beri-Beri bears a direct relation to the cost of rice; being limited entirely to the poorer classes, except on those few occasions when some of the richer class have by circumstances been forced to consume this cheaper quality of rice.

Beri-Beri in Siam is chiefly seen in those who compose the criminal classes; that is, amongst those who work sporadically and prefer to loaf if they possibly can. Hunter and Koch in Hongkong have come to the same conclusion, namely, that the moneyed classes are practically, if not entirely, immured from/
**Chart 1.**

Price of Hospital-based Pen Ore Admissions for Pen Ore for Kuala Lumpur, 1892, 1893, 1894, 1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904.

- **Pen Ore per Ton, in Sterling:**
  - 150: 1000
  - 140: 900
  - 130: 800
  - 120: 100
  - 110: 10
  - 100: 50
  - 90: 100
  - 80: 300
  - 70: 200
  - 60: 100
  - 0: 0

**Number of cases of Bari-Bari in Selangor Hospitals, in 1890's:**

**Number of cases of Bari-Bari in Selangor Prison, Kuala Lumpur, in 1900's:**

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**Chart II.**

Price for Admissions to Selangor Hospitals for Bari-Bari in Dollars, Kuala Lumpur, 1892-1904.

- 90: 9000
- 80: 8000
- 70: 7000
- 60: 6000
- 50: 5000
- 40: 4000
- 30: 3000
- 20: 2000
- 10: 1000
- 0: 0

**Price of Pen Ore per Pekul in Dollar Silver:**

- 150: 1000
- 140: 900
- 130: 800
- 120: 100
- 110: 10
- 100: 50
- 90: 100
- 80: 300
- 70: 200
- 60: 100
- 0: 0

**Admissions to Selangor Hospitals for Bari-Bari:**

**Admissions to Prison Hospital, Kuala Lumpur, for Bari-Bari:**

---

Note: The production of tin more than doubled between 1894 and 1896, and labour (Chinese) was flocking to the country. In 1897, 1898, and 1899 the production diminished but has since steadily risen, though, as the price is higher, deeper mines are now worked, and more labour per ton of ore is required than in the earlier years.
from the disease.

Daniels remarks on a close relationship between the gold value of tin in the Malay States and the admission rate for Beri-Beri into both prisons and hospitals. As the price of tin falls so does Beri-Beri increase. The attached charts will show this very clearly.

Many varying causes have been given to explain the above facts.

1. Braddon states that Beri-Beri is probably due to the ingestion of a poison formed in the rice which is the result of some specific organism, fungus or mould; but he does not believe that it is due to the ingestion of the organism itself. It is not rice, as an article of diet, that causes the disease, but diseased rice from which a poison is derived, the poison originating from decay or due perhaps to some fungus mould or germ or spore, perhaps originally growing on the husk and becoming mixed with the rice during the process of milling, or upon which such fungus may have grown or poison may have been produced after milling.

I will show clearly that stale rice per se does not cause Beri-Beri.

2. Fraser/
Fraser and Stanton after much detailed work have come to the following conclusions.

A. That Beri-Beri is a disorder of nutrition and as it occurs in the Malay States is associated with a diet in which rice is the principal constituent.

B. White rice, as produced in the steam-mills in the Malay States, is commonly deficient in respect of some substance essential for the maintenance of the normal nutrition of nervous tissues.

   The substances exist in sufficient amount in the original grain and super-abundant amount in polishings from white rice.

C. That the estimation in terms of phosphorus pentoxide (P2O5) of the total phosphorus present in any given rice may be used as an indicator of the Beri-Beri producing power of such rice when forming the staple diet in man.

The prevention of Beri-Beri will be achieved by substituting, for the ordinary white rice, a rice in which the polishing process has been omitted or carried out to a very small extent or by the addition to a white rice diet of articles rich in those substances in which such white rice is now deficient.
The use of parboiled rice as suggested by Braddon will achieve a like result.

I will show that though the quantity of P2 O5 is reduced in those rices which are associated with Beri-Beri, it is also reduced to even a greater amount in rices which do not and have not caused Beri-Beri, so in my opinion it cannot be taken as a certain indicator of the Beri-Beri producing power of rice.

Schaumann after many experiments concludes that nucleo-proteids are absolutely necessary for the organism and that their absence gives rise to degeneration of nerve tissue, polyneuritis etc., that Beri-Beri is due to a marked deficiency of these nucleo-proteids in stale steam-milled rice. He remarks that in sailing ships starchy food stuffs are often mouldy. That moulds have a great avidity for phosphorus and to obtain this phosphorus they break up the nucleo-proteids and so render the food deficient in a necessary component. Personally I think that ship Beri-Beri is due to an adulteration of flour, with rice flour, so Beri-Beri on ships invariably occurs on the voyage from the East where this adulterated flour has been obtained.
Hans Aron has been investigating the association between diminished organic phosphorus (phytin) in diet and Beri-Beri. He holds that the lack in sufficiency of this component is the important factor in the causation of this disease and produces experiments on chickens and prisoners to prove his theory.

1. Most investigators have succeeded in causing a polyneuritis in chickens by feeding them on polished rice, but no investigator, so far as I can gather, has definitely succeeded in infecting any of the higher animals with a similar polyneuritis by the same means. I cannot believe that Beri-Beri only attacks two species so far apart as fowls and human beings.

2. His test diets for studying the metabolism of patients, with a reduced organic phosphorus in their food, have a much more liberal supply of organic P₂O₅ than the diet which many poor women in the slums of any European city live on daily throughout the year. His patients get rice, bacon, bread and sugar and he shows by analysis that white bread is very deficient in organic P₂O₅, yet the same women that I have just mentioned live on little else than tea and bread and butter/
butter combined with far worse sanitary surroundings than are ever present even in a Manilla gaol. One never hears of these women suffering from Beri-Beri.

Dr. Shibayama, delegate for the Japanese Government at the meeting of the association of tropical medicine held at Manilla in March 1910, criticizes Dr. Arons work as follows:

"It has been known for ten years that fowls fed exclusively on polished rice may contract polyneuritis whereas the birds given the unpolished grain remain free from the disease. On the other hand unpolished rice can produce polyneuritis when it has been heated to 120°C. There is no chemical difference especially in regard to the content of phosphorus between heated and non-heated rice. Further more the occurrence of Beri-Beri in fishing villages has taught us that the inhabitants of the latter eat large quantities of fresh fish and this diet contains relatively a large amount of phosphorus. We have treated many cases of Beri-Beri with phytin but we could not observe any favourable results. I would also in this place wish especially to emphasise the fact that the polyneuritis of fowls is not identical with Beri-Beri and that the experimental/
experimental results obtained with these birds cannot directly be interpreted in the same sense with human beings, so, for example, polyneuritis accompanies general cachexia and inanition in fowls, whereas Beri-Beri, especially the acute pernicious form, generally attacks well nourished muscular men."

When examined clinically, Beri-Beri in Siam, at any rate, does not resemble a disease caused by the deprivation of compounds essential to the nutrition of the body. The extreme irregularity of the symptoms, their variation in intensity, their often acute exacerbation often ending in rapid death, point rather to an actual poisoning.

The Manchester epidemic of arsenical poisoning following the consumption of arsenical beer was at first diagnosed by Ross of Liverpool as epidemic Beri-Beri, but it was afterwards proved to be due to arsenic. This surely shows the close similarity between the two diseases.

The rapid initial improvement under proper treatment even in the most acute cases - far too rapid to be accounted for by the starvation theory - clearly points out that a definite poison is no longer being administered/
administered rather than that a necessary component of
the diet, previously absent, is now being added in
minute quantities, and so gradually absorbed into the
system.

Haviland, from his investigations, was led to
attach little importance to the mode of the preparation
of rices, but rather to the place where the rice was
grown; and to suppose that the local rices grown in the
country districts of the Malay States, where Beri-Beri
is never seen endemic, however, milled, will not pro-
duce Beri-Beri in the consumers; but milled rice
which is grown in Burma and Siam where Beri-Beri is en-
demic, he considers able to produce the disease.
He, however, suggests that such rice becomes more
dangerous and more liable to produce Beri-Beri if
badly kept or kept too long.

Evidence will be given in the following pages that
such rice, as is eaten by that class of native in
Siam amongst whom Beri-Beri is prevalent, is milled
from a poor and adulterated quality of padi and is
often stale and mouldy. I here put forward that it
is this quality of rice prepared from this quality of
padi that is the main factor in the causation of Beri-
Beri/
Beri-Beri in Siam and perhaps in those other parts of the world in which Beri-Beri occurs.

I hope to prove this under four headings:

1. The history of Beri-Beri in Siam.
2. The rices of Siam, their mode of preparation, cultivation, milling and the condition of such rice as it is sold in the local markets of Siam.
3. Experiments with various forms of padi and rice to show their influence on Beri-Beri.
4. The analysis of various rices from different parts of the world.
   A. The rices from countries where Beri-Beri occurs.
   B. Where Beri-Beri never occurs.
CHAPTER II.

THE HISTORY OF BERI-BERI IN SIAM.

Siam is a country which may be geographically described as lying between the 4th and 21st parallels, N. Lat., and between the 97th and 106th parallels E. Long.

The valley of Siam's principal river - the river Menam - has been one vast padi-field for centuries past and the present inhabitants of the country, living outside the capital, still use implements for sowing, reaping, and milling, this padi identical with those used by their predecessors a thousand years ago. The only change which has occurred has been the introduction of machinery for milling this padi into rice and this has been limited to Bangkok, the capital city, and its immediate surrounding districts.

Rice, from time immemorial has formed the staple diet of the Siamese, yet previous to A.D. 1890 epidemic Beri-Beri was unknown in Siam, only isolated cases being seen. But since that date the disease has been both epidemic and endemic.

The qualities of each variety of padi have remained unchanged, but the quantity cultivated has increased enormously.
enormously, especially that variety milled into rice for export.

The only other striking change that has occurred has been in the rice, namely that about thirty years ago all rice in Siam was milled by hand, now a very large quantity is milled in steam mills.

The occurrence of Beri-Beri in Siam coincides most accurately with the erection of those steam mills. The epidemic occurrence of Beri-Beri coincides with the retail of steam-milled rice in the local markets and finally Beri-Beri has followed the track of steam-milled rice throughout the country.

1. Early records of epidemic Beri-Beri in Siam are difficult to obtain. The earliest record is that of an outbreak of the disease amongst some sailors in the Siamese Navy in the year 1885. But the Navy at that time was stationed on the west side of the Malay Peninsula at Puket - the port of the Island of Junk Ceylon so this outbreak did not occur in Siam proper. The disease was recognised as Beri-Beri by the European Admiral in charge of the fleet, Admiral Richelieu, who had formerly seen the disease in Java, and it is stated that energetic measures were adopted to get rid of it, viz., bread was substituted for rice as far as possible/
possible and large quantities of fresh vegetables (beans, tomatoes and various kinds of green vegetables) were added to the diet. It is stated that these measures were successful.

2. In Bangkok city itself the first reliable record of Beri-Beri is that of an outbreak of the disease in the New Goal in 1890. The cases were of the acute wet variety and rapidly fatal. The European doctor in charge at once took active steps to eliminate this new scourge. Hearing that the prisoners complained bitterly of the quality of the rice — which at that time was white steam-milled rice and a recent introduction into the goal, he asked each prisoner individually which rice he preferred, steam-milled or hand-milled, and they unanimously decided on hand-milled rice. So hand-mills were at once instituted and since that date up to the present time hand-milled rice only has been consumed in the goal by the prisoners, and since 1890 there has been no further outbreak of Beri-Beri amongst them. It is interesting to note that the warders of the New Goal live outside the goal precincts, and feed themselves, buying their own rice in the market. This is steam-milled and not hand-milled such as the prisoners eat.

Beri-Beri/
Beri-Beri is a very common disease amongst these warders but never occurs now amongst the prisoners. Yet the exact opposite to this has been seen to occur at Kwala Lumpur in the Malay States where the officials of the goal were immune and the prisoners were attacked by Beri-Beri. The difference in this case being that both sections ate steam-milled rice, the officers probably selecting rice of better quality than that supplied to the prisoners.

3. In the year 1893 Beri-Beri first attacked the soldiers of His Siamese Majesty's Body guard. The epidemic commenced with two men, rapidly increasing to twenty. These men were all recruited from the country and as soon as they became ill were invalided home till cured. They quickly recovered whilst at their homes and soon returned to work in Bangkok but in a few weeks were again attacked and again sent home. Some men had as many as five attacks in eight years. In all there were eighty men attacked with this disease out of a total of 1,500.

This epidemic occurred within the same year that steam-milled rice was first introduced to replace hand-milled rice in these barracks. For previous to 1892 all troops were fed on hand-milled rice. But at their homes, where they so quickly recovered, they without one/
one exception milled their own rice every few days in hand mills.

4. In 1896 Beri-Beri broke out amongst the Chinese coolies working on the construction of the Korat Railway north of Bangkok. Again the disease was of the acute wet variety and rapidly fatal. As this construction work was all through uncultivated jungle, the rice was all brought from Bangkok, and was steam-milled rice.

5. In 1897 Beri-Beri broke out on the ships of the Siamese Navy, which accompanied the King of Siam to Java. It broke out on all the ships simultaneously and there were eighty or ninety cases. There had been no Beri-Beri in the Navy since 1885. There are no records of the steps taken to combat this epidemic.

From inquiries made amongst many old Siamese doctors, who now, at any rate, can diagnose Beri-Beri as well as any European doctor, it is evident that up to 1898, Beri-Beri was very seldom met with in Siam amongst the general public; and, up to this time, the disease had been strictly limited to goals, the Army and Navy, and to slaves who were fed on rice milled from the cheapest forms of padi, though previous to this, Beri-Beri was prevalent and well known for many years in Singapore and Hongkong. It was not till 1890 that it became common in Bangkok. It is interesting to note/
note that up to this period, hand-milled rice was almost universally eaten by the ordinary native throughout Siam, and that steam-milled rice was not yet being sold retail in the local markets in any quantity. But in Singapore and Hongkong, where Beri-Beri was well known, steam-milled rice which had been milled in Bangkok and Rangoon, was almost universally consumed, because of its cheapness and the facility with which it could be obtained.

Subsequent to 1897 and the epidemic in the Navy there are no records of any further outbreak for three years. In fact Doctors Nightingale and H. Campbell Hightet, who had previously practised in Singapore for some years and then transferred to Bangkok, were surprised at the remarkable absence of Beri-Beri from the ordinary indigenous diseases of Bangkok; accustomed as they had been to see so many cases in Singapore. On inquiring of their colleagues in Bangkok, who had previously seen Beri-Beri in Java and elsewhere, the same opinion was expressed; viz., that this disease was practically unknown in general practice in Siam. It was not till the year 1900 that Doctors Nightingale and Hightet saw their first case, namely a Siamese police constable who was admitted to the Police Hospital on August 29th, 1900.
Return of cases of and deaths from Beri-Beri during the last eight years.

<table>
<thead>
<tr>
<th>Era</th>
<th>120 Cases Deaths</th>
<th>121 Cases Deaths</th>
<th>122 Cases Deaths</th>
<th>123 Cases Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital Department</td>
<td>18 2</td>
<td>171 74</td>
<td>327 72</td>
<td>129 27</td>
</tr>
<tr>
<td>Navy</td>
<td>2 2</td>
<td>172 0</td>
<td>304 51</td>
<td>524 19</td>
</tr>
<tr>
<td>Army Monthon Krung Theb</td>
<td>1,084 9</td>
<td>650 5</td>
<td>1,920 37</td>
<td>2,004 54</td>
</tr>
<tr>
<td>Police</td>
<td>24 1</td>
<td>14 2</td>
<td>64 1</td>
<td>156 3</td>
</tr>
<tr>
<td>Totals</td>
<td>1,128 14</td>
<td>1,007 81</td>
<td>2,615 161</td>
<td>2,813 103</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Era</th>
<th>124 Cases Deaths</th>
<th>125 Cases Deaths</th>
<th>126 Cases Deaths</th>
<th>127 Cases Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital Department</td>
<td>127 30</td>
<td>128 27</td>
<td>402 138</td>
<td>797 178</td>
</tr>
<tr>
<td>Navy</td>
<td>1,599 17</td>
<td>347 11</td>
<td>656 12</td>
<td>623 24</td>
</tr>
<tr>
<td>Army Monthon Krung Theb</td>
<td>1,456 41</td>
<td>2,038 54</td>
<td>3,040 76</td>
<td>2,307 75</td>
</tr>
<tr>
<td>Police</td>
<td>179 4</td>
<td>199 9</td>
<td>329 3</td>
<td>880 5</td>
</tr>
<tr>
<td>Totals</td>
<td>3,361 92</td>
<td>2,712 101</td>
<td>4,427 229</td>
<td>4,607 282</td>
</tr>
</tbody>
</table>

Total Cases in eight years . . . . . . 22,670

Total Deaths . . . . . . . . . . . . . 1,063
1900. Another case was admitted a month later, then no further cases were noted till April 1901, when several cases were rapidly admitted one after another. It is since this last date that Beri-Beri has come to be one of the most frequent diseases to be met with in hospital practice in Siam.

In 1901 a very severe epidemic broke out amongst the soldiers occupying the central barracks. Two cases were reported from the Navy and cases began to appear in the general hospitals and in private practice.

The following figures compiled from the records of the Army, Navy, Police and some of the hospitals of Bangkok, though they do not give a complete record, still will give an idea of the progressing increase of Beri-Beri in Bangkok during the past eight years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases of Beri-Beri</th>
</tr>
</thead>
<tbody>
<tr>
<td>1901</td>
<td>1128</td>
</tr>
<tr>
<td>1902</td>
<td>1007</td>
</tr>
<tr>
<td>1903</td>
<td>2615</td>
</tr>
<tr>
<td>1904</td>
<td>2613</td>
</tr>
<tr>
<td>1905</td>
<td>3361</td>
</tr>
<tr>
<td>1906</td>
<td>2712</td>
</tr>
<tr>
<td>1907</td>
<td>4427</td>
</tr>
<tr>
<td>1908</td>
<td>4607</td>
</tr>
<tr>
<td>Total</td>
<td>22670</td>
</tr>
</tbody>
</table>

As these are records of sickness from this one disease amongst men of the various government services only, it will be seen what a very serious danger Beri-Beri has become to the efficiency of these services.
Records of Beri-Beri
at the Asylum for Insane at Bangkok.

<table>
<thead>
<tr>
<th>Year</th>
<th>Insane Siamese Era.</th>
<th>Insane Remaining under treatment at beginning of year.</th>
<th>New Admissions.</th>
<th>Insane Total under treatment during year.</th>
<th>Beri-Beri Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M. F.</td>
<td>M. F.</td>
<td>M. F.</td>
<td>M. F.</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>127 18</td>
<td>202 55</td>
<td>402</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>121</td>
<td>140 14</td>
<td>202 55</td>
<td>411</td>
<td>98</td>
<td>26</td>
</tr>
<tr>
<td>122</td>
<td>34 15</td>
<td>127 51</td>
<td>337</td>
<td>77</td>
<td>22</td>
</tr>
<tr>
<td>123</td>
<td>69 14</td>
<td>200 52</td>
<td>341</td>
<td>78</td>
<td>27</td>
</tr>
<tr>
<td>124</td>
<td>64 12</td>
<td>189 51</td>
<td>316</td>
<td>81</td>
<td>20</td>
</tr>
<tr>
<td>125</td>
<td>73 11</td>
<td>194 46</td>
<td>329</td>
<td>94</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deaths</th>
<th>Deaths Total</th>
<th>Percentage of deaths to cases treated</th>
<th>Average daily number</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.</td>
<td>F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>14</td>
<td>54</td>
<td>13.4</td>
</tr>
<tr>
<td>106</td>
<td>34</td>
<td>140</td>
<td>34.0</td>
</tr>
<tr>
<td>84</td>
<td>25</td>
<td>109</td>
<td>32.5</td>
</tr>
<tr>
<td>86</td>
<td>34</td>
<td>120</td>
<td>35.0</td>
</tr>
<tr>
<td>91</td>
<td>22</td>
<td>113</td>
<td>35.7</td>
</tr>
<tr>
<td>101</td>
<td>13</td>
<td>114</td>
<td>34.6</td>
</tr>
</tbody>
</table>
In April 1906 the Lunatic Asylum came under the Medical Officer of Health for Bangkok.

There were eight-nine patients present at that time including nineteen cases of Beri-Beri and this disease had accounted for an enormous mortality amongst the lunatics for the past five years. The building was in a very insanitary condition and in every way unsuited for its purpose. In spite of every preventive method being adopted, e.g. thorough cleanliness and disinfection, supervision of food, etc. etc., Beri-Beri continued to rage and in fact became worse. The records for the year 1906 give the following data:

- Lunatics under treatment from previous year: 89
- New admissions of Lunatics for 1906: 240
- Total treated in 1906: 329

Beri-Beri cases:
- Total treated in 1906: 135
- Died: 113
- Recovered: 8
- Remaining under treatment: 14
- Mortality: 83.7%

Total deaths from all diseases: 114

Mortality for the Asylum for 1906: 346 per mille
Here is given ten Seasonal occurrence of Beri-Beri at the Asylum during three consecutive years where it will be noticed that it tends to be much less in the dry months of the year, that is from January to May.
This means that the deaths from Beri-Beri nearly kept pace with the admission of new patients.

The Asylum records show that Beri-Beri commenced here in the Autumn of 1901 previous to which date there had never been a case. From this time the death rate at once sprung up from 13.4% to 34% in the succeeding year and it has remained about this figure till the year 1909.

The records of deaths from Beri-Beri in the Asylum are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>0</td>
</tr>
<tr>
<td>1901</td>
<td>2</td>
</tr>
<tr>
<td>1902</td>
<td>124</td>
</tr>
<tr>
<td>1903</td>
<td>99</td>
</tr>
<tr>
<td>1904</td>
<td>105</td>
</tr>
<tr>
<td>1905</td>
<td>101</td>
</tr>
<tr>
<td>1906</td>
<td>113</td>
</tr>
<tr>
<td>1907</td>
<td>104</td>
</tr>
<tr>
<td>1908</td>
<td>122</td>
</tr>
</tbody>
</table>

The type of the disease was of the acute wet variety and as has been seen extraordinarily fatal. It is interesting to note the history of the rice such as/
as was supplied for consumption by the insane patients.

In 1897 and previous to this, hand-milled rice only, had been eaten by the patients. It was bought in quantity from a Chinese hand mill once a month, Beri-Beri had never yet been seen in the Asylum.

In 1898 steam-milled rice was bought for the first time for consumption by the lunatics. Twenty bags, a supply sufficient to last four or five weeks was bought each month. In 1901 Beri-Beri commenced in the asylum and very quickly became epidemic. In 1906 thinking that stale rice might possibly be a cause of this disease I ordered the rice to be bought once a month from a rice mill that advertised "the best quality rice for sale". I however have since found out that the rice bought was of a cheaper quality and was milled from mixed padi, i.e., old and new, sown and planted padi and not the quality I ordered. This change made no difference in the incidence of Beri-Beri. It is important to note that that this rice at this time was stored in a dark unventilated room which had always been used for this purpose, since steam-milled rice had been first bought.

Experiments/

(*) Braddon insists on there being no latent period for the disease. The term of exposure to, or absorption of, the poison before the effects are produced, will vary with the individual and the dose, and therefore will be irregular.
Experiments were then tried to see whether monkeys could be infected with Beri-Beri, by feeding them on the rice that the patients eat, and contaminated with the urine and faeces of Beri-Beri patients, but the results were negative. Notwithstanding this I considered Beri-Beri to be an infectious and contagious disease and all Beri-Beri patients were carefully isolated.

During 1907 and 1908 Doctors Fraser and Stanton of the Institute for Medical Research at Kuala Lumpur had been experimenting with parboiled rice as a preventive for Beri-Beri on the lines suggested by Dr. Braddon in his original investigations in 1906. It was discovered that coolies fed on parboiled rice did not contract the disease while those fed on steam-milled rice did so within a period of three to four months. Having heard of these results Dr. Highet, Medical Officer of Health determined to try the effect of this differently prepared rice at the Asylum. A small handmill worked by the patients themselves was started. The padi was previously parboiled and the first issue of parboiled rice took place on February 12th, 1909. Absolutely no other changes were made in the diet or surroundings or hygiene of the Asylum but/
but the results were immediate and very striking.

On February 12th, 1909 there were present twenty-two patients suffering from Beri-Beri; but from that date, during the whole period that parboiled rice was used, not one single fresh case of Beri-Beri has occurred; and only four cases out of the twenty-two present died; the others recovering rapidly, and the mortality has fallen from 34.4% to nil in 1910. The number of deaths being so much lessened, the asylum has become very overcrowded; and there is now in September 1910, a daily average of inmates of 350 compared with 100 for the same period of 1908. On those actually suffering from Beri-Beri, this parboiled rice had a very striking and rapid effect, noticeable even within seven days.

Patients who were lying absolutely helpless, water-logged with oedema, so as to scarcely resemble a human being, completely paralysed, with all reflexes in abeyance; within fourteen days could sit up and feed themselves; and the oedema had all disappeared; though the convalescent stage was of long duration. Less acute cases were completely cured within three weeks to one month, where previously they only became progressively worse. This parboiled rice was consumed/
consumed without interruption till August 1st, 1909, when a trial was made with other forms of rice, the results of which will be mentioned later.

Since the issue of parboiled rice it was seen that Beri-Beri could no longer be considered a contagious disease so all Beri-Beri patients were allowed to mix with other patients, and still no fresh cases have occurred. This same system has been carried out, wherever parboiled rice has been used in Siam as a preventive of Beri-Beri; and in no case whilst on this treatment has one patient infected another. Hence I cannot agree with Daniels that the disease is infectious.

History of an Epidemic of Beri-Beri at the Reformatory School on the Island of Koh Sichang in the Gulf of Siam. This institution was started on March 5th, 1908 and was supplied with white steam-milled rice sent down from Bangkok. The school was in charge of an European Inspector of Police and the average daily number of boys totalled fifty. In September 1908 reports were sent to Bangkok of epidemic sickness amongst the boys. On October 4th, 1908 a boy was sent up to the Police Hospital suffering from a severe attack of Beri-Beri. Up to April 15th, 1909 four more cases were sent to Bangkok for treatment.
Exact figures of the actual number of cases cannot be given owing to the absence of medical advice on the island, for only severe cases were sent up to Bangkok. It is however certain that many of the boys suffered from a milder form of the disease.

In April 1909 parboiled rice was served out to the reformatory, and Beri-Beri forthwith ceased, and no new case has arisen in the school while parboiled rice has been eaten. Later on in the year hand-milled rice was used, and found to be just as satisfactory as a prophylactic.

History of an epidemic of Beri-Beri amongst police conscripts in Bangkok.

In Autumn 1908 conscription came into force for supplying police for Bangkok. These men were all drawn from the country districts around Bangkok, and were chiefly padi cultivators accustomed to eat rice which was hand-milled every few days. The first batch of men arrived in December 1908, they were housed in temporary quarters for a few days and then removed to the Police School. These men were fed on white steam-milled rice No. II "Straits" quality. The cooked rice was examined daily after being cooked and was of ordinary fair quality, but on one or two occasions/
occasions was found to be badly cooked. The remaining diet consisted of various curries with dried salt fish, fresh fish, onions, beans, other fresh vegetables, coconut oil and salt. Thus all the required constituents of a satisfactory diet were present in this latter portion of the food, which was varied and nutritious.

On December 30th, the first case of Beri-Beri occurred; then the next case on January 6th and soon several cases were seen daily. On February 7th, 1909 out of an original total of 400 men only 227 remained; and of these 180 were found to be suffering from the initial symptoms of Beri-Beri, i.e. rapid heart action and anaesthesia of hands or legs. So these were also returned to their homes on sick leave, leaving only 47 men out of an original 400 to be drafted to the various police stations. Previous to the introduction of parboiled rice, it has long been known in Bangkok in the various government services, recruited from country people, that the one and only way of curing Beri-Beri cases individually, was to send them back to their country homes, where they soon got better — the reason being unknown. It was always seen that if the cases were kept in Bangkok in their stations or at various hospitals, notwithstanding the recognised treatment of/
of those days with cardiac tonics and purgatives, that
the mortality was very heavy, and that even if they did
recover the disease remained in a very chronic form,
causing great weakness and unfitness for work. So
the invariable rule was to give every case three months'
leave of absence and send him away from Bangkok if
possible.

Everything was done in the way of attention to
hygiene, good food, etc.; but no difference was seen
in the daily average of men who reported themselves
sick. Having then seen the excellent results from
parboiled rice at the asylum, it was then determined
to put the police on this diet also; the rice being
prepared at the asylum and sent over to the Police
School.

While parboiled rice was being consumed at the
Police School, i.e., from February 9th, 1909 onwards,
no fresh case of Beri-Beri occurred there; whilst
previous to this there had been 300 cases in three
months. Daniels theory of infection from pediculi
cannot explain this striking change.

As parboiled rice by this local method of prepar-
ation, had a sour and unpleasant smell after cooking
it caused considerable complaint amongst those fed on
it, so, once that Beri-Beri was eliminated from the
school/
school the parboiled rice was stopped and fresh hand-milled rice substituted with practically the same results, i.e., Beri-Beri did not occur in what six months previously had been a very hot bed of this disease. The actual number of cases that have occurred since, is eight in fifteen months.

10. History of Beri-Beri at the Lower Customs Station, Bangkok.

Some 200 customs guards live at this station and for the past six years Beri-Beri has been endemic, though not of a very acute form. In the year 1908, 120 men were off duty 2794 days suffering from this disease. In May 1909 parboiled rice was issued to them, previously they had been fed on steam-milled rice No. II Straits quality. After a trial they refused to eat the parboiled rice saying that they did not like the smell of it and only those who actually had Beri-Beri ate it, so in August 1909 fresh hand-milled rice was supplied weekly and since that date there has not been a single case of Beri-Beri reported.
### Returns of Beri-Beri from the Provincial Goals

#### Bangkok Province for 1908.

<table>
<thead>
<tr>
<th>Name of Goal</th>
<th>Cases of B.B.</th>
<th>Deaths</th>
<th>recovered</th>
<th>remaining</th>
<th>discharged</th>
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<tbody>
<tr>
<td>Nontaburi</td>
<td>13</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Samut Prakarn</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pratoomthance</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tanyaburee</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Minburee</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nakonkhuen Khan</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
</tbody>
</table>

#### Remarks. Rice consumed etc.,

<table>
<thead>
<tr>
<th>Name of Goal</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nontaburi</td>
<td>Steam-milled rice eaten - 90 prisoners.</td>
</tr>
<tr>
<td>Samut Prakarn</td>
<td>Steam-milled rice eaten.</td>
</tr>
<tr>
<td>Pratoomthance</td>
<td>Hand-milled rice used.</td>
</tr>
<tr>
<td>Tanyaburee</td>
<td>Hand-milled rice used.</td>
</tr>
<tr>
<td>Minburee</td>
<td>Hand-milled rice used.</td>
</tr>
<tr>
<td>Nakonkhuen Khan</td>
<td>Hand-milled rice used.</td>
</tr>
</tbody>
</table>

#### Summary:

- Two goals which consume steam-milled rice have twenty cases of Beri-Beri.
- Four goals which consume hand-milled rice have five cases of Beri-Beri.
Facts regarding Beri-Beri in Siam and the relation of these facts to the consumption of rice.

1. The Army, Navy and Police have all been seriously affected.
   The Army, Navy and Police were all using steam-milled rice when the outbreak occurred.

2. The Gendarmerie numbering about 6000 men have never been affected at all.
   The Gendarmerie being entirely stationed in the country districts only use hand-milled rice.
   They are much more crowded in their stations than the police and yet no cases of Beri-Beri occur amongst them.

3. The warders of the Central Prison have been badly affected.
   The warders live away from the prison and eat steam-milled rice.

4. There has not been a single case of Beri-Beri amongst the 1600 prisoners in the Central Prison nor in the 1400 prisoners in the short sentence prison, since the year 1890.
   Both these prisons are very overcrowded but in both the rice used by the prisoners is hand-milled.

5. There has been a bad outbreak at the Nontaberi prison/
5. prison where there are ninety prisoners.
   At Nontaberi the rice eaten by the prisoners is steam-milled rice sent from Bangkok.

6. There has not been a single case in the Tanyaburi prison where there are 200 prisoners.
   At Tanyaburi the rice is hand-milled within the prison itself.

7. There has been an outbreak at Koh Si Chang amongst Police and Reformatory School boys.
   There was no Beri-Beri at Koh Si Chang while the local hand ground rice was used. It did not occur till at the men's own request steam-milled rice was sent to them from Bangkok.

8. There has not been a single case amongst Europeans or Indian constables.
   Neither Europeans nor Indian constables eat rice to any extent.

9. Up to February 9th, the men confined at the Police School were constantly affected, since then there has not been one fresh case.
   Previous to February 3rd steam-milled rice was used; after that date it was forbidden and hand-milled rice substituted. There has not been a single fresh case of Beri-Beri since February 9th, 1909.

   Such then is the history of Beri-Beri in the various/
various services and Institutions of Siam the only places where any reliable data can be obtained. Amongst the general public the disease in its typical three forms is seen every day but entirely limited to the poorer class. The death rate for Bangkok from Beri-Beri for six months, i.e., from August 1909 to January 1910 is 6.1 mile.

The deaths from Beri-Beri in September, October, November and December 1909 have been 254 recorded.
CONCLUSIONS.

From the general history thus obtained of the spread of Beri-Beri in Siam it can be clearly seen that

1. The consumption of rice is closely associated with this disease. In each instance those attacked are persons who have consumed a cheap form of steam-milled rice as their chief article of diet.

2. It is most strikingly shown that Beri-Beri does not attack those fed on parboiled rice and that the change from steam-milled rice to parboiled rice at once stops the spread of the disease. Not only this but that the consumption of parboiled rice by Beri-Beri patients seems to have a marked curative affect.

3. Beri-Beri seldom attacks those fed on hand-milled rice and therefore hand-milled rices are to all intents and purposes as efficient a prophylactic as parboiled rice.

4. I have no doubt that the factors of temperature, humidity and place - the last so emphasized by Sir Patrick Manson - must also be taken into serious consideration.
CHAPTER III.

THE RICES OF SIAM

AND THE METHODS OF CULTIVATION.

Varieties of Padi

It must be recognised that the term "Siam rice" is a purely commercial term for various mixed qualities of rices, many of which never come from Siam.

Definition of Padi.

"Padi is the grain of the rice plant and consists of the fruit (rice) enclosed in a husk. The fruit possesses a thin pericarp which is firmly adherent to the seed and varying in colour from gray to black. Under the pericarp are two inner linings the spermoderm and the perisperm. These linings are specially rich in fat and salts, the fat being chiefly confined to the layers which surround the endosperm. The cells of the outer layer of the endosperm are filled with aleurone grains while the central portion consists entirely of starched granules."

The varieties of padi in Siam number more than a hundred but the distinction between many of them is so small that only a local expert can differentiate between them. Others however present highly distinctive/
distinctive qualities either in size, colour or flavour, e.g. the small grained hill padi, red padi, glutinous rice, etc. These distinctive characteristics have undoubtedly been evolved from peculiar conditions of the soil flooding elevation temperature, etc. under which the padi has during succeeding centuries been cultivated. By far the greater part of the padi grown, however is the "padi of the plains"; which is to all intents the very life of Siam. For it is this padi, which pays most of the taxes, and is the source of most of the public and private wealth of the country. This is the padi which is milled for export and for local consumption within 150 miles from Bangkok.

The "padi of the plains" is classified according to:

a. The method of cultivation.
b. The season of sowing.

Hence the origin of the many varieties.

A. The method of cultivation.

1. The usual method employed throughout the whole East and in fact wherever padi is grown, is that of "planting" the padi. Here artificial irrigation is required to soften the land; to allow of ploughing and harrowing./
harrowing. In the meantime the padi seeds have been planted thickly in a nursery of specially selected and manured soil which causes very rapid germination and the young plants rapidly sprout up. After reaching a suitable stage these young plants are taken up by hand and replanted out in the larger fields. Such padi is called "garden" padi and the rice exported as "garden" rice.

By this method the best quality of padi is grown but is compared with method No. II an expensive one for it needs more experience, more capital and labour.

It is eminently suited to those countries with a large population where labour is cheap such as Japan, India and Java and where the ground is irrigated.

Hence in Siam padi growing in bulk is limited to certain districts which are well populated, and where the very rapid rise and fall of the river can be regulated by irrigation.

2. There is another method of cultivating padi peculiar to Burma Cochin China and particularly to Siam. This method is not used in other parts of the world; such as America, Italy and Japan, even though they produce larger quantities of padi, for the local conditions are unsuitable. The requirements are countries which are provided with a very rich alluvial soil/
soil and drained by large rivers subject each year to very great floods. In those parts of the above mentioned countries, where irrigation is not carried out; this seasonal flooding would drown and spoil any ordinary padi; but this special seed is capable of growing so quickly, that it can keep pace with the rapidly rising floods and so always keep its head above water.

This seed is sown broadcast on the land on which it is to grow, the land having been first ploughed as soon as there has been sufficient rain to moisten the soil. The chief difference being that it is not first of all allowed to germinate in a nursery.

This elementary method of cultivation does not produce nearly such a good quality crop as the former and more careful method. The seeds through long exposure to the sun and winds are cracked and dirty and the high floods often prevent them being reaped at maturity and the padi when reaped may be in all stages up to maturity and sometimes beyond this, germinating and even sprouting on the parent stock.

B. The season of the cultivation of Padi.

1. With extensive lands and a small population available as labour the Siamese, Burmese, and Anamite cultivator/
cultivator is obliged to find varieties of padi, which will take varying lengths of time to mature; ranging from seventy-five days to six months. He plants three to six crops in the course of the year, and, as they do not take the same length of time to mature, he is thus enabled to harvest one crop, before another one is nearly ready for cutting. In Carolina, Italy, India, China, Japan and Java, the population is much more numerous, and cheap labour is available; so only one large crop is planted; and the padi is always reaped when ripe, and not allowed to stand ripe for many weeks; the latter delay being necessary in Siam when waiting for the floods to fall; thus a much more even quality of padi and rice is obtained. There are three main crops in Siam, early middle and late, but there may be three intermediate ones also. The Early and Middle crops usually provide the finest padi for the cultivator can select his time for reaping and threshing; the seeds not having been exposed too unnecessarily to the water, sun and wind, are in good condition and not cracked or sun-dried. The Late crop is the heavy crop and constitutes two-thirds of the padi grown. A large part of export rice is milled from it. Being so large in amount the same care in reaping and threshing can not be expended on it; so the grains are liable to be sun-dried.
The various padies can thus be qualified as follows:

- **Padi**
  - Garden Padi
  - Sown Padi
    - Early
    - Middle
    - Late

- Sown with Garden Padi seed
  - Early
  - Middle
  - Late

It will therefore be seen from the above that there are at least eight very different qualities of padi coming from Bangkok each year.

There the poorer qualities are all mixed and milled into rice and either exported or sold locally as cheap rice, the best quality only being sent to Europe unadulterated.
sun-dried, cracked and dusty. This crop is reaped in January or February and that being the dry season in Siam all the water-ways and canals are dried up so it does not reach Bangkok for milling till the following May and June, i.e. at the same that the ensuing early crop arrives for milling.

There is another variety of padi which has only been cultivated in Siam and especially in Burma and Cochin China within the past fifty years, i.e. the seeds of garden padi are sown broadcast on land where the floods are not so great nor so sudden as in those districts where the ordinary sown padi is grown. This now produces a very large crop of padi which though better in quality than ordinary sown padi is still far below garden padi in quality; as the grain is exposed to sun, rain and wind long after it is ripe. This quality of padi is now very extensively used for adulteration with the Late season crop of planted padi. In Rangoon the rice mills are of specially large size and only mill padi when the marked price of padi is high. The supply of first quality padi is limited so they take in all kinds and mix them and turn out huge quantities of rice milled from these mixed and adulterated padi for export to all parts of the world.
A comparison between the various forms of padi and the rices prepared from them.


   The seeds are heavy, long and unbroken with little dust, the most distinctive feature being the heavy rice grain which is heavier than in any other quality.

   Garden Rice Early Crop.

   The grains are long and large white and transparent in colour with a thin husk and a large quantity of natural oil. The grains are equal in size and weight and are round and straight with a short head, no cracks, no stains and a pleasant, fresh smell. This rice is of excellent quality and is all exported to Europe, very little being retained for consumption in Siam.

   It is largely used in Europe for adulterating Patna (India) rice which is much more expensive than even the best quality of Siam rice.

2. Garden Padi Middle Crop.

3. Garden Padi Late Crop.

   Both these resemble No. 1 except that their best qualities are not so marked, i.e. the seeds are lighter, shorter and dryer.

   This/
This rice also resembles No. 1 quality except that the grains are lighter, less oily, less transparent and not equal in size and in the late crop rice very liable to be cracked owing to long exposure to the sun and wind. These form a large part of the padi milled for local consumption and for export to those parts of the world where rice is consumed.

Sown Padi.

The seeds have a thick and heavy husk compared with the weight of the rice grain; they are very cracked and dusty.

In the worst qualities the rice grains are of a reddish or brown colour and the better qualities even are much darker in colour than the garden rice, the grains are opaque and dusty, light in weight and badly cracked, they contain little oil and little gluten. The grains are uneven in size and weight. After boiling the rice grains are harder and not of that pure white appearance which a Siamese considers so essential in good rice, the grains being badly broken from the mill. This rice is not so easily digested as other forms of rice, and causes a feeling of oppression in the pit of the stomach.

This class of padi previous to thirty years ago/
ago was chiefly used for feeding animals; only the better class of this sown padi was used for human consumption, and then reserved for slaves, prisoners, the army and police.

It is now largely exported as rice to Europe for making into starch and spirit. It is exported as padi to Singapore and Hongkong, there roughly milled and sold to make into rice porridge which is so largely eaten by the poorer class of Chinese coolie.

In Siam however, it is now very largely used to adulterate garden padi. At the present time padi of one quality only, is very difficult to obtain in Bangkok. The cultivator after threshing each crop, keeps it till all his crops are finished and mixes the whole lot, early, middle and late crops and then brings them down to Bangkok. Should he grow padi, cultivated by the "Sown" method from "garden" seed, he also mixes this in with the garden padi; in the proportion of one part to two parts of garden padi; in order to be able to undersell his neighbours. He will even mix the worst qualities of sown padi with his garden padi, but he cannot get a good price for it, as the adulteration is easy to detect by any unexperienced person.
It is safe to say, that, with the exception of the padi milled into rice for export to Europe as garden rice, all the padi of Siam consists of garden padi, adulterated with "sown" padi in varying proportions, depending on the price; thus the cheaper the rice, the larger proportion of this rice from "sown" padi is present in it; and in the process of milling more of the grain has to be removed in order to produce a white saleable grain. It is this class of rice which is exported all over the world for consumptions by natives; and this quality is only grown to any extent in the three countries of Burma, Siam and Cochin China. Most natives prefer what is called "old rice", i.e. fresh rice milled from old padi i.e. which has been kept for one season. This form of rice is less oily and more digestible than rice from new padi. The grains swell up much more and in fact the consumer seems to get more for his money; thus a large proportion of the padi of Siam is stored either by the cultivator or the miller for one year. In May and June which is the beginning of the padi season the early new crop, of sown and planted padi, is coming into Bangkok; also the old padi of the previous season. The local demand for old padi being greater than for the new, it brings a higher price and so is mixed freely with new padi and/
and milled, the production being called "old rice".

Cultivators and old-fashioned Siamese, who hand-mill their own rice, never mix their padi for their own use; as they say that the rice spoils so quickly. Also that the admixture of sown with garden padi produces the same effect only in a worse form. So this adulteration of garden padi dates from the introduction of steam-mills. In the days of the hand-mill any such admixture could easily be seen; as the hand-mill could never polish away the red and brown stains, present on the rice grain from sown padi. While the steam-mill with its polishing machinery can do this perfectly. Sown padi being 50% cheaper than garden padi, it can be seen what a temptation there is to make large profits by mixing the two kinds.

According to Braddon the degree to which particular parcels of rice would be poisonous will vary with:

1. The quantity in virulence of the poisonous agent originally present upon the padi when gathered.

   This again varies with such factors as maturity, or immaturity, of both padi and fungus when reaped; place season, rain, heat and other factors affecting fungus growth.

2. The manner in which the padi is stored.

3. Age of grain from which the rice is prepared; and
he suggests that, as with Ergot, the assumed fungus, or its toxic properties, may increase at first but ultimately perish.

4. Method of dressing or preparing rice from padi.

5. Method of storing rice after milling.

6. Length of exposure of rice after milling the effects of this exposure, varying with conditions such as temperature, light, moisture, etc.

Braddon therefore concludes that the incidence of Beri-Beri amongst rice eaters will therefore vary.

1. It will be most frequent amongst those whose rice is subjected to no process that could "cure" rice, i.e. destroy the fungus or its spores in the outer coat of the padi.

2. It will be less frequent amongst those who eat grain freshly husked and carefully sorted and cleansed.

3. It will occur least amongst those who eat rice sterilized before husking.

Further:

1. The incidence of the disease will vary directly with the quantity eaten either absolutely or relatively to other food or other circumstances.

2. The course of the disease will be aggravated by continued/
continued use of the same (noxious) rice and cease
on its discontinuance.

3. There will be no fixed "latent period". The term
of exposure, or absorption of, the poison before the
effects are produced, will vary with the individual
and the dose and therefore be irregular.

4. It will not result from mere association with
those afflicted (contagion or infection) unless the
food also is shared.

5. Epidemics of Beri-Beri both begin and end abruptly,
without any change in outward circumstances to
explain the event - apart from change in the food
supply.

6. That rice, as an annual crop, is conditioned by
season, and that therefore there may be apparent
seasonal and annual variation in the prevalence of
Beri-Beri, depending on the amount of the disease
(assumed to be a fungus ) in the successive crops
and the time of year at which they come into
consumption.

These observations of Braddon coincide very
accurately with statements given in preceding pages.

The adulteration and mixing of padi and rice,
occurs throughout the whole rice eating world.

Siam/
Siam, Burma and Cochin China padi already mixed up are milled and sold under various commercial names such as "Siam" and "Rangoon" rice, though in fact only a very small proportion of the rice sold may come from the place after which it is named.

The same thing occurs in Europe with the better qualities of padi; and even with the rice exported as such; for No. 1 "Garden Siam rice" is there screened, the large grains picked out and mixed with Patna (India) rice, and sold as the latter. Burma rice having a short round grain, and so resembling Japan rice, is exported to Japan and largely used to adulterate Japanese rice; which is much more expensive and is largely exported; the cheaper grain being imported to take its place.

Since 1890 many thousand tons of steam-milled rice have been exported from Siam and Anam to Japan. The period of greatest export being just before and last during the two wars which Japan has engaged in, in the last twenty years; namely— in 1894 in her war with China and in 1904 in her war against Russia. During the latter period there were 200,000 cases of Beri-Beri in the Japanese Army. Takaki in 1885 promulgated a theory that Beri-Beri was due to nitrogen starvation, and/
and therefore advised the addition of extra nitrogen to the diet of the Japanese soldier. In 1886, and 1887, he issued detailed reports, showing the great difference in the occurrence of Beri-Beri before and after these modifications had been introduced. From the above figures it does not seem as if the improvement of the diet was of any permanent service. But many other observers give all the credit to the simultaneous improved hygienic conditions of the soldier carried out in the barracks.

I mention this fact, in order to point out that the period of greatest prevalence of Beri-Beri in the Japanese Army, corresponds with a period of greatest importation of a low quality of steam-milled rice from Siam and Anam.

An average of fifteen million kilos of rice per annum have been imported into Manilla from Siam for the past ten years. Saigon sends 200,000,000 kilos and Burma 20,000,000. Beri-Beri in Manilla is chiefly limited to the coast ports and those towns which can be easily reached by railway. Enormous quantities of adulterated and inferior quality Siam rice are exported to South Africa, South America (East and West coasts) and to Western Australia. None of the better qualities of rice are exported to these places. Beri-
Beri-Beri has become endemic in portions of all three continents. In no cases can I gain definite information that rice grown in Siam, Burma or Anam has not been eaten in any place where Beri-Beri is epidemic. On the other hand I have tried to prove in the above statements that the majority of places where Beri-Beri is prevalent do import these special qualities of rice. It is not generally understood that the various rices of the world are so varying in quality and price.

As I have already stated in my introduction Beri-Beri bears a distinct relationship to the price of the rice eaten.

It is not generally understood that the various rices of the world are so varying in quality and price.

There are nine main qualities sold wholesale in the European markets viz:

1. Carolina at a price about 22/- per cwt.
2. Italian " " " 20/- " "
3. Patna (India) " " " 16/- " "
4. Javanese " " " 12/- " "
5. Japanese " " " 12/- " "
6. Siamese No. 1 garden quality 11/- to 9/6 per cwt.
7. Moulmein Burma 1st. quality 8/9 per cwt.
8. Rangoon " " " 8/9 " "
9. Saigon " " " 7/9 " "

Qualities/
Qualities from one to five are good and in the countries in which they are grown form the large part of the crop, practically no inferior qualities being grown there. Siamese rice as has been stated is of many qualities, some being good, the larger part of medium quality and some very inferior.

Burma rice is of medium and very inferior qualities though the worst are not so bad as the Siamese worst qualities.

Saigon rice is all of poor and inferior quality. Rice that is sold in the Singapore and Hongkong markets is generally imported from the three following countries:— Siam, Anam and Burma.

The Siam rice commands the highest price, Anam the second and Burma rice is the cheapest.

The price of Siam rice is as follows:—

No. 1 quality coolie rice 6/- per cwt.
No. 2 " " " 5/6 " "
No. 3 " " " 5/- " "

Note:— Compare the prices of these rices with those of page 48.

From the above list it is seen that Siam No. 1 garden rice even though the first rice produced in Siam and unadulterated is still sixth only in the world's/
From The Economic Atlas
J. G. Bartholomew.

From Scheube Tropical Diseases, 1902.
world's supply. It can therefore be well imagined what is the quality of the Siam rice such as is freely adulterated and badly milled in Bangkok for local consumption by the poorest class of native and of the even worse quality such as is exported to Singapore and China for the lowest class of coolie there. Its remarkable cheapness being its only recommendation.

A glance at the two maps on the opposite page will convince even the most sceptical that there must be some connecting link between rice and Beri-Beri. In the Eastern world the endemic foci of Beri-Beri exactly correspond with rice growing countries or such countries as import cheaper rice for the consumption by coolies. For example, the Pearl Fishing districts of North West Australia, or the mining districts on the west coast of South America. The marked exceptions to this are two in number, namely Carolina and Italy, but in this place only the very finest padi is grown and they do not import rice from other countries. Thence I wish to emphasize that Beri-Beri is only connected with the poor qualities of rice. These maps show clearly that Beri-Beri is now most distinctly endemic in those countries where the most/
most inferior padi is grown and milled in steam mills. It is also a fact that all countries which produce only a good quality and expensive rice, e.g. Japan and Java, in all cases are countries with a very large population; and that they very largely export their good rice, and import cheap Siam, Burma and Cochin China rice to take its place.

Hand-milled Rice.

Here the padi is husked between two slabs of hard clay enclosed in basket work to which a circular grinding motion is given. After husking the rice grain is then separated from the husk by winnowing and at this period still has the entire pericarp present and is called "red rice". The rice is then pounded in a wooden mortar to remove the pericarp and embryo and to make the rice white in colour. It is again winnowed to remove the dust.

The resultant being a greyish white translucent grain with a well marked sweet oily odour. Should the inner lining membranes be stained or coloured as in the poorer qualities of padi, the resulting rice grain is unpleasant in appearance; and as a white rice only is in demand, it has to be over milled in a steam-mill to remove the stains thus leaving nothing but/
but the starchy part of the grain.

Parboiled Rice.
The padi is taken in bulk and soaked in several changes of fresh water for forty-eight hours. It is then transferred to lightly covered cylinders and steamed for half-an-hour. It is then removed to an open paved court and dried by exposure to the sun and thereafter stored as padi or milled into rice. The resulting rice is yellowish in colour opaque and heavier than steam-milled rice. It has a distinctly oily feel and 5°C. higher in temperature than steam-milled rice. This form of rice has been used on the East Coast of India by the Tamils for many generations past. The reasons given by those natives for the use of this peculiar custom is that:

1. In the soaking and steaming of the padi all animals such as beetles, weevils, moths on the padi are destroyed and consequently it will keep very much longer.

2. The grains are harder and firmer and the padi therefore mills more economically, there being less dust and fewer broken grains.

3. The rice is more digestible and keeps for a longer period than ordinary rice.

4. That from the larger amount of oil it contains it is far more nutritious. The padi is not sterilized by/
by the process of parboiling; for if it be removed from the steamer, and incubated, many forms of spore-bearing moulds show in a few days. The padi infusion shows an enormous increase in the various saprophytic bacteria and moulds.

I cannot in any way explain the action of parboiled rice on Beri-Beri. The preliminary infusion must cause all spore-bearing forms of organisms to germinate and lose their spore formation. These are then destroyed by the steaming, though the remaining spores are not destroyed.

I can however discover no pathogenic action of the infusion of padi (see pp. exper. on Monkeys). Many moulds were isolated but none were pathogenic either to monkeys or guinea pigs.

Rice is not sterilized by cooking in the ordinary way, neither is parboiled rice, but there are many forms of mould which grow on the former after cooking, that do not appear in parboiled rice.

Siam Steam-milled rice.
Though the various qualities of padi and rice have been already described, it must be clearly understood that very little of the padi which is milled in Siam is of one quality, nine tenths of it consists of the various qualities first mixed on the farm, secondly by/
by the middle man, thirdly at the rice mill; and therefore the resulting rice is prepared from a mixture of garden padi, and sown padi of various seasons.

For this reason the milled rice has certain commercial names, viz.

1. Extra No. 1 Garden Rice.
   Milled from unmixed selected garden padi, only very small quantities are available, and all is exported to Europe at a price of about 11/- per cwt. wholesale.
   This rice will keep perfectly fresh for many months even up to one year if properly looked after.

2. No. 1 Garden Rice, milled from good quality garden padi but from mixed crops. It is comparatively small in quantity and nearly all exported. Locally it is only eaten by the wealthy Siamese and Chinese, and is expensive costing about 20/- per cwt. retail.
   This rice also keeps well.

3. Straits Quality Rice.
   This forms nine tenths of the rice milled in Siam for local consumption and for export to all those countries where Asiatics are used as labourers.
   This commercial term includes rices which vary enormously in quality depending entirely on the amount of the inferior sown padi which is mixed to adulterate the/
the garden padi. In this quality of rice the grains are dryer, lighter, less oily than in the better qualities, they are uneven in length, many are broken; and an experienced eye can pick out those milled from "sown padi", as differentiated from those milled from "planted padi". There is a much larger percentage of rice dust, the amount depending on how carefully the rice is screened.

Such rice will not keep for more than three months after which time it gets stale and mouldy and loses its translucent appearance. The poorest qualities will not keep unchanged in appearance for more than a month. If kept in a badly ventilated or damp dark room it spoils much quicker. The export price of this rice varies from 5/- to 7/- per cwt. wholesale. The local prices are retail from 3/- to 15/- per cwt.

Straits quality rice is divided into two classes, Nos. 1 and 2 both derived from the same milling and the difference in quality depending on the amount of screening the rice is subjected to, i.e. the less the broken grains are removed the larger the proportion of "sown"padi and hence the cheaper the rice, and it is this second quality that is consumed by 4 out of every/
every ten Siamese and Chinese in Bangkok.

About 30,000 tons of Siamese padi are imported into Singapore and Penang, to be milled into parboiled rice, eaten exclusively by the Tamils and they never get Beri-Beri.

In 1907 out of a total of 400,000 tons of steam-milled rice, imported into Singapore from various parts of the East, 170,000 tons came from Bangkok, Siam, the larger part of it being No. II quality "Straits" rice, chiefly to be eaten by Chinese coolies at the tin mines. There is little necessity to point out the enormous prevalence of Beri-Beri amongst these coolies.

Broken Rice.

When garden rice and Straits quality rice are being milled many grains are broken in the process, the poorer the quality of padi, the greater the breakage. These broken grains are sifted out and sold in three sizes. The largest grains are sold largely to food contractors in Siam, and also exported to Singapore and Hongkong for feeding Chinese coolies, who eat it as rice porridge.

In Europe it is only used for manufacturing purposes. This rice being so much broken essentially contains a large proportion of the inferior sown padi which/
P A D I.

Garden Padi

Early Middle Heavy crop

The Rice Mill

No. 1 Extra No. 1 Garden

Garden Rice Rice

Rice Polishings Broken Rice

Polishings

Sown Padi

Sown with garden seed

Sown with ordinary seed

Early Middle Heavy Ordinary Middle Heavy

No. 1 Straits Quality Rice

No. 2 Straits Quality

Broken Rice

Polishings.
which has been mixed with the better quality padi. If milled well and all the dust removed it will keep without spoiling for three months. Its price is from 5/- to 6/- per cwt. It is largely used locally by rice dealers to adulterate the better quality rices.

Rice dust or polishings. consist of the pericarp and cotyledones of the grain and also a small amount of broken grain. It contains a large amount of oil. It will keep in this country for about a month, then becomes very mouldy and full of weevils.

The miller who exports rice fears the presence of this dust; and to him, this, is the chief cause of rice becoming mouldy, therefore the most elaborate part of his machinery is that, which separates out this dust very carefully. Only the largest mills are provided with this machinery. The smaller mills not exporting to Europe do not find it worth their will to spend such care on the milling.

As soon as the best milled rice has been kept sufficient time to become cracked, and dry and dusty, and then only does it become mouldy and weevilly. These parasites evidently not being able to attack the polished/
polished unbroken grain. This rice dust, in its fresh state, is often eaten by the poorest natives who live near a rice mill; and seem to be perfectly harmless though not very satisfying diet.

History of steam-milled rice after milling.

As the two best qualities are almost entirely exported to Europe I will only give details regarding Straits Quality Rice.

1. After milling the rice is only kept at the mill for a period up to ten days, it is got rid of each day if possible, either to a ship for export, or the wholesale local dealers.

Inquiries were made at twenty-five wholesale rice shops and it was elicited that the quantity bought varied from 100 to 500 bags at a time of both No. 1 and No. 2 qualities and at varying prices. This rice is kept in the shop on an average of fifteen days before it is all sold, the maxim time being thirty days (one shop even kept it sixty days). The old stock is constantly being "freshened up" by the addition of new rice, this is especially applicable to the No. 2 Straits quality.

2. The wholesale dealer sells it to the retailer; from half a bag to thirty bags at a time; and this rice is again kept in the shop for an average of fifteen days before/
before being sold; the maxim being thirty days. The
same "refreshing" process goes on only more so, as is
the rice here stored in a bin and not in bags.
The retailer employs Chinamen, who sell the rice from
house to house; each house buying a few pounds every
two - five days according to its requirements.
3. The retailer sells to the consumer
a. The wealthy Siamese Chinese.
Inquiries were made at fifty houses and palaces,
fifty-seven eat steam-milled rice.
The maxim time the rice is kept is thirty days.
The average time 13.3 days. The best and freshest
qualities of Straits rice at a price of about 15/-
per cwt. were used. In some cases No. 1 garden
rice was used at a price of 20/- per cwt. In one
case only was inferior quality rice at a price of
9/- per cwt used, namely at the house of a very
poor nobleman; and it is interesting to note that this
gentlemen and one of his servants had Beri-Beri at
the time of the inquiries.
b. Middle Class Siamese and Chinese.
Inquiries were made at 100 houses. All eat steam-
milled rice of No. 1 Straits quality. The maximum
time the rice was kept in the house was twenty-five
days, the average time 9.4 days. No case of Beri-
Ber1/
Beri-Beri had occurred in any of these houses.

c. Coolie Class.

Inquiries were made at fifty cook shops of varying sizes.

No. 2 Straits rice is bought in all these shops in varying quantities from half a bag to five bags at a time. The maximum time it is kept, before all is consumed, is thirty days; the average time seven days. Here the "freshening" process before mentioned is resorted to in every case.

d. The death registration records were examined and 200 deaths from Beri-Beri were noted. The houses visited and inquiries made with the following results:

All these deaths occurred amongst the lower class of native, such as coolies, carpenters, boatmen, etc.

Males 172. Females 28.

Siamese 132 Chinese 68.

Average Age 39 - 1 years.

194 eat steam-milled rice, six eat hand-milled rice. The average length of time the rice was kept in the house was 13 - 6 days. The maximum length of time thirty days. The steam-milled rice was in every case No. 2 Straits quality.

With reference to the six men that eat hand-milled rice all six were coolies and therefore had at least one/
one meal per day at a cook shop, though hand-milled rice was eaten at their houses.

Thus to put it shortly the age of the rice as consumed by the native of Bangkok is

1. **Maximum** -
   - In the rice mill: 10 days
   - " wholesale shop: 30 "
   - " retail: 30 "
   - Consumer's House: 30 "
   - Total: 100 "

2. **Average** -
   - In the rice mill: 3 days
   - " wholesale shop: 15 "
   - " retail: 15 "
   - Consumer's House: 9 "
   - Total: 42 "

Now as will be seen in the following pages, Straits quality rice even of the No. 1 quality and carefully milled with all the dust removed will not keep fresh under ordinary conditions in this climate for 100 days. It gets mouldy in about two months; worse qualities in about six weeks. Also with the frequent mixing of fresh with old rice, portions of the rice sold to the consumer must of necessity be of a far/
far greater age than even 100 days; but being well mixed is not very apparent to the consumer desirous of a cheap article.

Therefore, this consumer is, throughout a large part of the year, eating rice prepared from "Sown" padi and part of the rice is distinctly stale. It is amongst this class of native entirely that Beri-Beri occurs in Siam.

In the days of the hand-mill, a cheap rice certainly was eaten by the lower classes. But at that time Siam was owned entirely by the Royal Family and the nobles; who had their extensive lands cultivated by slaves, who were paid nothing but their food, thus their labour cost nothing. The rice was milled daily, and was never eaten in a stale or mouldy condition; and Beri-Beri never occurred. But nowadays the same rice is milled in a steam-mill, and is eaten in a mouldy or stale condition, and Beri-Beri is very prevalent.

Stale Rice.
Specimens were taken as follows -
1. No. 1 quality Straits rice fresh milled.
3. Parboiled rice hand-milled from garden padi.

These were kept in order to observe what changes occurred/
occurred. They were stored at the Asylum in a room (exactly similar to the old rice store room there, which had been destroyed) having a fairly constant temperature of 26°C. A sample of fresh rice was taken daily in order that the comparison might be more detailed.

Firstly it was noticed that these three rices did not have the same temperature, did not remain constant, but slowly rose and then dropped again; and that parboiled rice had a much higher temperature than the other two. On the 21st day it was noticed that the steam-milled rice and hand-milled rice in the baskets were becoming mouldy and had present various cocoon-like forms and weevils (Acarus Farinae) which developed into beetles (Calandria Granaria) and moths (Ephestia Elutella) on the 27th day.

The rice kept in the bags did not become spoilt in appearance till the thirty-sixth day and then changes were noticed in all three bags, viz. the grains were opaque and covered with a fine dust like mould. Weevils showing on the forty-sixth day.

The parboiled rice never showed any weevils but only the beetles. It became much more dusty than the other two forms. Such rice if winnowed, and exposed to the sun again, almost resumes its normal appearance; and is eaten daily by the native. It is not considered to be spoilt. Such spoiling is considered to/
to have occurred, only when this rice has a distinct earthly smell and tastes bitter. This change did not occur till after the rice had been kept for two months.

The above results may be taken as similar to those which occur in rice kept in any ordinary Siamese house. Though in the shops from which it is bought these changes are probably delayed for a few days owing to it being kept under better conditions.

The Incidence of Steam Mills for milling rice in Siam.

a. Fifty-six years ago the first steam rice mills were erected in Bangkok; two in number; but were only used to husk the rice and not remove the pericarp. All was exported as cargo rice, i.e. red rice to be remilled and polished.

b. Thirty years ago, i.e. in A.D. 1930 the first mill for milling white polished rice was erected, all the rice being exported to Europe, Singapore and Hongkong. By the use of this machinery, which had already been established for some years in Java and Burma, the miller was so able to polish and whiten rice, milled from mixed qualities of padi; that it resembled first quality rice, and to sell it as such, thus making enormous profits.

He was also able to mill sown padi, so as to remove/
remove the stains; hence the rice resembled an inferior quality of "garden rice" and he exported this to Singapore and Hongkong, as a cheap rice, underselling other markets.

c. During the succeeding ten years, five more mills were erected; and they only milled for export to Singapore and Hongkong, though these were in reality ports of transhipment to Japan, South America and India.

d. In the next ten years, i.e. from A.D. 1890-1900 five more mills were erected. But some of these now catered for local consumption; and white polished steam-milled began to be consumed in Siam. At first the rice was only sold in small quantities and then only to food contractors. The Bangkok New Goal being one of the first institutions to be supplied with it, followed by the Army, Navy and Railway. Previous to 1895 steam-milled rice had never been sold in the bazaars of Bangkok; but after that date it rapidly became popular from its cheapness, the ease with which it could be procured and its white appearance; and soon was practically the only rice eaten by all classes of natives, with the exception of a few epicures and the Malays who preferred hand-milled rice. Since 1895, twenty-three new rice mills have been erected in Bangkok; about four mills being erected every five years/
are years. So at present there thirty-six rice mills in Bangkok, and a further twenty in other parts of the plain of Siam outside of Bangkok.

In Siam there is grown per annum 1,290,000 tons of padi (a rough estimate), 930,000 tons of padi and rice are exported, 350,00 tons of padi and rice are consumed in Siam for a population of about 4,000,000 people.

Of the padi consumed in Siam
100,000 tons is steam-milled
250,000 " " hand-milled.

These approximate figures have been fairly constant for the past six years, but show a slight increase as more land comes under cultivation. Steam-milled rice is only eaten by natives around Bangkok and these only form one-third of the population of Siam.

So here we have fifty-six rice mills turning out annually about a million tons of rice from a total quantity of 1,280,000 tons of padi grown. This rice being milled from all qualities of padi from the best to the worst. The best only coming sixth in the world's supply; and then only very limited in quantity; the worst being easily the worst in the world's supply. These worst qualities being exported to Singapore and Hongkong, and thence over the world to those/
those parts demanding a very cheap rice.

100,000 tons of the best quality Siam rice are and exported to Europe each year, Beri-Beri is practically unheard of in Europe. 100,000 tons of inferior Siam rice are eaten in Siam each year and this country has a death rate of 6.1 per mille from Beri-Beri.

At this present time there are 100,000 tons per annum retained in Siam for local consumption; whilst fifteen years ago only some 15,000 tons of steam-milled rice were consumed per annum. In the days of the hand-mill, i.e. previous to 1895, unmixed padi is used for milling for local consumption, and the rice was never stored more than a few days. Now unmixed padi is difficult to obtain, and the steam-milled rice is stored for many weeks. This same rice being exported in huge quantities over the world.

It is important to note, that during the thousand odd years in which the hand mill has been used in Siam, Beri-Beri is seldom, if ever, known in there and probably in other countries also, but no sooner has the steam-mill been erected and the before mentioned inferior rice exported, than from then Beri-Beri is heard of; but only in such places as this rice is eaten.

In 1895 A rice was not yet being eaten in Siam, though to other countries exported and there was yet no Beri-Beri in Siam.
A few more years pass and this rice is sold locally; this rice Beri-Beri at once is seen in Siam, and since A has replaced hand-milled rice in Bangkok district, Beri-Beri has become endemic and epidemic, and has most accurately followed the track of this rice, along the railway, rivers and canals - the only means of communication in Siam, till it is now known in every village - within 150 miles of Bangkok, where steam-milled rice is eaten. In those parts of Siam which cannot be included in the plain of Siam, Beri-Beri is unknown, and never met with by the missionary doctors who travel from place to place. One small epidemic far up the country has been carefully reported by an European doctor, who states that it occurred in two or three villages only; and that the flooding of the river had been excessively prolonged, and that the people were forced in consequence, to mill their padi and store it as rice, and could not mill it every few days. The cases were all of a mild type and the disease entirely disappeared simultaneously with the floods.
CONCLUSIONS.

1. That some kinds of rice are much more liable to cause Beri-Beri than others and that such are those chiefly eaten by the poorer class of native owing to their cheapness.

2. That these cheaper kinds of rice are milled from a very mixed and inferior quality of padi; and that this padi is freely adulterated with a still more inferior padi, which is peculiar to the countries, Burma, Siam and Cochin China.

3. That such rice, as is eaten now by the lower class native in Siam, is seldom really fresh, and usually is stale and spoilt in parts.

4. That previous to the erection of steam rice mills in Siam, padi was never mixed, and adulteration difficult, and that stale rice was very seldom if ever consumed; and that the connection that Beri-Beri has with steam-milled rice, is simply owing to the fact, that the milling by machinery allows this mixing and adulteration to become possible; and the sale in bulk of the rice predisposes to its becoming stale.

5. That the main factor in Beri-Beri is the consumption of steam-milled rice milled from padi which has been adulterated freely with what has been so far termed "sown/
"sown padi", i.e. a very poor class of padi, and that this rice - though if eaten fresh is innocuous - after keeping for as yet an undetermined period - can and will cause Beri-Beri.
EXPERIMENTS WITH VARIOUS FORMS OF PADI AND RICE
TO SHOW THEIR INFLUENCE ON BERI-BERI.

CHAPTER IV.

July 1908.

As at this period Beri-Beri was almost universally recognised as an infectious disease I tried to infect monkeys.

Three healthy monkeys, which had already been under observation for six months; were taken and fed on the same rice as that supplied to the patients in the lunatic asylum; where Beri-Beri was causing an enormous mortality.

Monkey A.

Placed in a dark badly ventilated room on the ground floor, in which Beri-Beri patients had been living continuously for the past four years. The monkey was allowed to run loose in the room and fed with rice such as was supplied to the lunatics. On October 1908 no change being noticed and the monkey being perfectly well and healthy it was removed. The experiment is therefore negative.

Monkey B.

Placed/
Monkey B.

Placed next door to Monkey A. As I had noticed that the disease seemed to attack those patients with greater severity who were listless, inactive, drowsy, and indolent and as this monkey was the very reverse; I gave it opium night and morning and tied it down with a very short chain. The monkey slept most of the day and did not take its food well, but notwithstanding this at the end of four months there was no sign of any disease, so it was removed.

Monkey C.

Placed next door to Monkey B.

Hamilton Wright at Kuala Lumpur having laid great stress on the infectability of one patient to another by means of contamination from urine and faeces, I fed this monkey with rice soaked with the urine of a Beri-Beri patient, wrapped it up in the blanket of a Beri-Beri patient, the food was thrown on the floor and not given in a dish, floor bugs were collected from the rooms of Beri-Beri patients and scattered near him, all of which he ate. He was also given pediculi obtained from Beri-Beri patients. Notwithstanding this he remained perfectly healthy and so was removed on October 1st.

Notwithstanding/
Notwithstanding the negative results of these experiments I still at that time continued to think that Beri-Beri was an infectious disease and carefully isolated all Beri-Beri patients in the Asylum.

FURTHER EXPERIMENTS ON MONKEYS.

June 1st 1909.

Having obtained such remarkable results with the introduction of parboiled rice I again attempted to infect monkeys in order to be able to try the effect of parboiled and other forms of rice on them. Monkey 1 was kept as a control and fed on fresh hand-milled rice, such as was at this time supplied to the lunatics when no Beri-Beri was present. Monkey 2 fed on No. 1 quality steam-milled rice which has been kept in the Asylum for exactly thirty five days and to all appearances is mouldy and stale. (vide page ) the rice unwashed before boiling, and given in the form of porridge, with the water not removed. After feeding for four months, a negative result. No other food except an occasional banana was given to these Monkeys. Monkey 3 fed on hand-milled rice which has been kept exactly/
exactly thirty five days in the Asylum and which is stale, mouldy and spoiled. The rice to be unwashed before boiling and given as porridge.

My attention had been drawn by Siamese officials that Beri-Beri was more prevalent in its acute form in gaols and similar institutions where the occupants were fed by contract. They explained that this might be due to improper washing of the rice in bulk previous to boiling and that the poison, if any, was thus carried to the consumer. Every native of every class pays great attention to the careful washing of his rice before cooking, it being a household custom to wash it with three changes of clean water. This of course is not done with such detail in institutions.

Monkey 4. Thinking that the infection might lie in the husk of the padi, this monkey was fed on fresh steam-milled rice which was soaked in the infusion obtained previous to parboiling rice. The experiment was negative.

Monkey 5. Thinking that the poison might be due to the improper cocking of rice, I fed this monkey on old hand-milled rice which was stale and mouldy combined with an equal quantity of powdered uncooked steam-milled /
steam-milled rice obtained from Nontaburi gaol, where Beri-Beri was very prevalent. The monkey was fed on this for four months and as at the end of that time it showed no symptoms of Beri-Beri it was removed.

All these rices had been obtained absolutely fresh and stored under the same conditions as to temperature, ventilation, moisture, as the rice for consumption by lunatics in the previous four years.
Experiment No. I.

Parboiled rice commenced 12.2.09.

This parboiled rice was prepared from "planted" padi grown at Ayuthia, 60 miles from Bangkok. It was of a "late" crop and not of the best quality. This rice contained 0.5% P2O5.

Patients present in the Asylum.

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>20</td>
<td>108</td>
</tr>
</tbody>
</table>

Out of this number there were Beri-Beri patients

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>6</td>
<td>22</td>
</tr>
</tbody>
</table>

All patients consumed parboiled rice with no other change in the diet till 24.5.09 i.e. three months and twelve days. They were under identically the same conditions as regards sanitation, water supply, temperature, humidity, place and food, as they had been for the preceding three years with the exception of this one change, namely rice. On this latter date there were patients present in the Asylum.

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>25</td>
<td>145</td>
</tr>
</tbody>
</table>

Out/
Out of this number there were Beri-Beri patients

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

From 12.2.09 till 24.5.09 no fresh case of Beri-Beri had occurred in the Asylum. During this period the mortality amongst the old cases of Beri-Beri was as follows:

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb. 1909</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>March &quot;</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>April &quot;</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May &quot;</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Parboiled rice was continued to be consumed in the Asylum till 1.8.09 and no fresh case of Beri-Beri occurred. This experiment proves that parboiled rice is a certain preventive of Beri-Beri.

Before 12.2.09 Beri-Beri patients had always been allowed an extra diet in the shape of bread spread with condensed milk (the only form in which I could get them to take milk) also an extra allowance of meat, but little benefit if any was ever noticed.

Experiment No. II.

Twenty lunatics who had never had Beri-Beri were taken/
taken and fed on red rice, i.e. padi husked and the middle red cuticle not removed. This padi was not parboiled and the rice was milled each day. They continued to eat this rice till 9.9.09 and no case of Beri-Beri occurred amongst them. They complained, however, that this rice was not so digestible as either parboiled rice or steam-milled rice.

Experiment No. III.

On August 1st 1909 all the lunatics except the twenty in Experiment II were put on freshly milled hand-milled rice. This rice contained 0.29% P2 O5, and was prepared from the same padi as the parboiled rice in Experiment I, which contained 5% of P2 O5. On August 25th three Siamese patients showed typical symptoms of Beri-Beri, viz.

Nai Phan admitted 9.7.09
Nai Chien " 7.7.09
Nai Warn " 28.7.09

None of these three had ever had Beri-Beri before, though Nai Phan was a returned insane case and had only been discharged from the Asylum in March 1909. These three cases were at once put on to parboiled rice, the other lunatics remained on hand-milled rice. Nai Phan and Nai Chien resumed work in a week's time being/
being perfectly cured, but Nai Warn rapidly got worse and died suddenly on 7.9.09.

There were no other cases. On 9.9.09 Nai Phan and Nai Chien were put back on to hand-milled rice.

Hand-milled rice is now eaten by the bulk of the lunatics and up to date no case of Beri-Beri has arisen.

The hand-milled rice milled in August 1909 being in large quantity, was stored in the old rice store room; but after the occurrence of the three above mentioned cases of Beri-Beri, the old store room was destroyed, and the rice store for the future, is a well ventilated shed at the rice mill.

As from August 25th 1909 up to 17th March 1910 no other cases of Beri-Beri have occurred amongst those lunatics fed on fresh hand-milled rice, I cannot account for these three cases unless the rice was infected in some way from the old store room.

Experiment IV.

Twenty patients were taken on September 10th 1909 and fed on hand-milled rice which had been stored in an open dry shed near the rice mill for exactly thirty days. This was the same hand-milled rice as in Experiment III with the only difference that it was old. It contained 0.18% P2 O5. This rice appears fresh and sweet.
sweet and resembles new rice. On January 1st 1910 no case of Beri-Beri having arisen amongst these twenty patients, they were put back on to ordinary fresh hand-milled rice.

Experiment VI commenced 23.11.09.

Twenty five patients taken and given fresh steam-milled rice No. 1 "Straits" quality, price 15/- per cwt. but obtained fresh from the mill each day. This rice is milled from a mixture of old and new "planted" padi, is well milled and has no sown padi in it, and has very little dust. It contains 0.23% P2O5.

<table>
<thead>
<tr>
<th>Women Prisoners (in chains)</th>
<th>Ordinary working lunatics</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Up to March 17th 1910 no case of Beri-Beri had occurred amongst these 25 patients.

Experiment VII.

A basket of fresh steam-milled rice of the best quality procurable and milled entirely from No. 1 "garden" padi, obtained each day from the steam mill and stored in a room in the Asylum as much resembling the old store room as possible, i.e. dark, no ventilation, damp, musty and hot. Stored from day to day for/
for exactly thirty five days. This rice contains 0.11% P2 05. Ten lunatics taken and fed on this rice (which is thirty five days old) from January 1st 1910.

<table>
<thead>
<tr>
<th>Prisoners</th>
<th>Ordinary working lunatics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The rice appears stale and has lost all its gloss, is opaque of a greenish or brownish colour, very dusty and the grains stick together into clumps. It has weevils, a moth, and two kinds of beetles in it, besides numerous eggs of the moth in a hard calcareous shell. The temperature of the rice has risen from 25° C. to 31° C., the room temperature remaining constantly at 26° C. This rice has a stale bitter smell. I am, however, assured by natives that such rice is quite fit for food if properly washed and that this rice mixed with fresher rice is what is constantly being sold to the poorer class in Bangkok. The above rice when cooked, looses all its stains and smell, and differs in no way, as far as one can see, from fresh steam-milled rice. Up to March 17th 1910 no infection with Beri-Beri had occurred.

Experiment VIII commenced on January 1st 1910.

A basket of hand-milled rice stored each day as in Experiment/
Experiment VII for a period of thirty five days.
Ten patients taken, four women and six men fed on this rice daily. This hand-milled rice resembles the steam-milled rice of Experiment VII but is much worse and is more stained and mouldy probably because in the process of hand milling dust is not so carefully removed as in the steam mill. It would be impossible to sell such rice in the market, as, being hand-milled, it is already dark in colour and this is much increased by the mould growing on it. This rice when cooked, however, does not differ in any way visibly from fresh hand-milled rice. Up to March 17th no infection of Beri-Beri had occurred.

Daniels states:—"It must therefore be admitted that "uncured" rices if they are the cause of the disease are only capable of producing it at certain times or in other words that many of the "uncured" rices do not contain the necessary ingredients for the production of Beri-Beri."
At this Hospital a limited number of cases of Beri-Beri from the Siamese Government Services under our charge have been treated for the past four years. They were not in any way selected cases, and so, formed appropriate material for experiments.

During the two previous years these patients had been fed on fresh steam-milled rice, but with varying quantities of Indian beans and lentils added to it; with the idea of increasing the nitrogen in their diet. No marked benefit had been seen from this treatment.

Experiment I.

Parboiled rice was given to all the Beri-Beri patients on 12.2.09. This rice when first eaten causes gastric distension and slight diarrhoea, but after three to five days these slight unpleasant symptoms disappeared, to be replaced by a feeling of benefit derived from its consumption. The bowels still continued loose, but the gastric distension which is a marked/
marked symptom throughout the whole course of Beri-Beri rapidly disappear. Flatus is constantly and easily passed, though a Beri-Beri patient fed on ordinary rice always complains of constipation and flatus due to the paralysis of the intestine. After eating parboiled rice from ten to fourteen days, the oedema of the face, body and legs has largely disappeared. The arms and legs, which previous to this were paralysied and felt to the patient very heavy, now feel, by contrast, abnormally light. The appetite increases markedly. A patient can eat half as much again of parboiled rice as ordinary rice. Cardiac symptoms and all other general symptoms rapidly improve till the convalescent stage is reached. Having now reached this stage, the improvement is far slower; the actual paralysis and neuritis only gradually getting better. In few other diseases have I seen such marked benefit derived from treatment in so little time. The records of the Hospital for 1908 compared with those for 1909 show very clearly the benefit derived from feeding the patients on this rice.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total No. of Cases</th>
<th>Recovered</th>
<th>Died</th>
<th>Av. No. of Days</th>
<th>Bedridden</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1908</td>
<td>189</td>
<td>150</td>
<td>39</td>
<td>55.7</td>
<td>34.6 days</td>
<td>20.6</td>
</tr>
<tr>
<td>1909</td>
<td>235</td>
<td>215</td>
<td>20</td>
<td>55.5</td>
<td>21.3</td>
<td>8.5</td>
</tr>
</tbody>
</table>
These figures show that feeding Beri-Beri patients on parboiled rice for a year has reduced the mortality from 20.6% down to 6.5%; and has also lessened the acute stage of the disease from 34.6 days to 21.8 days. Though the number of patients treated is comparatively small for statistical purposes, still they were not selected from any one district, but were sent in from all parts of Bangkok province. Therefore it cannot be said that the improved figures are due to a milder form of the disease. In fact it was the opposite, for the hospital was gaining a reputation for the cure of Beri-Beri, and so more acute cases were sent in.

Experiment II. commenced 12.6.09.

The effect of "red rice" was tried on five patients. This rice is simply padi with the husk taken off, but retaining all its inner linings. The idea being that the phosphorus contents being high it might suit the treatment of disease even better than parboiled rice. The rice did not alleviate the symptoms in any way, in fact the patients soon refused to eat it as they said it was so indigestible.

Experiment III.

Five patients were fed on fresh No. 1 quality steam-milled rice to which two ounces of rice polishings/
polishings were added. No improvement of any kind followed this treatment, so it was stopped; as we already had had such definite good results from par-boiled rice.


CHAPTER V.

ANALYSES OF VARIOUS RICES.

1. Fraser and Stanton. (4)

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>Fats</th>
<th>Proteins</th>
<th>Ash</th>
<th>P₂O₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Siam Rice</td>
<td>90.11</td>
<td>0.17</td>
<td>9.07</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>steam-milled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rangoon Rice</td>
<td>89.9</td>
<td>0.61</td>
<td>8.44</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>steam-milled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parboiled Rice</td>
<td>89.12</td>
<td>0.51</td>
<td>9.48</td>
<td>0.89</td>
<td></td>
</tr>
</tbody>
</table>

Note. Parboiled rice containing P₂O₅ 0.469% did not cause polyneuritis in fowls. Steam-milled polished rice containing only 0.277% P₂O₅ caused polyneuritis in the same fowls.

2. Balland. (2)

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>Fats</th>
<th>Proteins</th>
<th>Ash</th>
<th>P₂O₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand Husked Rice</td>
<td>64.93</td>
<td>2.8</td>
<td>9.05</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Machine Husked Rice</td>
<td>77.74</td>
<td>0.60</td>
<td>7.82</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>Husked and ground</td>
<td>78.20</td>
<td>0.40</td>
<td>7.82</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>Husked, ground and polished</td>
<td>78.18</td>
<td>0.30</td>
<td>7.65</td>
<td>0.36</td>
<td></td>
</tr>
</tbody>
</table>

Note. He/
He states that nearly all the ash consists of phosphates 53.7% being $P_2O_5$.

### Aron, Manilla (6)

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>Fats</th>
<th>Proteins</th>
<th>Ash</th>
<th>$P_2O_5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laguna Rice</td>
<td>-</td>
<td>-</td>
<td>9.0</td>
<td>-</td>
<td>0.557</td>
</tr>
<tr>
<td>polished</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery Rice</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.340</td>
</tr>
<tr>
<td>Hand-milled Rice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.445</td>
</tr>
<tr>
<td>Highly polished Rice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.197</td>
</tr>
<tr>
<td>Average Manilla Rice</td>
<td>-</td>
<td></td>
<td></td>
<td>-</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Note. He does not give any detail whether the consumption of any of these rices is associated with Beri-Beri, neither does he state the quality of the rice nor padi from which it was milled.

### Also.

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>Fats</th>
<th>Proteins</th>
<th>Ash</th>
<th>$P_2O_5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Calcutta&quot; Rice</td>
<td>-</td>
<td>-</td>
<td>7.75</td>
<td>-</td>
<td>0.446</td>
</tr>
<tr>
<td>&quot;Bombay&quot; Rice</td>
<td>-</td>
<td>-</td>
<td>7.94</td>
<td>-</td>
<td>0.408</td>
</tr>
<tr>
<td>&quot;Liverpool&quot; Rice</td>
<td>-</td>
<td></td>
<td>6.69</td>
<td>-</td>
<td>0.148</td>
</tr>
</tbody>
</table>

These three rices were eaten on a ship the "S.S. Knight Templar". Whilst Qualities 1 and 2 were eaten.
eaten no Beri-Beri occurred, but when the supply was short and rice was bought at Liverpool, then epidemic Beri-Beri broke out amongst the crew. As far as I can understand Calcutta and Bombay rices were hand-milled. Liverpool rice was steam-milled.
Dr. Rankyn,
Bangkok Laboratory,
(done for me at my request.)

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>Fats</th>
<th>Proteids</th>
<th>Ash</th>
<th>P₂O₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam-milled Rice. three months old. (No.1 Garden padi.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.11</td>
</tr>
<tr>
<td>Steam-milled Rice. No.2 &quot;Straits&quot; Quality from Nontaburi Gacl.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Hand-milled Rice from Chinese Hand-Mill (No.1 Garden Padi.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.18</td>
</tr>
<tr>
<td>Hand-milled Rice Asylum. (No. 2 quality Padi.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.29</td>
</tr>
<tr>
<td>Parboiled rice Hand-milled from (No. 2 quality Padi).</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Parboiled Rice as above but after extraction with hot alcohol.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.34</td>
</tr>
<tr>
<td>Rice Polishings I II</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.48</td>
</tr>
<tr>
<td>Rangoon Rice steam-milled and polished</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Note. All/
Note.

All these rices were used in feeding experiments at the Asylum, with the exception of the steam-milled rice from Nontaburi Gaol marked +. But in that gaol Beri-Beri was and had been epidemic for many months. Though the P₂O₅ was so limited in amount except in the parboiled rice, no Beri-Beri occurred in the Asylum whilst these rices were being eaten.
Analyses at Dr. Drinkwater's Laboratory, 
College of Surgeons, Edinburgh, Nov. 1910.
(done at my request for inclusion in this paper.)

A. Bangkok Rices.

<table>
<thead>
<tr>
<th>Starch</th>
<th>Fats</th>
<th>Proteins</th>
<th>Ash</th>
<th>P_{0.05}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Hand-milled Rice (Police School)</td>
<td>72.08</td>
<td>0.7</td>
<td>7.71</td>
<td>0.59</td>
</tr>
<tr>
<td>Old Hand-Milled Rice (Asylum)</td>
<td>67.35</td>
<td>0.5</td>
<td>8.60</td>
<td>0.76</td>
</tr>
<tr>
<td>Fresh Parboiled Rice (Police School)</td>
<td>70.62</td>
<td>1.14</td>
<td>7.99</td>
<td>0.83</td>
</tr>
<tr>
<td>Old Steam-Milled Rice (from No. 1 garden padi.)</td>
<td>72.85</td>
<td>0.49</td>
<td>7.90</td>
<td>0.67</td>
</tr>
<tr>
<td>Fresh Steam-milled Rice (inferior mixed padi.)</td>
<td>70.29</td>
<td>0.8</td>
<td>8.1</td>
<td>0.416</td>
</tr>
</tbody>
</table>

Note. The last marked + is the quality of rice which we associate with Beri-Beri.

Steam-milled rice from No. 1 quality padi never gave rise to Beri-Beri in feeding experiments, even though it has an almost equal percentage of P_{0.05} to the former quality.

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>Fats</th>
<th>Proteids</th>
<th>Ash</th>
<th>P2 O5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Carolina Rice No. 1 quality</td>
<td>-</td>
<td>-</td>
<td>8.15</td>
<td>0.39</td>
<td>0.154</td>
</tr>
<tr>
<td>Fresh Patna Rice No. 1 quality</td>
<td>-</td>
<td>-</td>
<td>8.33</td>
<td>0.49</td>
<td>0.17</td>
</tr>
<tr>
<td>Fresh Java Rice No. 1 quality</td>
<td>-</td>
<td>-</td>
<td>8.24</td>
<td>0.65</td>
<td>0.14</td>
</tr>
<tr>
<td>Rangoon Rice cheapest quality only used for feeding Chickens</td>
<td>-</td>
<td>-</td>
<td>7.99</td>
<td>0.38</td>
<td>0.105</td>
</tr>
</tbody>
</table>

It is remarkable what a small proportion of P2 O5 is present in the three first rices, even though they are supposed to be the finest and most expensive in the world. I have not heard of Beri-Beri being prevalent in Carolina or in Europe where large quantities of this rice is exported.

As regards the Patna and Java rices they are of far too good a quality for the poor native to procure and only used for export. They are never eaten in those countries, except by the wealthiest native, and he never gets Beri-Beri.

The True Organic Phosphorus (Ketone) in the Samples gave
A. Parboiled Rice which is an undoubted prophylactic + probable
cure for Beri Beri.
B. Low quality Steamed Milled Rice from Bangkok. Obtained from S.S.
"Gleaner" on which sick challenge Beri Beri occurred
Gleaner. Parboiled

<table>
<thead>
<tr>
<th></th>
<th>Total P2O5</th>
<th>Organic P2O5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Extracted &amp; Alcohol</td>
<td>0.148</td>
<td>0.381</td>
</tr>
<tr>
<td>Extracted &amp; Ether</td>
<td>0.0106</td>
<td>0.155</td>
</tr>
<tr>
<td>Alcohol Extract</td>
<td>0.7</td>
<td>0.15</td>
</tr>
<tr>
<td>Total</td>
<td>1.52</td>
<td>1.14</td>
</tr>
</tbody>
</table>

The points which attract attention are:
(a) The comparative minute quantities of organic P2O5 compared
with Fraser + Stainton + Arron's analyses.
(b) The large amount of alcohol extract in the "Gleaner" rice,
which would be accounted for if some organic form were
present in quantity and absent from the Parboiled Rice.

These analyses were performed according to the standard method
for the extraction of organic phosphorus (S. analyses of Oils
Fats + Waxes, J. Newknowitche [Macmillan + Co]).

The quantities found correspond approximately with those
of other cereals. (Rice not being mentioned in any text books)
Fraser & Stainton results or Hance Aron results, be taken
the organic P2O5 from extraction with hot alcohol will be
found to be greater than the total P2O5 given for any rice
in any standard text book, and at least 20 times
greater than the organic P2O5 given for any other
grain. As however full details of their processes are not
given it is impossible to criticise them further.

From Dr. Drinkwater's analysis above, it is impossible
to say that such a minute difference in organic P2O5
would cause such an acute disease as Beri Beri.
C. Rice from "S.S. Glenesk". (See Addenda).

<table>
<thead>
<tr>
<th>Starch</th>
<th>Fats</th>
<th>Proteids</th>
<th>Ash</th>
<th>P₂O₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>7.89</td>
<td>0.41</td>
<td>0.148</td>
</tr>
</tbody>
</table>

Note.

The P₂O₅ is certainly low in quantity, but no lower than that contained in the various rices purchased at Gibson's; or than those usually eaten by the high class natives in Siam. Hence the epidemic of Beri-Beri on this ship cannot be explained by a phosphorus starvation, nor is the amount of phosphorus present any indication of the Beri-Beri producing power of this rice.

On contrasting the analyses from all five laboratories, it is remarkable what great differences there are in the results, especially in the first three. Dr. Drinkwater's and Dr. Rankyn's results agree better than any of the others. This limits their collective value very much as very differing qualities of rice must have been used, and so a detailed contrast cannot be given. But taking only those analyses done for me, I think that they very distinctly show what I have endeavoured to prove all through, viz., that the quantity of P₂O₅ varies enormously with various rices, and cannot be taken as any indication of its Beri-Beri producing power.
CHAPTER VI.

CONCLUSION.

1. I have attempted in this paper to prove, that Beri-Beri is closely associated with the consumption of rice.

2. Not rice generally but limited to certain distinct qualities of rice and to the class of native who consumes that quality of rice. I have traced with great, - and I am afraid tiresome, - detail, this rice, from the Beri-Beri patient, through the mill, to its original padi; in order to show what forms of padi I consider implicated. Other investigators on Beri-Beri, in my own opinion, do not seem to recognize the the many varying qualities of rice in the market, nor of padi grown. In their analysis they do not state where the rice is grown, but simply give it the commercial name by which it is known in the place where they work. It is necessary in order for their work to be of the greatest service that these details should be filled in.

3. By experiments I have further tried to prove that Beri-Beri/
Beri-Beri is not infectious and that it is limited to these certain qualities of rice.

4. By analysis I have tried to show that the phosphorus contents are not a correct nor certain indicator of the Beri-Beri producing power of rice and that we must look to some other agent apart from phosphorus starvation.

5. Siam derives a very large part of her revenue from the duty on export rice. If Siam rices are collectively blamed as the cause of Beri-Beri it will be a very serious thing for the finances of that country. The larger part of her export rice is certainly of a poor quality, but is sold at a price that accords with the low wages earned by the working classes in the East. In these experiments I have tried to prove that all Siamese rices cannot thus be indiscriminately condemned. Eliminate the steam-milled rice; prepared from padi, grown on the poor soils by the method of scattering the seed on unirrigated soil, by uncareful husbandmen; who sow a larger crop of inferior seed, than they can possibly hope to reap with due care at the proper time when the grain is ripe; then Beri-Beri will no longer be seen in Siam.

The padi cultivator is a poor man who lives from hand/
hand to mouth. He is a gambler by heredity and disposition and is always in debt, so much so that he has usually pawned his next year's crop to the rice miller.

King Chulalongkorn, the late King of Siam, in the latter years of his reign, tried his best to do away with gambling in his country; and, as the laws on gambling become more and more stringent, the cultivator will find he has more money to spend on his farm, and so I hope, will only spend his efforts in cultivating the best qualities of padi. Nearly all the rice mills in Bangkok are owned by Chinese who have no interest in the country apart from the money they can make out of it. Their chief efforts being to make money as quick as possible, so that they may return to China. It is the smaller rice mills in Bangkok, run on small capital, which cannot afford to pay big prices for good padi, that encourage the cultivation of the lower qualities of padi. If legislation in Siam and other countries will prohibit the sale of low quality rice prepared from low quality padi, only this class of miller would suffer; and I have little or no sympathy for him, for I think his extinction would be to the advantage of the world at large, and that epidemic Beri-Beri would then be eliminated/
eliminated. In Burma and Anam, conditions identical with the above are present and I include these countries in my criticism.
On the 28th November 1910 the "S.S. Glenesk" arrived in Leith with six cases of Beri-Beri on board. At the request of the master they were removed and taken to the Royal Infirmary, where I had the opportunity of examining one case in Professor Wyllie's ward; and investigating the history of the outbreak, which is as follows:

Name: Shee Piufong, a Chinaman from Ningpo near Shanghai, admitted to ward 34, 29.11.1910.

Occupation: Deck sailor on "S.S. Glenesk".

Complaint: Numbness, loss of power, loss of movement and difficulty in movement in both legs.

Duration: More than one month.

Family history: Good, no history of paralysis.

Personal history: No previous serious illnesses, no previous history of Beri-Beri. He does not smoke opium, tobacco nor drug in any form.

History of present illness.

The "S.S. Glenesk" left Hongkong in July 1910 with
a deck crew of fourteen men, all from Ningpo and all well and healthy. She went to Shanghai, Japan, and then back to Hongkong. She then went to Bangkok in Siam, reaching that place in the beginning of October 1910, where she took on a cargo of rice for Hamburg. Up to this time the health of all on board was good. She stayed in Bangkok for a few days and then sailed for Singapore, reaching the latter place in thirteen days. Three days before reaching Singapore and ten days after leaving Bangkok, the patient who had previously been feeling perfectly well, now complained of gastric distress, nausea, and a feeling of distension and tightness in his stomach. In his own words he describes it as follows:—

"He felt very sea sick but could not get anything up." Complete loss of appetite, no constipation, no difficulty in passing flatus. These symptoms continued to increase for four days. He then noticed that he could not walk so well, owing to a feeling of stiffness in his ankle joints, weakness of his legs, and difficulty in keeping his balance when walking, and pain in his legs. He did not specially refer to any particular group of muscles. Marked hyperaesthesia on pressing/
pressing firmly over his feet, legs and thighs, breathless on the slightest exertion, no palpitation. Simultaneously with this man two others of the deck crew were similarly affected, but in addition they complained of oedema of the legs and feet. One man's (Chin Char) symptoms were so acute that he took to bed at once and has done no work since. Four days after leaving Singapore, three of the engineer's crew became ill with the same disease, but being of a different faction, patient cannot tell me anything about them. From about a week after leaving Singapore all the patients symptoms started to improve slightly, with the exception in this man's case on the four days when he stopped work. He is quite positive that he felt much better while doing light work and that directly he ceased work his symptoms increased. He complained of oedema of the feet and increased weakness. With the exception of these four days, patient has continued to do light work for the whole voyage; but his work was made more difficult by the weakness of his legs.

Conditions as to food.

Patient eats eight bowls of rice (that is about 1 1/2 lbs. of raw rice) per day. The rice is steam-milled rice/
rice, boiled, and then steamed, till nearly dry. Up to the time that the ship reached Bangkok they had been eating rice purchased in Shanghai, but in Bangkok they bought a fresh supply. As far as I can gather from his account and my personal inspection of the rice procured in Bangkok, it is a No. 2 "Straits" quality rice such as is usually consumed by the Coolie classes in Bangkok and which has been described in detail in previous pages. There are no complaints from the patient as to the quality of the rice.

Other food.

When in port the sailors got fresh meat twice a day, such as pork, beef and mutton; when at sea they had tinned meat, supplemented with fish (fresh and salt) onions and other forms of vegetables. The food has been good in quality, and abundant, with only slight deterioration for the last week or two. Patient is very definite that the deterioration in food did not appear till a week or two after the disease broke out on board.

The patient's present symptoms are those of the convalescent stage of a mild attack of dry Beri-Beri, without any secondary affection of the heart, lungs and kidneys/
There are four striking points which may be brought out in the above history.

1. That from the time that the ship left Hongkong till she reached Bangkok and while eating Shanghai rice there was no sickness on board.

2. Within three weeks after daily consuming rice purchased in Bangkok, six of the crew simultaneously were affected with Beri-Beri.

3. The preliminary symptoms of gastric disturbance.

4. The tendency of spontaneous recovery after leaving port.

No better clinical picture of the poisoning of this crew, by some unknown substance, between the dates of leaving Bangkok and reaching Singapore, could possibly be obtained. Personally I look upon the preliminary gastric symptoms as the acute stage of the disease and I do not consider the secondary paralysis as being any more than a symptom of the subacute stage, resembling the diphtheritic paralysis following diphtheria or paralysis following arsenic poisoning. I cannot see that any theory of phosphorus starvation could possibly account for it.
I have already demonstrated that this rice they obtained in Bangkok is such as we blame for being the cause of Beri-Beri in that place.
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