SCIENCE

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CONTRIBUTION TO THE ETIOLOGY OF BERI-BERI.[1]

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THROUGH the courtesy of Captain J. R. Durke, of the bark "H. B. Cann," whose crew were prostrated by beri beri in the tropics, two of them dying of the disease, and of Messrs. Edward Hincken & Son, the consignees of the cargo, I have been enabled to extract the following data from the ship's log-book, to which I add some informations otherwise imparted. The bark (registered 1,299 tons) sailed April 27 from Ilo-ilo, Philippine Islands, with a cargo of raw sugar, 70,284 sacks. Let me say that this is a considerable freight, for a sack amounts to 66 pounds, which gives a total amount of over 2,300 tons! The sugar was mostly No. 3, the lowest grade, and the most liable to fermentation.[2] Fermentation in such a mass of sugar must have set free an enormous quantity of gases. Her crew consisted of fifteen men. On May 22 bad weather set in; there were 18 inches of water in the well in 12 hours, a condition which necessitated pumping every two hours. On June 5, heavy squalls, the bark ships large quantities of water; this weather continues until the 20th. Even when the squally weather has ceased. the pumps are worked every two hours. On July 15 a terrific storm strikes them, and continues until July 20. The decks for 24 hours were continually filled with water. A strong south-west current (60 miles an hour), lasting many days, set in. I observe here that it is generally supposed that there is a connection between the south-west winds and beri-beri. But the current called south-west is the current naturally due to the emptying of the waters of the Indian Ocean into the South Atlantic, around the Cape of Good Hope. It flows, therefore, toward the south-west and not from the south-west. In fact, throughout the voyage the bark never met the south-western trades. The following data show that the bark had less to deal with trade-winds than vessels usually do. When she left Ilo-ilo April 27, the north-east monsoons were becoming very weak; they carried the ship to the Basilan channel. The captain tried to get through Macassar Strait, but the wind was too weak; so he changed his course, and came down, with variable winds, Molucca passage. He was 45 days getting free of the East Indies into the Indian Ocean, through Lombock, an extraordinarily long passage. He had south-east trades, strong and squally, to Port Natal. He had 10 days' hard weather around the Cape of Good Hope, three days of which there was a heavy gale. From the Cape of Good Hope he had variable winds and calms until he struck the south-east trades in the South Atlantic (Aug. 7), which carried the ship past the equatorial line, 3° north latitude. Then he had calms and doldrums to Sept. 11, at which date, latitude 9° 39′ north, longitude 44° 21′ west, he found south-east winds prevailing instead of the usual north east trades, which he should have met here. These carried him to the North Atlantic and to port. Considering these facts, and the comparatively violent outbreak of beri-beri on the vessel, we must conclude that the etiological importance of the south-west trades in beri-beri has been very much exaggerated, if it is not altogether imaginary. Of course they have clearly an influence, inasmuch as they bring wet and heavy weather, which wet and heavy weather would be, I think, as innocent as the winds themselves if the really toxic action of carbonic emanations was absent.

Bodily exhaustion has always been considered as an etiological factor in beri-beri. Here is added, what, as I just said, is in my opinion, a much more important factor, the influence of carbonic gases. One month after they left Ilo-ilo, the water got into the hold, and the sugar began to ferment. Strong and stifling fumes permeated the vessel, which continued until she got into still water at Norfolk, Va. On Sept. 3 (this happened — the observation is not without its bearing — in latitude 2° 40′ north, longitude 41° 28′ west, near St. Helena, 139 days from the Philippines, the 111th day of the fermentation, on the very edge of the range of the trades) Russell, a seaman, was laid up with swollen limbs; he died Sept. 23. The pumping, meanwhile, continued every two hours. On Sept. 16 (latitude 13° 27′ north, longitude 52° 14′ west) the carpenter was laid up with swollen feet. Sept. 25 Andrew, Sept. 26 Peterson, Sept. 27 Kemp, seamen, were afflicted likewise. The carpenter died Oct. 9. At this date all were more or less ill, except four. The work at the pumps was being continued with fewer hands. A signal of distress was hoisted Oct. 10. There got then 5 inches of water into the well every two hours. Oct. 11 (167th day of the voyage) the tug Rescue came to the relief, took the bark in tow to Hampton Roads, where six men sick of beri-beri were left in the hospital. A new crew was enlisted, and the vessel, having been well pumped out, was towed to New York harbor. It has been said somewhere that there had been a famine on board and a scarcity of water. This, says the captain, has not been the case. They had plenty of water, as appears by the following notation in the log-book: May 20, Filled up starboard water-tank on deck. Aug. 30, Put about 150 gallons of water into the starboard tank. Sept. 16, Saved about 300 gallons of water. Sept. 19, Five feet of fresh water in the tank. And the water was good throughout. Vegetables were the only thing wanting, and rice and ship's bread (hard tack) were plentiful. They had Australian beef, of which they had broached seven casks (a cask is 300 pounds), and one cask of pork (200 pounds). I extract again from the log-book the following insertions to show how far a cask of beef goes: April 27, broached a cask of beef; May 17, beef; May 29, pork; June 8, beef; July 5, beef; Aug. 17, beef; Sept. 14, beef; Oct. 3, beef. It is just a little inferior to American beef. Besides the salt meat, the men had twice a week fresh beef packed in tins, also lime-juice every day, and fresh wheat bread baked every day. The ration table was that required by the English Marine Service.

The crew consisted exclusively of Europeans, the captain himself is a Nova Scotian, and the bark flies the English flag. The disease undoubtedly was beri-beri, so I hear from Surgeon J. C. Perry of the United States Marine Hospital Service, Norfolk, Va. Being English, the patients were placed in charge of Quarantine Medical Officer Dr. W. A. Thom, Jr. All of them have now recovered. One of them, the first mate, reached New York by rail and met the ship at her arrival. There had been eleven men sick; four had resisted, the captain, aged 40; a Londoner, aged 25; the steward, a German, aged 60; and the second mate, an Englishman, aged 35.

I extract from the log-book: Oct. 9, Andrew and Peterson both still laid up, which makes it very hard for the rest of us. It takes all hands to take in top gallant sail, or in fact do almost anything, as we are getting weak from this sickness that has overtaken us. More water than usual coming to the pumps. Mill going almost all the time. Monday, Oct. 10, There are now three men laid up, and we have to-day finished the last of our provisions. The remaining of us are more or less affected by this sickness. It is as much as we can do to pump ship with all hands. Hoisted the signal P.H. to a steamer; apparently he took no notice of us. Five inches of water in the well every two hours. Observe that the victuals gave out only the day before they touched port.

I myself visited the ship and inspected the sleeping apartments of the men. The forecastle is on deck; it has twelve bunks in a room 15 feet long, 10 wide, 7 high; doors and a scuttle give free ventilation. The bunks were tight-boarded pens and, of course, would hold gases.

[1] Communicated to the Sei-I-Kwai, or Society for the Advancement of Medical Science in Japan.

[2] The fact that the cargo in question came from Ilo-ilo to the United States shews it to be of the lowest grade. The Philippines send us but their meanest wares, strange as that may be, and for some unknown reason always from Ilo-ilo. Nos. 1 and 2 go to Germany and England, always from Manilla.

The ship's carpenter, who died, slept by himself in the store-room; his was a closed bunk, like all the others. The first mate slept alone off the mess-room, in the after part of the ship; he contracted the disease.

We have then here the following situation: Toxic matters in the atmosphere, either directly by the fermentation of an enormous mass of sugar[1] and the formation of the poisonous compounds of carbon, or by a decomposition of the air depriving it of part of its oxygen. We have a wet trip, the very weather in which beri-beri, or kakké, flourishes in Japan. We have muscles and peripheral nerves more or less exhausted by the pumping work rendered necessary by the leak.

We have, therefore, an image of the disease, accompanied in the most manifest way by all its etiological factors, which leaves nothing to be desired.

The following facts relating to the export of sugars will perhaps be of some interest. Captain Durke tells me that all sugar cargoes in the voyage blacken the paint;[2] he says, however, that unless water gets into the cargo the sugar will not really ferment. He has carried many cargoes from the West Indies, the Barbadoes, and all gave off the blackening gas; but he had never a ship ferment before, nor had he ever an outbreak of beri-beri. Therefore the fermentation is not the cause of the formation of that sulphuretted hydrogen. The elder Mr. Hincken, a sugar broker, one of the consignees, says he has many times entered the holds of incoming sugar ships and always found them sweating from the heat in the hold. It must be noted that in the East Indies lime containing sulphur[3] is used in the preparation (tempering) of sugar for export to prevent fermentation; hence the blackening gases. In the preparation of the cane-juice for export sugar in the Philippines no molasses is formed. This is the only difference in preparation between it and West Indian sugar; in the latter there is always a formation of molasses. It is the addition of an excess of lime to sugar which prevents the formation of molasses, by the more abundant production of saccharates; hence, if the lime is very sulphurous, we naturally have an excess of sulphuretted hydrogen developed. The sulphuretted hydrogen, if you consider these data, can have nothing to do with the disease; it blackened the walls, that is all. The captain has had walls blackened frequently without beri-beri. One question in passing, Why did beri-beri never occur in any ship exporting sugar from Brazil and the West Indies? The cause may be that the trips of these vessels are comparatively short. Moreover, peculiar care is taken of the Brazilian sugar, for it is known to be a very poisonous stuff; that is, to ferment very easily.

Each of the facts mentioned above; that is, emanations of carbonic compounds, exhaustion, tropical wet weather, may not by itself produce beri-beri. But here we have them united, and their union is strong enough to overcome the resistance of Europeans.

I have elsewhere affirmed my belief in the operation of carbonic compounds in the production of kakké in Japan.[4] I think that I have a right to consider this case as strongly corroborating my theory. Dr. Takaki, while admitting the action of the carbonic compounds, supposes them to act in a quite different way from that in which they have evidently acted in this case. He believes carbonaceous food to be the cause of the intoxication. Here the effect was produced by inhalation; this is evident by the indisposition of the ship's dog. That animal, as well as the four men who had not contracted beri-beri, was continually vomiting. If the gas operated to make these beri-beri-free men sick, and it was undoubtedly the gas, it was by being inhaled. Now why should the gas not have produced the disease in the others in the same manner; that is, by inhalation? This does away with the theory of beri-beri intoxication through carbonaceous food.

Dr. Takaki claims to have eradicated kakké, which is the same as European beri-beri, from the Japanese Navy, by the elimination of rice from the diet of the men. That he has eradicated it, I believe. But that it is due entirely to the change in the diet, I do not believe. The men have been at the same time removed from the influence of those fumes of carbon, amidst which the Japanese live and breathe. In Japanese houses charcoal is continually burned for heating and cooking, and the natural humidity of the hot season keeps over everything a deep layer of pernicious gases. In the new navy the men are not exposed to the same influences, their heating being done by steam or coal. The fact that the removal of the beri-beri patients to higher altitudes, where the air is pure, results in improvement is proof positive that the poison is inhaled. This fact, that is, the advantage of altitude, must remind most readers of that unfortunate Neapolitan dog, who inhales the oxide of carbon of the "cave of the dog," for the instruction and amusement of the visitor. The gas, which in this grotto issues from some fissures, is so heavy that it remains in the inferior part of it, and does not reach the nostrils of men; but the dog, breathing in the nether layers, falls down at once in a paroxysm of asphyxia.

It is my opinion, if similar changes in the heating methods to those which were introduced into the navy, were adopted by the people at large the benefit conferred on the navy would become a general, a national one. They have only to stop the burning of charcoal.

That Europeans in Japan rarely contract beri-beri is partly explained by the fact that they are not exposed to charcoal fumes in their houses.

However I do not contend that inhalation of carbonic gases, is the only etiological factor of beri-beri. These factors are necessary: Weakness, produced, on the one hand, by a feeble non-albuminous diet, incapable of maintaining the natural resistance of the body to morbid influences, or by climatic or other like influences,[5] debilitating the muscular fibres and peripheral nerves, and *the toxic influence itself*, that is, the presence of carbonic gases when it continues for a sufficient time.

[1] 10,000 sacks out of 50,000 up to this time unloaded have been involved in the process, and it is expected that about one-third of what remains in the bottom of the bark will be found damaged; that is, about one-fourth of the whole cargo, 500 tons, has suffered.

[2] The ship's paint was black from sulphuretted hydrogen. I tested some of it.

[3] In the Icery process, bisulphite of lime is used.

[4] Univ. Med. Mag., January, 1891. Sei-I-Kwai Med. Journ. XI., No. 2.

[5] The temperature in the ship's cabin, during the entire voyage nearly, was over 80°; in the sun, in the Indian Ocean and tropics, it was as high as 126°. In Japan, kakké occurs in the season when the sun is very hot and the air very damp, and the days when these conditions are particularly oppressive, the patients are regularly worse.

ORIGIN OF THE LINES OF MARS.

BY PROFESSOR HENRY W. PARKER.

ON examining a copy of Schiaparelli's Map of Mars, May, 1889, I called the attention of the geology class of Iowa College to the striking general coincidence in the direction of the lines with those of coast and mountain trends on the earth, and I referred to the observations on these by Professor Benjamin Peirce, and a suggested explanation by Professor James D. Dana. The coincidence must have occurred to many persons; but I find no reference to it except in a paper by the younger Darwin (G. H. Darwin) read before the Royal Society in 1878, and printed in the "Transactions," to which, as dealing with coast-lines, I was recently referred by Professor Wolcott Gibbs and by S. C. Becker of the U. S. Geological Survey. Mr. Darwin's remarks were founded on a previous and probably much less detailed map of Mars in "Appendice alle Memorie della Societa degli Spettroscopesti Italiani," Vol. VII., 1878. His papers (in Parts 1 and 2 of "Transactions," Vol. 170) relating to terrestrial physics are "On the Bodily Tides of Viscous and Semi-elastic Spheroids, and on the Ocean Tides upon a Yielding Nucleus," and "On the Precession of a Viscous Spheroid, and on the Remote History of the Earth."[6] In the latter paper, referring to the dragging of tidal protuberance greater at the equatorial regions than at the polar, and the consequent distortion of a yielding globe, he says:

"The screwing of the earth's mass [as a viscous spheroid in remote ages, his meaning seems to be] varies inversely as the sixth power of the moon's distance multiplied by the angular velocity

[6] For some pertinent comparisons between the physics of the earth and of Mars, with special reference to the state of internal stress of an elastic sphere under tide-generating forces, but with no mention of the lines of Mars, see Mr. Darwin's paper, "On the Stresses caused in the Interior of the Earth by Weight of Continents and Mountains," in the same "Transactions," Vol. 173.