MALARIA IN RELATION TO THE COASTAL LAGOONS OF BENGAL AND ORISSA

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CHANGES in level of the currents of water that flow on the Earth's surface are of course an everyday phenomenon: the streams at a comparatively high level being described as 'in flood', and the antithetic condition 'low-water', or 'at the ebb'. Now it is well known, at any rate in deltaic lands, that along a certain line between the margin of the flood and that of the stream at low-water—and this is true whether the current be a sea-current or the flow of a river—a relatively high bank of sediment settles down, and it is such banks on either side that confine the river at low-water. The channel so formed by this disposition is ordinarily regarded as all that 'the river' is, whereas it would be more correct to look upon the uttermost and vaguer limits set to the margins of the current while it is in flood as demarcating 'the river', the stream when more clearly limited by the banks of sediment referred to being only its low-water phase.

During this phase, it must now be mentioned, there remains behind the bank a residuum of the flood-level water known as a *lagoon**.

Now whether one be by the sea-coast on the one hand, or by the courses of the rivers in the uplands or paradelta on the other, this moulding of the land may be observed. In the hills, the streams in flood stretch from scarp to scarp of the old rocks that confine them; but at their low-water or 'fair-weather' flow their channels lie between banks of deposit behind which are shallow sheets of water, that are sometimes called 'lateral lakes', and they are *homologous in every respect to the lagoons of shallow water in the delta.*

It is only, however, the formation of the lagoons at or near the sea-coast that will be here considered, and again it must be remarked that they are characteristically shallow expanses of water shut off at times of low-water from the river, or sea-currents, by a bank, while they are flooded over at the times of high-water.

The secular history also of such a lagoon may be here recounted. Originating from an expanse of water which is at no time shut off from the sea or estuary, as far as one can see at the surface, it is only a later circumstance that the bank of sediment, that has been gradually laid down along a wayside current, appears above the surface of the water and separates off what is now the lagoon. Coral growing on a ring bank and an atoll forming is the manifestation of an exactly homologous phenomenon. Gradually the lagoon silts up, relatively to the surrounding land, and so becomes ever shallower and less often or less extensively inundated by the floods. The silt that effects this transformation is carried into the lagoon by the surrounding waters when in flood and it is deposited as the waters recede, as also—and this factor is perhaps not sufficiently appreciated—by wind-blown material, for in the vicinity of the sea-coast it can readily be realized that this is a circumstance to be reckoned with. Meanwhile as the lagoon becomes shallower and shallower it becomes relatively less brackish, and more and more sweet-water plants invade it and cover its surface.

Along a sea-coast the nascent formation of lagoons is represented by the series of parallel gutters and sand-banks between the beach and the open sea. This parallel formation is a consequence of the fact that wind-waves of the open sea, whatever be their direction, gradually become parallel with the coast as they run on shore, owing to the greater drag exercised by the bottom as the water shallows. The water-currents for the same reason assume a direction parallel with the line of the shore, and just as a river-current elevates a bank the summit of

*The reason why there is a residuum of the flood is explained by the writer in a paper *Holland and Bengal, vide* Transactions of the Royal Society of Tropical Medicine and Hygiene, 1938 (in the press).

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myocarditis, we at the same time assert that such heart-sound changes are in part at least early expressions of myocardial failure.

The development of cardiac dilatation during the course of typhoid fever is primary evidence of acute myocarditis. It is displayed by an outward movement beyond the left mid-clavicular line of a wavy cardiac impulse with corresponding shift of the left border of cardiac dullness. Provided, firstly, that the diaphragm is not displaced unduly upwards by the commonly prevailing meteorism and, secondly, that we exclude organic valvular disease, hypertension and coronary disease, the appearance of such dilatation clearly proclaims the presence of acute myocarditis. The most emphatic auscultatory sign is succinctly given by gallop rhythm, which in our experience may often be foretold at an earlier phase by so-called impurity or splitting of the first heart sound. It may be interesting and profitable to note that, quite apart from typhoid myocarditis and circulatory failure in acute infections, gallop rhythm is now recognized as an outstanding, facile and often early sign of the failing arteriosclerotic or hypertensive heart, which is by far the commonest type of failing heart encountered in India. Dilatation of the typhoid heart, however, is most usually announced to the unwary observer by the development of an apical systolic murmur which rarely fails to evoke an immediate diagnosis of some sort of myocarditis or endocarditis, and a suitable sense of auscultatory pride and satisfactory accomplishment.

which follows a line somewhere between its low-water margin and its high-water limits, behind which bank is the lagoon, so do the sea-currents throw down a series of sand-banks between which and the 'sea-beach' are gutters of comparatively placid water, the beginnings of lagoons, which are beautifully shown in map 1. In the course of time such a sea-bank is raised to a level at which it remains above the sea for comparatively long periods and meanwhile it becomes consolidated by the cementing action of the water and by the growth of plants, and derives accession of wind-borne material.

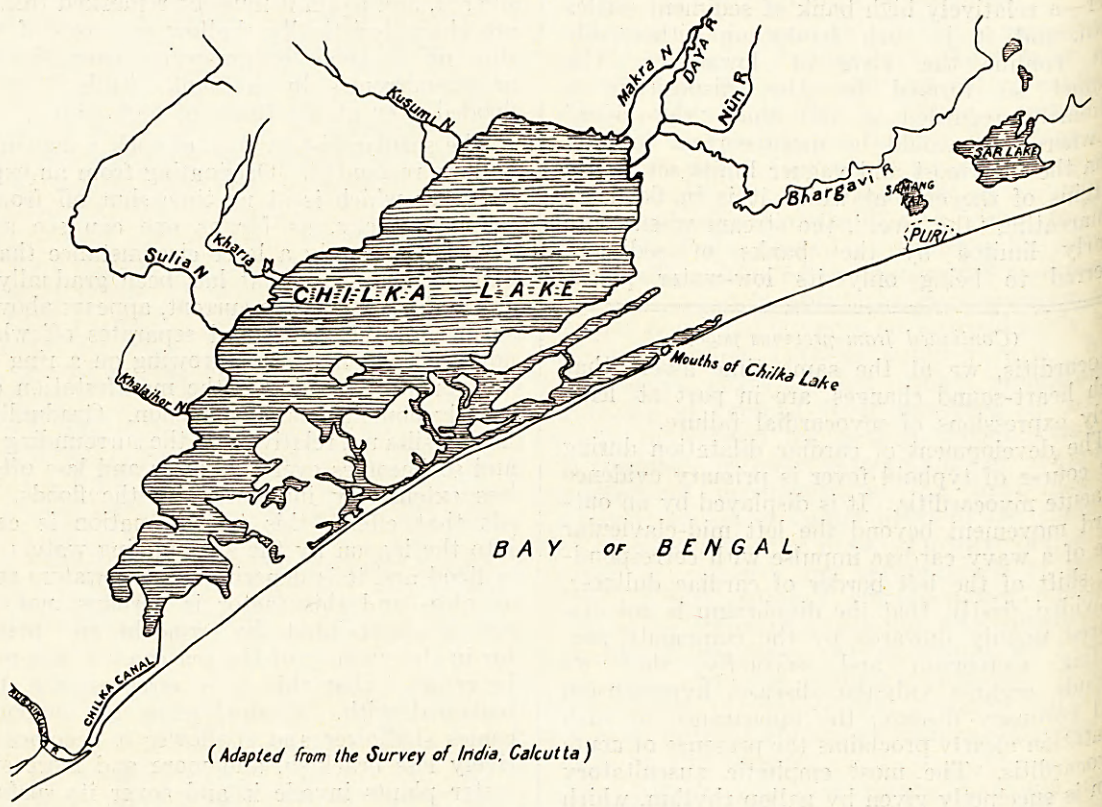
If the sea-waves only should hold sway, the lagoon might be wholly continuous along the sea-coast, and there would not be any cloaca (*see* map 1) in the seaward sand-bank, but the rivers draining the hinterland and passing through the lagoon have to find an outlet to the sea, and in doing so they build up the inevitable bank of sediment, as described above, and tend to separate off their channels from the lagoon, incidentally retaining a passage through the sea-bank for the passage of their waters. Before, however, the rivers crossing a lagoon demarcate themselves their waters mingle with those of the lagoon, finally finding an outlet through the sea-bank, and when the river has demarcated itself there always remains in the river-bank a passage for flooding the lagoon over a low bank exposed in the fair-weather.

The Chilka Lake in Orissa (*see* map 1) illustrates these points on a grand scale. Here the sea-currents have laid down a bank of sand that would be completely continuous if it were not that the fresh waters brought into the lake by the Daya, Bhargavi, and other rivers provide a potential head for keeping a small and shallow channel scoured out through the seaward bank. They have not as yet demarcated a channel for themselves thus occluding the rest of the lagoon. The tendency is always for the sea to form a continuous bank and repair any breaches in it, but the opposing rivers must prevail to a greater or less extent—to a greater when they are in flood, to a less in the fair-weather. When the rivers during the rainy season are in flood the waters widen the exit through the sea-wall and then they press back the sea and as they prevail the lagoon becomes ever sweeter, whereas when the rivers are at their fair-weather flow the sea prevails and the waters of the lagoon become more brackish, although at the same time the sea-bank is to some extent repaired by the sea.

There is at Chatrapur (*see* map 2) an example of a lagoon or *tempara*, as in Orissa it is called, shut off nearly completely from a river, the Rushikuliya, that floods and drains the *tempara*, a river that doubtless once flowed through it at all times as does the Bhargavi now through the Chilka Lake. Seaward it is completely limited by a sea-bank or sand dune (*see* plate VII, figures 1 and 1*a*).

The persistence of the lagoon-structure continuously right along the coastal belt of Bengal

MAP 1



(Adapted from the Survey of India, Calcutta)

Fig. 1.

Fig. 1*a*.

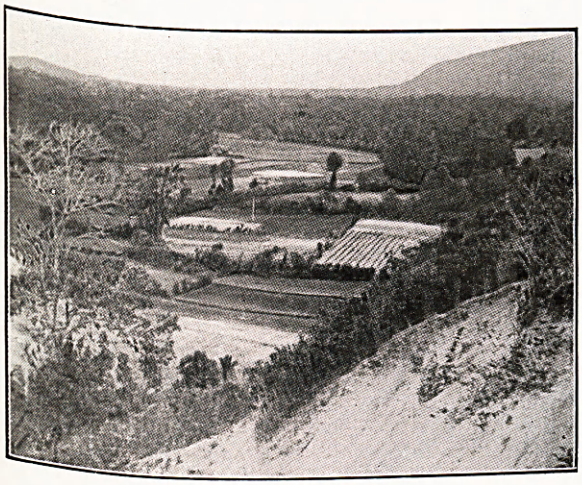


Fig. 2.

Fig. 3.

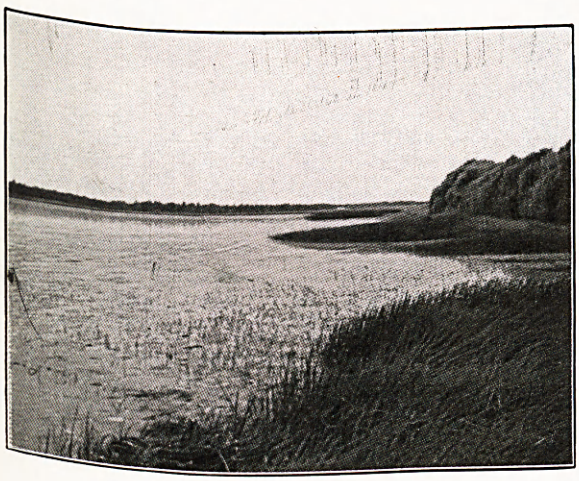


Fig. 4.

Fig. 4*a*.

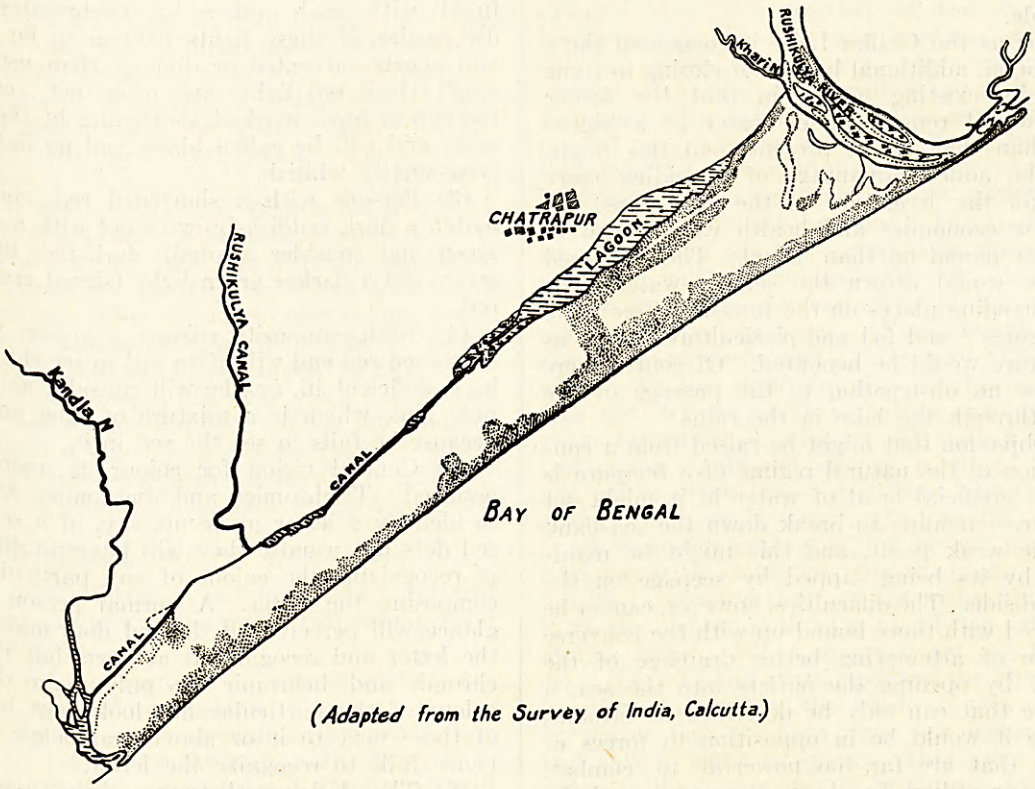
and Orissa, of which a section is shown in map 2, indeed made feasible the building of the Orissa Coast Canal, along an endless chain of *temparas*, while their feeders, the great rivers that crossed the lagoons and shut them off, have made water available for the canal.

The *temparas* are not reproduced in any such striking way at the Bengal sea-face, and probably this is due to the fact that here the littoral drift is of a finer material than in Orissa. However, in the Contai sub-division of Midnapore district there are the vestiges of such tracts; for instance, there is a small *tempara* at Jinput, and at Fraserganj on the south of the district of the 24-Pergannas there are also some such formations.

With regard to the relationship of the *temparas* with malaria, the writer has elsewhere pointed out that their homologues in the Bengal Sunderbans are non-malarious, but on the coast at Fraserganj (*see* map) the *rayats** showed a 25 per cent spleen index, and *Anopheles ludlowi* was captured here. This was in marked contrast with the very low spleen index in the immediate hinterland.

In lower Bengal in general one may say that if the basins of the *dwips* that represent the lagoons are protected from the ingress of flood-water from the rivers they are non-malariagenic, while on the sea-coast where grassy sandy maidans abound with intervening swamps that are not bunded, and carry *Anopheles ludlowi*,

MAP 2



(Adapted from the Survey of India, Calcutta.)

In the deltaic Bengal Sunderbans the relatively low-lying area in a *dwip*, as the naturally-formed island is named, is called a *bhil* and this is characterized by a comparative lack of tree-growth, so that in the hot weather its surface becomes sun-dried mud. In Malaya, along or near the coast, sand-banks may be found here and there and are called *permatang*, which are usually grassy 'maidans', as in Bengal, while in that country too it is interesting to note that a place called Singarang in Johore State occupies the site of an old *tempara*, and *singaram* is an alternative Kling name for the *tempara* of Orissa. Also at Batu Burok in Tringganu State (*see* plate VII, figure 2) there is a similar old lagoon silted up and now intensively cultivated.

the people suffer from malaria. At Jinput near Contai outside the great sea-dyke a few poor people living beside a small *tempara* eke out a scanty existence. The children who were available for examination here were only seven in number but every one had splenomegaly, while inside the great sea-dyke where the water is sweet enough for the cultivation of *padi*, the spleen-index was under 5 per cent.

It is exactly the same in Orissa; one has the coastal brackish water *tempara* represented on a great scale by the Chilka Lake, and the sweet-water inland *tempara* now silted up and planted with *dalua padi* as at the Samang Pat (*see*

* Cultivators.

map 1) behind Puri, the one intensely malarious, the other practically free from malaria.

The indication of these observations would seem to be the closure of the basins as far as possible, only allowing to accumulate the fresh sweet water entering them from the hinterland. In deltaic Bengal, the garden of aquatic vegetation growing on the surface of the waters collecting in the natural basins does not appear to conduce to malaria, and if the *tempara* be closed, it is probable that the shallow sweet water supporting a garden of aquatic vegetation would not breed malaria-carrying mosquitoes as it does now (plate VII, figure 3). It is probable that it is the close embankment of the *dwips* of Bengal that has saved its people from malaria, though of course they would not be there if they had not embanked their land, for it would not have been habitable.

As far as the Chilka Lake is concerned there would be an additional benefit of closing to some extent its existing outlet, in that the feeder rivers would remain under water at a higher level than they do at present, and this might have the added advantage of providing more water for the irrigation of the *rabi* crops. In this case economics and health would seem to be closer bound up than usual. The proposed measure would drown the shallow-water mosquito-breeding places on the foreshore (*see* plate VII, figures 4 and 4*a*) and pisciculture as well as agriculture would be benefited. Of course there must be no obstruction to the passage of the rivers through the lake in the rains.

An objection that might be raised from a consideration of the natural régime of a *tempara* is that an artificial head of water in it might set up a stress tending to break down the sea-bank at some weak point, and this might be manifested by its being sapped by seepage on the seaward side. The difficulties, however, cannot be compared with those bound up with the converse measure of attempting better drainage of the country by opening the outlets into the sea, a measure that can only be described as fatuous, because it would be in opposition to forces of Nature that are far too powerful to combat. Such a procedure has been attempted at Lake Sar (*see* map 1) with ill success.

Apart, however, from any interference with the levels of the waters in the Chilka Lake, or any other *tempara*, the foreshore which is a prolific breeding place of the mosquito might be warped by one method or another. The best would seem to be by the growth of mangroves, or other plant life such as the *nal* reed, both of which have an economic value, and probably have both been cleared away in the past, just as is a corn-field by a swarm of locusts. Otherwise warping should be resorted to by physical means such as groynes or baffles of some sort or other.

To do anything at all to alter the *status quo* is in a sense to combat Nature and her agent

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COLOUR PERCEPTION, AND COLOUR-BLINDNESS TESTS

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THIS paper is a short study of colour-blind persons, and the relation of their colour perception, as shown by the spectrometer, to the answers given by them when examined by the Edridge Green lantern and Ishihara's tests.

For practical purposes a person may be said to be colour-blind, if he is a trichromic, dichromic, or has a marked shortening of the red end of his spectrum. Persons in these three categories exhibit the following peculiarities :—

(1) Red, green, yellow and white lights owing to their common property of brightness are confused with each other by trichromics and dichromics, if these lights happen to be bright and poorly saturated or dimmer than usual.

(2) Dark red lights are often not seen by those who have marked shortening of their red ends, and will be called black and no light and occasionally whitish.

(3) Persons with a shortened red end will match a dark reddish-brown wool with a darker green and consider a small dark-red light as green and a darker green light (signal green) as red.

(4) With composite colours a person with a shortened red end will often fail to see the colour he is deficient in, *i.e.*, he will consider as blue a pale pink which is a mixture of blue and red, because he fails to see the red in it.

(5) Central vision for colour is more pronounced. Trichromics and dichromics will fail to identify a letter made up, say, of a series of red dots but usually they will have no difficulty in recognizing the colour of any particular dot composing the letter. A normal person at a glance will perceive all the red dots making up the letter and recognize it at once, but the trichromic and dichromic can only make out the colour of the particular dot looked at but not of those next to it or above and below it and hence fails to recognize the letter.

(6) The balance between brightness and saturation, on which the correct interpretation of colour appears to depend, seems to be interfered with, particularly if there is any shortening of the spectrum. If the balance is upset, and the sense of saturation for reds and violets is diminished and they are paler than what appears to the normal person, brightness not saturation gains the upper hand and reds are mistaken for yellows, blues for violets giving

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Man, so one comes down to a choice of the measures that will encounter least opposition and will involve least difficulty. Closing up the *tempara* to a certain extent would seem to be such a measure.