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REPORT

ON THE

PREVENTION OF MALARIA

IN MAURITIUS

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REPORT

ON THE

PREVENTION OF MALARIA IN MAURITIUS

BY

RONALD ROSS

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LONDON:
J. & A. CHURCHILL,
7, GREAT MARLBOROUGH STREET.
February, 1909.

11016

LONDON:
WATERLOW AND SONS LIMITED, PRINTERS,
LONDON WALL.

To His Excellency

Sir CAVENDISH BOYLE, K.C.M.G.

Governor of Mauritius

Dated, the 15th June, 1908

University of Liverpool

Your Excellency,

In a letter No. 16148 of the 9th May, 1907, the Right Honourable the Earl of Elgin, His Majesty's Secretary of State for the Colonies, informed me that your Excellency desired me to visit Mauritius in order to report on measures for the prevention of malaria there. With the consent of the University of Liverpool and of the Liverpool School of Tropical Medicine, I was able to accept the duties, and the honour, involved in this mission. In subsequent letters the Secretary of State adopted the suggestions that I should visit Mauritius at the commencement of the next malaria season, and that I should remain there at least three months in order to collect the information required for my report. In accordance with this decision, I left England on the 23rd October, 1907. Arriving in Mauritius on the 20th November, I was able to complete my studies by the 25th February, 1908, on which date I was permitted to return to England, where I arrived on the 28th March. I have now the honour to present for your Excellency's consideration my Report on the Prevention of Malaria in Mauritius.

2. I trust that I may be permitted, before proceeding to my subject, to refer to several points connected with my visit. On hearing of my mission, Surgeon-General Sir Alfred Keogh, K.C.B., Director-General of the Army Medical Service, was kind enough to appoint Major C. E. P. Fowler, Royal Army Medical Corps, to assist me in the work, especially as it affected His Majesty's troops in Mauritius. Major Fowler arrived in the Colony before me, but left with me; and I should like to add that I have received from him the greatest possible help in connection with my study of malaria, not only among the military, but also among the civil population.

3. During the visit it was necessary for me to carry out inspections of numerous localities in the Island. I was able to spend ten days at Port Louis, and to examine, sometimes frequently, the principal towns and villages, and many of the sugar estates.

I am very greatly indebted to the Hon. Dr. Lorans, Director of the Medical and Health Department, for the excellent arrangements which he made for the performance of these duties, and, not less, for the benefits of his advice and of the information which he collected for me. I owe my sincere thanks, for accompanying and assisting me on many of these inspections, to Dr. Edwards, C.M.G., Chairman of the Town Board of Commissioners of Curepipe; to the Hon. Dr. Laurent, Mayor of Port Louis; to the Hon. Sir William Newton, K.C., Chairman of the Board of Quatre Bornes; to the Hon. Mr. Trotter, Chairman of the Board of Rose Hill and Beau Bassin; to the Hon. Mr. Leclézio, Member of the Council of Government for Moka; to the Hon. Mr. Dumat, Member for Savanne; to the Hon. Mr. Gébert, Member for Grand Port; to the Hon. Mr. Duclos, Member for Flacq; to the Hon. Mr. Souchon, Member for Rivière du Rempart; to the Hon.

Mr. Sauzier, K.C., Member for Pamplemousses; to the Hon. Mr. Antelme, Member for Black River; and to the Sanitary Wardens of the Districts.

4. It was necessary also to obtain for the purpose of my report much statistical and other information; and I am much indebted, for the promptness and regularity with which this was collected, to the Hon. Sir Graham Bower, K.C.M.G., Colonial Secretary; to Dr. Lorans; to the Hon. Mr. Trotter, Protector of Immigrants; to the Hon. Mr. Le Juge de Segrais, Director of Public Works and Surveys; to Mr. P. Koenig, Director of Forests and Gardens. I am particularly grateful to Dr. Bolton, Medical Officer and Inspector of Immigrants, for the copious information and the most useful advice which he gave me regarding malaria on the Estates; to Dr. Castel, Dr. Keisler, Dr. Masson, Dr. Milne, of the Health Department, for their laborious computations of the spleen-rates in Schools and Villages; and to Dr. Bour, Dr. Chauvin, Dr. Clarenc, Dr. Guérin, Dr. Harel, Dr. Leclézio, Dr. Lesur, Dr. Ménagé, Dr. de la Roche, Dr. Senneville, Dr. Tennant, Dr. Ulcoq, Dr. Vinson, for their similar studies on the Estates. I am much obliged also to Dr. Clarenc and Dr. Lesur for valuable literature regarding the original outbreak of malaria in Mauritius, in 1865–67; to Dr. de Chazal for his excellent report on the recent outbreak at Phœnix; to Dr. Momplé for information regarding Sanitary Legislation; to Mr. Naz of the Health Department; to Mr. A. Walter of the Observatory, for information on certain meteorological points; and to Drs. Cretin, Gromett, Lafont, Lesur, Ménagé, Rouget, and all the members of the medical profession whom I met in Mauritius, for help rendered in various ways.

5. Early in the course of my studies, your Excellency was pleased to place at my disposal the services of

Mr. d'Emmerez de Charmoy, Curator of the Museum, whose early and admirable work on the Culicidæ of Mauritius and on malaria there, carried out partly in conjunction with Mr. Daruty de Grandpré, is well known to students of these subjects. The assistance of Mr. d'Emmerez, and, I may add, the voluntary help rendered by Mr. Daruty, proved to be invaluable to us; without their aid we should not have had time to complete the essential laboratory work which it was our duty to attend to. Major Fowler and I would like it to be considered that, as regards the examination of cases of malaria and of mosquitoes, these gentlemen acted in scientific collaboration with us.

6. The whole subject of the prevention of malaria in Mauritius was frequently discussed with many members of the medical profession in the Island; and on the 24th January, owing to the kindness of Drs. Clarenc and Chevreau, President and Secretary of the Société Médicale, I had an opportunity of considering the matter with that body. I think it may be accepted that there will be a very general consensus among the profession as regards the principal measures to be undertaken.

7. The nature of these measures became evident fairly early in the period of my mission—though indeed they had been recognised long previously. It had therefore appeared to me to be highly desirable that, before the submission of this report, and during my stay in Mauritius, some attempt should be made to commence the necessary organisation on a preliminary scale by training a small staff of men to the work. Your Excellency responded at once to this suggestion by placing the sum of Rs.6,000 at the disposal of the Medical and Health Department for the purpose. Out of this fund ten "moustiquiers" and ten working gangs of three men each were enlisted, were instructed in the duties described in the Report, and, even before I left, had done a considerable

amount of work. Moreover, the Chairman of Quatre Bornes, Curepipe, and Beau Bassin, and the municipality and District of Port Louis commenced similar measures; the managers of many of the Sugar Estates asked for the services of the moustiquiers; a small fund, generously subscribed to by the Hon. Mr. Souchon, Messrs. Ireland and Fraser, and the Bank of Mauritius, was started to supply working gangs to certain villages; and the elected members of Council for the Districts took similar action. On the 29th January I had the honour to deliver a public lecture on the subject before your Excellency at Curepipe, and, on the 8th February, a similar one before the Mayor and Councillors of Port Louis. Before I left, your Excellency appointed Mr. d'Emmerez de Charmoy to superintend the malaria work under the Medical and Health Department, as a temporary measure pending the receipt of this report.

8. Among larger measures for the suppression of malaria recently undertaken in Mauritius, I should like to mention the drainage of the marshes at Phœnix by your Government and the handsome assistance given by the Imperial Government through the military authorities.

9. We are also much indebted to Major General Creagh, C.B., Commanding the Troops; to Colonel Peterkin, Major Wilson, Lieut. Buchanan, and Lieut. Wallace of the Royal Army Medical Corps; to numerous Officers of the Garrison; and to a large number of private gentlemen in Mauritius; all of whom have helped us in many ways.

10. Lastly, Sir, our warmest thanks are due to yourself, not only for much personal kindness, but for the great assistance which you have always been pleased to give us. I can only hope that the marked and intelligent interest in the subject of malaria shown by everyone in Mauritius will be ultimately rewarded by a large reduction in the disease, and an increase of health and prosperity throughout the Colony.

PREFACE.

The prevention of malaria must always make demands on the public purse and, in the case of estates and plantations, on the private purse also. Hence all recommendations for dealing with the disease should be supported by thoroughly reasoned arguments in their favour ; and such reasoning must obviously be based upon our modern knowledge of the subject. I have therefore thought it advisable to commence this Report with a chapter written in non-technical language on malaria in general—a course which is demanded the more because there is no good text-book on the subject.

I fear that there is considerable evidence of haste in the work. The necessity for completing it as early as possible, in order to permit of preparations being made for the commencement of the proposed campaign at the beginning of the next malaria season, has been exigent. The labour of tabulating and analysing the returns of the spleen-census (probably the largest one ever made), and of considering the historical statistics of malaria in Mauritius, has occupied much of the available time ; and I have been obliged to defer to another opportunity the examination of many questions of theoretical interest arising from these figures.

In making my recommendations I have endeavoured to select only those preventive measures which, I think, are certainly feasible and which, when combined in the way indicated, are likely to give the best and most definite results for the least expenditure; and I have considered very carefully the special organisation required for the prevention of malaria in the tropics.

Summaries of the substance of the Report are contained in sections 21 and 40.

RONALD ROSS.

UNIVERSITY OF LIVERPOOL
15*th June*, 1908

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REPORT

ON

THE PREVENTION OF MALARIA IN MAURITIUS.

PART I.—MALARIA IN GENERAL.

1. **HISTORY.**—Malarial Fever was well known to the *Ancients*, who certainly recognised three main facts connected with it. They observed that the disease occurs in several different forms, the *quartan*, the *tertian*, and the *continued* form. They knew that it tends to be most prevalent in the vicinity of marshes; and that it may be reduced by drainage.

The *Middle Ages* added little to our knowledge of the subject. In 1640, however, the specific remedy for the disease, the so-called Cinchona or Peruvian Bark, began to be known in Europe; and in 1820 Pelletier and Caventou extracted from this substance its essential principle, quinine. The extensive use of the drug made by physicians ultimately showed that it does not cure all fevers, but only those which possess the so-called *intermittent* tendency—that is, the tendency to a succession of attacks at regular periods. This fact enabled them to separate these fevers clearly from the others, known as the Continued Fevers. It is true that the Intermittent Fevers may become continued at times; but, as Torti showed in 1712, this is merely due to the overlapping of the successive attacks.

In 1691, Morton, and in 1716, Lancisi, strongly emphasised the ancient opinion that the Intermittent Fevers are caused in some way by noxious effluvia from marshes. Accepted widely throughout the world, this hypothesis ultimately gave another name to the Intermittent Fevers, namely, that of *Malarial Fever*—which connotes that the disease is due to *bad air*. It should, however, be clearly recognised at this point that the last conception was entirely an hypothesis—a conjecture. It was absolutely true that Intermittent Fever is caused in *some* way by *something* which emanates from marshes; but it was never proved, either by induction or by experiment, that this "something" is the air of the marsh. The conception regarding the "bad air" was therefore nothing but an attempt to explain with plausibility the great fact that the Intermittent Fevers are, for some reason, certainly connected with marshes. Nevertheless, it shortly began to be accepted everywhere as a dogma. Later still, when these fevers were found to occur in certain places where there were no marshes, the dogma was expanded into the hypothesis of the *telluric miasma*. According to this the malarial poison exists, not only in marshes, but anywhere in certain soils, especially where there is much decaying vegetation. It was thought that if such soils be disturbed in any way the poison will rush out into the air and infect the neighbourhood. Here again there was no experimental evidence, and the whole speculation rested merely on some loose inductions.

About the middle of last century, however, the science of experimental pathology came into being. We no longer accepted coincidences and conjectures as proofs, but studied disease by strict experimental methods. Gerhardt produced malarial fever in men by inoculating them with a small quantity of blood taken from patients—thus proving that the disease is caused by an organism existing in the blood; and in 1880 Laveran discovered this organism itself. It proved to be a minute animal parasite of very low order, and visible only by the microscope, which lives in the blood in enormous numbers. Some years later Golgi and others showed that these minute bodies proliferate indefinitely in human blood by the simultaneous production of spores; that the successive attacks of fever in the patient commence at the moment when the spores are set free from the parent organisms; and that there are at least three varieties of the parasites, all of which can be distinguished by the microscope —namely, one which produces spores every three days and causes quartan fever, one which produces spores every other day and causes tertian fever, and one (at least) which causes less distinct, but often more dangerous, attacks. About the same time Danielewsky showed that closely allied parasites occur in birds (they have now been found also in monkeys, bats, and squirrels); and discovered many more distantly related organisms in numerous animals. Laveran, Marchiafava, Celli, Bignami, Canalis, and many others made a close study of infected persons. Romanowsky and Ziemann developed a method of staining the parasites which serves to demonstrate them with certainty; and Theobald Smith discovered a nearly related parasite of cattle which is carried from ox to ox by a species of tick —as he proved by direct experiment.

This brilliant series of researches, which were soon confirmed and amplified by numbers of observers in many parts of the world, gave us most exact and detailed information regarding the processes which cause the disease in man. But a great problem still remained— to ascertain the route by which the parasites enter the human body. As soon as these had been discovered, many workers, remembering the connection between Malarial Fever and marshes, sought for them in such localities, thinking that they probably bred there and infected man by inhalation; and others, especially Celli, Agenore, and Calandruccio, attempted to cause infection by the air or water taken from malarious localities—but all without success. In the meantime another, but very old, hypothesis had been revived. Even some centuries ago it was stated in certain religious books of Ceylon that mosquitoes can produce fever; and the same idea now occurred to several eminent men of science. It must be remarked, however, that the views of these authors were still only speculations, which they themselves did not verify by serious experiments (although such might easily have been attempted), and that their hypotheses were often as much wrong as right.

Obviously the whole problem was a very difficult one, which could be solved only by long thought and investigation. This was attempted by my own work, commencing in India about 1891 and not concluded until 1899. It became early apparent that the old hypothesis of an aerial miasm was not tenable, simply because the disease was frequently too local to be assigned to any widely-diffusible poison. Early in 1895, therefore, I commenced an experimental study of the mosquito hypothesis. After long failures with the commoner kinds of mosquito of the genera *Culex* and *Stegomyia*, I succeeded at last (August, 1897) in growing the malignant parasite of man in mosquitoes of the sub-family Anophelina. Next year the life-history of the whole group of these parasites was worked out in the case of one of the parasites of birds in a mosquito of the genus *Culex*, and the wonderful and unexpected result was obtained, both on microscopical evidence and by the actual production of the disease among the birds, that the malarial infection takes place through the proboscis of the mosquito. After an interruption, I was finally able to demonstrate the exactly similar life-history of all the human parasites in the Anophelines *costalis* and *funestus* in Sierra Leone in 1899. This completed the solution, but at the end of 1898 my work had already been verified by Koch, Daniels, Bignami, Bastianelli and Grassi, the latter of whom, entirely by following my methods, infected healthy men in Italy and showed that the tertian parasites are also carried by Anophelines in that country. These results were rapidly confirmed and amplified by a host of observers—by Daniels, Stephens and Christophers of the Malaria Commission of the Royal Society, by various expeditions, and by many private workers. Koch discovered the important fact that native children are the principal source of infection in the tropics. Ziemann, Fernside, Buchanan and Manson produced infections by mosquitoes in more human beings, the last in the middle of London, by mosquitoes brought from Italy. Low and Sambon remained free from malaria in the Campagna by living in a mosquito-proof house. Austen, Giles, Stephens and Christophers, Howard, Blanchard and Theobald studied the mosquitoes themselves, the last producing his exhaustive monograph on the subject. The similar development of several parasites allied to those of malaria has been worked out in various insects. Local mosquitoes and their habits have been studied in many places—notably by Daruty de Grandpré and d'Emmerez de Charmoy in Mauritius.

It should be added here that even before the discovery of the malaria parasite Manson had worked out part of the life-history of *Filaria bancrofti*, the worm which causes elephantiasis and allied diseases, in a species of mosquito; and that a little later Finlay conjectured that yellow fever, the scourge of tropical America, might be carried by the same insects. Now, following the suggestions of my work on malaria, James and Low (1900) completed the life-history of *Filaria bancrofti*, and showed that it also probably gains an entrance into the human body through the mosquito's proboscis; and Reed, Carrol, Lazear and Agramonte proved (1901) by the most conclusive experiments that yellow fever is transmitted in the same way. Hence we are now certain that at least three diseases of man are carried by mosquitoes; while dengue and some other fevers may perhaps be added to the list. Bruce had long previously shown that Tsetse Fly disease is carried by the insects of that name.

My studies had been undertaken solely with the object of improving our methods of preventing malaria; and the history now turns to this, the most important branch of the subject. When my work commenced little was known about mosquitoes. Only about one hundred species had been distinguished; the classification was elementary; and the little knowledge of their habits we possessed was not generalised, was buried in the works of a few entomologists, and was not familiar to sanitary science. Thus King in 1883, and Bignami in 1896 evidently thought that all mosquitoes breed in marshes; and even Manson in 1896 believed that they live only for four or five days. But the long Indian researches, carried out in many parts of that empire, brought to light several generalisations which I have subsequently found to hold good in countries so far apart as Sierra Leone, Gambia, the Gold Coast, Lagos, Panama, Ismailia, Greece, and Mauritius, and which should now be mentioned briefly, as they form the basis of the prevention of disease by mosquito reduction. Thus mosquitoes do not live only for a few days, but for a month or more, even in captivity—feeding and laying their eggs regularly during their life. The commonest mosquitoes in the tropics nearly always belong to three groups, now known as *Culex*, *Stegomyia*, and *Anophelina*, which carry different parasites, have different habits, and can be generally distinguished by certain salient characteristics which are easily recognisable by any one—even by native villagers. All mosquitoes tend to abound most nearest to their breeding places, and can with certainty be reduced in numbers anywhere by appropriate and continuous measures directed against the latter. *Culex* and *Stegomyia* breed principally in artificial collections of water (in the tropics); but the Anophelines breed principally in natural collections of water.

The last point was made out in India and Sierra Leone from 1897 to 1899, and gives a full explanation of the long-known connection between malaria and marshes—the mosquitoes which carry malaria breed in marshes. For the same reason it is unlikely (as indeed my work had already proved) that *Culex* and *Stegomyia* carry malaria—because they do not breed so much in marshes as elsewhere, for example, in pots and tubs round houses. Lastly, the fact explained and justified the ancient method of reducing malaria by drainage—that is, by mosquito reduction.

At the same time this ancient method was now rendered much more simple, cheap and yet exact by the knowledge that we have to drain only those waters which breed Anophelines. The improved system, and the precise habits of the larvæ of the insects upon which it depends, were first described by me in a series of articles (1)* during my first visit to Sierra Leone in 1899. I proposed, in short, to free towns of malaria by the simple and radical process of clearing them of mosquitoes by destroying the breeding places of the insects. Unfortunately, however, the extraordinary objection was urged that this measure would be useless, owing to the immigration of mosquitoes from without (section 13); and for three years I failed in obtaining a trial for my method. At last, in 1901–2, it was put into practice at my visits to Sierra Leone and Ismailia, in the latter place with the most brilliant success; and was also used with as good results in the Federated Malay States by Dr. Malcolm Watson. In the meantime the discovery that yellow fever is carried by *Stegomyia*, led the Americans, under Gorgas, to adopt similar measures in Havana and subsequently at Panama. In detail, the system is somewhat different for the two diseases, as the habits of the carrying insects are dissimilar; but the great principle, the idea of making a general clearance of mosquitoes and diseases together is the same. In places where it is intelligently followed it will probably reduce sickness at one sweep by from one-quarter to one-half or more. Like Listerism, however, the idea has spread slowly, and the practice more slowly still. The history of the progress made will be found in a recent paper by me (2), and in section 22.

Meanwhile other methods of prophylaxis were urged by various workers. Koch and Celli elaborated prevention by quinine, and put it into practice in Italy and elsewhere; and Celli, Manson and others advocated the protection of houses by wire-gauze; while administrators like Sir William MacGregor adopted all methods. Very successful results have been obtained; but the conditions in the tropics are as a rule more favourable for the radical measure of drainage.

* The references will be found on page 146.

It is impossible in this brief history to mention the names of all the workers—even of some of the most distinguished—who have built up our modern knowledge of malaria; and the details mentioned have been given only in order to convince the lay reader that that knowledge was not obtained in a day, and is not a mere speculation on the part of the medical profession.

2.—COMPENDIUM OF FACTS REGARDING MALARIAL FEVER.—(1) *The Parasites and the Fever.*—Malarial Fever occurs more or less in all warm climates, especially in the summer, after rains, and near marshy ground; and produces a quarter or more of the total sickness in the tropics.

It is caused by enormous numbers of the minute parasites of the blood, called Plasmodia or Hæmamœbidæ.

These parasites are introduced into the blood through the proboscis of certain species of the mosquitoes called Anophelines.

On being introduced, each parasite enters one of the red corpuscles of the blood, in which it lives and grows.

On reaching maturity each parasite produces a number of spores which escape from the containing corpuscle, and enter fresh corpuscles; and this method of propagation may be continued indefinitely for years.

Thus, though only a few hundreds or thousands of the parasites may have been originally introduced through the mosquito's proboscis, their number rapidly increases, until as many as some millions of millions of them may exist in the blood.

At first, while the number of parasites is still small, the infected person may remain apparently well. When however the number is large enough, he begins to suffer from fever.

The parasites tend to produce their spores all at the same time; and it is at the moment when these spores escape that the patient's fever begins.

The fever is probably caused by a little poison which escapes from the parasites with the spores.

After from six to forty hours or more this poison is eliminated from the patient's system; and his fever then leaves him temporarily.

In the meantime, however, another generation of parasites may be approaching maturity, and may cause another attack of fever like the first ; and so on, indefinitely, for weeks or months. In this manner the attacks of fever follow each other at regular intervals.

But it often happens that before one attack has entirely ceased another one commences ; so that the attacks overlap each other, and the fever is continued.

After a time, even without treatment, the number of parasites may decrease, until not enough of them are left to produce fever ; when the patient improves temporarily.

It generally happens, however, sooner or later, that the number of parasites increases again ; when the patient again suffers from another series of attacks.

Such relapses are frequently encouraged by fatigue, heat, chill, wetting, dissipation, and attacks of other illness.

They may occur at intervals for many years after the patient was first infected, and after he has moved to localities where there is no malaria.

It is probable that so long as one parasite remains alive in the patient's blood, he may remain subject to such relapses.

Besides fever, the parasites often produce anæmia and enlargement of the spleen, especially in patients who have suffered from many relapses.

Death is sometimes caused by sudden and grave symptoms. Chief among these are the symptoms known as Blackwater Fever, or Hæmoglobinuria, which generally occurs in old and neglected infections.

Death is also often caused during the course of a malarial infection by other diseases, such as pneumonia or dysentery, acting on a constitution enfeebled by the parasites.

If the patient survives, the parasites tend to die out of themselves without treatment after a long period of illness, leaving him more or less "immune."

The parasites are of at least three kinds, which can easily be distinguished in blood placed under the microscope. These are (1) the parasite which produces its spores every three days and causes *quartan fever ;* (2) the parasite which produces its spores every other day and causes *tertian fever ;* (3) parasites which cause the so-called *malignant fever*, in which dangerous complications most frequently occur.

Closely similar parasites are found also in monkeys, bats, squirrels and birds.

As proved by centuries of experience, Cinchona bark, from which quinine is made, possesses the power of destroying the parasites and curing the infection. But it will not generally destroy all the parasites in the body unless it is given in sufficient doses and continued for several months.

(2) *The Mode of Infection.*—Besides those forms of the malaria parasite which produce spores in the human body, there are other forms, male and female.

When certain species of the mosquitoes called Anophelines happen to feed on a patient whose blood contains the parasites of malaria, these are drawn with the blood into the insect's stomach.

If the sexual forms of the parasites are present these undergo certain changes in the mosquito's stomach ; the females pass through its wall ; and finally fix themselves to its outer surface—that is, between the stomach and the skin of the insect.

In this position they grow largely in size, and after a week, in favourable circumstances, produce a number of spores.

The spores find their way into the insect's salivary glands. This gland secretes the irritating fluid which the insect injects through its proboscis under the human skin when it commences to feed, and the spores can easily be found in the fluid by the microscope.

Thus when a proper species of Anopheline, which has more than a week previously fed upon a patient containing the sexual forms of the parasites of malaria, next bites another person, it injects the spores together with its saliva under his skin—that is generally into his blood.

These spores now cause, or may cause, infection or re-infection in this second person, as described at the beginning of this compendium.

Numerous birds and men have been infected experimentally in this manner.

Thus the parasites of malaria pass alternately from men to certain mosquitoes, and back from these mosquitoes to men.

A very large number of parasites are known which pass in this manner from one animal to a second animal which preys on the first ; and back again from the second animal to the first.

It is not known with certainty when and how this process first commenced ; but probably all such parasites were originally free living animals, which, by the gradual evolution of ages, acquired the power of living in other animals.

Thus also, it is evident that malarial fever is an infectious disease which is communicated from the sick to the healthy by the agency of certain mosquitoes.

From the time of the ancients it has been known that malarial fever is most prevalent in the vicinity of marshes.

The parasites of malaria have never been found in the water or air of marshes ; nor in decaying vegetation ; nor in the soil. But the Anophelines which carry the parasites breed in marshes and marshy pools and streams.

Rising from these marshes, they enter the adjacent houses and feed on the inmates, mostly at night ; biting first one person and then others ; and living for weeks or months.

If an infected person happens to be present in any of these houses, the infection is likely to be carried by the Anophelines from him to the other inmates, and to neighbouring houses.

Thus the whole neighbourhood tends to become infected, and the locality is called " malarious."

In such localities, it is easy to find the parasites of malaria in the Anophelines of the proper species ; even in as many as 25 % of them.

Such Anophelines when taken from a malarious locality to a healthy one (*e.g.* from the Campagna near Rome to London) will still infect healthy persons whom they have been caused to bite.

So also, in malarious localities, the Anophelines bite the healthy new-born children and infect many of them.

Such children, if not thoroughly treated, may remain infected for years ; may become anæmic and possess enlarged spleens ; and may spread the infection to others. Later however, at the age of twelve years or more, the survivors tend to become "immune."

In many malarious localities, almost every child has been found to contain the parasites of malaria, or to possess an enlarged spleen.

In such a locality therefore, the infection is constantly passed on from the older children, or from adults, to the new-born infants ; so that the locality may remain malarious for years or for centuries.

Similarly, a new-comer arriving in such a locality is very likely to become infected, especially if he sleeps in an infected house, even for one night.

A locality is said to be malarious only when healthy persons become infected in it ; not when persons who have become infected elsewhere happen to reside in it.

A locality is malarious only when it contains persons already infected with the parasite, and also sufficient numbers of the proper species or varieties of Anophelines to carry the infection to healthy persons.

The chances of infection tend to be great in localities where there are already numerous infected persons, not treated with quinine ; or where there are numerous Anophelines of the proper species, not prevented from biting.

Conversely, the chances of infection tend to be less where infected persons are excluded, or properly treated with quinine ; or where the Anophelines are few in number, or are prevented from biting.

(3) *Facts about Mosquitoes.*—Gnats, which in the tropics are commonly called mosquitoes, belong to the zoological family of insects known as the Culicidæ (from the Latin *culex*, a gnat). They are distinguished from other insects by a number of characters ; and always possess only one wing on each side, and a long proboscis.

Like that of other insects, their life is divided into four stages, the *egg* ; the *larva* (or caterpillar) ; the *pupa* (or chrysalis) ; and the *imago* (or adult, winged insect).

The *egg* is laid on water or near it, and in warm moist weather hatches out in a day or two.

The *larva* is entirely aquatic, and always lives in water. It swims and dives by means of paddles and hairs, and feeds on various aquatic organisms. It cannot however breathe under water, but must always rise to the surface in order to obtain air. After a week or more it becomes a pupa.

The *pupa* still remains in the water, generally floating on the surface. After two days or more its skin cracks and the imago emerges.

The *imago* remains standing for a little while on the empty floating skin of the pupa and then flies away. Both males and females are able to suck fluids through the proboscis. As a rule the male feeds only on the juices of plants ; but the female sucks the blood of men, beasts, birds and reptiles. The female returns to water every few days in order to lay her eggs, of which she may deposit several hundreds at a time ; and then seeks another meal.

Female gnats have been kept alive in captivity for months. In unsuitable weather, both males and females may take refuge in damp places such as cellars, wells, outhouses and woods, where they may remain dormant for months until better conditions prevail.

As a rule, gnats like other animals tend to remain in the locality where they were born ; but a few may occasionally stray to some distance. When a strong wind prevails they usually take shelter ; but on warm, still nights or days many of them may wander to a distance of half a mile or more from their breeding places. If however plenty of places exist near at hand where they can obtain food, there is no reason why they should travel further for it. They must also remain near water to drink and to lay their eggs in.

Gnats are favoured by warm weather ; by plenty of water suitable for their larvæ ; by abundance of food ; and by the absence of various kinds of bats, birds, fish, insects and spiders which devour them or their larvæ. During its life, a single gnat may succeed in biting many persons or animals, and in propagating diseases amongst them.

The family of Culicidæ or Gnats is divided into many sub-families and genera, and contains some five or six hundred known species. Although all these species have many habits and structural characters in common, yet they all differ in small details. These have been described at length in a number of special books written on the subject.

In the tropics, as a broad general rule, the gnats which most concern human beings belong to the groups called *Culex*, *Stegomyia* and Anophelina.

Culex pipiens is a very common gnat in Europe, and allied species are found almost everywhere in the tropics. The larvæ occur principally in tubs, barrels, cisterns and other vessels containing water, in stagnant ditches, garden pits, holes in rocks and trees, and so on. They possess a long breathing tube close to the tail fins, and float at the surface of the water with the end of this tube attached to the " surface film," and the head hanging downwards.

When disturbed, they wriggle at once to the bottom. The adult insects generally present a uniform grey appearance, with pale yellowish bars across the back of the abdomen, and plain unspotted wings. They bite almost entirely in the evening and night, and principally indoors (in the tropics). The parasite which causes elephantiasis, namely the *Filaria bancrofti*, is carried by them in a manner very similar to that in which the Anophelines carry the parasites of malaria.

Stegomyia fasciata and *S. scutellaris* are very common in the tropics, but much less so in temperate climates. The larvæ breed in much the same places as those of *Culex*, but more frequently in vessels. Any old biscuit or oil tins, flower pots, broken bottles, and crockery, tubs and barrels, choked drains, roof gutters, &c., in which rain or other water has collected, is almost sure to contain them, and they frequently occur in holes in trees and in certain plants. They possess a short stumpy breathing tube, and float head downwards, like the larvæ of *Culex*. The adult insects are more or less striped or speckled black and white, and have plain unspotted wings. They bite chiefly in the day time, and often abound in woods and in the shade of trees. In America *Stegomyia fasciata* carries yellow fever.

The Anophelines consist of about 120 known species, some of which carry malaria, and are always found in malarious places. The larvæ occur chiefly in water on the ground, particularly in water which stands or flows amongst grass or water weeds. Thus they abound in the weedy margins of rivers, streams, lakes, and ponds; in small sluggish streams and streamlets; in water-courses, drains and gutters choked with weeds; in pools of rainwater lying on grass; in pits from which earth has been removed, such as the "borrow pits" by the side of railway embankments; in cisterns and pits used for watering gardens; in ornamental waters; in hollows in rocks; and in water at the bottom of boats, &c. Thus while the larvæ of *Culex* and *Stegomyia* occur in any small collections of water, such as those which abound in and around houses, on the other hand the Anophelines are essentially *marsh mosquitoes*—owing to which malaria is always more or less connected with marshy conditions, and is called Marsh Fever, or Paludism. The larvæ feed chiefly on the surface of the water—on which they float like sticks, and not with the head hanging downwards. When disturbed they swim away backwards on the surface, and sink to the bottom only when much alarmed. They have no breathing tube like those of *Culex* and *Stegomyia.* The adults are speckled brown and white, or black and white; and the wings are not plain but generally possess three or four black marks along or near the front border. When the insect is seated at rest on a wall the tail projects outward at an angle from the wall; whereas the *Culex* and *Stegomyia* sit with the tail hanging downwards, or even nearly touching the wall. All these facts enable anyone to distinguish at sight both the larvæ and the adults of Anophelines from those of *Culex* and *Stegomyia.* Anophelines bite chiefly at night or in the dusk—owing to which the malarial infection is generally acquired at night. They enter houses, but also bite in the open in spots sheltered from wind.

(4) *Personal Prevention.* —If they can avoid it, people should not go to live in known malarious places, or in the vicinity of marshes, or close to an infected native population.

Even in such however, the chances of infection can be much reduced by the careful use of mosquito nets. The net should not have the smallest hole. It should be hung *inside* the poles, when these are provided, and not outside them. It should be tucked under the mattress all round, and should never be allowed to hang down anywhere to the floor; and it should be stretched tight, in order to allow every breeze to enter, and not be hung in loose folds, which check ventilation.

Those who can afford it should protect the windows of the house with wire gauze, and provide the doors with automatic closing arrangements. It is especially advisable to protect a room or a part of the veranda, for sitting in during the day or evening.

Punkas and electric fans, not only drive away mosquitoes, but also keep the body cool, comfortable and vigorous, even in great tropical heat.

Where there is great danger of malaria five grains ($\frac{1}{3}$rd gramme) of quinine should be taken regularly every day just before breakfast; but it is advisable to take a double dose at least once a week—say on every Sunday.

In such localities, the hands and feet may also be protected by gloves and boots; but these cannot always be endured owing to the heat; and it is preferable instead to carry and use constantly a palm-leaf fan, with which mosquitoes can be largely driven off, and the body kept cool.

It is extremely dangerous to sleep in a house which is occupied, or has recently been occupied, by infected persons, especially native children; or in or close to an infected native village.

(5) *Public Prevention*:—As a broad general rule, malaria causes from a quarter to half the total sickness in the tropics.

Malaria can always be greatly reduced, or may even be extirpated, in any locality.

Large marshes in populous places must be drained, deepened, or filled up.

A proper permanent organisation must be established for dealing with the smaller breeding places of Anophelines, and for distributing quinine, especially to infected children. Other measures can be adopted where called for.

The cost is likely to be more than recouped by saving in life, labour, invaliding, medical attendance, and hospital accommodation.

The campaign will remove other mosquito-borne diseases as well as malaria; and will tend to improve general sanitation in the locality where it is undertaken.

3. **THE DURATION OF INFECTION.**—The foregoing sections show that we have acquired much knowledge about malaria; but several points remain to be discussed. The discussion is the more necessary because these points, although of cardinal importance in connection with the art of prevention, receive no adequate attention in text books.

The first question is this: How long after a non-immune person becomes infected do the parasites remain in his blood, provided he receives no medical treatment and no fresh infection?

We must first ask: How long may they possibly remain? In every case they certainly remain while the fever lasts; that is, in untreated cases, for some weeks or months, at least. Sailors infected during a few days' stay in a West African river come to Liverpool after a month's journey at sea, and are frequently found to be infected for weeks and even for months after their return to Liverpool. In such cases re-infection on board vessels is not likely, owing to the rapidity with which mosquitoes are blown out of a steamship: and malarial infection in England at the present day is almost unknown. I have found the parasites in several persons after residence in England for six months: and in one case they were certainly found in Liverpool after four years' absence from any malarious locality. Another case well known to me was that of my father. He had suffered much from malaria in India. In 1880 he left India permanently and resided in the South of England. In 1889 he informed me that he still continued to have one or two attacks every year; and a little later I witnessed one of these—a typical attack with severe rigor followed by high fever, and without symptoms of influenza or other disease. His blood was not examined. I have also been told by three different persons that they continued to suffer from occasional attacks twenty years and more after leaving the tropics. In such cases microscopical verification is difficult to obtain owing to the fact that a large dose of quinine is generally taken at the onset of the paroxysm.

We have therefore the right to say that the infection occasionally remains for some years. The next question is: How long does it remain *on the average*? That is to say, out of a thousand untreated persons removed from possibility of re-infection, how many will continue to have attacks after one, two, three years, and so on? I can suggest only one way to obtain a reply. Taking Northern India, for example, we observe that the Anophelines do not begin to abound until July and disappear in November or December. The admissions for malaria continue all the year, but show a great increase in September or October, that is, as we may expect, two months or so after the reappearance of the Anophelines. Hence we may infer that the admission rate for malaria before the annual appearance of Anophelines is due chiefly to relapses occurring among persons infected in previous years; while the admission rate after the appearance of the Anophelines is due to relapses plus fresh infections or re-infections. In other words, the minimum admission rate for the year represents roughly the relapses only; while the difference between the maximum and the minimum rates is caused by the new infections.

The Annual Reports of the Sanitary Commissioner with the Government of India give abundant material for this enquiry. It will be seen that in station after station and year after year, the admission rate for Intermittent Fever tends to be lowest in February and March and to be highest in September, October and November, That is, the admissions begin to increase about two months after the commencement of the rains, and continue to increase with the accumulation of cases until November, after which a decline, due to recoveries, occurs. The October maximum may be from two to five or more times greater than the February minimum. For illustration, I select at random the Native Troops on the North-West Frontier, Indus Valley and North-West Rajputana; Returns (tables) for 1900-3, Table XXXV., Group VII.

ADMISSIONS.

Year.	Average strength.	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total	Average to 1,000 strength
1900 ...	15,861	328	168	109	121	246	357	301	246	499	1,611	1,189	920	6,095	384·3
1901 ...	16,951	400	198	265	437	483	583	509	461	628	1,712	1,101	522	7,299	430·6
1902 ...	16,472	309	248	199	297	475	338	449	482	568	867	1,166	764	6,162	374·1
Average...	16,428	379	205	191	285	401	326	420	396	565	1,397	1,152	735	6,519	396·8

Here the average maximum in October is more than six times greater than the average minimum in March, and the increase must be due to the new infections caused by the summer hatch of Anophelines. Of course the difference is not always so marked. In the south of India, owing to the warmer winter, the insects breed and infect more continuously; and in other places, where there are streams, lakes or irrigation waters, they are not so dependent on rainfall.

As a very rough estimate then, I am inclined to infer that after the six winter months, during which we may suppose few fresh infections to occur, the cases would tend to fall to about one-quarter the original maximum number. Suppose now that we could suppress entirely the next summer rise, and that the admissions for relapses continue falling at the same rate, namely to one-quarter every six months; at the end of twelve months, the cases would be one-sixteenth the original maximum; and at the end of eighteen months would be one-sixty-fourth of it, and so on. In other words half the cases tend to recover every three months, if no re-infection occurs. Thus out of 1,000 original cases, 500 would remain infected at the end of the first quarter; 250 at the end of the second; 125 at the end of the third; and three or four after two years.

The truth lies somewhere near these figures, but so many factors are concerned in the result that it is difficult to make a more exact estimate. For example, the Indian statistics refer to soldiers who were certainly given medical treatment; and this treatment must have resulted in reducing the number of relapses, although it was evidently insufficient to cure the cases altogether. Again, if many of the patients have suffered from malaria in childhood (as most Indians have) many would be partially immunised, and the number remaining infected after a given lapse of time would be less than with people exposed to the disease for the first time. But the estimate of a 50 per cent. reduction every three months may be adopted for the present as a working hypothesis, which will at least serve to give precision to our ideas.

4. **THE PARASITES BETWEEN THE RELAPSES.**—If the infection is not cured at once, the patient suffers from a succession of relapses with intervals of several weeks between each, the parasites being found readily in the blood during the relapse, but not so easily during the interval. Marchiafava and Bignami were, I believe, the first to suggest that they enter upon a latent (*e.g.*, an encysted) phase in the interval, but admitted that they could find no microscopical verification of this conjecture. Several writers thought that certain known forms of the parasites (the sexual forms) serve to continue their existence at these times; and quite recently F. Schaudinn repeated the same speculation. There is, however, no need for it. My own position has always been that the parasites simply vary in numbers within the body, as the tubercle bacillus does. When they are numerous the patient suffers; when they are few he does not feel them.

It is easy to estimate the number of malaria parasites in a patient by comparing them under the microscope with the number of red blood corpuscles. In severe cases the number of parasites may exceed 10 % of the number of red corpuscles. For example, we made a careful estimate in the blood of a soldier from Vacoas early this year, and found that his parasites numbered 12 % of his red corpuscles. Now a medium person of 150 lbs. (68 kilograms) body-weight, contains about 25,000,000,000,000 red corpuscles; so that this man must have contained about 3,000,000,000,000 parasites when his blood was taken. When there is less fever the parasites (excluding the sexual forms, which do not produce fever) are much fewer. If there is only one parasite to 100,000 corpuscles, that is, only 250,000,000 in the whole body, there will be little fever, and it will be difficult to find the parasites at all in the small droplet of blood examined. Hence, when the parasites fall below this standard (which may be fixed at this figure for a rough estimate), the patient will scarcely feel them, and the physician may scarcely be able to find them. If they number only a few thousands, they will not be discoverable; and yet they will be amply numerous enough to keep the infection alive—just as a few rats in a ship will suffice to keep the ship infested. Later on the parasites may increase again, and reach sufficient numbers to produce another attack of fever and to be again discoverable by the microscope.

As I have said, no one has yet succeeded in proving the existence of a resting stage of the parasites, though many attempts have been made. The task should be easy with the parasites of birds; but in 1899 I searched many infected birds in vain—only the ordinary forms could be found. Moreover, with a resting stage we should expect to find relapses occurring after definite intervals—that is, in regular biological cycles; but in my experience they occur quite irregularly. The explanation given above is sufficient and probable; and no other one is required until it has been proved to be wrong.

5. **CAUSES OF THE RELAPSES.**—But it will now be asked, what causes the parasites to increase and decrease in the manner suggested above? Probably the same thing that causes the increase or decrease of other invading organisms—the varying resistance of the host. When the resistance is great, the parasites diminish; when it weakens, they multiply. Probably anything which weakens the resistance—fatigue, heat, chill, dissipation, other illness—tends to encourage the parasites and to precipitate a relapse.

This is shown by a large number of observations. Probably every military surgeon who has dealt with malaria infected troops has noted that a heavy march or parade has been followed by numerous admissions into hospital for relapses. A costly item in military expeditions is the invaliding of infected soldiers who, though able to do the light work of peace time, break down with relapse after relapse of malaria when subjected to the fatigues of war. In 1889 I was in charge of a regiment of picked Madras troops sent by sea to Rangoon for active service in Burma. The voyage was oppressive and rainy, and most of the men were frequently wet through ; and dozens of them began to be attacked with typical malaria while still at sea. African travellers frequently remark that their native carriers are attacked even during the first days of a journey. Every planter knows that when his coolies are first put upon the heavy work of the season, scores of them suffer from fever. Engineers often observe the same thing. The frequency with which relapses of malaria follow upon other diseases, such as pneumonia, influenza, typhoid, and venereal diseases, or upon child-birth, accidents, and surgical operations, is well known to the physician, and has resulted in the ancient aphorism that the intermittent tendency is apt to be impressed on all diseases occurring in old cases of malaria. Most educated febricitants will aver that exposure to great fatigue, heat, or wetting will encourage relapses ; and probably a large number of cases of so-called sunstroke or heat-stroke are due merely to this cause, often perhaps aggravated by intemperance. For definite statistical evidence, however, I wish to call attention to a phenomenon which I have named the "hot weather rise" in the malaria admission rate. This is well seen in the Indian statistics referred to in section 3, even in the small table there given. Almost throughout India the admissions tend to increase slightly in the months of March or April, and this increase is so constant that it cannot be due to accident. To what then is it due? The season is too early for the rise to be attributed to fresh infections by Anophelines ; and I can therefore place it only to the score of relapses caused by the rapidly increasing heat of the tropical spring. Quite on other grounds I have long been forced to infer that great external heat is favourable to the parasites of malaria, both human and avian. Thus the obstinacy of cases in the hot weather and the great improvement caused by removal to a hill-station or to Europe are well recognised by practitioners. In 1898 I frequently took infected birds from Calcutta to the Himalayas and back again, and was always struck by the fact (which was very inconvenient for my researches) that the parasites diminished greatly when the birds were in the mountains and increased again when they were brought back to the plains. Moreover, while 11 per cent. of the Calcutta sparrows were found infected in August, Dr. Daniels and myself had great difficulty in obtaining infected birds in December and January. I assume then that the "hot weather" rise is merely due to relapses encouraged by the temperature. It is easy to conjecture why the temperature should have this effect, on the ground that the parasites breed more rapidly in the hot weather in the expectation, so to speak, of finding the mosquito-host which bites only at that season. In fact, warm weather is their natural climate, and doubtless they can feel its influence even in the artificially heated medium in which they live.

The malarial infection, then, is one which may last for a long time and cause many relapses, and I have dwelt at some length on this point because, as will be seen later, confusion in regard to it is apt to generate confusion in regard to the mode of propagaticn of the disease.

6. THE PROPER DURATION OF TREATMENT.—By treatment is here meant treatment with the specific, quinine, given in any of the methods usually adopted by practitioners. The question is, how long must it be continued in order to extirpate the infection entirely.

It is a very important question as regards both cure and prevention, but is not sufficiently regarded either in text-books or in practice. In many of the former the drug is recommended to be given while the fever lasts and for a few weeks later. In military practice the soldier is often, or indeed generally, discharged to duty a few days after the temperature has returned to normal. The result is that the patient frequently falls sick again with a relapse, is treated again in a similar manner, and so has relapse after relapse, until he becomes a chronic febricitant, or a cachectic, or dies of blackwater fever. It is impossible to deny the frequency of such inadequate treatment in malaria because one is called upon over and over again to see patients who give this history.

Obviously the final aim of treatment is not merely to reduce the present attack of fever, but to remove the parasites altogether; and for this the patient must be kept under observation and treated for a considerable length of time. The period which I have always suggested is three months in temperate climates and four in the tropics (in view of the observation that the parasites flourish more readily in the latter). If a relapse occurs within these periods, the treatment must be recommenced from the beginning. I have known numerous cases cured by such a course, but still am not willing to declare that it is sufficient for all patients. Needless to say, warnings against reinfection should always be given. Many practitioners think that intramuscular injection is so much more potent than medication by the mouth that with it a shorter course will suffice.

The question arises here chiefly in connection with prevention (section 24); but also in connection with the treatment of coolies. With them, as with soldiers, it is bad economy as well as bad medical practice to return men to duty, or at least to release them from observation and outdoor treatment, before a complete extirpation of the infection has probably been effected. Not only do they tend to be useless as workers, but they spread infection among the healthy; and strict rules should be made on the subject in every plantation and factory.

7. **THE PROOFS OF THE MOSQUITO THEOREM.**—The word *theorem* is used here in its correct sense as expressing not a mere speculation, but a body of established fact. I wish now merely to summarise the proofs by which the mosquito theorem has been established. They are briefly as follows:—

1. Every stage of the life history of the parasites, not only in infected men, but in Anophelines of the proper kind who have been fed upon them, has been closely followed, described, and figured by many competent observers.

2. No such parasites have ever been found in Anophelines of the same kind which have been fed only on healthy persons.

3. Healthy persons bitten by infected Anophelines at the proper time have subsequently developed the symptoms of malarial fever, and have been found to contain the parasites.

4. The same phenomena have been observed in the closely allied malaria of birds; and similar phenomena in the case of many other parasites.

5. Where the Anophelines have been banished, as at Ismailia, the disease and the parasites have also disappeared.

I might add that the great weight of all this evidence can perhaps scarcely be fully appreciated except by those who have made a study of pathology and parasitology, and have read the voluminous literature of the subject. But the theorem has now been before men of science for nearly ten years, and has been so completely accepted by them that the public may safely follow them without misgiving.

8. **DO OTHER INSECTS CARRY MALARIA.**—But though the general theorem has been so definitely determined, we are not quite so certain regarding several details. If Anophelines can carry malaria, why not other insects? First, we should note that not all, but only certain species of Anophelines carry it, and that according to some, only certain varieties of some of these species are effective. As a fairly general rule, animal parasites are very particular in their choice of hosts. Thus, no one has succeeded in infecting animals with human malaria, and the probability is that it will not exist in many kinds of mosquitoes. Between 1895 and 1899 I failed entirely in infecting several species of *Culex* and *Stegomyia*, though I made experiments on hundreds of the insects; and these results were confirmed by the Italian observers, by Stephens and Christophers, and by many others. But nevertheless such negative results are never absolutely conclusive unless enormous numbers of experiments are made, because it is always possible that some condition such as of temperature or humidity, may have been overlooked, or that the proper species or variety may not have been used. But there is a strong argument against mosquitoes in general being concerned, namely that from the oldest times malaria has been known to be connected with marshes, while many mosquitoes, such as most *Culex* and *Stegomyia*, do not breed in marshes as a rule, but in petty collections of water round houses. If these carry malaria, then malaria should abound everywhere, especially in towns, and not so exclusively near marshes. A good contrast is found in the case of yellow fever, which does abound in towns and not particularly near marshes—for the simple reason that it is carried by *Stegomyia*.

On the whole then, though we cannot say definitely that malaria is not carried by other hosts than Anophelines, yet there are strong reasons for this opinion. At all events we are fairly certain that all insects which carry it must be marsh-born, like the Anophelines; so that the principal preventive measure of drainage is not seriously affected by the question.

9. IS MALARIA DUE TO THE SOIL?—Even after the mosquito theorem was established, many capable medical men remained of the opinion that there might be another method of infection as well. They still thought (and indeed some still think) that the soil gives off an infective effluvium, or miasma, which produces malaria in those who inhale it. Let us examine this hypothesis with care.

As stated in section 1, the ancients knew that malaria abounds mostly near marshes. It was only reasonable to suppose, then, that the disease is produced by something which comes from the marsh. When Laveran discovered the parasites in 1880, everyone thought that they originate in marshes, but (as already noted) efforts to prove this by experiment were failures. When the Anophelines were incriminated, and were at the same time shown to breed in marshes, the connection between the marsh and malaria was so well explained that there seemed to be no longer any need for the old miasmic hypothesis. Nevertheless it still received the confidence of many, for reasons which I will now classify and criticise.

(1) *Mosquitoes may abound where there is no malaria.*—This is quite true, but has no bearing on the case. When people talk of there being many mosquitoes in a locality they generally refer to *Culex* and *Stegomyia*, which so frequently swarm in houses in the tropics. But these do not carry malaria, and their prevalence does not, therefore, affect the question.

(2) *Malarial infections may occur where there are no Anophelines.* So far as we know, this is not true. In not a single case as yet has it been proved by competent observers that Anophelines are absent when fresh malarial infections are occurring. I say competent observers, because untrained persons are not at all to be relied upon to find them. For example, the Hon. Dr. Strachan and I once spent two nights at Ibadan, near Lagos, in a new house in which I did not see a single mosquito the whole time. In the mosquito trap however (a net with a small hole or two and a man inside for bait), five or six, mostly Anophelines, were captured each night; so that the insects were really very numerous. Again, in Mauritius, we failed for some weeks, even with the aid of a number of trained "moustiquiers," to find the real culprits at Clairfond marsh (addendum 2). It is obvious that an "ordinary visitor" might easily be misled in circumstances like these.

We must not expect that in every malarious locality, the malaria-bearing gnats are the commonest. Their presence is often lost among swarms of other mosquitoes ; but nevertheless it is the few and not the many which work the mischief. In other places, as at Ibadan, the unwary observer, failing to see any mosquitoes at all, might go away declaring that there were none ; whereas, as a matter of fact, there may be many. The Anophelines are often very surreptitious in their visits to houses—they may pour in late at night and leave before day-break (as Stephens and Christophers first showed) ; and they are not such domestic insects as the *Culicines*. Our moustiquiers stated that the Anophelines at Clairfond scarcely commenced feeding before 9 p.m. or later, either in verandas or in the open (addendum 2).

Again, it is quite possible that at the moment when we visit even an intensely malarious place, few Anophelines at all may be there It does not follow that they abound equally all the year round. Even in the rainy season, they often appear, not continuously, but in swarms ; and between the swarms few may be visible. Thus, in one such place many years ago I obtained only a single individual, though the rains had commenced. Want of recognition of this fact has led even capable students of the subject to declare, without sufficient reason, that there is no constant ratio between the amount of malaria in a locality and the number of Anophelines.

(3) *Attacks of malarial fever may occur where there are no Anophelines.* This also is quite true ; and the fact has been cited over and over again in opposition to the mosquito theorem. For instance, persons may suffer from attacks of malaria anywhere—in Britain, on high mountains, and in the arctic regions. As we have seen, there is a rise in the malaria rate in India in April, before the Anopheline season has commenced. Attacks are very common in the winter, in the desert, and far out at sea. In Mauritius and elsewhere it has often been noticed that the disease is very prevalent in plantations and factories at times when the workmen undergo their most strenuous labour, as when furrows are being dug, crops transplanted, etc. Soldiers and coolies frequently fall sick when commencing active service and works of construction ; and all this without any particular or excessive prevalence of the Anophelines.

Most of such cases are of course merely instances of *relapse* of malarial fever. The mosquito is responsible only for the initial inoculation, not for the subsequent relapses, which, as stated in section 3, may continue for years anywhere, from the north pole to the south pole. The occurrence of an attack quite apart from the Anophelines has therefore no bearing on the question unless it can be proved to be the first attack.

But even this will not always suffice to prove that the infection can be caused in other ways than by mosquitoes. One often meets patients who give the following history: that they had lived long in a malarious place without having suffered from fever, but on returning to the coast and embarking for Europe, they were attacked while out at sea. On examining such patients, I have always found, either that the fever was not certainly malaria, or that the patient had been in the habit of taking quinine regularly when he lived in the malarious place. On embarkation he thinks himself safe and leaves off the quinine; but without his knowledge he was probably infected all the time; and the quinine taken by him had sufficed to keep down the numbers of parasites without extirpating them entirely. Hence, when he discontinued the drug on board ship, the parasites began to multiply rapidly and shortly gave him fever. As it was his first attack, he comes away with the belief that he was infected on board the ship, and is cited as a case in which the malarial infection was produced where there were no Anophelines.

It is proper however to admit that while most such cases can be explained in a similarly easy manner, we meet one occasionally which is more difficult. But I have never yet met one in which explanation on the mosquito theorem was quite impossible. Every recorded case, even one recently recorded in the south of England, may have been bitten by an infected Anopheline.

(4) *Malaria is produced by digging.*—In section 1 we saw that the theory of the marsh miasma gradually grew into the telluric hypothesis, according to which malaria is caused by a poison which exists in suitable soil and which escapes from it when it is disturbed; and instances which apparently support this idea are still cited. From what has just been said, the reader will gather that many of them are probably only relapses occurring among previously infected workmen; while others may quite possibly be caused in the usual way by Anophelines bred in marshes close to the spot where the soil has been disturbed. Both of these explanations are extremely probable in

the case of large operations such as railway and canal works, where hundreds of native workmen are crowded together, housed in rough tents or huts, and perhaps exposed to much fatigue and to the attacks of many mosquitoes. But nevertheless malaria may be caused actually by the digging, though not in the way suggested by the telluric hypothesis. I believe that this point was first cleared up by my own observations made in connection with the Sierra Leone railway in 1899. Severe malaria had occurred along the course of the railway while it was being made. On visiting the scene we found innumerable puddles full of the larvæ of the Anophelines by the side of the railway embankments, in the "borrow pits" from which earth had been taken for building the embankments, and even under the railway "sleepers." I saw the same thing in connection with the Lagos railway in 1901, and near the Greek village of Moulki in 1896. In fact the matter has now become a common-place with the students of malaria. Hence we must end by admitting that disturbance of the soil is really apt to cause malaria; but that it may do so, not by liberating any telluric miasm, but by encouraging the breeding of Anophelines, and the occurrence of relapses among the workmen.

We see, therefore, that there is little or no evidence in favour of the idea that malaria may be caused by other agencies than by the Anophelines. Let us now examine the strong arguments which may be cited against the hypothesis.

I have already argued the case against other insect carriers (section 8). The case against the telluric miasm is very much stronger. In the first place, all experiments to infect men with air or water brought from malarious localities have failed (section 1). Secondly, if malaria were due to any particular kind of soil under certain conditions (as has been supposed) it should always be present where that soil and those conditions exist. But we know that actually it comes and goes. For example, it came to Mauritius in 1866, and to Reunion in 1867; it is still absent from Seychelles and Rodrigues, though favourable conditions for it exist in those islands (annexure 1); and it has disappeared from Great Britain. But the soil and the climate of these areas have not changed. Thirdly, if the poison is diffused in the air it ought to affect everyone within a considerable area round the generating centre;

but as a rule the disease is limited to the immediate vicinity of the marsh (addendum 2). Fourthly, the telluric miasm ought to attack especially those who are engaged in digging, but I have never observed that cultivators and gardeners suffer much more than their neighbours; while, as a matter of fact, it is generally the children and even the infants who suffer the most. Lastly, the idea that the parasites can live in soil, water and air, as well as in men and mosquitoes is extremely improbable in the light of our general knowledge of parasites.

The last is probably the clinching argument. Living organisms do not possess independent properties; but accord more or less in their structure, capacities, habits and life-history with other organisms. We are cognisant of thousands of parasites of men, animals and plants; and what we know of the parasites of malaria shows that they are not markedly exceptional. In fact they belong to a class of parasites which infect two hosts, one of which feeds on the other—as, for instance, parasites of the deer and the tiger, the mouse and the cat, the ox and man, the ox and the cattle tick, and now man and mosquitoes. The general law is, therefore satisfied by the known life-history of malaria. We have no reason to expect another life-history for the malaria parasites in soil, water or air, any more than for the other parasites. Then again, every animal possesses only the limited powers which have been given to it by the evolution of ages, and for which it has acquired definite organs and habits of life. The mole burrows, the fish swims, the bird flies, the parasite occupies the higher animal or plant. But if this telluric hypothesis is sound, what remarkable animals must these parasites of malaria be! They already possess a structure wonderfully adapted for their life in men and also in mosquitoes; but we must now expect that they are also able to burrow like the mole, swim like the fish, and fly like the bird! To do all these things they must have the suitable organs; and not only this, but they or their spores must be protected against heat and cold and hosts of enemies in soil, water and air. If all this were true we should have to put the parasites of malaria in a special class by themselves, apart from the rest of creation.

These reasons have now led pathologists and parasitologists (who can perhaps appreciate their weight better than others) to abandon the telluric hypothesis as a likely one. There is no evidence in favour of it, and there are very strong arguments against it. The true theorem is obvious. The connection between malaria and the marsh, so long known to suffering humanity, is now fully explained by the fact that the Anophelines breed in the marsh. There is no necessity to believe that the germs also breed in the marsh. Malaria comes from the marsh, not because the germs of the disease come from it, but because the carriers of the germs do so. It is the same thing in the end. The ancient theory was quite right. Malaria *is* caused by a marsh miasm. The Anophelines themselves, the mosquitoes, *are* the march miasm.

10. **WHAT DO WE MEAN BY THE AMOUNT OF MALARIA IN A LOCALITY?**—It is very necessary to obtain perfectly clear ideas on this point. If we could examine all the people in a locality and could ascertain exactly where and when each patient was infected, we could then divide all the cases into two classes, namely, those who were infected outside the locality and those who were infected within it. We might call these classes respectively the *imported cases* and the *indigenous cases*; and the ratio of the numbers of each class to the total population of the locality might be called respectively the *imported malaria rate* and the *indigenous malaria rate*.

The imported cases may be very numerous in some places, such as military stations, into which badly infected regiments are introduced; or sanatoria or hill stations, such as Curepipe in Mauritius, where patients congregate for change of air or security. Or they may be very few, as in rural villages, the inhabitants of which do not migrate much.

If, then, we talk of the amount of malarial *fever* in a locality, we include both classes, since the imported as well as the indigenous cases may suffer from relapses in it. But if we talk of the amount of *malaria* in it, we generally mean the amount of malaria which is or has been contracted within it—that is we refer to the indigenous cases only.

It is often difficult or impossible to distinguish whether a case was or was not infected within the locality. Careful enquiry may fail to determine the point; and there are many cases which were originally infected without, but which have been cured and then re-infected within—so that if we omit these from our list of indigenous cases we shall obtain wrong results. Again, many of our indigenous cases may have emigrated elsewhere since becoming infected. In many localities, however, unless people are especially attracted or repelled to or from them, the number of emigrants and immigrants will tend to be equal. That is to say, on a rough average, as many patients will be leaving the locality as entering it ; so that the *total* malaria rate of the locality will represent fairly accurately the *indigenous* malaria rate.

The indigenous cases may be further classified according to the dates when they were infected ; some may have been infected a month ago, others two months ago and so on. If we ascertain the number of persons infected in a year or in a month, we can obtain what may be called the *annual* or *monthly infection rates* of the locality.

When we say that a place is very malarious, we mean that its infection rate is very high. When we say that it is very malarious at a given season, we mean that its infection rate is very high at that season—not necessarily at other seasons.

These rates are difficult to obtain, and, in fact, can be obtained only after mathematical investigation. Similar rates may be ascertained for all diseases ; and I have suggested the name *pathometry* for this branch of study. As a rule in medical statistics, most of the considerations given above are ignored ; with the result that the statistics are often quite useless. We shall consider later (section 19) the best methods for measuring the amount of malaria in a locality.

11. **FACTORS WHICH INFLUENCE THE INFECTION RATE.**— The infection rate varies, not only in neighbouring places, but even in the same place from year to year. It rose suddenly from zero to a high figure in Mauritius in 1866 : and has long fallen to zero in Britain. What is the cause of these variations ?

This question is so important as regards both the general theory of malaria and the subject of prevention that we must endeavour to obtain clear ideas about it by careful reasoning.

The number of infections occurring in a locality during any interval of time (say one month) depends on the number of infected Anophelines ; which in its turn depends on the number of

Anophelines which have bitten previously infected persons. We can therefore calculate the former if we can calculate the latter. Let *p* denote the average population of the locality; *mp*, the average number of infected persons in the locality during the first month of the enquiry; and *imp*, the average number of these whose blood contains enough of the sexual forms of the parasites to infect Anophelines. Here *m* and *i* are fractions, since *mp* must be less than *p*, and *imp* less than *mp*. Next, let *a* denote the average number of Anophelines in the locality capable of carrying malaria, and *ba* the average number of these which succeed in feeding on a single person during the month. Here *b* must be a very small fraction, since probably many mosquitoes never succeed in biting men at all, and of those that do succeed only a few will have bitten a particular individual. Hence the average number of Anophelines which have bitten the suitably infected persons during the months will be *baimp*.

Now if any of these insects are, in their turn, to infect human beings, they must survive for at least a week or more, in order to give time for the parasites to mature within them; and by no means all of them will survive so long. Let *s* be the average proportion of Anophelines which can survive for that period; then *sbaimp* will be the number of the infected mosquitoes which have survived long enough to infect men in their turn, where *s* is also a fraction. But not all of these will find opportunities to bite human beings again, though they have survived long enough to do so Let *f* be the proportion which succeed in biting. Then *fsbaimp* will be the average number of infected Anophelines which succeed in infecting men; and if each of these infects a separate person and only one person, the same expression will denote the average number of persons infected during the month.

Thus *fsbaimp* not only gives the monthly number of infections occurring among the population *p*, but also shows that this number depends upon the factors *f*, *s*, *b*, *a*, *i*, *m*. The greater these factors are, the greater will be the infection rate. If *m*, the proportion of infected persons at the beginning of the enquiry, is high, the infection rate also will be high, but if $m = o$ to begin with, that is, if there are no infected persons in the locality to begin with, then there will be no new infections, because the Anophelines cannot become infected—as at present in Britain. Again, if a, the total number of Anophelines in the locality, is high, the infection rate will also be high (if the other factors remain the same); but if $a = o$, new infections will cease.

The factors i, s, f, b, are likely to be fairly constant and may be roughly calculated. Thus i denotes the proportion of infected persons capable of infecting Anophelines of the proper kind; and we shall not be far wrong if we take it that, on the average, only one quarter of the malaria patients contain enough parasites ripe for this function; so that we may put $i=\frac{1}{4}$. Again, s denotes the proportion of Anophelines which can survive for a week or more, and will vary with the number of enemies of mosquitoes present, the warmth of the weather, the abundance of the food, and so on; but at a rough estimate it might be put at $\frac{1}{3}$; so that we may write $s=\frac{1}{3}$. The factor f denotes the proportion of Anophelines which succeed in biting human beings during one month—that is, I suppose, during their average life. It must be less than $\frac{1}{2}$ because only about half the Anophelines, the females, attempt to bite human beings, and certainly all of these do not succeed in their quest. Let us therefore put $f=\frac{1}{4}$. Lastly b denotes the proportion of Anophelines which succeed in biting one individual. Now if p is the human population of the locality, and f is the proportion of Anophelines which can bite any of these, then obviously $\frac{f}{p}$ is the proportion which can bite only one person; that is, $b=\frac{f}{p}$; and as we have taken $f=\frac{1}{4}$, then $b=\frac{1}{4p}$.

Let us now consider an example. Let the population, $p=1{,}000$; let $m=\frac{1}{2}$, so that mp, the number of infected persons $=500$. Then of these only one quarter will be able to infect Anophelines; or $imp=125$. Next suppose that there are 12,000 Anophelines (a) in the locality, or 12 to each person. Then since only $\frac{1}{4}$ of these, or 3, are likely to succeed in biting, $baimp$, the number of them which have bitten the 125 suitably infected persons, $=3\times125=375$. But of these only about $\frac{1}{3}$ are likely to survive long enough to infect people in their turn; that is, $sbaimp=125$. Lastly only about $\frac{1}{4}$ of the survivors are likely to succeed in biting again; so that the final residue of infecting Anophelines, given by $fsbaimp$, amounts only to 31·25. If each of these bites a single and a different person, 31 people will now become infected. Thus the infection rate of the locality during the month will be 3·125 % of the population.

If we adopt the values suggested above for the constants i, s, f, b, namely, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{4p}$ respectively, we have,

$$No.\ of\ infections = fsbaimp = \frac{am}{192}$$

To obtain the infection rate per 100 of the population, we have to multiply the number of infections by $\frac{100}{p}$, so that :—

$$Infection\ rate\ \% = \frac{am}{192} \cdot \frac{100}{p} = \frac{m}{2} \cdot \frac{a}{p}, \text{ roughly};$$

that is to say, the monthly infection rate per 100 of the population equals roughly half the malaria rate multiplied by the number of Anophelines in the locality to each person.

Thus in a village in which there are 1,250 people, 750 infected persons, and 3,000 Anophelines, the malaria rate is 0·6, the number of Anophelines to each person is 2·4, and the monthly infection rate % is 0·72. That is, if a person lives in the village for a month, his chances of becoming infected will be as 72 to 10,000.

Such calculations as these, which may appear far-fetched to many, are useful, not so much for the numerical estimates yielded by them, but because they give more precision to our ideas and a guide for future investigations. Thus, whatever numerical value the symbols f, s, a, i, m, p may have, we see that the infection rate is dependent not only on two of them, a and m, as is often stated, but on all, and is therefore not so easy to calculate as may be thought.

12. **CONDITIONS WHICH CHANGE THE NUMBER OF INFECTED PEOPLE IN A LOCALITY.**—The number of infecting mosquitoes which succeed in biting again is $fsbaimp$. If we adopt the values for f, s, b, i, suggested in the last section, this becomes $\frac{a}{192p} \cdot mp$. Now, if all these bite different people, some will bite healthy people and give them fresh infections; and others will bite persons already infected. If, as before, mp is the number of persons already infected, then $p - mp$, that is, $(1 - m)p$, will be the number of healthy people. Hence, by proportion, the number of the infecting mosquitoes which bite the healthy people will be $(1 - m)\ \frac{a}{192\,p} \cdot mp$; and if each bites a different person,

and each person becomes infected, the same expression will denote the addition made to the number of infected persons in the locality at the end of the month.

But during the same time some of the persons originally infected may have recovered. Let us denote the number of these by *rmp*, where *r* must be a fraction. Hence, if the number of newly infected persons, $(1 - m)\frac{a}{192} \cdot mp$ is greater than *rmp*, the number of recoveries, the total number of infected persons will be increased; but it will be decreased if the former is less than the latter. Thus the change depends upon whether $(1 - m)\frac{a}{192p}$ is greater or less than *r*.

In section 3, I estimated roughly that half the infected people remain ill after three months. Thus $\sqrt[3]{\frac{1}{2}}$ remain ill after only one month, and $1 - \sqrt[3]{\frac{1}{2}}$, or 0·2063, recover; so that we may write for a rough estimate, $r = 0{\cdot}2063$. Thus the malaria remains unchanged if $\frac{a}{192p} = \frac{0{\cdot}2}{1-m}$; that is, if

$$\frac{a}{p} = \frac{39{\cdot}60}{1-m},$$

that is, if the number of Anophelines to each person is about $\frac{40}{1-m}$. If *m*, the original malaria rate, is very small, the rate will remain constant if there are not more than 40 Anophelines to each person. If it is high, say $\frac{1}{2}$, it will remain constant even when the number of Anophelines is doubled. If the number of Anophelines is higher or lower than $\frac{40}{1-m}$, the malaria will increase or diminish, as the case may be.

Of course the actual number 40 is only a rough approximation, because we have adopted more or less arbitrary values for the constants *f*, *s*, *i*, *r*, and because we have made certain assumptions which may not be quite exact. But, as I have said, the calculation is useful, not for its numerical results, but because it helps to give precision to our ideas.

It is often thought and said that, if the mosquito theorem is true, malaria should exist wherever there are any Anophelines of the proper kind, and when this is found not to be the case, the theorem is doubted. Similarly, it has often been stated that anti-mosquito measures will be useless because, as long as any Anophelines remain, the disease will remain also. But these fears will now be seen to be groundless. The Anophelines must not only exist but must be numerous, if the disease is to remain constant or to increase. The above calculation suggests that they must average *at least* 40 to each person during a month if this is to happen ; and if they fall below this standard, the malaria will begin to diminish. Whether the figure 40 is quite exact or not does not matter—the important thing is that there is and must be some standard, whatever it is. And a little thought will convince us further of this valuable law. Obviously, unless the number of Anophelines is large, the dangers and difficulties which confront them will end by making them too few to infect numerous enough healthy persons to compensate for the recoveries among patients which are happily always occurring, and the disease will diminish and die out—as has frequently happened.

It is possible to obtain the general *malaria function* or expression which gives the number of infected persons after the lapse of x months, but the full calculation is scarcely necessary for this report.* If, however, m is small, and if $m_x p$ denotes the number of infected persons at the end of x months, then approximately

$$m_x p = \left(1 - r + sif^2 \frac{a}{p}\right)^x mp.$$

This increases or diminishes when x increases, if $1 - r + sif^2 \frac{a}{p}$ is greater or less than unity, that is, if $sif^2 \frac{a}{p}$ is greater or less than r. If s, i, f, r have the values already suggested,

$$m_x p = \left(\cdot 7937 + \frac{a}{192p}\right)^x mp = \left(\frac{152p + a}{192p}\right)^x mp$$

so that the malaria rate increases or decreases indefinitely if a is greater or less than about $40p$. The function is what is called an *exponential function*, and changes slowly at first, and rapidly later. Thus, suppose that $mp = 2$ (so that the epidemic starts with only two cases) ; that $p = 1{,}000$ and $a = 136{,}000$. Then

$$m_x = (\tfrac{3}{2})^x \cdot 2.$$

From this we find that the number of infected persons will be about 2, 3, 4, 7, 10, 15 in successive months, rising to 115 after ten months, and 665 after twenty months. This explains the outbreak of epidemics

* I hope to publish the full analysis later. Obviously, deaths and other factors have been omitted from consideration in the above rough estimates.

consequent on the introduction of cases from without, in places where there are enough Anophelines.

The same equation holds approximately, even when m is high if a is comparatively small—that is, if the mosquitoes are reduced ; but in this case the malarial rate will fall. Suppose that $m = \frac{1}{2}$ and $p = 1{,}000$, so that there are 500 infected persons to start with ; and let $a = 8{,}000$. Then $\frac{152p + a}{192\,p} = \frac{5}{6}$. Hence the number of infected persons in successive months will be 500, 417, 347, 289, 241 ; falling to 64 in ten months, and 8 in twenty.

In this case the malaria decreased even when there were as many as eight Anophelines to each person. If all the Anophelines are destroyed, $m_x p = (i - r)\ mp = (\cdot 7937)^x mp$ that is, the cases d minish according to the adopted rate of recovery (section 3) without any new infections occurring. If $p = 1{,}000$ and $mp = 500$ as before, the number of infected persons in successive months will be 400, 396, 314, 250, 198, 157, 125 ; falling to 50 in ten months ; 5 in twenty ; and 4 in two years. This fall is not much greater than that shown in the preceding paragraph ; so that the reduction of Anophelines from 6,000 to zero does not make very much difference. In other words, in order to produce a marked diminution in the malaria rate, it is not necessary to get rid of every Anopheline —a reduction will suffice.*

The important question now arises, What reduction must be made in the number of Anophelines in order that the malaria rate shall fall to an assigned fraction in a given time ? Suppose that in the village of 1,000 inhabitants the malaria rate has been standing at about $\frac{1}{2}$, so that on the average 500 people in it have been infected. Then $\frac{a}{p} = \frac{40}{1-\frac{1}{2}} = 80$; so that there must have been about 80 Anophelines to each person in the village. Now, suppose that we do not possess sufficient funds to make a complete clearance of the mosquitoes, but would like to reduce the malaria rate to one-tenth of the population in one year, what reduction must we make in the number of Anophelines to effect this object ?

From the approximate general equation, when a is small, we have

$$\frac{a}{p} = 192\sqrt[x]{\frac{m_x}{m}} - 152.$$

* Compare page 148.

Here $x = 12$; $\frac{m_x}{m} = \frac{1}{5}$; $192\sqrt[12]{\tfrac{1}{5}}$ = about 168 ; and therefore $\frac{a}{p} = 16$. Hence we must reduce the Anophelines to one-fifth if we wish to reduce the malaria rate in the same proportion, that is, from a half to one tenth, in a year. If we are given two years for the reduction, the Anopheline ratio need not be less than 27, or one-third of the 80, which might be cheaper to effect.

The following table gives the fall in the number of infected persons, which, according to the formula, should occur if a is reduced to $2p$, to p, to $\frac{1}{2}p$, and to zero :—

a	Months	0	1	2	3	4	10	20
$= 2p$	Cases	500	407·2	331·7	270·1	220·0	64·2	8·2
$= p$	,,	500	402·0	323·2	259·9	209·0	56·5	6·3
$= \frac{1}{2}p$	,,	500	399·4	319·1	254·9	203·9	52·9	5·6
$= 0$	,,	500	396·8	314·9	250·0	198·4	49·6	4·9

Of course, the greatest fall in the cases occurs when there are no Anophelines ; but even when there are two Anophelines to each person, the fall is not very much less.

13. **THE NUMBER, LENGTH OF LIFE, AND DIFFUSION OF ANOPHELINES IN A LOCALITY.**—The important ratio $\frac{a}{p}$ denotes the average number of Anophelines to each person in a locality ; and we have seen that, if it falls below the critical figure of about $\frac{40}{1-m}$, the malaria rate will diminish. The number may seem somewhat high ; but we must remember the values we gave to the constants f and s. We judged that only one-quarter of the Anophelines are likely to succeed in biting human beings ; that only one-third of these are likely to survive for a week or more ; and that only one-quarter of the remainder are likely to succeed in biting a second person. Hence only one in forty-eight is ever likely to give infection. What really is the average number of adult Anophelines in a locality ? It is impossible to say. Sometimes in a single room twenty or more of certain species may be captured ; at other times they are difficult to find. At Clairfond, in Mauritius, our moustiquiers were searching for some weeks before they caught a single *P. costalis*, which is the carrier there. As a rule, in the houses of Indians about one Anopheline for each occupant may be a rough

average for the insects actually caught. But the insects caught are probably mostly the gorged and gravid ones, which have recently had a good meal, the majority escaping out of doors in the morning. On the whole, it is quite possible that close to marshes there may be a hundred or more Anophelines to each person. My experiment to estimate the output of *Myzorhynchus mauritianus* from the Clairfond marsh (addendum 2) showed that 1,000 square yards of marsh might yield 423 every night, or 12,690 a month during the season.

As to the *length of life* of mosquitoes. It used to be thought that they live only for a few days, until I kept them alive by repeated feedings for a month or more in 1899. Since then *Stegomyiæ* have been kept in captivity for several months. Anophelines are more difficult to manage, but will live for some weeks. Such experiments, however, give little evidence as to the question, What is the average length of life of the insects in nature? In captivity they are preserved from enemies, wind and weather; but, on the other hand, probably suffer from their imprisonment. The only criterion which I can suggest is a somewhat curious one, based on the length of life of their parasites. Thus the parasites of malaria and yellow fever and the worms called *Filaria bancrofti* take from one to three weeks to develop in the insects. Hence I infer that the average life of the hosts probably exceeds that period, as otherwise the parasites would have little chance of completing their life cycle. Of course, large numbers of gnats hibernate and æstivate for months, but this suggests only their maximum life. What we want to know is their average life. I fancy that a month may be a good rough estimate during the most favourable season.

The diffusion of mosquitoes is a question of the first importance in the prevention of mosquito-borne diseases. When I first proposed in 1899 to rid towns of malaria by clearing them of the breeding places of mosquitoes, many people objected at once that the clearance would be futile, as the insects would certainly rush in on all sides from the surrounding uncleared country; and for three years no one could be persuaded to try the measure. In fact, an experiment was attempted later in India which showed that, if anything, the clearance increased their numbers! In 1903, however, the brilliant examples of Ismailia and the Federated Malay States served to discredit such fancies. In 1904 I read a paper (3) in which the whole subject was examined from a mathematical or rather logical basis, and the following points were made clear.

The diffusion of mosquitoes depends on laws which regulate the diffusion of all animals.

The animals within a given area consist partly of natives and partly of immigrants ; and the larger the area the smaller will be the proportion of immigrants to natives. If the population (that is, the number of animals) is in a static condition in a country, the number of immigrants and emigrants which cross a given length of border will tend to be equal and opposite—that is, the number of immigrants into an area will be compensated for by the number of emigrants out of it.

If we suppress the birth-rate within the area, the population must henceforth, after the death of all the natives, consist merely of immigrants. If the area is large, and if such suppression does not specially attract the immigrants, the result must be that the population will be greatly reduced.

Obviously, if we were to suppress the human birth-rate in Mauritius without increasing the rate of immigration into it, or checking the emigration out of it, the human population would be vastly reduced in time. A precisely similar thing must happen with the mosquito population. The immigrants constitute only a small fraction of the natives, and when the latter cease to exist, the population must fall (see also 4).

The rate of the fall according to radius of area was a difficult mathematical question, for which I attempted only a partial answer ; but I asked Professor Karl Pearson, F.R.S., to solve it. This he has done in a thorough and admirable way (5). For example, he shows that, if we suppress mosquito propagation within a circular area one mile in diameter, the mosquito density will be reduced at the centre to only 3 % of the normal mosquito density outside the area. A quarter of a mile from the centre it will be 18 %, and at the boundary of the area it will be 75 % of the normal density. If we clear a rectangular patch of country, two miles long and one mile broad, the mosquito density at the centre will fall to 1 %. If we clear a square of one mile wide, the density at the centre will be 2 % ; at a quarter of a mile from the boundary it will be 11 %; and at the boundary it will be 50 %, or one-half. Of course these mosquitoes found in the area after propagation has been checked within it consist entirely of immigrants.

Take, for example, the case of a village of 1,000 people collected within a circle of a ¼-mile radius in which the number of infected persons has been standing at 500. In this case, by last section, there must have been about 80 Anophelines to each person. Now, let us drain within a circle of half-a-mile radius round the centre of the village. Then the mosquito density at the centre will be 3 %, and at the outskirts of the village 18 %, or 14·4 to each person at most. Hence, by last section, the number of infected persons will fall as follows:—

Months	0	1	2	3	4	10	20
	500	472	445	420	396	279	156

But, of course, the *average* number of mosquitoes in the village would be less than 18 to each person, and the fall in the malaria would be greater.

Professor Pearson's estimates, like mine, are based on values of constants conjectured by myself on a basis of general probability, not determined by investigation. I have had no opportunity to make such investigation; and no one else has attempted it—the enquiry would be difficult, and would demand mathematical as well as experimental skill. In the meantime, however, there is this excuse for adopting tentative values—that the process enables us to form a clear mental picture of the factors concerned in malaria rate, and, perhaps, to investigate them in the future.

Lastly, we should note that what are called constants above may be constant only for definite or even short periods. Thus the number of Anophelines varies from season to season, and may increase or diminish in the same locality owing to the formation or disappearance of breeding pools. If it were not so, the malaria rate would tend either to vanish or to reach the maximum; but generally it increases and decreases at different times, according to fluctuations in the value of this constant.

PART II.—MALARIA IN MAURITIUS.

14. **SHORT DESCRIPTION OF MAURITIUS.**—The island of Mauritius is situated in the Indian Ocean, about 550 miles east of Madagascar, and lies between the parallels 19° 50′ and 20° 31′ south latitude and 57° 17′ and 57° 46′ east longitude, thus being just within the Tropics. It is 36 miles long and 28 miles broad, has an area of 705 square miles, and a coast line of about 154 miles. It consists of a table-land, of which the highest ridge, 2,300 feet above the sea, runs across the island in a N.E. direction. On either side of this ridge there are extensive plains, sloping down gently, or more abruptly in places, to the sea. Several small mountain ranges, of which the highest peak is 2,711 feet high, border the table-land. Near the sea, especially to the north and west, the plains have little elevation. Numerous small rivers cross the plateau from the medial watershed to the sea, cutting out deeper and deeper channels as they go. The mountains and parts of the plains are well wooded, but most of the surface of the island is under sugar cane cultivation. The geological formation is volcanic.

The climate is that of tropical islands, warm, equable, and humid. The cooler season lasts from May to October, the warmer from November to April. The mean annual temperature at the Observatory (near sea-level) is put at 74–75° F., the mean lowest being about 58–59° F., and the mean highest about 87–88° F. The prevailing wind is the S.E. trade wind; and severe cyclones occur in the warm season. Rain falls at all seasons, but there are two rainfall maxima, one in February and one in August, and two minima, one in June and one in September. The mean annual amount and number of days of rain vary with elevation and other factors from about 33 inches and 86 days to about 150 inches and nearly 300 days—the rainiest spots being at elevated points exposed to the S.E. wind. Heavy falls occur with the cyclones.

Mauritius was discovered by the Portuguese in 1507, and occupied in 1589 by the Dutch, who, however, abandoned it in 1712. Three years later the French took possession of it, and in 1810 it was occupied by the British. In 1834 the slaves were set free; in 1835 the importation of Indian immigrant labour commenced, and in 1865–66 malaria first appeared in the island.

At the census of 1901 the population was found to be 373,336, and was divided officially into General Population (111,440), Indian Population (259,086), and Military and Shipping (2,810). The "general population" included whites, Africans, and half-castes. At present the population is estimated at 375,400 (1906).

The capital, Port Louis, is also the principal seaport, and with the small surrounding district had a population of 50,342 in 1906. Recently the population has been drifting more and more to the cooler and healthier district of Plaines Wilhems, on the table-land, which, in 1906, showed a population of 66,157, gathered mostly in a chain of towns and villages along the railway. Chief of these towns are Beau Bassin (750 feet), Quatre Bornes (1,050 feet), Phœnix and Vacoas (1,400 feet), and Curepipe (1,800 feet). Other villages are Pamplemousses, Poudre d'Or, Flacq, Mahebourg, Souillac, Rose Belle, and Moka, most of which also are tending to lose many of their inhabitants for the same cause. The island has a network of railways, by which it can be traversed in about two hours.

Scattered over the country there are about a hundred sugar plantations and factories, each with a considerable population of Indian coolies; and villages and huts of Indians abound almost everywhere, mostly hidden among trees. As might be expected in so old and civilised a colony, it possesses many good buildings, not only in the towns, but on the sugar estates and in the villages. Many of the private houses, especially in Port Louis, are two-storeyed; but the majority are built on the model of the Indian bungalow, with a single floor and verandas, and servants' quarters behind, lying within a garden or "compound." The lower class of house is not so good, and is largely made of wood (though not raised on piles); and the lowest class is the mud hut of the Indian, or even a structure composed of old pieces of kerosene oil tins, the danger from cyclones being the reason given for such poor buildings. Churches, schools, and other public institutions are numerous.*

Plaines Wilhems district has an extremely good water supply from the Mare-aux-Vacoas, and other pipe supplies are given to Port Louis and several villages; but wells and streams are largely resorted to. Food is good and cheap. Horse and mule transit

* Views of the plateau, of the houses, &c., will be found in the Photographs at the end of this Report.

is expensive owing to loss of animals on account of trypanosomiasis (surra). Night soil and rubbish conservancy is placed by the Health Department in the hands of contractors, and, in my opinion, is fairly well carried out. Labour is fairly cheap, though not so cheap as in India, as unskilled labour costs about Rs.15 a month.

In 1906 the birth rate was 33·5 per mille, and the death rate 40 per mille. The Revenue and Receipts for 1905-6 amounted to Rs.11,169,783, and the expenditure to Rs.9,915,863, of which Rs.749,827 was spent on the Medical and Health Department and on quarantine. £50,000

At the census of 1901 there were 93,031 "houses" in the Colony, each containing 4·25 persons on the average.

In the same year the average density of population was 534 persons to a square mile, almost equal to that of England.

15. THE OUTBREAK OF MALARIA IN MAURITIUS.—When Bernardin Saint-Pierre wrote his classical tale, *Paul and Virginia* (published in 1789), the scene of which is laid in Mauritius, there could have been no endemic malaria in the island. The author, who had lived there, pictured it as a country of pastoral romance, benign and healthy as it was beautiful. The hero and heroine, born in the island of white parents, and supposed to live in the Vallée des Prêtres, very little above sea-level, were represented as vigorous ideal types of the European race. Yet the author evidently knew of the existence of malaria elsewhere, for he describes the death of the heroine's father from fever contracted in Madagascar, and says "he landed (in Madagascar) at that unhealthy season which commences about the middle of October, ... which prevails in that country for six months in the year, and which will for ever baffle the attempts of the European nations to colonise that fatal soil"—quite evidently malaria. No mention is made of a similar disease, or of similar results, in Mauritius, although an excellent description is given of the hot weather in December, including a reference to the "noise of insects which seek to allay their thirst in the blood of men and of animals."

Yet we read that, when the Dutch first attempted to settle in Mauritius, they brought over numerous slaves from Madagascar, who afterwards peopled the island. Unless Madagascar was newly infected between that time and the date of Saint-Pierre's novel, many of these slaves must probably have had fever; and this fever should have spread in Mauritius if the conditions had been favourable.

The introduction of slaves from Africa continued during the French occupation, and early last century many Indians began to find their way to the island. In 1835 the wholesale importation of indentured Indian coolies (with women and children) commenced. Infected regiments from India and elsewhere have frequently been introduced. Hence cases of malarial infection must have been brought in, not only by scores, but probably by hundreds and thousands, from the beginning of the history of Mauritius.

Yet there is abundant evidence, apart from that in *Paul and Virginia*, to prove that no endemic malaria existed there before 1865—that is to say that, though cases were introduced from without, the disease did not spread in the island before that date. Then, however, the great tragedy occurred, and in two years the island of pastoral romance fell to the condition of West Africa or the Himalayan Terai.

It is not necessary for the purposes of this report to compile a laboured account of the outbreak, and I will therefore give only the outlines. The literature of the subject is large. Shortly after the commencement of the epidemic the government very wisely appointed a commission of enquiry, which published a bulky report in 1868 (6). Since then numerous publications on the subject have appeared. An admirable summary has been published by so great an authority as Dr. Andrew Davidson, who was in Mauritius at the time (7); and I have read a valuable critique in manuscript on the subject by Dr. A. Lesur. After studying probably most of this material, I conclude that endemic malaria on a large scale certainly appeared in Mauritius for the first time in 1866. The evidence in favour of this opinion may be summarised as follows.

(1) Almost all medical writers on Mauritius prior to 1866 state definitely that there was no endemic malaria there. Some note expressly that, when cases occurred, they were imported cases. Others remark with surprise on the absence of the disease, in view of the fact that all the conditions which favour its prevalence in other countries were present. Such testimony is really conclusive in itself. We may object that, after all, the writers may have made mistakes of diagnosis,

and that malarial fever might really have existed, but was returned under other names. But the total amount of fever of any kind was small, and medical men of wide experience in the tropics must be credited with sufficient acumen to detect malarial fever, even before the discovery of the parasites. If the disease had existed even to a fraction of its present prevalence, the fact would certainly have been noted, not only by physicians, but by the general public as well. As a matter of fact, it was " conspicuous by its absence "—so much so that Mauritius was considered a sanatorium for sick officers from India and elsewhere.

(2) The medical statistics of the troops in Mauritius demonstrate the same fact quite clearly. I give the figures for malarial fevers (collected by Major Fowler).

Years	1838–54	1855	1856	1857	1858	1859	1860	1861
Admissions per 1,000 ...	0·6	0·56	5·02	4·08	22·39	31·89	21·13	3·04
Deaths per 1,000 ...	0·0	0·0	0·0	0·0	0·0	0·0	1·7	0·0

Years...	1862	1863	1864	1865	1866	1867	1868
Admissions per 1,000	21·6	2·52	1·65	2·06	21·32	1487·06	1243·26
Deaths per 1,000	1·45	0·50	0·55	0·0	0·56	16·61	10·0

Years...	1877–86	1887–96	1897	1898	1899	1900	1901
Admissions per 1,000	1171·0	608·2	406·1	380·0	245·0	207	389
Deaths per 1,000	5·4	3·12	1·32	0·0	0·0	2·0	4·6
Strength	...	...	...	...	...	463	429

Years	1902	1903	1904	1905	1906	1907
Admissions per 1,000	369	150	201	524	137·4	231·6
Deaths per 1,000	0·0	0·0	0·7	3·7	0·84	1·96
Strength	425	746	1,358	1,357	1,193	1,019

The small rises in 1858 and 1862 were due to relapses among troops newly arrived from India and China. The enormous rise in 1867 was due to the appearance of endemic malaria. The comparatively high figure for 1905 was probably due to mobilisation of the troops during the malaria season. The death rate tends to fall more and more owing to improved treatment and to early invaliding. Dr. Davidson remarks:—" From 1823 to 1858, out of a strength varying, as a rule, from 1145 to 2321, there were 51 admissions into the military hospital for intermittent fever, which gives an average of less than two cases per annum. During these thirty-five years only one death occurred from intermittent fever. During the same period there were only ten cases of remittent fever, with no deaths. It is doubtful whether during this period a single soldier was admitted for paroxysmal fever contracted on the island."

The admissions into the Civil Hospital at Port Louis told the same story, there having been only twelve for malaria during forty-five years.

(3) Perhaps the most conclusive statistical evidence was that adduced by Dr. C. Meldrum, F.R.S., C.M.G., in 1880-90 in quarterly reports on the relations of climate to disease in Mauritius (8). His argument is this. Previous to 1867 the deaths in the colony were fairly evenly distributed from month to month, without any special rise at any particular season, except, of course, when various epidemics occurred. Since then, however, the whole character of the mortality returns has changed owing to a marked rise in the number of deaths during the summer—that is, the malaria season. This rise is precisely what occurs in all very malarious regions ; so that the absence of it before 1867 shows that there could have been little malaria then in the island (see also section 18, 4).

Although that disease did not exist, there were other fevers which prevailed, and which have somewhat confused the issue. Chief of these was a fever locally known as *Bombay fever*. It was much studied by the commission of enquiry, and by many medical men later, especially Drs. Barraut and Lesur. It attacked chiefly the Indian population ; was most prevalent during the cool months ; was epidemic, " contagious," fatal, and prone to relapses ; did not become chronic, and was not influenced by quinine ; was accompanied by enlargement of the liver and jaundice ; and was not particularly prevalent in marshy areas. Dr. Lesur thinks it was merely relapsing or spirochæte fever ; and Davidson suggests this, and also considers that many of the cases were due to typhoid. In these views I entirely concur. Curiously enough, directly the epidemic of malaria commenced, the Bombay fever disappeared ; and Dr. Lorans has asked me to suggest an explanation. It may be that the disease really did disappear at that moment owing to accidental coincidence (and relapsing fever always comes and goes) ; but there is another explanation, namely, that, when the great epidemic commenced, the two fevers were confused, and the minor one was lost among the numbers of cases of malaria, under cover of which, so to speak, it gradually died out. In those days, of course, microscopical diagnosis between the two diseases was not known.

But it should be remarked that from 1862 to 1865 another fever seems to have appeared, which the Commission called the "spurious Bombay fever." This occurred entirely among Indians, but was not contagious. At the same time Dr. Beaugeard, Medical Officer of the Civil Hospital at Port Louis, stated that "Cases of ague have been admitted occurring in persons who had long been resident in the Colony, and in others who had never left the island at all—those latter, however few, still existed prior to 1865." Some of the medical witnesses before the commission also stated that they had seen a few indigenous cases as far back as (?) 1857. We must therefore admit the possibility, if not the probability, that scattered indigenous cases had been occurring in Mauritius prior to 1865.

Dr. Davidson thus describes the onset of the great epidemic:— "Sporadic cases of malarial fever contracted in the island were observed from the beginning of 1865 and throughout the year. They were few in number, and seem to have been chiefly confined to the marshy localities near the mouth of Grand River, or to the unhealthy spots near the shore in Port Louis. A slight local epidemic occurred towards the end of the year 1865 among the Indian labourers on Wolmar Estate, a specially marshy locality on the sea-coast in Black River district. A considerable number of cases were also observed in November on Albion Estate, and near the church at Petite Rivière, at the latter place from the 15th to the 25th November."

These cases attracted little attention at the time, but next year the epidemic broke out with severity. On Albion Estate there were 207 cases and 31 deaths, and on Gros Cailloux Estate 517 cases and 41 deaths, during 1866. From these it spread north and south. It crept up to Port Louis, Arsenal, Pamplemousses, and elsewhere during the first half of 1866. Southward it spread to Bambou and further. At the first invasion it occupied, according to Davidson, 13½ miles of sea coast, and spread from two to four miles inland. After June it began to abate during the cool season; but at the commencement of the next warm season (1866 to 1867) it broke out with increased violence. Not only were the same districts affected worse than before, but the disease "invaded the whole of the west coast from south to north, passed round the northern extremity of the island, and extended down the east coast as far as Grand River S.E." At these extremities it was arrested by mountain ranges. During 1867 the epidemic raged in the occupied territory, extending along sixty miles of coastline. Accounts of eye-witnesses of the fever at Port Louis recall descriptions of plague and cholera. One quarter of the inhabitants died during 1867 from all causes, and more than one-fifth from fever alone. The survivors "were so prostrated by disease that the living were scarcely able to bury the dead." The highest mortality in Port Louis in one day was 234, on the 27th April 1867, and 6,224 during the whole month, out of a population of 87,000. In the whole island, out of a population of 360,378, there were 31,920 deaths in 1867 ascribed to fever alone; and the total death rate rose from 32 per mille in 1866 to 120·5 in 1867. The actual malaria death rate was probably about 90 per mille. Those who have witnessed malaria in its worst will not doubt these figures.*

The third wave, starting in November 1867, completed the conquest of the island by occupying the south and south-east coast. Of course, it reappeared after the winter lull in the areas previously attacked; but in 1868 the death rate was only 10,923 for the whole island, about a third of that of the previous year. Though it spread inland, especially in the Flacq district, it failed then, as now, to reach some of the highest areas of the table-land. At its worst, the fever was, as usual, of the remittent type. Many of the cases were certainly blackwater fever, a point which (as I have not seen noted before) strongly supports the theory that that disease is purely malarial, since it does not seem to have existed previously in the island. The usual pernicious paroxysms were common. I cannot find any statistics regarding the percentage of the deaths which occurred among children. For further details, Davidson's book is the most accessible (7).

It is most necessary to note that a similar first appearance of malaria occurred in the sister island of Réunion, 125 miles distant, shortly after the outbreak in Mauritius. Davidson gives the date as

* Fever Enquiry Commission's Report, page 23.

1869, but others adopt an earlier one. MacAuliffe, in his book "Cilaos" (1902), says that it commenced in 1865, owing to the arrival of the ship *Eastern Empire* with immigrants from Calcutta in December 1864. He saw the immigrants two months later, and thought they had recurrent typhus (? relapsing fever); but later the epidemic took the malarial type, and prevailed chiefly round marshes. He warned the inhabitants of Cilaos (1214 metres high) against the marshes near the town; but nothing was done, and malaria entered the locality in 1901–2, in spite of its altitude. Possibly the sickness of 1865 was nothing but relapsing fever, and true malaria did not enter until later. At all events, malaria appeared in both these islands almost simultaneously, while it still remains absent from Rodrigues and the neighbouring islands, and from Seychelles, in none of which Anophelines have been found. The Anophelines of Réunion hitherto recorded are *Pyretophorus costalis* (the deadly African and Mauritian one) and *Myzorhynchus coustani*; and malaria is extremely prevalent in the island at the present.

16. **EXPLANATION OF OUTBREAKS OF MALARIA.**—This astonishing occurrence caused much perplexity at the time among the more thoughtful students of malaria. It showed that the disease is at all events not due to any inherent poisonous property of soil, but rather that it might be caused by some living organism capable of invading a country from without. Numerous hypotheses were proposed. Indian immigration was accused of introducing the poison, though a similar introduction by natives of Madagascar, as well as by Indians, had been possible for centuries. Certain ships which arrived in 1865 were suspected—but ships had been arriving for centuries. Floods and droughts were blamed—but floods and droughts had occurred for centuries. Disturbance of the soil in connection with the railway and other works in the Black River district afforded a popular refuge from the difficulty—but it was pointed out that the soil had often been disturbed; that the largest railway work, done in 1864, was not followed by malaria, and that laying the gas supply in Port Louis in 1864–5 remained equally harmless.

The mosquito theorem gives a ready solution of the problem. The appearance of malaria in a locality depends upon the introduction (*a*) of Anophelines capable of carrying the disease, and (*b*) of infected persons (section 12). Hence the Mauritian outbreak can be readily explained in either or both of two ways.

The carrier of malaria in Mauritius is at present *Pyretophorus costalis*, the dangerous African Anopheline, and it might have been introduced a little time before the outbreak. Mosquitoes do not easily travel far on board ships. They find difficulty, I imagine, in obtaining water to drink and lay their eggs in, and are apt to be swept away by the wind when seeking it; while the movement and vibration prevent them from resting or feeding in comfort (as I have actually observed on several occasions). Sometimes, however, they endure these difficulties with success. On several ships, especially river steamers, I have found Culicines breeding in water cans in the cabins, and once in flower vases on an ocean steamer. Possibly Anophelines may be equally successful, but only, I think, on rare occasions, when there are open tubs on deck, or heaps of rain-collecting fruits or vegetables, and so on. For short voyages Anophelines might certainly live in the hold. But for proof that *P. costalis* is not easily transported in this way I may note only that it is not found in the Seychelles, Rodrigues, or the neighbouring smaller islands, and that (fortunately) it has not yet reached India. In other words, if it can be transported at all on board ship, it can be transported only in a very small percentage of ships. Hence it is quite reasonable to suppose that the ships which visited Mauritius from the date of its discovery until about 1865 did not carry *P. costalis*, but that, at last, about that time, a single ship was unfortunate enough to bring them. Quite possibly the insects were breeding on that ship, and equally possibly the same vessel conveyed them to Réunion about the same time.

We must remember also that it is necessary for the insects, not only to survive the voyage, but to obtain a foothold in their new possession—a serious difficulty, which must tend to limit their diffusion still further. But, supposing that, on a single occasion, all these difficulties were overcome, the further course of events would be obvious; the new country would be overrun by the invaders in the course of a year or two. Next, if there are infected persons present, and the mosquitoes become numerous enough (section 11), healthy persons would be attacked, and an epidemic would begin.

All this is very obvious; but there is another possible explanation of the appearance of endemic malaria in a country—which has not yet been suggested. Suppose that the Anophelines have been present from the first, but that the number of infected immigrants has been few. Then, possibly, some of these people have happened to take up their abode in places where the mosquitoes are rare; others may have recovered quickly; others may not have chanced to possess parasites in suitable stages when they have been bitten. Thus the probability of their spreading the infection would be very small. Or, supposing even that some few new infections have been caused, yet, by our rough calculations in section 12, unless the mosquitoes are sufficiently numerous in the locality, the little epidemic may die out after a while—for instance, during the cool season. And, if the number of infected persons introduced from outside remains small, this state of things may continue for years or centuries—the disease will fail to make headway and will die out. Now, suppose that the number of infected immigrants is suddenly greatly increased. Then much larger numbers of mosquitoes will become infected, and may in their turn infect more healthy people than the recovery rate will compensate for. Endemic cases will begin, will increase; at first slowly, then rapidly, until suddenly there will be a wide-spread epidemic. It is like the case of a careless person who throws lighted matches into a dry jungle; the first matches may fall on rock, bare ground, or damp vegetation, but at last one will set the forest on fire.

On the whole I incline to the opinion that the first explanation is the more plausible one in the particular case of the great outbreak in Mauritius and Réunion—I think that *P. costalis* was probably introduced a little previously. It is difficult to believe that, if this gnat had been present from the first, and had been as widely diffused as now, the disease would never have spread from the hundreds of infected Africans and Indians who must have entered the Colony during nearly three centuries. No very specially large immigration occurred before the outbreak. True, there were 20,283 immigrants in 1865; but as many or more had been introduced in 1843, 1854, 1858, and 1859—in the last year 48,377—without causing any epidemic. The occurrence of a few sporadic endemic cases (the "false Bombay fever" cases) would fit either theory; and so would the fact that the epidemic spread from a centre at Petite Rivière. Either, by the first theory, the *P. costalis* landed there, and spread rapidly round the coast; or else, by the second theory, the first effective concentration of imported malaria cases occurred there. On the other hand, the facts that the disease occuried almost simultaneously in Mauritius and Réunion, and that *P. costalis* has not yet reached the smaller neighbouring islands, are strongly in favour of the first theory. Other local outbreaks, however, such as the recent one at Phœnix, I am more inclined to attribute to the second cause, or to both together.

The whole subject of the invasion of countries by malaria is of great historical interest. There are many reasons for thinking that Greece and Rome were attacked in ancient times as Mauritius was in modern days. The matter has been ably discussed by Mr. W. H. S. Jones, M.A. (11).

17. **FURTHER HISTORY OF MALARIA IN MAURITIUS.**—From the date of its introduction, the disease has become permanently endemic in the lower parts of the island.

Before attempting to examine details, it will be advisable to mention the various enquiries on the subject which were made from that time up to the present date. In May, 1867, the Government appointed, as already stated, a *Fever Enquiry Commission* to report upon the causes of the outbreak; and their report was published next year (6). It is a bulky volume, containing a vast mass of evidence, mostly in the form of a *questionaire* in which numerous medical men and others record their observations and opinions on the epidemic. A full description is given by Dr. Barraut, the General Sanitary Inspector; and the Commission adds its own conclusions and recommendations. Among the latter, I note, especially, *re-afforestation*, *cleansing of rivers*, "so that their waters may run clear, and no longer stagnate in pools," and *drainage* or *filling of marshes*. The whole book is a very interesting one.

In 1881 Dr. C. Meldrum, Director of the Observatory at Pamplemousses, issued a large report (8) on *The Relations of Weather to Mortality and on the Climatic Effects of Forests*—which is only the abstract of the full title of the work! It is an able production, packed with suggestive remarks and figures well analysed. The author shows that before 1867 the mortality in the island did not possess the summer increase which it has exhibited ever since ; concludes that this increase is due to malaria, which in its turn is encouraged by certain conditions of rainfall and temperature, and goes on to suggest a theory regarding cyclical variations of death rates all over the world. He recommends drainage of marshes, re-wooding of mountains and slopes, draining of streams in the interior so as to create reservoirs, and strict sanitary rules. The report was apparently written by request of a sanitary commission which was appointed in 1879 "to enquire whether the General Board of Health had been successful in its attempts to check and abate the prevalent fever," and also whether the sanitary works performed by this body had given results commensurate with the outlay.

This commission seems to have concluded that, though the expenditure of the Board of Health had amounted to Rs.1,596,488 during nine years (about £15,000 a year at that time), yet that the mortality of Port Louis and the rural districts had been on the increase since 1870. In 1888 Dr. Meldrum wrote another report dealing with the subject (9). In this he states (page 20) that "the total death rate of the Colony has increased from an average of 28·03 for the five years 1871–75 to an average of 32·88 for the five years 1881–85, and the fever death rate from an average of 12·55 to an average of 18·50." He considers that the increase is due to malaria, and is not due to poverty, increase of population, or decrease of sanitary works ; that the increased expenditure of the Board of Health (now amounting to nearly five million rupees during sixteen years) has not been accompanied by any improvement in public health ; and that a similar increase in the expenditure of the Poor Law Commission from Rs.279,000 in 1879 to Rs.367,546 in 1886 is partly due to malaria.

Later he wrote a third report of a similar nature (10), bringing the figures up to date.

In 1891–92 Mr. O. Chadwick, C.E., C.M.G., wrote a series of reports on engineering matters, including sanitary works, which have been collected in one volume (12). He emphasises many of Dr. Meldrum's remarks and recommendations ; but he objects to too many trees in towns, such as Port Louis, because, as he remarks, "though afforestation is in every respect desirable, a town is not the place for it." He recommends underground sewers for Port

Louis. He does not easily credit the hypothesis that malaria is due to turning the soil, and insists on surface and subsoil drainage against that disease. Like Dr. Meldrum, he suggests that reservoirs for irrigation could be easily constructed in the course of the streams. He gives other advice, with most of which I entirely concur, and urges reorganisation of the public health administration.

Dr. Davidson's book *Geographical Pathology* (7), published in 1892, gives an excellent account of the malaria in Mauritius up to that date. He admits the connection between the annual increase of malaria and of rainfall, but shows that the former does not really depend on the actual amount of the latter—that heavy rain is not always followed by heavy malaria.

In Ordinance No. 32 of 1894–95 the Government amended the constitution of the General Board of Health, created a Medical and Health Department, and amended and consolidated the laws relating to the public health. The Director of the Department was made president of the board, which now became purely consultative. Two sanitary wardens, possessing public health diplomas, were to be appointed, and numerous other changes were ordered. This organisation was certainly a great improvement, and much in advance of the same department under many other governments.

It is remarkable, as evidence of the slowness with which new discoveries affect mankind, that Laveran's discovery of the parasites of malaria, made so long previously as 1880, had scarcely yet been put to scientific or practical use in the tropics, including Mauritius, and is hardly mentioned in most medical works, including Davidson's book and Meldrum's reports. When, however, in 1897–99 the mode of infection by means of Anophelines was established, Mauritius almost led the way in recognising the fact. As early as May 1900 M. Daruty de Grandpré, Superintendent of the Museum, and M. d'Emmerez de Charmoy, Assistant Superintendent, report (13) that they have been following the work since 1899; that they have found in Mauritius five species of Culicines and three of Anophelines; and that one of these, *P. costalis*, "has the same area of dispersion as the malaria in Mauritius." The second year they published a most excellent paper on mosquitoes and their rôle in the propagation of malaria and filariasis (14). The anatomy and life history of the insects were investigated in detail, and recommendations for prevention made. I believe that Drs. Alfred and Aimé Lesur had been among the first in Mauritius to study the parasites themselves.

With great promptitude, Government appointed a second Malaria Enquiry Committee (1901). All this time the disease had been ravaging the coast and lower parts of the island, apparently unchecked by the expensive measures which had been taken—now waning, now waxing, now almost disappearing, now flaring up in epidemics. The wealthier residents had been practically driven out of these regions; the beautiful houses of the planters could be occupied only during two or three months of the cool season; their families could no longer enjoy rural life at the seaside, as they were able formerly to do. Everywhere the villages became more and more deserted. Even the patient Indians sought the upper regions. From 5 per cent. to 30 per cent. of the labour in the malarious plantations was often incapacitated by fever, thus hampering further the resources of the planters, already greatly reduced by the fall in the price of sugar. Houses fell into ruins, or were removed part by part to healthier areas. The population of the capital, Port Louis, which had always suffered most of all, began to fall. The richer citizens now used it only as a place of business by day, returning to the plateau every evening, as the citizens of London retire to the suburbs. Even the houses were removed; and everywhere one sees the ruined basements, overgrown gardens, deserted fountains, and mouldy gateways of the more prosperous past, now surrounded only by the poorest huts of Indians. It is the classical picture of a great endemic epidemic. Plague and cholera visit a country and vanish; but malaria and dysentery remain.

Still, however, there was a secure refuge—the central table-land. But suddenly a part of this was invaded by a sharp epidemic—much to the consternation of everyone. The disease broke out in the summer of 1900-01 in a district of Moka, 1,400 feet above sea-level. Dr. Clarenc, the medical officer, reported promptly and ably on the occurrence, and the second Enquiry Committee was appointed. It consisted of Dr. Lorans (chairman), Dr. Edwards, C.M.G., Dr. Rohan, Dr. Clarenc, Dr. Bolton, Dr. A. Lesur, and M. Daruty de Grandpré.

The suggestions of the committee were not only quite up to date, but were as good as could be made. Streams near Moka clogged with vegetation were cleaned out, and quinine was distributed; with the result that the epidemic ceased. Curepipe, Grandport, Savanne, and other localities were visited, and similar work was started in them. Later on M. d'Emmerez de Charmoy was appointed Technical Assistant to the Committee for the purpose of continuing the study of mosquitoes and their haunts, and for disseminating knowledge on the subject among the public. With the latter object in view, the committee concluded its report with a set of instructions. The only defect which can be found in the work of this committee was that it was not generalised, nor continued long enough.

Early in 1906 the public alarm was intensified by another outbreak on high ground, namely, at Phœnix (1,400 feet), close to Curepipe. This epidemic, which is fully described by Dr. de Chazal in this report (addendum 2), occurred in connection with the large Clairfond marsh, for the drainage of which Government allotted funds, which, with the assistance of the Imperial Government, sufficed for the purpose, the work being nearly completed when I left.

In addition to the literature referred to above, many other reports and papers on the subject have been published—notably articles in the *Bulletin de la Société Médicale de l'Ile Maurice*; a report on fever at the Beau Bassin Central Prisons, 1901 (15), and a correspondence on the high death rates on sugar estates, 1906 (16). There is also, of course, a large official correspondence connected with malaria, showing the concern with which the disease has been viewed; and, lastly, we have the excellent Annual Reports of the Medical and Health Department and the Annual Reports on the Estate Hospitals—all giving evidence of work done by the Health and Immigration Departments.

18. STATISTICS OF MALARIA IN MAURITIUS SINCE THE OUTBREAK.—The writings referred to above, together with the Annual Reports of the Registrar-General of Mauritius on Births, Deaths, and Marriages, give us an enormous mass of figures on the subject of malaria in the colony. After a careful consideration of them, I conclude that it will not be advisable to attempt an exhaustive analysis of them in this report. The figures have already been given in the publications mentioned, and have already been ably analysed by Dr. Meldrum and others. To repeat them at length would double the size of this report, without yielding information of corresponding value. I shall therefore discuss them now as briefly as possible, and will then proceed to examine by other methods the present state of malaria in the Colony—which, after all, is the important point.

(1). *The General Death Rates of certain Non-malarious Islands.*— It is advisable to commence by noting the death rates in the Seychelles and other islands, where neither Anophelines nor malaria exist. For the Seychelles, we have—

Years	1904.	1905.	1906.
Population	20,418	20,767	20,976
Death rates per 1,000	16·12	14·98	16·48

The average death rate for the seven years preceding 1904 was 17·07. Out of 359 deaths in 1906, 21 % occurred in infants under one year of age, 18 % in children under five years, 46 % in people under seventy years, and 15 % in people over seventy. In 1904 no fewer than five centenarians died, one having reached the age of 114 years. On two visits to the Seychelles, I was assured by his Excellency Governor Davidson, C.M.G., and by the chief Medical Officers that the deaths are rigorously registered and the vital statistics well kept.

The following table gives the deaths in a number of non-malarious islands under the Mauritius Government :—

Islands.	Population at Census 1901.	Deaths.					Average Death Rate per 1,000.
		1902.	1903.	1904.	1905.	1906.	
Rodrigues	3,437	72	69	64	29	98	19·3
Diego Garcia	526	14	18	12	18	9	27·0
Agalega	372	18	8	8	7	17	31·2
Peros Banhos	184	7	2	2	6	5	24·0
Coetivy	143	11	3	4	5	3	36·4
Salomon...	119	3	4	6	3	3	32·0
Six Islands	117	4	3	2	2	6	29·0
St. Brandon	87	2	7	1	8	6	55·3
St. Jean de Nové ...	75	1	2	0	1	2	16·0
Eagle Island	74	1	1	5	3	6	43·0
	5,134	133	117	104	82	155	31·3

The death rates are slightly too high, as they are computed on the population for 1902 only ; but still they show much higher figures than Seychelles. To what is this due? On studying recent reports by Drs. Bolton and Keisler, I find that there is a considerable degree of sickness on many of the islands, including beri-beri, infantile tetanus, dysentery and diarrhœa, ovarian and uterine diseases, &c., while there seem to be no fully qualified medical men on most of them. At Seychelles and at Rodrigues, however, where the death rates are low, medical advice is accessible. Of course, there is considerable statistical error for the lesser islands, owing to the smallness of their population, but I think that we may attribute their mortality largely to insufficient medical attendance.

(2). *The General Death Rate of Mauritius.*—Dr. Meldrum has carefully compared these statistics with those of Mauritius. The annual death rates of Rodrigues and Seychelles from 1872 to 1880 averaged 15·8 and 20·5 respectively. In Mauritius, from 1804 to 1824 inclusive, the average white population was 7,106, with a mean death rate of 18·89, and the average "free population" (exclusive of slaves) was 9,419, with a mean death rate of 12·53. Thus the total mean death rate was 15·26. For the five years from 1825 to 1830 the average population, exclusive of slaves, was 24,502, and the mean death rate was 21·44. All this time deaths among the slaves were not recorded. In 1829, however, there were 18,019 slaves, and these had an estimated death rate of 34·53—much higher than that of the whites and free coloured people. After 1831, according to Meldrum, the deaths among the slaves were registered, and they were emancipated in 1834. From this point, then, the registered death rates were higher.

The following table gives them from 1831 to 1906 per 1,000 of population :—

Years	1831	1832	1833	1834	1835	1836	1837	1838	1839	1840	Mean.
Death rates	26·8	31·3	27·4	39·8	36·0	31·0	37·2	30·7	39·0	30·0	32·9
Years	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	Mean.
Death rates	41·5	42·4	34·6	58·4	39·5	32·7	29·3	26·4	30·8	31·5	36·7
Years	1851	1852	1853	1854	1855	1856	1857	1858	1859	1860	Mean.
Death rates	26·5	28·1	29·6	84·6	33·0	50·6	26·1	28·1	30·9	31·6	36·9
Years	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	Mean.
Death rates	31·1	41·5	34·8	34·1	33·4	32·1	120·5	56·7	35·0	22·6	44·2
Years	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	Mean.
Death rates	25·6	26·8	33·7	29·5	24·9	27·5	29·6	27·2	32·1	28·1	28·5
Years	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	Mean.
Death rates	29·9	35·0	35·5	31·2	33·5	28·9	34·4	30·4	33·7	34·3	32·7

Years	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	Mean.
Death rates	27·2	38·4	40·9	29·0	37·1	41·9	29·5	31·9	34·8	34·8	34·6
Years	1901	1902	1903	1904	1905	1906	—	—	—	—	Mean.
Death rates	40·3	34·0	39·9	32·2	40·6	40·0	—	—	—	—	37·8

Mean of 76 years ... 35·4.

The mean annual death rate for the 36 years from 1831 to 1866, before the epidemic of malaria developed, was 35·3, and for the 40 years from 1867 to 1906, since malaria has been present in the island, was 35·7—almost the same. It might therefore be inferred that malaria has had no effect on the death rate; but this inference can only be accepted if it can be shown that no influence has been at work to counterbalance the influence of malaria—that is, to decrease the death rate, while the malaria has increased it.

Comparing the Mauritius death rates before the development of malaria in 1867 with those of the lesser islands, we observe that they are not very dissimilar. Mauritius was then probably in much the same condition regarding medical assistance as the islands are now in. I suspect that fully qualified medical assistance was not always available, and know that what was available was not nearly so expert as at the present day. Probably much loss of life occurred at childbirth, or owing to smallpox and undeveloped surgery, and the sanitary organisation was certainly immature. Many serious epidemics swept the colony. In 1837–40 there were epidemics of measles and smallpox; in 1841, 1842, 1844, 1845 epidemics of smallpox and relapsing fever; in 1854, 1856, 1861–63, epidemics of cholera—all of which must have greatly swelled the death rates in the days before malaria. Since then, so far as I can ascertain, there have been only minor epidemics of measles and influenza, while the plague has caused only about 5,000 deaths since 1899. I cannot find (in time for this report) when compulsory vaccination was introduced, but it must have made a large reduction in the mortality.

On examining the figures, we find that, after the great rise in mortality during 1867 and 1868, due to the epidemic of malaria, there was a most marked decrease, the death rates for the whole decade 1871–80 averaging only 28·5. This is a phenomenon frequently seen after severe epidemics. As Meldrum remarks, "Many persons died who, if there had been no epidemic in 1867–69, would probably have died in 1870–72," or later. But there are other explanations. The great mortality during the epidemic was largely due to the fact that the supply of quinine ran short. Later the drug was poured in, and taken widely. It was evidently not given in quantities sufficient to exterminate the malaria in all the patients, but it must have saved, from then up to the present, many thousands of lives. Lastly, there was probably a great developmeut of natural immunity among the survivors of the great epidemic.

The assumption that malaria has had no effect on the mortality since 1868 implies, therefore, the assumption that the whole of medical science and practice, vaccination, quarantine, quinine, and sanitary organisation have done nothing since that date to reduce the mortality. More correctly, the matter should be put in this way: that, since the death rates now are much the same as they were before malaria entered the island, the effect of the disease has been to counterbalance all the results of medical and sanitary science during the last forty years, put together.

After all, the remarkable fact remains that, of the four neighbouring islands, Seychelles, Rodrigues, Mauritius, and Réunion, the first two, which have no Anophelines and no malaria, possess a death rate of less than 20 *per mille*, while the other two, which possess both, have a death rate of 35 and more, or about double.

(3). *Monthly Variation in the Deaths.* — As a general rule, in malarious countries the admissions for malaria and the total number of deaths tend to increase largely in the rainy season; but in non-malarious countries this variation does not occur with regularity. In the following table I give the average monthly deaths from all causes (*a*) in the Seychelles during three years, 1901, 1902, and 1904; (*b*) in Mauritius during 1861–66 (excluding 1862 before the entry of malaria; (*c*) in Mauritius during 1870–89, that is, for 19 years after the entry of malaria; and (*d*) in Mauritius during three recent years.

	Average Population.	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Seychelles 1901–04	19,442	31	28	27	30	26	33	30	23	26	27	26	25
Mauritius 1861–66	345,275	1,003	936	987	920	972	898	970	971	947	970	910	967
Mauritius 1870–89	353,958	790	809	1,005	1,043	1,118	1,059	1,004	893	783	759	718	740
Mauritius 1904–06	376,974	1,012	981	1,307	1,314	1,357	1,262	1,597	1,284	1,125	1,089	1,285	909

If we divide the highest figure in each of these lines by the lowest figure in the same line, we obtain the fractions 1·35, 1·10, 1·55, and 1·76—the first two for Seychelles and Mauritius before malaria, the latter two for Mauritius after the entry of malaria. That is to say, the ratio between the highest and lowest monthly deaths tend to be greater in malarious places. Dr. Meldrum gave statistics to show that the greatest mortality tends to occur about two months after the heaviest rainfall. This is now easily explained by the impetus given to the breeding of mosquitoes by the rains. A few weeks later many new infections would be produced by them, causing or accelerating deaths a few weeks later still.

(4) *The Declared Fever Mortality.* — In every civilised community at the present day deaths are registered with sufficient care to make the total mortality returns fairly reliable ; but it is quite another matter regarding returns which attempt to give accurately the various causes of death. Even where only qualified medical men are permitted to furnish death reports, the sources of error are numerous. Many patients die from a complex of causes ; and others are not seen by a medical man until they are *in extremis*, or even until after death—such being particularly the case with children, whose deaths constitute such a large proportion of the total. In malarious countries deaths due to many diseases are apt to be returned under the heading of fever, especially by unqualified registrars, thus swelling the declared fever mortality ; while, on the other hand, many deaths from malaria are returned under the headings of secondary complaints which have really only precipitated the fatal ending—thus reducing the declared fever mortality. On the whole, then, the fever death rates are very apt to be unreliable. In Mauritius, however, with its dense population and large qualified medical staff, the error is, I think, likely to be less than in any other tropical country I have seen, including India ; and we must remember that the factors just mentioned, which tend to increase or decrease the error, must also tend to neutralise each other.

The following figures give the average monthly fever deaths in Mauritius during two sets of years :—

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Totals.	Rates per 1,000.
1870-89 ...	393	437	578	629	673	601	518	430	369	358	335	351	5,674	15·9
1904-06 ...	377	428	662	673	666	565	328	305	369	350	321	338	5,382	14·3

They agree very closely, and show a distinct seasonal variation. The fever mortality is least in November and greatest in the autumn months, as usual. This fact itself gives strong evidence in favour of the view that the fever returns in Mauritius are not as unreliable as might be supposed. Had there been very great error, the probability is that that error would have been equally distributed over all the months, so that the known malarial seasonal variation would not have been so apparent. But we find that the maximum monthly deaths are twice the minimum, as might be expected. Of course, in a disease which relapses so frequently, deaths may occur long after the infective season; while chilly weather kills many cachectics—facts which account for the continuance of some deaths during the cool season.

The sets of years just given correspond with the two latter sets given in the previous table. By subtracting the fever deaths from the total deaths, we obtain a remainder of deaths declared not to be due to malaria.

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Totals.	Rates per 1,000.
1870–89...	397	372	427	414	445	458	486	463	414	401	383	389	5,049	14·3
1904–06...	640	553	645	641	691	697	1,269	979	756	739	964	571	9,145	24·3

The sudden rise in July in the last line was apparently due to an outbreak of influenza in 1906, which carried off a number of old and debilitated persons. Excepting when such epidemics occur, the non-malarial deaths show no such marked seasonal variation as the malaria deaths do. As Dr. Meldrum demonstrated, this absence of seasonal variation was the characteristic of the total deaths in the Colony before malaria broke out in it. There is, however, always a slight summer increase owing chiefly to dysentery and diarrhœa, and a winter increase owing to influenza, chest affections, and so on

Tables I and II give the population, deaths, declared fever deaths, and other necessary details, for many years. During the seven years 1900–06 the declared fever deaths averaged 5,384 per annum, or 31·0 % of the total deaths, and 14·0 *per mille* of the total population.

(5). *Cases of Malaria admitted into Hospitals and Asylums.*—There is an immense amount of statistical material on this subject. I propose to epitomise it as briefly as possible. The following table is taken from the Reports of the Director, Medical and Health Department. It gives the total admissions into the various government hospitals and asylums (numbering fourteen in 1906), and also the number of admissions due to malaria and the number of deaths during the seven years 1900–06.

Years	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Total.
Total admissions... ...	15,449	18,542	17,874	20,867	17,492	20,735	20,371	131,330
Total deaths	1,152	1,313	1,018	1,277	973	1,267	1,221	8,221
Malaria admissions ...	2,848	4,182	3,360	4,788	3,039	5,123	3,674	27,014
Malaria deaths	84	70	35	94	37	91	38	449
Enlargement of spleen	163	546	467	507	395	669	672	3,419
Deaths from enlargement of spleen.	2	8	24	15	21	30	40	140

The average total annual admissions were 18,761; the average admissions for malaria (as given above) were 3,859, and the average deaths for malaria in these institutions were 64·1 a year. The percentage of admissions due to malaria was 20·6 %, and the percentage of deaths from malaria to admissions for malaria was 1·66, or only 16 in a thousand.

This case mortality occurred in hospital in spite of the best treatment. We must not infer that it would be equally low outside hospital, especially among the poorest classes and the children, who, as I witnessed myself, often take no treatment at all. Nevertheless, it suggests that the declared mortality from fever in the colony must be too high. The Hon. Dr. Lorans makes some pertinent remarks on this subject in the report for 1906. The case mortality was 1·02 % in that year; and applying it to the number of deaths attributed to malaria in the returns, we should have to admit that, according to the same ratio, there were 582,700 cases of the disease in the island during the year—about three attacks to every two persons. Certainly the Indian admissions for malaria do often exceed half the strength, or sometimes the whole strength, even among troops; but this is only at isolated stations.

It seems that since 1899 the *medical* certification of deaths was more generally and systematically enforced in two of the districts, Port Louis and Plaines Wilhems; with the result that the declared malaria death rate fell at once in these areas to a fraction of the former figures. In Table II, I give Dr. Lorans' useful table showing the annual total and malaria deaths in the various districts for eleven years. For example, in Port Louis and Plaines

Wilhems in 1896 the malaria deaths were about half the total deaths; but in 1904 they fell to about one-sixth and one-ninth of the latter, respectively. More exactly, the malaria deaths during 1896, 1897, and 1898 were 45·3 % of the total deaths; but during 1899–1906 they were only 25·2 % of them—by which we may infer with some degree of probability that before 1899 20 % of the total deaths had been wrongly returned under the heading of malaria. This therefore would bring down the average declared fever mortality from 31·0 % of the total mortality to only 11·0 % for the whole island during the seven years 1900–1906.

But we must now turn to an item in the last table not yet considered, namely the hospital cases and deaths due to enlargement of spleen (with which I have included the small proportion of cases of splenitis). These have not been previously added to the malaria cases; but, for reasons which will be given in the next section, I infer that they should be. They make the serious addition during 1900–1906 of 3,419 hospital cases and 140 hospital deaths. The total malaria cases now stand at 30,433, or 23·2 % of all the cases; and the total malaria deaths at 589, or 1·935 % of the malaria cases. This puts the hospital case mortality of malaria in Mauritius at nearly 2 %.

As will be seen in the next section, the cases of enlargement of spleen treated in those hospitals are only a minute fraction of the cases existing throughout the island; and the same thing evidently holds regarding the cases of fever.

The total number of deaths in hospital given in the above table was 8,221, and the deaths from malaria, 589, or 7·1 %. Supposing the same ratio were to hold for the whole island, then the malaria deaths would have been only 9,324 for the seven years, or an average of 1,332 deaths a year, instead of the average of 5,384 malaria deaths in the general mortality returns—a great difference. But we must again remember that the deaths in hospital are not likely to be so great as those outside.

(6). *Cases of Malaria attending the Hospitals and Dispensaries.*—In addition to the patients treated inside the various hospitals, a great number attended them and the dispensaries (numbering twenty-eight in 1907) as out-patients. The Director of the Medical and Health Department (Dr. Lorans) was kind enough to collect for me the number of such attendances for malarial disease during past years; and I give the figures in Table III. Only a few of the institutions have records extending further back than 1878; and I have consequently taken the statistics only for the thirty years from then to 1907 inclusive. Altogether 403,918 cases of malaria visited the institutions during that period, averaging 13,464 a year—though of course not all these cases were different persons, many attending for medicine over and over again. During the last seven years the attendances averaged 23,637 a year. The figures do not always indicate the local prevalence of malaria, because many of the patients come from a distance. For example, at Moka, which is generally healthy, Dr. Clarenc states that many patients visit the hospital from Pailles, which is unhealthy. So also the Curepipe dispensary is attended by many from Phœnix and Black River.

During 1907 the total attendances at these institutions for all causes numbered, according to information given me by Dr. Lorans, 79,053, while the attendances for malarial diseases alone was 28,294, or 35·8 % of the total attendances; a very high ratio.

Dr. Lorans' figures separate malarial diseases into fever, cachexia, and enlargement of the spleen. On examination, I infer that the distinctions have been made somewhat arbitrarily, and, indeed, it is often difficult to make any, so that I have thought it best to lump them together in Table III. The total numbers, however, were as follows:—

	Totals.	Percentages to total Malaria.
Malarial Fever	358,079	87·6
Malarial cachexia	26,394	6·4
Enlargement of spleen	24,021	5·8
Total malaria*	408,494	—
Dysentery...	38,713	9·4

Dysentery was included in the return at Dr. Lorans' suggestion for the purpose of comparison—a very useful one being obtained.

19. THE MEASUREMENT OF MALARIA IN MAURITIUS.— Having considered past statistics, we must now endeavour to obtain some idea of the present prevalence of the disease.

(1). *Recent Statistics.*—The figures for 1907 have not reached

* This total is in excess of that given by Table III., because the latter deals with attendances during only thirty years, while the former goes back some years earlier.

me in time for this report, but those for 1906 will suffice for the following table :—

	Total.	Malarial.	Percentage.
Population (1906)	377,532	—	—
Declared deaths (1906)	15,118	5,827	38·5
Death rates per mille	40·0	15·4	38·5
Admissons (1906)	20,371	4,346	21·3
Hospital deaths (1906)	1,221	78	6·4
Hospital cases (1907)	23,759	4,306	18·1
Dispensary cases (1907)	79,053	28,294	35·8

We thus have many figures but, I fear, few results. The general fever mortality returns probably have a large margin of error, and it is difficult to say how far the hospital statistics apply to the entire population. We cannot say how many patients attend hospital more than once, or how many never attend at all.

(2). *Direct Methods for Measuring the Amount of Malaria in a Locality.*—The principal point to be ascertained is, by section 10, the proportion of infected persons in the locality, but this is not given, either by death rates or by attendance at hospital.

The ideal way to ascertain this ratio would be to search for the parasites in the blood of every person in the locality. But the parasites often cannot be found, even when they must be present in considerable numbers. Even when they are fairly numerous the search for them in a single person may occupy a skilled worker for half an hour or more, and may have to be repeated on several occasions. I doubt whether such a worker could examine properly the blood of a thousand people under two months' hard work. If he were to content himself with examining smaller numbers by what is called "random sampling," the statistical error might be considerable. Hence to estimate correctly the proportion of infected people throughout a large population like that of Mauritius would be a great task.

There is, however, a much easier though less rigid method, which consists in examining the people for the enlargement of spleen which occurs so frequently in cases of malaria. This can be done literally in a few seconds for each person. The people to be examined are lined up, and then made to pass the examiner one by one, while an assistant writes down the result; or else the facts may be ascertained by a rapid house to house visitation. Thus a large population can be dealt with in a much briefer time than would suffice for a thorough blood-examination. The method is a very old one, which was often practised in India.

The best method, however, when practicable, is to combine the two.

(3). *The Endemic-Index.*—This useful term was proposed by Stephens and Christophers to denote the proportion of persons with parasites in the blood. I suggest, however, that the term *parasite-rate* would be more suitable for this purpose; that the term *spleen-rate* should be given to the proportion of people with enlarged spleen due to malaria; and that the term *endemic-index* should be reserved for both of the others together—or rather for the proportion of infected persons ascertained by all methods.

The combined methods were used by me in Greece in 1906. Out of 60 infected children whose blood and spleen were examined very carefully, 27, or 45 % had enlarged spleen, but parasites too few to be found; 21, or 35 % had both enlarged spleen and parasites numerous enough to be found; and 12, or 20 % had parasites but no enlargement of the spleen. Now, if we had taken only the parasite-rate or the spleen-rate we should have obtained too low an estimate. The combined method is especially useful, because early cases of malaria generally show numerous parasites but have little enlargement of the spleen; while older cases, in my experience, show the converse.

For practical purposes, the parasite-rate can be determined only (with much trouble) for small populations; and for large ones, such as that of Mauritius, we must resort to the spleen-rate. But when we confine ourselves to the latter, we ought to add a certain percentage for cases in which, had we examined them, we would probably have found parasites, though they had no enlarged spleen. In the Greek cases, there were 12 such for 48 with enlarged spleens; and though these cases were too few to give a very reliable estimate, we may for the present accept the proportion for rough calculation.

In practice also, we usually confine our examinations to children—say of under 16 years of age. This is done for several reasons. Children are easily accessible in schools, or, for a small reward, in villages. Men are generally out at work, and women often object to the examination. But the most important reason is that adults have in many cases become partially immune (section 2). Thus if we were to take people of each year of age from one to a hundred, say a thousand of each age, we should find that the endemic-index rises from one to about ten years, and then falls; until at puberty the bulk of people in a malarious locality show few signs of the disease, though they may occasionally suffer from short attacks and are probably really infected all the time. If, however, we had examined only the adults, we should have discovered few objective symptoms of malaria in them, and might have come to the conclusion that there was no malaria in the locality.

It, therefore, becomes apparent that we do not really possess any very practical method for determining the exact ratio of infected persons in a locality. We can find children with enlarged spleens or with numerous parasites; but when partial immunity has banished these symptoms we are left in doubt. A person is "infected" as long as any parasites are left in him, but, unfortunately, we can never find definitely whether or no they have died out completely. All we can do is to take the children up to some arbitrary age, say 16, and then compare results. If none of them show signs of infection, the place is healthy. If some are infected, all we can state is that the endemic-index among so many children examined is such-and-such; and we must examine enough children to avoid statistical error.

(4). *Does Kala-Azar exist in Mauritius?*—A most important point remains to be studied. There are several diseases, besides malaria, which cause enlargement of the spleen; but only one of these causes wide-spread enlargement, such as malaria does. This is the famous Indian disease *kala-azar*, which is produced by the minute parasites called *Leishmania donovani*. Where it exists the spleen-test for malaria becomes obviously unreliable.

Hitherto it has never been found in Mauritius. Unfortunately during my stay there, no opportunity for searching for the parasites in the liver and spleen presented itself; but we examined several suspicious looking ulcers in vain. Owing to the large Indian immigration one would expect to find the disease in plenty; but, on the whole, I infer that it is absent, or rare. I was sent by the Government of India to investigate *kala-azar* in Assam in 1898: but neither in Mauritius nor in Greece did I observe cases altogether similar. The *kala-azar* patient has a depressed, anxious expression which is not often seen in malaria; the liver is generally enlarged, as well as the spleen ; there is generally a continued fever not cured by quinine ; and the patient almost invariably dies. Now if all, or even a fraction, of the children in Mauritius with enlarged spleen have *kala-azar* the death-rate would be appalling. As a matter of fact, the children recover. The malady which causes enlargement of spleen among them, as in Greece, is a benign affection. It is also too frequently accompanied by the parasites of malaria, and too easily cured by quinine, to leave much doubt as to its nature. I gather then that the carrying agent of *kala-azar* is probably absent from Mauritius ; and that the spleen-rate will, therefore, give a reliable estimate of the endemic-index there.

20. THE SPLEEN-RATES OF CHILDREN IN MAURITIUS, AND OTHER DETAILS.—With these considerations in view, I advised Government, when I reached the Colony, to carry out a systematic spleen-census of the child population. This was done (*a*) by the Sanitary Wardens, Drs. Castel, Keisler, Masson, and Milne, for the children in schools ; (*b*) by the Medical Officers of the Sugar Estates and Factories for the children belonging to them ; and by Dr. Milne, Major Fowler and myself for a certain number of children scattered in villages and hamlets. Owing to the large number of children examined, the work was arduous ; and my warm thanks are due to these gentlemen for their assistance, and also to Dr. Lorans and Dr. Bolton for their supervision of the statistics. So far, as I know, it is the largest spleen-census which has ever been taken.

The details are given in Table IV.

(1) *Total Spleen-Rate.*—At the census of 1901, out of 370,831 persons whose ages are recorded, there where 178,139 children of 15 years and under, or 48·04 % of the total. In 1906 the total population is estimated by the Registrar General at 377,532 ; so that according to the same proportion there ought to have been 181,366 children in that year, or say 182,000 children of 15 years and under in 1907.

The following table gives the results of the spleen-test (carried out for the most part early in 1908).

	Children examined.	Children with enlarged spleen.	Percentages.
Children on Estates	18,909	6,307	33·3
School Children	6,188	1,455	23 5
Miscellaneous	5,925	2,833	47·8
Totals ...	31,022	10,595	34·1

Thus, out of about 182,000 children in Mauritius, 31,022 were examined and 10,595 were found to have enlargement of the spleen; or 34·1 %. The statistical percentage of error according to the Poisson-Pearson formula (addendum 4) is only 0·693, and may be neglected. Hence we may calculate that out of all the 182,000 children under 15 years of age in Mauritius, one-third probably suffer from enlarged spleen.

(2). *Total Probable Endemic-Index.*—But if we had examined the blood of all these children for the parasites of malaria (which was of course quite impossible in the time at our disposal) we should certainly have found a proportion of them containing the parasites, but not having enlargement of the spleen. According to the rough Greek estimate (section 19), these would number as many as a quarter of the spleen cases. Adding this proportion, we estimate that 13,244 children, or 42·7 % of the total, would probably have shown objective symptoms of malaria had we examined them all. Thus the endemic-index for children of 15 years or under in Mauritius early in 1908 may be put at about 42·7 %, or over two-fifths.

The children were examined largely before the great annual rise of malaria begins. Had we examined them later, the endemic index would certainly have been much larger.

(3). *Some Small Sources of Error.*—It is likely that some of the children examined in the schools, on the estates, and elsewhere were the same children. I have not been able to ascertain the likely proportion in time for this report. But, as we are here dealing with ratios, the matter will not seriously affect the general result. I have just been informed by Dr. Bolton that few of the children of the indentured coolies on the estates attend the schools, and that in his opinion the overlapping cannot exceed 0·25 %, and will not therefore seriously alter the returns (annexure 1).

Another point. I asked for children of 16 years and under to be examined. This was unfortunate, as the census deals only with five-yearly groups. But for the same reason, just given, the error caused may be practically neglected. Moreover, the exact ages of the poorer classes are always very doubtful quantities.

(4). *Average Spleen.*—I asked for records, not only for enlargement of the spleen, but for degree of enlargement—whether the enlargement was small, medium, or great. I have collected the figures for 30,137 children examined. The enlargement is given as none in 19,711, or 65·4%; as small in 4,381, or 14·5%; medium in 3,479, or 11·5%; and great in 2,566, or 8·5%. As a rough estimate I take the "small," the "medium," and the "great" enlargements as being, respectively, three, six, and nine times the size of the normal spleen, which is taken at unity. Hence, adding together the children with no enlargement, three times the children with small enlargement, six times and nine times those with medium and great enlargements, and dividing by the total numbers examined, we obtain what I call the *Average Spleen*. This works out at 2·54 for Mauritian children early in 1908, with small statistical error. See also Table IV, D.

I do not think that this estimate has been attempted before. It is likely to give a more delicate index of the amount of malaria in a locality than the mere spleen rate; but, unfortunately, medical men may differ as to the standards of small, medium, and large; and the estimate is, therefore, not rigid.

(5). *Age and Sex Distribution.*—I asked also for the ages and sexes of the children to be recorded. As a matter of fact, the ages generally have to be guessed by the examiner; so that here again the estimate is far from rigid. In fact, on scrutinising the figures, I find so many elements of doubt that I have finally decided to omit the full age analysis from the table of details—more especially as it would add immensely to the bulk of figures. But I have computed the totals for 4,025 children with enlarged spleen on the estates, and find that they were distributed according to age as below :—

Age	1	2	3	4	5	6	7	8
Children ...	208	254	293	285	311	346	340	355
Age	9	10	11	12	13	14	15	16
Children ...	247	328	192	255	172	185	153	97

Thus there were 1,351 children with enlarged spleen of five years and under; 1,648 of five to ten years; and only 1,056 of ten to sixteen years.

Out of the same number of children with enlarged spleen, 2,095 were males and 1,930 were females—showing no marked difference.

(6). *Local Distribution.*—The declared deaths from fever in the various districts during the last eleven years, 1896–1906, will be found in Table II, and the spleen rates and average spleen in Table IV. Flacq and Black River districts have the highest spleen rates and average spleens; and Plaines Wilhems and Moka the least. The local prevalence of malaria varies so greatly, even within a few hundred yards, that it is quite impossible to examine all the details here.

(7). *The Imported Spleen Rate.*—In every locality anywhere near to a malarious area there must be a certain number of imported cases which will give a small spleen rate by themselves. This I call *the imported spleen rate.* As a rough rule it must tend to vary inversely as the square of the distance from the infectious area. On reference to Table IV it will be seen that there are small spleen rates in Moka and Plaines Wilhems; and the remarks of the reporting Medical Officers show that these are mostly imported—although in both these districts there are a few infecting centres.

Of course the imported spleen rate tends to be increased in places which are frequented from outside, as Curepipe; but on the whole I think that, if the spleen rate of a locality is not higher than 5 %, there is likely to be little endemic malaria there. If only a few children are examined, so that the statistical error is large, the apparent rate may be much higher than this without giving proof of endemic malaria. For instance, in the schools of Moka the rate is 20·5 % according to Dr. Castel. This is large enough to suggest a malarial focus somewhere there; but on the other hand the statistical error is nearly 8 %, so that the true spleen rate may be anything between 12 % and 28 %. Quite possibly the lower figure may be due only to importation, especially in schools.

(8). *The Effect of Altitude.*—That malaria decreases with increased altitude is known everywhere, and has been frequently noted in Mauritius, where the conditions are very suitable for such a variation. Dr. Meldrum (10) and the writers of the Annual Medical Reports and Reports of the Estates Hospitals have frequently shown that the death rate tends to diminish with altitude. Table IV, E gives the variation of the spleen rates according to altitude in a large number of children in Mauritius.

Altitude must affect malaria chiefly by reduction of temperature —one degree Fahrenheit (0·56° C.) for every 300 feet. Temperature affects it in many ways. Cold is inimical to mosquitoes; it retards the development of the parasites within them, and also, I think, in man; and causes men to wear more clothing and to shut up their houses at night. On the other hand, large breeding places close at hand may neutralise all these factors—as, for instance, near the Clairfond marsh at Phœnix (1,400 feet). Hence, while the average infection rate diminishes with altitude, local rates must vary largely owing to other factors.

(9). *Relation between the Spleen Rates and General Death Rates.*—In Table IV, A, giving the spleen rates on estates, the death rates averaged for the two years ending June, 1907, are also given. But there is a large statistical error in these death rates, owing to the small numbers of deaths on many of the estates; so that the relation between them and the spleen rates cannot be dealt with satisfactorily. In Table IV, F the same figures are given for whole districts, and are therefore more useful; but I have been obliged to give the death rates for 1906, as those for 1907 (which should have been shown in order to correspond with the spleen rates) have not yet reached me. There is evidently a marked, though not exact, relation—which I will not analyse without the figures for 1907. The separate death rates of estates are not an exact measure of the malaria in them, owing partly to statistical error.

(10). *The Parasites and the Fevers in Mauritius.*—There is nothing of importance to our present purpose under this heading. The parasites can be found easily in man and in *P. costalis*, and do not differ in any respect from those observed all over the tropics. All species were seen by us. To determine which was most abundant was not necessary, and would have required many months' special work. Quartan abounds at Phœnix, and the malignant parasites are common. The clinical features of the disease have been excellently studied in many scientific papers, especially in those of the Société Médicale; and call for no remark here. Blackwater fever is common (addendum 2).

21. SUMMARY OF FACTS REGARDING THE AMOUNT OF MALARIA IN MAURITIUS.—

A. The following figures give important averages during the seven years 1900-06 :—

(1) The average population of Mauritius was 384,676.

(2) The average total deaths per annum were 14,139.

The average annual total death rate *per mille* of population was 37·4.

The average annual deaths reported as due to fever were 5,384 (doubtful).

The average annual death rate *per mille* of population reported as due to fever was 14·0 (doubtful).

The average reported fever deaths were 31·0 % of the average total deaths (doubtful).

(3) The total admissions into the hospital for all causes averaged 18,761 a year.

The admissions into the hospitals for malarial diseases alone averaged 4,348 a year, or nearly one quarter (23·2 %) of the total admissions.

The total deaths in hospital from all causes averaged 1,174 a year.

The deaths in hospital from malarial diseases alone averaged 84 a year, or 7·1 % of the total deaths.

The ratio of deaths in hospital from malaria to admissions into hospital for that disease (case mortality) was 1·935 %.

(4) The attendances of out-patients at all the hospitals and dispensaries for malaria alone averaged 13,464 a year since 1878.

In 1907, alone, the total attendances for all causes were 79,053, and for malaria alone were 28,294, or 35·8 % of the total.

B. (1) There are about 182,000 children of fifteen years and under in Mauritius.

(2) Out of 30,137 of these examined in all parts of Mauritius at the end of 1907 and the beginning of 1908, that is, before the middle of the malaria season,

19,711, or 65·4 %, had no enlargement of the spleen ;
4,381, or 14·5 %, had small enlargement of the spleen ;
3,479, or 11·5 %, had medium enlargement ;
2,566, or 8·5 %, had great enlargement.

From these data it may be computed roughly that the average spleen of Mauritian children is 2·54 times the normal size.

(3) Out of 885 more children examined, 169 were found to have enlargement of the spleen.

Thus, out of a total of 31,022 children examined, 10,595, or more than one-third (34·1 %), had enlargement of the spleen.

Hence probably, out of the 182,000 children in Mauritius, about 62,062 suffered from enlargement of the spleen.

(4) If we suppose that children without enlargement of the spleen, but with the parasites in the blood, numbered as many as a quarter of the spleen cases, then we must infer that at the beginning of last malaria season 42·7 % of all the children in Mauritius—that is, about 77,714 children in all—were infected with malaria.

Dr. Bolton, Medical Officer of the Immigration Department, estimates that malaria costs the Estates in Mauritius Rs.650,000 a year in loss of labour, and the labourers themselves Rs.150,000 in loss of wages, besides similar losses to the general community (annexure 1).

PART III.—PREVENTION OF MALARIA IN MAURITIUS.

22. BRIEF HISTORY OF THE PREVENTION OF MALARIA.—In sections 2 and 11 it was made clear that malaria will not remain in a locality (1) unless the carrying agents (Anophelines) are numerous enough; (2) unless there are enough infected persons to infect the carriers; and (3) if the insects are prevented from biting human beings. There are thus three groups of preventive measures which may be employed by public authorities to reduce the disease, namely :—

(1) Anopheline Reduction,
(2) Case Reduction,
(3) Isolation.

The ancients knew that *drainage reduces malaria;* and the statement has become a sanitary aphorism for centuries. Numbers of instances occurring in Italy and France are cited in text-books. The total disappearance of the disease from Britain and its decrease in Holland and other countries has been certainly due in part to drainage of marshes, and in part to other causes—chiefly, I think, the frequent treatment of cases with quinine, and (?) the general use of glass windows which appears to have followed the repeal of the window tax early last century. Thus all the preventive measures mentioned above were used—unconsciously. The Anophelines were reduced by drainage, the cases by quinine, and the remaining insects were largely prevented from feeding by the glass windows.

But though drainage against malaria has been frequently used, it has been more frequently neglected. The Roman Campagna, for example, and many marshy settlements in the tropics have been allowed to remain malarious, in spite of the remedy being known. This has been due to many causes—to the expense of drainage; to the small political influence of the medical profession; to faulty public education; and, not least, to scepticism regarding the truth of the dogma, owing to absence of full explanation of it. When, however, the Anophelines were shown in 1897-99 to be the carriers of malaria, the reason why drainage reduces the disease was clearly revealed—it removes the stagnant weedy surface waters which breed the insects. In other words, drainage of the soil, as applied to malaria, merely means *Anopheline reduction* and nothing else. At the same time, as already stated in section 1, the new knowledge greatly improved our methods. Instead of being forced to drain a whole area, we could now define exactly which waters were or were not dangerous, and could deal with the latter by several other means than by drainage—thus cheapening the whole process, and rendering it more exact and feasible. The precise details of the method were first laid down in 1899 (1); and were first put into practice in a complete manner at Ismailia and in Klang and Port Swettenham in the Federated Malay States, in all of which localities the disease was banished in a couple of years. Later the same method has been made the basis of the great sanitary work of the Americans in the Panama Canal Zone, and has been attempted with more or less energy elsewhere. Latterly Anopheline reduction has been merged in the wider and still more useful measure of general *mosquito reduction*, especially at Ismailia, Panama, and Port Said.

Meanwhile the second great anti-malaria measure, that of *case reduction*, had been originated by Koch and Celli as early as 1900. These observers felt doubt as to the possibility of mosquito reduction (since established), and urged that the best way of dealing with malaria would be to leave the mosquitoes alone, but to cure the human patients, from whom the insects become infected. Thus, though mosquitoes would continue to abound, they would find no parasites to carry. The classical example of the use of this method was Stephansort, in New Guinea, which was cleared of malaria by Koch in a few months. Much similar work has been done in German possessions and in Italy, and also among the troops in India.

The third measure, that of *isolation* or *protection from bites of mosquitoes*, has been unconsciously in use for a long time. The ancient Egyptians and Romans used to employ mosquito nets during sleep; and I well remember being told, when I first went to India in 1881, that they would ward off malaria. Since 1898 I have always strongly advocated the use of them for that purpose. In America wire gauze screens for the windows and verandas of houses have long been employed; and these were now strongly recommended, especially in Italy, as a protection against malaria. The experiment of Low, Sambon, and Rees, who lived for two months of the malaria season in the Campagna in a mosquito-proof house without becoming infected, strengthened this recommendation. Though the experiment added nothing to our knowledge, and was not a strict test (since infection in two months is by no means a certainty anywhere), it was so widely advertised that wire-proofing was adopted in several places, notably in Lagos and Panama. Other precautions, such as boots, gloves, and veils, culicifuges (applications to the skin to keep off mosquitoes), and so on, were urged by some writers. Lastly, Stephens and Christophers emphasised the necessity for the *segregation* of Europeans in the tropics, on the ground that, if they live far from native villages, they are less likely to be bitten by infected mosquitoes—an excellent suggestion.

Last year I attempted to collect available information on the subject of anti-malaria campaigns in many countries. The task was difficult, owing to the inadequacy of most of the official and other reports on the subject; but I published what facts I could ascertain (2). Work on a large scale in British possessions was first commenced in an admirable way at Lagos by Sir William MacGregor, who, however, was forced later by ill-health to leave the tropics—much to the loss of tropical sanitation. Other campaigns have been commenced in Sierra Leone, the Gold Coast, British Gambia, Hong Kong, many stations in India, Durban, Khartum, Candia, St. Lucia, Havana, Mauritius (section 17), besides Italy, Greece, and French and German possessions.

The campaign in Sierra Leone was commenced in 1901 by Dr. Logan Taylor and myself, and was favourably reported on at the time by Dr. C. W. Daniels; but it is impossible to obtain adequate details of what has happened there since we left, and the statistics show little improvement. A campaign at Mian Mir, in India, was a failure, owing to insufficient expenditure and other reasons which I analysed in a paper published in 1904 (4). The campaigns in the other localities mentioned have been more or less successful, so far as I can ascertain.

Last year I urged that the authorities would do well to collect information on the subject in the form of special malaria reports; and, owing to the request of Colonel Seely, C.B., M.P., the Right Honourable the Secretary of State for the Colonies was good enough to order such reports for his department. These have recently been published by the Advisory Committee of the Colonial Office for the Tropical Diseases Research Fund (17).

On studying them I find that they give little evidence of a thorough and practical policy against malaria in most of the colonies. Strangely enough, all accounts of two of the best campaigns, namely, those at Klang and Port Swettenham, in the Federated Malay States, are omitted; while the campaign at Hong Kong is represented only by a single inadequate extract from a medical report. Similar extracts, often consisting of only a few lines, constitute all that is given for many colonies. One medical officer (Perak) remarks that "with our heavy rainfall the banishment of puddles and other suitable places for the breeding of mosquitoes is practically impossible"—ignoring the fact that this is just what has been done in the neighbouring State of Selangor. Free quinine, lectures on elementary hygiene, and covering of water barrels seem to constitute all that has been attempted in many localities. In several of the West Indian Islands, it is admitted that nothing at all has even been attempted. Statistics, where they are vouchsafed at all, are generally quite inadequate; and I have searched the reports in vain for any account of so simple and easy a measure as a spleen census. Suitable anti-malarial organisations have not really been constituted. The reports generally suggest the idea that the colonies have still much to learn regarding the prevention of malaria. There is much talk at present of research and instruction on tropical diseases; but it would seem that, though the cause and the mode of prevention of the most widespread and important of tropical diseases—one that often causes as much sickness as all the other diseases in the tropics put together—have already been discovered and taught, yet that little or no action is to follow the acquisition of that knowledge.

Nevertheless good work has been done in some of the colonies. I note especially Southern Nigeria (Lagos), where Dr. Strachan, the first Principal Medical Officer in West Africa to attempt malaria reduction by modern methods, and the Director of Public Works have continued the efforts of Sir William MacGregor by drainage, quinine, wire gauze, public instruction, and other methods. The former admits a great improvement in the health of the European officials. In Ceylon quinine has been largely issued at the cost of

Rs.73,299 during 1906, not including wages of distributors. At Bathurst (Gambia), where the work was started in 1901 by my junior, Dr. Dutton, according to my instructions, a malaria gang of ten men has been appointed for the purpose of "minor works," and the health of the European officials has improved ; but it appears that the larger swamps cannot be touched (?). In the island of Samarai (Papua) Anophelines are stated to have been entirely exterminated by the drainage of a swamp. The good work in Mauritius has already been touched upon (section 17).

I will now proceed to a description of the leading examples of malaria reduction by modern methods, taken from my publication already referred to (2).

23. THE PREVENTION OF MALARIA IN ISMAILIA, THE FEDERATED MALAY STATES, HONG KONG, AND THE PANAMA CANAL ZONE, ETC.—(1). *Ismailia.*—The town of Ismailia was founded by the great Ferdinand de Lesseps in 1862 at a little distance from the middle point of the Suez Canal and close to the salt lake, Timsa. Though built in the midst of the desert, which surrounds it everywhere with its ridges of white sand like the undulations of a vast snowfield, it has nevertheless now grown to contain about 8,000 inhabitants, most of whom are employees of the Suez Canal Company. Supplied with fresh water by means of a canal from the Nile, it possesses many good houses, gardens, and well-appointed streets, kept in admirable order by the officials of the company under the able and energetic President, Prince Auguste d'Arenberg, who himself resides here for many months every year. Immediately after the construction of the fresh water canal in 1877 malaria appeared for the first time in the town, which had been previously noted for its salubrity. The cases gradually increased in number until in 1886 almost all the inhabitants suffered from fever. In 1901 the President, having recognised the new discoveries, determined to employ them against this troublesome epidemic, and commenced by sending a member of his highly competent medical staff, Dr. A. Pressat, to Italy to study the subject. Early next year, however, shortly after the commencement of the operations at Freetown, he invited me to go Ismailia to advise upon the best means of attacking the disease. I arrived there in September, 1902, with

Sir William MacGregor, who did me the honour to accompany me, and with Dr. Pressat on his return from Italy.* On our arrival we found all the officials of the company keenly alive to the importance of the work. They had already detected the Anophelines in the town, had urged the general employment of mosquito nets, and had commenced an active quinine prophylaxis. On the other hand, the town was still swarming with mosquitoes. Even in the house of the President, where we were lodged, there were multitudes of Culex, which we showed were being bred in the well-constructed cesspit under the house; while abundance of Anophelines were found in the houses of the employees, and were evidently carrying the disease everywhere in spite of the mosquito nets and the segregation of the Europeans. I felt, therefore, that here, as in other places where I had studied the subject, we should have to introduce the radical method of mosquito reduction if we wished for complete results, and I reported strongly in favour of this course. As Dr. Pressat has said, we formed "the conviction that we should establish for Ismailia a plan of campaign sensibly different from that which we had seen followed in Italy, where the campaign against mosquitoes occupied only a secondary rank—so that this destruction appeared to us to be the capital article of our programme" (p. 130).† We found the larvæ of the Anophelines at once in various collections of water, principally in some small brackish marshes in the sand and some waters of irrigation, but happily not in the main fresh water canal, where small fish destroyed them. The campaign, conducted with intelligence and energy, presented no great difficulty. The marshes were filled up with sand, the irrigation channels were deepened or treated with oil, while the cesspits were soon rendered uninhabitable for the larvæ of Culex. As Dr. Pressat has said,‡ he was able to effect the preliminary work with a "mosquito brigade" of only four men, "qui a tout fait." Although hundreds of men were employed later for large permanent works, this was only after the mosquitoes had already disappeared "grace à notre brigade de quatre hommes." I may perhaps be pardoned for dwelling on this fact because it fully

* Ross: Report on Malaria at Ismailia and Suez. Liverpool School of Tropical Medicine, Memoir IX., 1903.

† Pressat: Le Paludisme et les Moustiques. Masson et Cie., Paris, 1905.

‡ Pressat: Prophylaxie du Paludisme dans l'Isthme de Suez. *La Presse Médicale*, 30 Juillet, 1904.

justifies the advice which I had given more than three years previously, but which had been met everywhere with scepticism. The results were most striking. It should be remembered that, as nearly all the inhabitants of Ismailia were employees of the Suez Canal Company, and as no other fever was prevalent in the town, exact statistics for many years had been possible. I give the following approximate figures from Dr. Pressat's works from the time when malaria first appeared in 1877 to 1905 :—

Years.	Cases of Malaria.	Years.	Cases of Malaria.	Years.	Cases of Malaria.
1877	300	1887	1,800	1897	2,089
1878	400	1888	1,400	1898	1,545
1879	500	1889	1,450	1899	1,784
1880	400	1890	1,900	1900	2,284
1881	450	1891	2,500	1901	1,990
1882	480	1892	2,050	1902	1,551
1883	550	1893	1,750	1903	214
1884	900	1894	1,100	1904	90
1885	2,000	1895	1,350	1905	37
1886	2,300	1896	1,150		

For more exact figures I must refer to Dr. Pressat's works. Since 1904 nearly all the cases have been relapses among persons previously infected, and last year the company officially reported that "toute trace de paludisme a disparu d'Ismailia." Of course, the treatment of old cases has constantly proceeded parallel to the anti-mosquito campaign. But the fortunate inhabitants have been relieved not only of malaria, but of the constant annoyance caused by the insects. In 1902 we were constantly being bitten in the houses. Now, as many visitors to Ismailia have testified,* one can sleep there without nets. This does not imply that the insects are absolutely unknown in the town, but only that their numbers have been very greatly reduced. Absolute extirpation is scarcely possible without bonification over a very wide area, but, as mathematically shown, reduction to a small percentage is much more feasible, and there are evident logical reasons for supposing that the amount of an insect-borne disease must ultimately vary, *cæteris paribus*, as the square of the number of the insects. The cost of the work has been officially reported† as being

* Boyce: The Anti-malaria Measures at Ismailia. Liverpool School of Tropical Medicine, 1904.

† Official Report of the Compagnie Universelle du Canal Maritime de Suez. Suppression du Paludisme à Ismailia, 1906.

about 50,000 frs. for the original drainage and filling up of the pools, with an annual expenditure of 18,300 frs. for the mosquito brigade, oil, maintenance, &c. This amounts to an initial expenditure of about 6·25 frs. and an annual expenditure of about 2·3 frs. per head of population—a small price to pay for the benefits given.

It has been said by the opponents of mosquito reduction that the success at Ismailia was not real, but merely consisted in the statistical transfer of cases from the heading of malaria to that of other fevers consequent on better diagnosis. This is untrue, as there is no other fever there. It has also been said that the success was due to the exceptionally easy conditions at Ismailia. True, the conditions are not so difficult as in places like Panama and Sierra Leone, but I have seen many areas where they were quite as easy as in Ismailia, but where nothing whatever has been done. The success at Ismailia is absolutely unquestionable. It is due chiefly to mosquito reduction and also largely to cinchonisation. We owe it entirely to the intelligence and capacity of Prince d'Arenberg and his excellent staff.

(2). *Federated Malay States.*—Commenced even before the campaign at Ismailia, as ably conducted and almost as decisive, the work at Klang and Port Swettenham, in the Federated Malay States, is an equally distinguished example of the radical method of malaria reduction. Klang is a town of 3,576 inhabitants (in 1901), situated on the banks of the river of the same name, in the State of Selangor, on a flat, swampy area lying between the river and a semicircle of low hills. In September, 1901, as the navigation of the river of Klang presented difficulties, a new port called Port Swettenham was opened five miles down the river from Klang on an area reclaimed from mangrove swamp. The population of the two settlements together was about 4,000 in 1903, while that scattered through the surrounding district was about 14,000. The rainfall averages about 100 inches (3 metres) a year. The full history of the campaigns in these two towns is given in the excellent papers by Dr. M. Watson, the district surgeon, and Mr. E. A. O. Travers,* the state surgeon. In the latter part of

* Travers : An Account of Anti-malaria Work . . . in Selangor. *Journal of Tropical Medicine*, Sept. 15th, 1903.

Watson : The Effect of Drainage and other Measures on the Malaria of Klang, Federated Malay States. *Journal of Tropical Medicine*, Nov. 16th and Dec. 1st, 1903.

Ibid. : Second Report. *Journal of Tropical Medicine*, April 1st, 1905.

Travers and Watson : A Further Report. *Journal of Tropical Medicine*, July 2nd, 1906.

1901 malaria became very serious in both towns, and, according to Dr. Watson, perhaps not more than three houses in the whole of Klang escaped infection, while the workmen at Port Swettenham began to leave the place. Dr. Watson immediately set himself to collect statistics, to observe the local Anophelines, and to take the preliminary steps for the campaign. Supported by Mr. Travers and the Sanitary Board and by the intelligence and liberality of the Government, he soon obtained realisation of the recommendations of himself and his colleagues made on the lines laid down by me (1). At Klang work was commenced in 1901 by extensive clearing of undergrowth, followed by drainage in the next year. The swamps in the town were rapidly filled in, and a contour drain to intercept the inflow from the surrounding hills was cut. At Port Swettenham forest and mangrove swamp were felled, and a complete drainage scheme, prepared by the state engineer, was carried out. In both towns, pending completion of the drainage, mosquito brigades were appointed; and their employment was extended subsequently under the name of "town gardeners." When the epidemic had already begun to subside, wire gauze was supplied to many of the houses, and an active quinine distribution was commenced. All the measures have been well maintained since then.

As regards cost, Mr. Travers and Dr. Watson state that at Klang it amounted at the end of 1905 to a total of £3,100, with an annual expenditure of £210 for town gardeners and of £60 for clearing drains. For this money 332 acres (134 hectares) have been dealt with, including virgin jungle, dense secondary growth, and swamp. At Port Swettenham the total cost has been £7,000 to the end of 1905, with an annual upkeep of £140. For this 110 acres (45 hectares) of mangrove swamp were drained, and a considerable area has been levelled, partly to provide building sites. The cost per head of population has therefore amounted to about £1. 4s. up to the end of 1905—a very small charge considering the heavy rainfall and the dense vegetation of the country. These towns did not possess the exact statistics of Ismailia for a long period previous to the campaign. Great credit is therefore due to Dr. Watson for the care and skill with which he has determined the results of his measures. The following table is compiled from the figures given by him :—

RESULTS OF THE ANTI-MALARIA CAMPAIGN IN KLANG AND PORT SWETTENHAM.

(From the *Journal of Tropical Medecine*, July 2nd, 1906, by Mr. Travers and Dr. Watson.)

Population of Klang and Port Swettenham about 4,000 in 1901 and now largely increased. District population 14,000 in 1901. Anti-malaria campaign commenced (only in Klang and Port Swettenham) in 1902.

1.—*Cases of Malaria admitted to Klang Hospital from the Two Towns compared with those admitted from District.*

Years	1901	1902	1903	1904	1905
Towns	610	199	69	32	23
District	197	204	150	266	353

2.—*Deaths in Klang and Port Swettenham.*

Years	1900	1901	1902	1903	1904	1905
Fever	259	368	59	46	48	45
Other diseases	215	214	85	69	74	68

3.—*Deaths registered in District, excluding Towns.*

Years	1900	1901	1902	1903	1904	1905
Fever	173	266	227	230	286	351
Other diseases ...	133	150	176	198	204	271

4.—*Infected Children in Towns and District.*

November and December, 1904.

	Klang.	Port Swettenham.	District.
Children examined	173	87	298
Children infected	1	1	101

November and December, 1905.

Children examined	119	76	247
Children infected	1	0	59

5.—*Sick Certificates and Sick Leave granted to Government Employees.*

(Numbering 176 in 1901 and 281 in 1904.)

Years	1901	1902	1903	1904	1905
Certificates	236	40	23	14	4
Days of leave...	1,026	198	73	71	30

To these figures Dr. Watson adds that so great has been the reduction of the malaria that he has lost a large part of his private practice as District Medical Officer. Regarding the reduction of mosquitoes, he remarks :—" A definite improvement in the health of Klang was evident when only the swamps nearest to the main groups of houses had been dealt with, and while other swamps within the town were still untouched. The mosquitoes from these did not appear to travel any distance, and there has been no evidence of dangerous immigration of Anophelines from the extensive breeding places which, until the middle of 1904, existed just outside the town boundary, and some of which still remain. Yet the species breeding in these swamps were identical with those breeding within the town"

The objection raised against the campaign at Ismailia—namely, that it possesses a dry soil and climate—cannot be raised against the well-conducted campaign of the Federated Malay States, and the world owes a debt of gratitude to the Government of these States, to Mr. Travers, and especially to Dr. Watson, for the fine example which they have set.

(3). *Hong Kong.*—One of the earliest and best of the campaigns in British territory. The city of Victoria, usually called Hong Kong, runs for nearly five miles along the north of the island of that name at the mouth of the Canton river in South-east China. The island, 11 miles long and from two to five miles broad, consists of a broken ridge of hills, rising to nearly 2,000 feet, and the city is built on a hill sloping down to the water, some of the terraces and houses being 500 feet above sea-level. There is also a large residential district on the mountains reached by a cable tramway. The soil is granitic. All along the face of the hill on which Victoria is built there are beds of streams, known as "nullas," which used to swarm with anopheline larvæ. The population of the colony was 377,850 in 1905, of which 10,835 were whites (nearly half belonging to the British Army and Navy). The rainfall is from 70 to 80 inches a year. Malaria has been always very prevalent here, and I remember that in 1881 the colony was cited as an example of the telluric miasma due to decaying granite. The first researches on the new lines were commenced as early as May, 1901, by Dr. J. C. Thomson,* who undertook an exhaustive study of the mosquitoes and their breeding-places. He examined over 32,000 specimens, of which he found about 4 per cent. to be Anophelines, and in November advised an active anti-malaria campaign by drainage, clearing of jungle, "training" of the nullas, the use of wire gauze, oiling pools, and quinine prophylaxis. As seen by his excellent papers,† his recommendations were not of a general

* Thomson: The Distribution of Anopheles and Culex at Hong Kong. *Brit. Med. Jour.* 1901, vol. i., pp. 749 and 1379.

† Ibid.: Malaria Prevention in Hong Kong. Official Report, containing many letters, 1900-1903.

nature, but were particular, practical, and exact. These recommendations were rapidly acted upon by the Government. Since 1901 all the nullas or water-courses within and near the city were "trained" —that is, rendered so smooth and even that the Anophelines could no longer breed in them; and much similar work was done wherever most needed elsewhere by training water-courses, buying up rice fields, and so on. The details of the campaign are so numerous that it is impossible to give them here. They will be found in the publications given in the bibliography and in a good paper by Mr. J. M. Young,* who took part in the early stages of the work. The results are given in the annual sanitary reports of the colony and in a recent address by the medical officer of health, Dr. W. Francis Clark.† Dr. Thomson informs me that before estimating them it is necessary to remember that malaria can never become extinct in Hong Kong owing to the fact that some 3,000 to 4,000 natives come and go from and to the country districts every day, and that a number of these will remain infected in spite of all local measures. Nevertheless the figures show a rapid diminution both in the admission and in the death-rates.

MALARIA STATISTICS OF TWO LARGE HOSPITALS.

Years	1897	1898	1899	1900	1901	1902	1903	1904	1905
Admissions	1,021	865	780	1,220	1,294	752	568	433	419
Deaths	197	126	63	163	132	128	63	58	54

ADMISSION RATE OF POLICE FOR MALARIA.

Years	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905
Admission, % ...	32	25	19	31	42	44	19	18	11	12

DEATHS FROM MALARIA.

Years	1896	1897	1898	1899	1900	1901	1902	1803	1904	1905
Population ...	239,419	—	—	—	—	—	—	—	—	377,850
Total deaths ...	533	554	530	546	555	574	425	300	301	285
Deaths in city (Chinese only) ...	290	302	280	218	242	281	189	152	90	87

The official sanitary reports give similar figures. The improvements have, of course, varied much in different localities. Thus in 1900 the western end of Bonham-road used to be one of the worst

* Young: The Prevention of Malaria at Hong Kong. *Brit. Med. Jour.*, 1901, vol. ii., p. 683.

† Clark: An Address on the Prevention of Malaria in Hong Kong. Noronha & Co., Hong Kong, 1906.

districts. Now in 1905 it is reported not to have sent a single case to the Government Civil Hospital.*

With regard to cost, Dr. Clark reports that up to the end of 1905 the Government had expended about £5,000 on anti-malaria measures, and estimates that £6,500 would be spent by the end of 1906—a small amount to pay for the good that has been done. The campaign in such a thickly populated district must be difficult. A larger expenditure would probably have produced still more marked results, and it would have been useful to estimate the endemic-index in various parts of the area. I am much indebted to Dr. Thomson and also to Mr. J. Bell for the detailed information which they have been so kind as to send me, but which I have no space to give more fully.

(4). *Panama Canal Zone.*—As is well known, the attempt of the French to cut the canal through the isthmus was foiled principally by yellow fever and malaria, and I was told that their effort had cost quite 50,000 lives. The Americans took possession of the works early in 1904, at a time when the mode of propagation and of prevention of both diseases was well known, and they wisely determined to commence their labours with sanitation. Colonel Gorgas, assisted by a capable and enthusiastic staff, was put in charge, and attacked the work with knowledge and energy. I visited the place at his invitation in the autumn of 1904, and was a witness of the skill shown in his dispositions. The country is one of the worst to deal with which I have ever seen. Hilly, with a great rainfall, a loose, crumbling soil, a luxuriant vegetation, and innumerable small marshes and pools, it was evidently the very stronghold of malaria. Step by step, with the aid of numerous experts and hundreds of workmen, the Americans cleared the forests, drained the pools, and banished the *Stegomyia*. The details and the results will be found in the monthly and annual reports of the work† and in a recent address by Colonel Gorgas.‡ Put briefly, the results

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* Reports on the Health and Sanitary Condition of the Colony of Hong Kong, 1900-1905, p. 54.

† Reports of the Department of Health of the Isthmian Canal Commission, Monthly and Annual. Government Printing Office, Washington.

‡ Gorgas: Sanitation in the Canal Zone. *Journal of the American Medical Association*, July 6th, 1907.

are that in 1906, amongst 5,000 white American employees, the total death rate was only 7 per mille, and of this only 3·8 per mille were due to disease. Last April the daily sick rate of the total force of about 40,000 people was only 17 per mille. Colonel Gorgas says :—"Among 6,000 Americans in the employ of the Commission, including some 1,200 American women and children, the families of these employees, we have but little sickness of any kind, and their general appearance is fully as vigorous and robust as that of the same number of people in the United States." These published statements are fully borne out by private communications from individuals living there. Colonel Gorgas adds :—"I think the sanitarian can now show that any population coming into the tropics can protect itself against these two diseases (yellow fever and malaria) by measures that are both simple and inexpensive . . . . ; and that again the centres of wealth, civilisation, and population will be in the tropics as they were in the dawn of man's history."

Sir Frederick Treves, who visited Panama last February, read an interesting paper on preventive medicine there, before the Royal Society of Medicine, Epidemiological Section, on the 22nd May, 1908 (18). Regarding malaria, he said :—"The crusade against malaria has been even more elaborate. Every new arrival on the isthmus is handed a printed circular explaining the cause of malaria and the means of its prevention, and advising the constant use of quinine in doses of at least 3 gr. a day. Quinine is placed on the table in the dining rooms and boarding camps, and large quantities of the drug are distributed broadcast. In the month of September, 1905, for example, 675,000 gr. were dispensed, mostly for prophylactic purposes. A large number of men are kept constantly employed in cutting down the dense tropical undergrowth, in mowing or burning the grass, in making and lining ditches, in filling in swamps, and in oiling the surface of any pool or puddle in which mosquitoes might breed. Others are employed to inspect water tanks and barrels, to destroy such as can be dispensed with, and to screen such as are retained. As an example of the work of the anopheles brigade it may be noted that in 1906, in Colon alone, the surface oiled amounted to 330,000 square feet. New ditches were cut to the extent of 200,000 lineal feet. Of these ditches, 20,000 feet were stoned or cemented. Two million lineal feet of old ditches were cleared, graded, stoned, or filled in. The area of brush and grass cleared amounted to 21,000,000 square yards. Never has a crusade been carried out with such completeness, for never has a chief sanitary officer had so free a hand. It is needless to point out that the mere oiling of pools does not constitute the sole prophylactic measure against malaria. In a well-to-do town in the tropics it may be supposed that the land has been thoroughly drained and every suspected area oiled, but there are still many varieties of vegetation which afford a breeding place for mosquitoes; as instances may be cited pines and such a palm as the traveller's palm. It may be sure that the pine grower will not sacrifice his harvest in the public interest, nor will the wealthy resident allow the palms, which are the glory of his garden, to be cut down. It is much to be hoped that a list will be forthcoming of garden and other plants in which mosquitoes breed. On the Canal Zone no such list was needed. The place denounced was swept bare."

Colonel Macpherson, C.M.G., R.A.M.C., who also has recently visited Panama, informs me that the total cost of the sanitary measure there is 2,000,000 dollars per annum, or about one-tenth of the total annual expenditure on the canal work. This includes the whole medical expenditure.

(5). *Anti-Stegomyia Campaign at Port Said.*—Although *Stegomyia* does not carry malaria, it is such a pest in the tropics that it ought to be attacked if possible. It has been almost completely banished from Port Said by a campaign carried out under the orders of the Governor, Mouheb Pasha, and the recent Director of the Egyptian Sanitary Department, Sir Horace Pinching, by my brother, E. H. Ross. Port Said has a crowded population of 56,000 people of many nationalities; and the insects used to breed chiefly in cellars and cesspits under the houses, the rainfall being small. The cost of removing them amounts to sixpence per annum per head of population. Dengue and other fevers have simultaneously disappeared from the town, and also from Ismailia, where similar work has been done (19, 20).

(6). *Italian and other Campaigns.*—I do not propose to describe these, as the conditions under which they were effected are not very similar to those in the tropics. In Italy there is a white population, close to large cities and with plenty of medical attendance at hand, so that the measures said to be most suitable have been chiefly quinine prophylaxis and isolation. In Greece the campaign has only just begun, and in many other places few statistics are available.

24. **PRELIMINARY CONSIDERATIONS REGARDING PREVENTION.**—At the beginning of section 22, the various measures for public malaria reduction were given as (*a*) mosquito reduction, (*b*) case reduction, and (*c*) isolation. It is obvious that any one of these, if completely carried out, must result in the complete suppression of endemic malaria in any locality. Unfortunately, however, public funds are limited, and the question arises, which of these measures will give the best results for the least expenditure?

The subject is a favourite one for discussion at medical conferences, but the conclusions are not always useful, owing to frequent inexperience in some of the speakers. Yet during the last ten years we have acquired considerable experience regarding the utility and feasibility of the various measures; and, I think, the men who have actually done the work—Gorgas, Pressat, Watson, and others—are agreed as to which are best.

The answer to the question is, of course, much modified by local conditions. Of what race and degree of intelligence are the inhabitants? Are we dealing with cultivated or uncultivated rural areas; with villages, towns, or cities? What is the rainfall? Does it fall mostly in summer or winter? Is there a sharp winter, or an arid summer? Is the ground flat, or gently or abruptly sloped? Is it pervious or impervious, high or low, forested or bare? What are the crops, and how are they watered? Are the people wealthy or poor? How are they housed? What are the methods of communication? Is there sufficient medical attendance? Is registration of death good? Is the form of government arbitrary, political, or practical? Has the medical profession any influence in it? And, above all, what is the state of the public purse? It is advisable to begin with some general remarks.

(1). *Form of government.*—It should be understood at once that with certain forms of government real malaria reduction is simply out of the question. I refer not only to the uncivilised despotism, but also to what is frequently worse, the small uncontrolled municipality, and minor "free" elected government. Every sanitarian recognises at a glance the unfortunate territories ruled by such. The ill-made roads and gutters ; the crumbling walls ; the dirty unpainted houses, built anywhere and anyhow ; the foul yards, with noisome latrines, and littered with rubbish ; the leaking water-pipes ; the choked street drains, converted into cesspits ; the idle police ; the scanty workers, and the numerous officers. We can see at once that the funds which should be devoted to making the place tidy, clean, and healthy for the good of the public are being diverted to other uses. The public councils and offices are the prey of persons who gain their position by advertisement, and who know and care nothing about management ; and order, discipline, and science are unknown, while the councillors pretend to quarrel over childish political issues which have long ceased to interest educated persons. To appeal to such to carry out a sustained anti-malaria policy is quite futile. No such body, so far as I know, has ever yet attempted this task. As Sir Frederick Treves points out, the great work at Panama is due simply to the strong scientific form of government in force there. If, then, any real sanitary work is to be expected, the form of government must be such that defaulting local authorities can be forced to attend to the duties for which they were appointed—foremost among which is sanitation.

(2). *The first preliminary to success.*—Granted then that we have to deal with a rational and practical form of government, the first step for that government to take is to decide definitely whether or no it really intends to attack the disease. Sanitation is a form of war. It requires money, discipline, organisation, and thought. A scientific government recognises that widespread disease is a great bar to prosperity, and can be fought only by concerted measures, which are mostly beyond the powers of the individual citizen, and must be, at least, directed by authority. On the other hand, it is the guardian of the public purse, and must refuse to sanction expenditure which may lead to no result. It must therefore begin by obtaining an estimate of the amount of mischief produced by the disease, and of the cost of reducing it thoroughly. Obvious as this principle is, it is frequently, if not generally, neglected ; no real efforts are made to measure the disease (as described in section 19) ; and the efforts made to reduce it are often merely nominal, and consist only of popular lectures on mosquitoes and rules about placing wire gauze on water-butts.

(3). *Necessity for repeated measurements of malaria.*—Not only should the disease be measured to begin with, but the process should be repeated regularly in order to ascertain whether the preventive measures, whatever they are, are producing the desired effect. With organisation, the spleen test can be applied once, if not twice, a year without serious difficulty. The authorities can thus obtain data to justify their expenditure, and can also ascertain which localities most require it. Without such methodical estimates, the anti-malaria campaign may show no tangible results, even if they exist, and will probably be abandoned before long.

(4). *Limits of expenditure on anti-malaria work.*—Theoretically it would be justifiable to spend as much money for the prevention of malaria as the disease costs the community. It is a great source of waste of money (*a*) by deaths and reduction of population ; (*b*) by loss of manual labour in plantations, factories, farms, &c. ; (*c*) by sickness among government labourers and officers ; (*d*) by invaliding and deaths among higher officials and soldiers (annexure 1). Practically, however, governments must be limited, not only by their own revenues, but by that part allotted to the medical and sanitary budget. Perhaps the best estimate under this head may be formed by comparing the total amount of sickness due to malaria with that due to all causes—generally a large percentage. It may be argued, for instance, that, if malaria causes one-third the total sickness, then one-third the medical budget should be expended on its prevention. This would be scarcely fair, as other diseases often produce a greater mortality though less sickness ; but the argument helps to put the matter in a clearer light. In many countries, while the total expenditure on medical staff, hospitals, dispensaries, conservancy, sewerage, water-supply, quarantine, registration, &c., is great, that on the prevention of malaria, which may cause nearly half the total sickness, may be almost nothing. Yet it might be urged that if malaria could be banished, the people would really receive more benefit than by most of the other sources of expenditure put together. Both Dr. Meldrum and Mr. Chadwick have touched upon this point.

(5). *All measures against malaria must be continued indefinitely.*—It is well that this should be understood clearly to begin with. The work, if it is to be anything but a futility, will be a permanent burden upon the estimates. It might be possible, I think, to extirpate the disease entirely from an island like Mauritius—but this could be done only at greater cost than is likely to be faced at present ; and even after that, very stringent quarantine measures would have to be taken to exclude infected immigrants. But with good organisation the disease can, I consider, be so largely reduced that many items of the cost of the campaign will also ultimately diminish—perhaps very largely. That is all that can be promised. At the same time the cost to Government ought to be recouped by saving to the public, and consequent addition to revenue.

(6). *Some legislation and discipline necessary.*—Although much anti-malaria work can be done without troubling the public, yet, if it is to be done with economy, the public must be called upon to take their share of the burden as well as of the advantages. Certain petty laws and regulations are necessary, and the public must comply with them. One of the most serious difficulties in the way of all sanitary improvement everywhere lies in the inadequacy of punishment often given by magistrates for sanitary contraventions. Fines are too small to be deterrent ; endless petitions are allowed ; and the time of the sanitary departments, which should be spent on useful work, is used up in attending courts and writing up cases—a simple waste of public funds. This is not freedom but licence. It is a very low form of civilisation in which individuals are allowed to abuse the freedom which civilisation has given them by poisoning or infecting their neighbours. If those who make and administer the laws were called upon to sit by the side of dying patients, as medical men too often are, and to watch the effects of the bereavements that follow, they would not so often treat these serious offences as jests or as petty failings. The success of the work at Panama has been largely due to the great powers given to the health department, and to the stringent discipline exerted ; and the public themselves have become thankful for this wise severity. Sanitary discipline is like the discipline of the sick room, against which only the most foolish patient rebels—to his own sorrow.

(7). *Special organisation advisable.*—As already frequently stated, in some countries malaria causes nearly as much sickness as all the other diseases put together. The prevention of it therefore deserves very serious and special attention from the Government. There must be a special working organisation ; and as a rule it should be placed under an officer of the Health Department, purposely selected for his knowledge of the subject and his capacity for scientific administration. He should be ordered to prepare every year a special malaria report, detailing the annual measurements of malaria, and the practical work done by his department. So far as I can see, without some such organisation, the work is not likely to be either general or thorough.

(8). *A firm continuous Government policy absolutely necessary.*—Although many of the successful campaigns mentioned above have been due to the enthusiasm and intelligence of individuals, success is not likely to be continued without a determined policy on the part of the Governments concerned. Permanent success is beyond the power of individuals. If Governments wish for lasting results on a large scale, they must make up their minds to push the preventive measures at all costs. Laws must be enforced, inefficient officials removed, and the proper expenditure incurred, regardless of popular talk. After all, unlike the prevention of plague and cholera, that of malaria gives little trouble to the public; but that is all the more reason why it should be prosecuted with resolution.

25. **THE VARIOUS PREVENTIVE MEASURES CONSIDERED.**—We must now examine the actual preventive measures mentioned at the beginning of last section.

(1). *Isolation.*—Suppose that the number of mosquitoes, and also the number of infected persons in a locality are allowed to remain as before, but that the former are prevented from biting the latter; then further infection both of insects and of human beings would cease.

This means that all the infected persons in a locality are to be isolated from mosquito bites until they recover. Not only this, but infected persons outside the locality, and within the range of immigration of mosquitoes, must be treated in the same manner; and persons entering the locality even for a single night must be examined. This measure may be called *isolation of the sick.*

Again, suppose that the mosquitoes and infected persons are left alone, but that the healthy persons are isolated from mosquito bites. This also would put a stop to further infection; but healthy persons outside the infected locality, and within range of infected mosquitoes coming from it, must also be protected; and so must persons who visit the place even for a night. This measure may be called *isolation of the healthy.*

Either of these methods *by itself* would imply the careful and repeated medical examination of all the persons in a locality, and also of visitors. But it is not always possible to say, even after prolonged microscopical search of the blood, whether a person is infected or not; and many people show the parasites only occasionally when they suffer from relapses. Others remain infected for years, and would, theoretically, have to be isolated all that time. To carry out all the necessary examinations, a large and expensive medical staff would be required. Hence neither measure by itself is, *usually* practicable, but both must be combined in a uniform system of *general isolation* from mosquito bites. There is an exception—the case of a locality in which only a few cases are beginning to occur. Here such cases may be notified and carefully isolated for the sake of the public. The attempt has been made at Durban, but abandoned; and it has often been proposed in America The cases must be controlled with the rigour adopted against plague, yellow fever, or cholera, but owing to the long continuance of the malaria infection, for a much longer period.

General isolation from mosquito bites is attempted by the use (*a*) of culicifuges; (*b*) of clothing; (*c*) of mosquito nets; and (*d*) of screens to the windows.

Culicifuges are medicaments, such as kerosine oil, lavender oil, and many patent fluids, for keeping away the insects. They may act for an hour or two; but the effect soon wears off. It is absurd to suppose that a large general population will ever consent to use such substances every day and night, indefinitely for years. They are useful (?) only for personal prophylaxis.

The same must be said of special articles of *clothing*—gloves veils, boots. Useful at specially dangerous moments, they are never likely to be used generally.

Mosquito nets round the bed at night are the first essential of personal prophylaxis. For years I have depended entirely upon them; and almost everyone of experience in the tropics does the same. I consider that, of all the Anopheline bites which an unprotected person would suffer in twenty-four hours, at least 90 % would probably be inflicted during his sleep at night. Hence, in my opinion, the jealous use of a mosquito net reduces the chances of infection anywhere by 90 %; and though I have been in many malarious places and do not trouble to take quinine, I have only once been infected—and that was before I had ascertained the route of infection. But a small net costs five rupees—the wage of a labourer for ten days in Mauritius. Nets wear out quickly; it is difficult for the occupants of poor huts to use them for themselves, and still more for their children; and they could scarcely be forced by law to do so.

Mosquito proofing, or the protection of whole houses or parts of houses with wire gauze, has long been used in the more southern states of America. It is employed (on a great scale) against yellow fever and malaria in Panama; by Sir William MacGregor and Dr. Strachan in Lagos; and at the Observatory and Central Prisons in Mauritius. "Tinned wire gauze" costs at least twopence a square foot, and brass and copper gauze costs half as much again—besides the cost of construction. The screens are most useful and pleasant. They exclude not only mosquitoes, but other insects and also the glare of the sun and the damp after rain; and they should certainly be used if possible in all public buildings and in good private houses. The cost is, however, prohibitive for the poor classes of house. Some of these, which are nothing but bamboo and leaf shelters, would practically have to be covered all over, at an expense greater than the value of the structure. Thus proofing is generally a measure only for the well to do.

There can be little doubt by sections 11 and 12, that even if a part of the population could be induced to adopt isolation against mosquitoes the result would be great—the new infections might fail to keep pace with the recoveries, and complete extinction of the disease might follow, especially if case-reduction is adopted in addition. Even for the poorest populations then, isolation must not be neglected: and I shall make definite recommendations under this head in section 31.

Isolation can never be complete. People must labour out of doors, where Anophelines frequently bite; nets and screens get out of order; and it is especially difficult to isolate children, the principle homes of the parasites. But for the same reasons as apply to mosquito and case-reduction (section 12), the theoretically complete measure is not necessary. Even partial adoption of it may suffice to break the vicious cycle.

(2) *Punkas and segregation.*—These are measures for the well-to-do. In 1899 I pointed out that Europeans in India are so much more healthy than those in West Africa, probably because they adopt these

measures (1). Even in India their health is better in the large cantonments, where nets, punkas and segregation are generally used, than in the planting districts where they are frequently neglected. This has probably been one of the chief causes of the magnificent success of the Indian empire as compared with the comparative failure of the African colonies. Punkas not only keep the body cool, but also drive away a large proportion of flies, and segregation protects from other diseases besides malaria. Both are forms of isolation.

The latter has been strongly urged against malaria by Stephens and Christophers and by Dutton ; and should be used when possible. Without the other measures, it must be very complete to be effective. It failed at Ismailia ; and also at Vacoas, where last January, seventy British soldiers were infected in the barracks, although the infecting native village is more than half a mile distant (addendum 2). Theoretically it is a class measure, and must be accompanied by restrictions which are difficult to enforce even with regard to troops.

(3) *Case-reduction.*—Suppose that the number of mosquitoes is allowed to remain as before, and that they are not prevented from biting, but that the number of infected persons is reduced by treatment to zero , then further infection must cease.

This means, if cessation of fresh infections is to be immediate, that all infected persons, not only in the locality to be protected, but within mosquito-range outside it, are to be sought out by skilled medical men and treated to the point of complete cure. If gradual reduction is permitted, a more partial measure is still likely to be successful.

The detection of cases can be effected only with the difficulty and expense referred to under " isolation of the sick." To this must be added the difficulty and expense of thorough treatment. I infer in section 6 that each case must be treated for several months on the average in order to extirpate the parasites. Moreover, the bulk of the cases are generally the children of the poor ; and the parents of these must be induced to give them the thorough treatment recommended. Repeated examinations will also be necessary ; and infected immigrants must be dealt with—a great difficulty in some cases, for instance that of market towns. For all these purposes a considerable medical staff is necessary, requiring a constant expenditure.

(4) *Quinine prophylaxis.*—This is really a form of case-reduction. To the person who takes it quinine is not exactly a prophylactic It does not exclude the parasites ; it merely destroys them in some cases after they have entered the body. For personal prophylaxis it is valuable at times of danger ; but as a measure of public prophylaxis it is difficult. We urge, in fact, that every healthy person in a locality shall take the drug continuously in the expectation that he might at any moment be bitten by an infected Anopheline. We thus attempt to provide for case-reduction among the newly infected, as distinct from the old declared infections. But the perpetual use of quinine is always trying to the system, while the contingency of being bitten by an infected mosquito is not always certain ; and many people will prefer the risk of malaria to the certainty of dyspepsia and other symptoms produced by quinine. Moreover I infer, though I am not sure, that as large doses must be taken to quell a new infection as to check an old one—that is, that the prophylactic dose must be as large as the therapeutic one. It is therefore difficult to persuade a large population, consisting let us say of poor labourers, to adopt such a measure continuously. For officials and soldiers it is generally possible ; but even then is objected to.

On the other hand, the general quinine treatment of a whole population, both sick and healthy, saves the trouble and expense of constant medical examination, though it adds to the amount of the drug used. But this difficulty may also be removed by a form of case-reduction, which I shall presently propose for Mauritius—namely the treatment of children with enlarged spleens.

(5) *Anopheline reduction.*—Suppose that the number of cases is allowed to remain as before, but that the Anophelines are banished, then further infection must cease.

This implies, if cessation of infection is to be immediate, that every breeding place of the insects within the area to be protected and also within mosquito range outside it is to be abolished. But a less thorough measure is still likely to produce more gradual reduction (section 12).

Mosquito-reduction is based on the certainty that if the birth-rate of the insects within a given area is abolished, their numbers will be reduced, not only in that area but for some distance round it; and will consist hereafter only of chance immigrants from without. The amount of the reduction will vary as the size of the area treated. The birth-rate is abolished or reduced by complete or partial treatment of the waters in which they breed; by drainage, deepening or filling of marshes and pools by dragging out the water weeds; by "training" the banks of streams, by introducing fish, using oil and other measures. All this requires (*a*) a capital expenditure and (*b*) an annual expenditure; and can be effected only by a special organisation indefinitely continued. The expense will vary largely according to local conditions.

By section 12, malaria will not continue in a locality unless the carrying Anophelines are above a certain standard in number. Hence absolute suppression of the insects is not necessary; and a mere reduction below the standard should suffice to produce gradual decrease.*

Practically, Anopheline-reduction may be merged in general *mosquito-reduction*, which costs little more to effect; and adds greatly to the advantages of the measure.

(6) *Public instruction.*—Lectures and pamphlets, though frequently repeated, are never attended to by more than a minute proportion of the public; and even school lessons are soon forgotten. Again, of those who have actually listened to instruction, very few trouble to act upon it. Numerous lectures and pamphlets on malaria will scarcely succeed, perhaps, in inducing one *per cent.* of the public to be more particular in the use of nets, to take a little quinine for a few weeks, or to collect broken bottles and tins in their back yards; and in this I speak from frequent experiences. More than these things, the private individual can scarcely do. He cannot undertake either case-reduction or mosquito-reduction in his neighbours' houses; nor force them to adopt isolation. It is well therefore to give public instruction on these matters; but the authorities must not hope to banish, or even seriously to reduce, malaria by this means alone. To do so is to abdicate public prophylaxis altogether—to attempt to throw on the individual the duties which can only be done by the State. Of course the individual must take his share of the work, but it must be in the form of part payment of the expenses of the concerted measures adopted. Public instruction by itself is as useless against malaria as against plague and cholera.

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* See page 148.

26. THE VARIOUS PREVENTIVE MEASURES COMPARED.—On comparing the above measures, the first consideration which must strike the practical sanitarian is the following. Isolation and case-reduction require compliance on the part of the public; mosquito-reduction does not. To use culicifuges and mosquito-nets; to put screens to the windows and verandahs; to take quinine day after day; to force one's children to take it; to attend dispensaries for the drug; and to submit to constant inspections; require an endless amount of trouble on the part of thousands of people. Will the people take the trouble? What can be done by poor labourers who must be at work at daybreak; or by their wives who labour equally at household affairs? Have they the time to wait for hours at the dispensary, or to rub unguents all night on their children; or the money to buy mosquito-nets? And to enforce attention to such details requires equal trouble on the part of the authorities—an army of inspectors and medical attendants, and an armoury of laws and regulations. What practical sanitarian is there who does not recognise what all this would mean—endless trouble, expense and perhaps friction with the people? On the other hand no one objects to the drainage of swamps and clearing of watercourses, which can be done at once by the authorities without (as a rule) troubling anyone. Here then an immense advantage—which will be most apparent to those most experienced in sanitation—lies with mosquito-reduction.

Next, case-reduction guards against malaria only; but isolation and mosquito-reduction against all mosquito-borne diseases—filariasis, yellow-fever, and probably dengue and other fevers. Here then, case-reduction is at a disadvantage.

Again, isolation gives only partial and temporary respite from mosquitoes; mosquito-reduction, where thoroughly carried out, a much greater security. The presence of many mosquitoes, especially *Stegomyia*, is a perfect curse in the tropics. One is bitten all day and everywhere. To get rid of them—even to reduce them—is a great boon. I remember Port Said before and after this was done; and many people have told me of the blessing conferred by the campaign at Ismailia—quite apart from the reduction of malaria. Here then, mosquito-reduction again has the advantage.

Lastly, mosquito-reduction has a great general sanitary advantage which is not conferred by the other measures. It forces the sanitary department to maintain always a minute inspection of the area in its charge—to keep the yards free from rubbish, the waterways open, the drains free, the cisterns clean, the gardens and open spaces dry. It tends therefore to become a kind of general insurance policy for good sanitation.

Hence, theoretically, mosquito-reduction has the advantage in every way. It does not demand trouble and direct expense on the part of individuals. It does not require the continued use of a nauseous and dyspepsia-giving drug. It can be enforced by the authorities without troubling the public. It protects from other diseases besides malaria, and also from a general source of annoyance; and it helps the whole cause of sanitation.

Practically however, questions of cost and feasibility have to be considered. It is almost impossible to give an estimate of the cost of mosquito-reduction, which must depend everywhere on the nature of the soil, the slope of the ground, the rainfall, the vegetation, the existence of large marshes, the character of the drainage and of the sanitary establishments already in use, and so on. The figures for Ismailia and the Federated Malay States include large items in excess of the actual anti-mosquito campaign, and those for Panama cannot be obtained. At Port Said the *Stegomyia* reduction (complete) costs about sixpence per head of population per annum (section 22). But those who imagine that the other measures will cost much less are mistaken.

Consider for example the case of a small town in the tropics containing, let us say, 2,000 tenements and 10,000 inhabitants of all classes—that is, mostly poor and coloured people. To supply them all with ordinary muslin mosquito-nets would cost several thousand pounds, and several hundred pounds a year for depreciation, besides a constant outlay for inspections. Wire gauze to the houses, even to the better-class houses alone, would add vastly to this expenditure. Free quinine distribution, at the rate of eighteenpence per ounce of the drug would cost perhaps £500 a year, if done generally, without including the large expense of the medical establishment necessary, and the endless trouble caused to the inhabitants. It is quite possible that mosquito-reduction for the whole place might be effected in many cases for a fraction of this expenditure. Thus for Ismailia, Pressat reports emphatically that he was able to do the essential work with only four men! For £500 a year—which would probably be much less than the cost of medical attendance, quinine, mosquito nets, and wire gauze—we could employ in Mauritius a staff of thirty or forty workmen to keep the waterways clear during the whole year, without troubling the inhabitants at all. I have no doubt which alternative would be chosen by a health officer of experience. Of course, the case may be different where there are large marshes with difficult outlets; but even here drainage may often be recouped by enhanced value of land for buildings, sites, &c., as in the Federated Malay States.

For larger towns and cities the case is even more clear. As a rule the cost of Anopheline reduction must vary directly as the size of area dealt with; though in crowded towns it may often be less, owing to so much of the space being occupied by houses and streets. Hence, by draining a square mile of city we shall benefit thousands of people; whereas by draining the same extent of open country we might benefit only a few houses. That is to say, the cost of Anopheline reduction varies as area, not as population. But the expenses for isolation and case-reduction vary as population and not as area. Hence, I enunciate the following general law; *the greater the density of population, the greater the advantages of mosquito-reduction per unit of cost.*

In rural areas mosquito-reduction may not be nearly so advantageous. Many absurd statements are made on this point by people who have never considered the subject properly, and who seem to imagine that the measure is proposed for the world in general. No one has ever made such a suggestion. Mosquito-reduction is for the city, the town, and perhaps the village; not for the wilderness. We do not propose to drain forests and fields for the good of the birds and beasts. For isolated houses, quinine, isolation, and treatment of small neighbouring waters, if possible, are called for; but larger works can be indulged in only by rich house-owners, not by the authorities.

Also in small towns and villages situated in the midst of large marshes, or marshy forests, or flat waterlogged country, the cost of mosquito-reduction may be too great. This must not be assumed hastily, without preliminary trials on a small scale; but, assuming this to be so, resort can then be had to the other measures.

On examining such considerations we shall see that for a large-scale public malaria campaign amongst a general population we are practically reduced to two or three measures. Such measures as the use of culicifuges, mosquito-nets, house-proofing, punkas, segregation, quinine prophylaxis for the healthy, cannot really be forced on the whole population. The campaign must depend upon mosquito-reduction, treatment of the sick, especially the children with enlargement of the spleen, isolation in certain localities only, and regular measurements of the amount of the disease.

Hitherto, for convenience of comparison, I have considered each measure separately, but obviously two or more may be combined. Instead of carrying out each measure by itself completely, it might be cheaper to carry out two measures partially. This will be more clearly understood by a study of section 12. For instance, a partial mosquito-reduction combined with a partial case-reduction would be likely to have excellent effects. But it is fruitless to consider further such details as these in connection with the general subject, as they obviously depend on local conditions.

27. **THE GENERAL PREVENTIVE MEASURES SELECTED FOR MAURITIUS.**—I will, therefore, now proceed to choose the measures which, in my opinion, are likely to do most good in Mauritius for the expenditure of money and labour involved. They are the following :—

(1) A periodical spleen census of children in schools and on estates.

(2) Treatment of children with enlarged spleen in schools and on estates, and a certain amount of quinine distribution.

(3) Occasional house protection.

(4) Mosquito-reduction where advisable, (*a*) by minor works, and (*b*) by major works.

(5) A suitable organisation and an annual malaria report.

Before proceeding to state the details, I should like to premise that I do not wish to make rigid recommendations regarding them. Experience will doubtless suggest many useful modifications which may safely be left to the future.

28. **THE PERIODICAL SPLEEN-CENSUS.**—The *objects* of this will be to determine,

(1) The localities most affected by malaria ;

(2) The effect of the preventive measures ;

(3) The children who require treatment.

The *proposals* are as follows :—

(1) That a register of all children of fifteen years or under with enlarged spleen be kept at each school by the schoolmaster, and at each estate hospital by the dispenser.

(2) That this register should contain the age, sex, and name of the parents of each child with enlarged spleen (but not necessarily of the other children) ; with columns for noting whether the enlargement is small, medium, or great, and a column for remarks.

(3) That an examination of all the children attending each school, or living on each estate, should be made every quarter of the year (for the present) by the appropriate medical or sanitary officer.

(4) That at this examination the medical officer should select all the children with enlarged spleen, and should direct the proper entries to be made in the register.

(5) That twice a year (for the present) the figures in the register of each school or estate hospital should be collected by the schoolmaster or dispenser, and that the result should be forwarded, countersigned by the medical officer, through the proper channels to the Medical and Health Department.

(6) That this half-yearly report should give the total number of children attending the school, or on the estate, and the number of children with small, medium, or great enlargement of the spleen.

(7) That the half-yearly reports of all the schools and estates should be collected by the Malaria Authority of the Medical and Health Department, and submitted in the form of Table IV of this report to Government (twice a year).

(8) The half-yearly reports should be submitted for June and December of each year ; that is, after and before the annual malaria season.

(9) For the *estates*, the half-yearly reports should also give the total number of infants of two years of age or under on the estate, and the number of these suffering from enlarged spleen.

(10) The half-yearly reports may also contain remarks by the medical or sanitary officer on the number of the children with enlarged spleen, who, in his opinion, were probably infected at a

distance from the school or estate; and on any local sources of infection which he thinks may exist.

Remarks.—The census here recommended will evidently be made on the lines of that already taken for me by the Health and Immigration Departments (section 20); but will be still more exact. The quarterly examinations are required for the purposes of treatment advised in the next section; and the half-yearly reports for the purpose of giving Government repeated and correct measurements of the amount of malaria present throughout the Colony. The quarterly examinations should, I suppose, be made, on the estates, by the medical officers of the estates; and, in the schools, by the sanitary wardens, according to the discretion of Government. I do not propose that they shall all be made on the same day or even in the same month. So long as they are made once a quarter, the exact date may be left to the convenience of the examiner. I fear that a certain amount of trouble may be caused; but, owing to the rapidity with which children can be examined for enlargement of the spleen, it will not be much; and as soon as the registers are in order it will become less. The information given will be invaluable for the campaign; and I do not think that any other country will have made such an attempt to obtain it.

The *infant spleen-rate*, mentioned in (9) above, will be particularly useful, as it will afford a very correct estimate of the *infection-rate* on each estate. The percentage of infants, who become infected within two years, will be a good measure of the chances of infection in the locality in that period. I regret much, that I omitted to ask for this information in connection with the spleen-census just taken.

The first census under this scheme may I think be carried out in September of this year; so as to prepare for the next malaria season.

29. **TREATMENT OF CHILDREN IN SCHOOLS AND ON ESTATES.**—This measure is the most feasible kind of case-reduction for Mauritius. Its *objects* are,

(1) To improve the health of the individual children;

(2) To prevent them from becoming a source of infection to others.

Children are the principal homes of the parasites, and can be treated more methodically in schools and on estates than elsewhere.

The *proposals* are as follows :—

(1) That the examining medical or sanitary officer shall, at each quarterly inspection, indicate the children with enlarged spleen who should be given quinine, and the dose for each.

(2) That the quinine should be regularly given to the children for whom it is ordered, by the schoolmaster in the case of schools ; and by the dispenser in the case of estates.

(3) That at the next quarterly examination, the examiner shall indicate the children who, he thinks, are now cured ; and also any children who, he thinks, have become infected since the last examination.

(4) That he may also order quinine for children who show no enlargement of the spleen, but who, he thinks, are infected, or likely to become infected.

(5) That the quinine be given gratuitously (at least in Government schools); and may be discontinued by order of the medical officer for a child with whom it is found to disagree.

With regard to *dosage and mode of administration of the quinine*, I would advise that the matter should be left largely in the hands of the medical officers, whose skill will be well proved by the results of the quarterly inspections. They should however report generally in their half-yearly returns on the special system of treatment adopted by them.

Personally I have always preferred small and frequently repeated doses to occasional large ones—which is also Professor Celli's view. The former method does not disturb the health of the patient so much, and appears to be equally effective against the parasites (which do not seem to become resistant as trypanosomes do against atoxyl). School children may be given a small dose by the schoolmaster every morning on coming to school ; and it is perhaps particularly necessary to guard against upsetting them by over-doses. But for children on estates, who must visit the hospital specially for the purpose (it is not safe to trust parents to give it) a larger dose two or three times a week would certainly be more convenient. A very useful scale of daily dosage is at the rate of one grain of sulphate of quinine (or its equivalent in other salts) for every three years of age, or rather, of bulk appropriate to age. For dosage twice or thrice a week, one grain for every two years of age is a good scale. I am not much in favour of quinine chocolates, and the like. The form which appears to me the most convenient in every way is that of the freshly made pill, or other form of bolus, which can be swallowed with water without leaving much taste. Each school may be supplied with large bottles or canisters, one containing pills of one grain, the next pills of two grains, and so on. Perhaps it would be safer not to allow pills of more than three grains of quinine for schools. The younger children may be bribed by the present of a sweet to be given after the pill.

With the proposed system (unless a better one can be devised) the examining medical officer visits the school only once a quarter, and must consequently instruct the schoolmaster as to what he should do during three whole months. It may not be considered advisable to dose the children every day during these three months—though this might, I think, be done without danger. In such case it may perhaps be advisable to order that the drug be given only during the first fortnight of each month. For the estates, which are visited frequently by the medical officers, the matter may safely be left to them.

The drug may perhaps be given for more days during the malaria season ; but should not be stopped during the non-malarious, cool season, which, I think, is a very good time to extirpate the infection, especially in the older cases with enlarged spleen.

Further details, and modifications of the system here proposed, must be left to the Medical Director.

30. **OTHER QUININE DISTRIBUTION.**—The *object* is to make as great a reduction as possible in the number of cases of malaria in the colony, with a small expenditure of money.

The *proposals* are as follows :—

A. *For towns, villages and isolated houses.*

(1) That five "Quinine Dispensers" be appointed to distribute the drug among the sick by means of house to house visitation ; namely one for Port Louis, one for Pamplemousses and R. du Rampart Districts, one for Moka and Flacq Districts, one for Grand Port and Savanne Districts, and one for Plaines Wilhelms and Black river Districts.

(2) That these men be duly qualified dispensers, acting under the Malaria Authority in the Medical and Health Department.

(3) That each dispenser shall be stationed at a convenient centre in the area allotted to him, and shall spend the whole of his time in house to house distribution of quinine to those who, he thinks, require it.

(4) He shall be provided with a small portable case, which he himself can carry, containing a day's supply of the medicine.

(5) The case shall contain six phials or canisters filled with quinine pills of half a grain, one grain, and two, three, four and five grains each; pills of different sizes being placed in different phials.

(6) He shall also be provided with a uniform, or an official badge.

(7) On coming to a house he shall offer the quinine gratis to all persons who suffer from fever or enlargement of the spleen.

(8) He shall not demand or take any payment whatever, either for medicine, or for his advice.

(9) He shall advise each person who accepts the quinine to take one pill every day, just before the morning meal, and shall give at one time to each person enough quinine for not less than seven days and for not more than fourteen days.

(10) The doses given should be as follows:—

Age in years	1	1–3	3-6	6–9	9–12	over 12
Age in grains	$\frac{1}{2}$	1	2	3	4	5

(11) He shall visit most frequently the most malarious localities, according to the direction of the Malaria Authority.

(12) He shall not be debarred from giving the quinine, in the doses and to the amount laid down, to any person who demands it, provided that he thinks the person is suffering from fever or enlarged spleen, or is in imminent danger of becoming infected.

(13) The Quinine Dispensers shall be well instructed in their duties; in a knowledge of malaria in general; and in examining persons for enlargement of the spleen.

(14) They shall report briefly on their work once a month.

B. For the Estates.

(1) Every adult on any estate who is known to be suffering from malariai fever or enlargement of the spleen shall be treated in

hospital, or given enough quinine to be taken in his own home during not less than seven days and not more than fourteen days.

(2) The treatment of every such case, either in hospital or out of it, shall not be discontinued until the medical officer thinks that the person has been completely cured of the infection ; unless good reason is shown for discontinuing it (see section 6).

(3) If possible, a report should be made every half-year of the total number of different persons on each estate who have been treated for malaria during the half-year—this report to be included in the one advised for children in section 28 (6).

C. Preparation and despatch of quinine pills.

This will have to be done, I presume, by special workers at the Medical Stores ; but I would prefer to leave details to the Medical Department. The pills should be as fresh as possible, and should be despatched in bulk to the various destinations. I venture to deprecate any demand for detailed returns regarding their issue by schoolmasters and dispensers, as such returns cause much trouble, which will result only in decrease of the issue. Leakage will be better ascertained by comparing the amounts issued by a schoolmaster or dispenser with the number of persons to whom he has given it, as returned in the half-yearly reports. The pills had better be supplied in large numbers in order to save the trouble, expense, and delay of asking for and sending small parcels. Efforts should be made to distinguish Government quinine by a certain colour, as done in India ; or by stamping the pills or other preparations. The authorities must guard against the possibility of their quinine being subsequently retailed to purchasers, or even exported. Too many precautions, however, will have the effect only of ruining the whole scheme, the object of which is wide distribution, for the sake of saving a few pounds of the drug. For the same reasons, efforts to sell it to the well-to-do, while giving it away to the poor, are likely to be futile. The cost of collecting the money will probably exceed the profits, and the trouble of doing so will limit the distribution. Government must, I fear, face a certain loss from leakage, which should be looked upon as an unavoidable part of the general cost of the campaign.

Remarks.—A system has already been in force in Mauritius since 1904 by which the drug has been sold or given away by the masters of thirty-five government schools. They have been remunerated at the rate of Rs.30 per annum, for which they kept an accurate register of expenditure of quinine and receipts by sale. During the first eight months of 1907 only 3,803 applications for the drug were made; and since the commencement of the scheme only about 35 lbs. of it altogether were issued (from 1904 to the end of 1907), although it was given to the general public as well as to sick children attending the school. This amount is insufficient to affect the disease seriously. On the other hand, a dispenser who was appointed to distribute quinine from house to house at Phœnix gave away 20 lbs. of it from January to September 1907. This year, while we were investigating the outbreak at Phœnix, the same dispenser continued this work; and every week visited about 200 houses, and gave away about 19,000 grains (3·3 lbs.) of quinine to about 650 sick, or nearly 30 grains to each. The result, partly of this and partly of drainage, has been, I hear, the rapid cessation of the outbreak. There is therefore no doubt as to which of the two methods, depôt distribution or house to-house distribution, is likely to be more effective. My recommendation to appoint house to house Quinine Dispensers is therefore based on the latter method (devised by Dr. Lorans). In fact, experience proves that the sick poor cannot or will not frequently attend schools and dispensaries for quinine; they must have it put into their hands, or they will not take it at all.

I must therefore advise that the old method of general distribution by schoolmasters be superseded by the new methods given above. The schoolmasters will now distribute only to the sick children attending their own institutions (for which I do not think they can ask to be paid).

The exact number of *five* Quinine Dispensers has been specified somewhat arbitrarily, and only tentatively. Doubtless experience in working may lead to modifications in this and other details.

The Quinine Dispensers may also be used to distribute vermifuges, such as santonine and beta-naphthol, and sulphur ointment for scabies; and generally to "keep an eye" on sanitary matters. They should be appointed in the Health rather than in the Medical Department.

I have said nothing about distribution of quinine at the ordinary dispensaries, as this may be left to the medical officers. I would only suggest that doses for a fortnight or a week at least should be given to out-patients, in order to save them frequent attendances for the medicine.

We must always remember that, if quinine is to be used at all as a general public measure against malaria, it must be *poured out wholesale.* Otherwise it can have little effect.

31. **HOUSE PROTECTION.**—The object of this measure is to exclude Anophelines in localities where, owing to large marshes or much forest, they cannot easily be reduced. I suggest it chiefly as a prospective vicarious measure.

The proposals are as follows :—

(1) That a small committee, consisting, say, of the Director of the Medical and Health Department, the Director of Public Works, the Medical Officer of the Immigration Department, and the Malaria Authority (proposed hereafter), should be appointed to consider if any type of house can be designed which will exclude mosquitoes, and which can be reasonably insisted upon by building laws for future adoption, especially on the estates and for the Indian population.

(2) That the Malaria Authority might make experiments with a few Indians' houses, as they are built at present, to see if they can be cheaply protected by wire or muslin netting.

Remarks.—I have some doubts whether either can be done ; but the attempt would be worth making for places like Post of Flacq or Petite Rivière, where mosquito reduction would be almost hopeless without large expenditure. In such cases this measure, combined with quinine distribution, seems to be the only refuge.

For general sanitary reasons I think it would be highly advantageous to the Colony if better houses could be demanded by the building laws. I always like to state as a sanitary aphorism that people live at the level of their houses. Poor and dirty houses mean poor and dirty people all over the world. To a large extent, the house makes the man. The opportunity may therefore be taken for a new departure in this respect. I can see no reason why coloured populations should not live in better houses in civilised countries.

32. **MOSQUITO REDUCTION.**—The object of this measure is to keep down the number of Anophelines in certain localities, so that new infections caused by them will no longer keep pace with the recoveries, and the disease will consequently tend to die out.

This object is attained by removing as far as possible the conditions favourable to the insects. The works required may be divided into two classes, minor and major works. By *minor works* I mean those which can be continuously carried out without the special services of an engineer, such as the clearing of water channels and drains, release of surface pools, filling of holes, removal of house breeding-waters, cutting of underwood, &c. By *major works* I mean those which require to be designed by an engineer, such as the drainage of some swamps, the canalisation of some streams, &c. By *bonification* of an area, I mean all the works necessary for reducing mosquitoes in it.

The measure is advised, as a rule, only for *densely populated areas*.

The *proposals* are as follows :—

A. For minor works.

(1) That sufficient *Workmen* be continuously employed in the towns and villages, and on the estates, to do and to maintain the minor works.

(2) That a number of men, who may be conveniently called *Moustiquiers*,* be engaged to detect the breeding places of mosquitoes, and to assist otherwise in the works.

(3) That an officer, to be called the *Malaria Authority*, be appointed under the Medical and Health Department to superintend the works ; to advise regarding them and other details of the anti-malaria campaign ; and to draw up an annual report.

(4) That some legislation for facilitating the works be considered.

(5) That some useful administrative adjustments be considered.

B. For major works.

That major works for draining, deepening, or filling marshes, or for canalising streams, &c., be undertaken when funds allow—

(*a*) If such waters cannot be dealt with efficiently or economically by minor works ; and

(*b*) If the neighbouring population is large enough to justify the expenditure.

33. **DETAILS OF MINOR WORKS.**—(1) *Nature of works.*—The habits of *Pyretophorus costalis*, which is responsible for the malaria in

* This useful term was invented by Colonel Peterkin, R.A.M.C., P.M.O., of the troops in Mauritius.

Mauritius, have been well known since 1899, when I described them in Sierra Leone (1). Daruty de Grandpré and d'Emmerez de Charmoy have added details for Mauritius (13, 14), and have stated that the insect "has the same area of dispersion as the malaria." A full account of the habits is therefore unnecessary here. The insects breed chiefly in stagnant or gently running water amongst grass and weeds, and also in holes and pits in the ground, hollows in rocks, cisterns, ponds, "regards" (or pits made in connection with water mains), and so on.

The methods of dealing with them are equally well known; and the Malaria Committee of 1901 has conducted the work absolutely correctly since that date.

In a letter dated the 1st January, 1908, I advised Government to start minor works at once, so that I might be able to assist in training a number of men during my stay in the Colony. His Excellency the Governor promptly allotted Rs.6,000 for the purpose; and with this sum the Medical Department hired ten moustiquiers and ten gangs of three workmen each for the work. These were fairly thoroughly trained by Major Fowler, Dr. Castel, Dr. Keisler, Dr. Ménagé, M. d'Emmerez, myself, and others, and did much useful work before my departure. It is therefore unnecessary to burden this report with laboured descriptions of details. The actual work required may be classified as follows:—

(*a*) Keeping clear of weeds and other obstructions built street gutters and surface drains.

(*b*) Clearing of weeds, levelling, and discharging roadside ditches and channels.

(*c*) Keeping made water channels clear of weeds and pools.

(*d*) Removing grass, weeds, and pools from the margin of ponds and streams, and rough canalisation of the latter.

(*e*) Discharging, filling, or deepening surface pools where practicable.

(*f*) Discharging leakage from standpipes.

(*g*) Filling or oiling certain pits.

(*h*) Concreting hollows in rocks and holes in trees.

(*i*) Cutting undergrowth.

(*j*) Dealing with house waters and other useful work in spare time, especially in the cooler and drier non-malarious season.

(2) *Organisation of workmen in gangs.*—This is better than to allow each man to work by himself. I generally suggest small gangs of three men each ; a headman at eighteen or twenty rupees a month, and two labourers at sixteen or fifteen rupees—the whole gang to cost fifty rupees a month. The headman must do manual work, but must also be responsible for the others on account of his larger salary. In some places larger gangs may be advisable, and it may prove advantageous to appoint headmen of tried capacity on larger salaries for whole localities. Indians of the *mali* class are especially good at this kind of work, and are generally already experienced in it. Two of our gangs drained considerable areas of the Clairfond marsh by themselves. It is astonishing what a large amount of work a gang like one of these will do when constantly employed at it. They will clear in one day several hundred yards of obstructed watercourse, or roughly canalise a long stretch of stream. They become more expert with practice—a further argument for employing them *continuously*.

(3) *Total number of gangs required for Mauritius.*—It is extremely difficult to form any exact estimate on this important point. The details of other countries are useless, as conditions vary so much. Nothing but experience extending over a year or two can decide the question. Moreover, reduction of the gangs may be possible after the execution of permanent or of certain preliminary works.

In a letter dated the 16th January, 1908, I asked Government for information regarding the total length of water channels, open drains, and roadside gutters, and the annual sum spent for the repair, cleansing, and supervision of them. It was not found possible to give exact details ; but I was informed (Colonial Secretary, No 496/08 of 17/2/08) that there were about 800 miles of roadside gutters in rural areas and 296 miles of drains and gutters in towns and villages, or about 1,100 miles in all.

It was still more difficult to ascertain the lengths of streams, number of pits and pools, &c., requiring bonification. I was therefore driven to fall back on the personal opinion of men of large experience in the Colony—perhaps the best course from the beginning ; and in letters to the Colonial Secretary dated the 5th January, 1908, I begged Dr. Lorans, Director of the Medical Department, and Dr. Bolton, Medical Officer of the Immigration Department, to advise me upon the point out of their large knowledge of the local conditions.

Their replies are given in effect in annexure 4, and should be generally looked upon as the basis upon which the work can be started, subject to modifications suggested by further experience.

It will be seen that Dr. Lorans estimates (very roughly, of course) that 104 gangs may be required for the rural districts and extra-urban Port Louis district, at a cost of Rs.62,400 per annum. Dr. Bolton suggests a somewhat different scheme in detail for the estates, for which he required 48 labourers at Rs.16 a month each and 16 sanitary guards (moustiquiers).

Added together, these schemes would require 360 labourers (exclusive of moustiquiers) for the villages, rural districts, and estates of the whole island. In addition to these, gangs would be required for the towns, namely, Port Louis, Curepipe, Quatre Bornes, and Rose Hill and Beau Bassin.

It is very difficult to make a specific recommendation as to the total number of men required. If I place the estimate too high, funds will be wasted ; if too low, Government will be misled as to the cost of the work. But it is necessary that I should state some figures to start with ; and I therefore adopt the conclusion that it is better to ask for a little too many men to commence the work than to ruin it by asking for too few. My suggestions are as follows :—

(4) *Number of workmen required for towns, villages, and populous areas* (*excluding estates*).

Locality.	Number of Gangs.	Annual Cost.
Port Louis town	5	3,000
Curepipe town	3	1,800
Quatre Bornes town	2	1,200
Rose Hill and Beau Bassin town... ...	3	1,800
Port Louis extra-urban	4	2,400
Pamplemousses	10	6,000
R. de Rempart	9	5,400
Flacq	15	9,000
Grand Port...	14	8,400
Savanne	9	5,400
Plaines Wilhems	13	7,800
Black River	10	6,000
Moka	12	7,200
	109	65,400

Each gang is estimated to consist of three labourers and to cost roughly Rs.50 a month. Thus the whole force will amount to 327 men. Dr. Lorans' estimate (annexure 4) is adopted for areas outside the towns. The authorities of the latter should, I think, maintain the thirteen gangs allotted to them.

The estimate is a liberal one, and every effort should be made to economise. Thus I think that the twenty-five gangs for Plaines Wilhems and Moka may soon be reduced, the men being used elsewhere. As a general principle, where the spleen rates are low, less work is called for; but there may be other factors, such as the importance of a locality, which demand more work as a precaution.

(5) *Minor works on estates.*—Owing to the large number ot labourers at their disposal, the managers of the sugar estates and factories should, I think, be able easily and always to effect their own minor works. Many of them told me that they were only too willing to do so, but they did not understand what exactly to do. At Union Vale, Grand Port, we found one morning an obstructed streamlet which was causing the malaria on the estate. Before evening it was cleaned out from beginning to end. Before I left, applications for the services of the moustiquiers were coming in rapidly from the managers, led by the Hon. M. Souchon, the Hon. M. Sauzier, the Hon. M. Dumat, and others. What is fundamentally necessary for the estates is guidance. The managers may be trusted to have enough intelligence to remove conditions which cause them such loss of money (see Dr. Bolton's letter in annexure 7).

What I propose then for the estates at present is that they should be visited frequently by the Malaria Authority and by the Government moustiquiers, who should tell the managers what exactly to do. If the work is not done, the Immigration Department can be made aware of the fact. A manager said to me, " We want no law to force us to eat—nor to force us to get rid of malaria." Of course, if this policy fails, legislation may, if necessary, be adopted.

(6) *The Moustiquiers.*—Ten of these men were appointed, and their functions were well understood before I left. These are—

(*a*) To seek out all breeding places in the area entrusted to them ;

(*b*) To keep a surveillance over the working gangs.

They must all be well trained, reliable men, and should report direct to the Malaria Authority or other superintendent. I recommend that moustiquiers be appointed as follows :—

For Plaines Wilhems	...	...	...		3
Port Louis town and district		...	...		2
The other seven districts	...	..	...		1 each
For the estates ...	...	...	...	...	3

There will thus be fifteen of them. The three men for the estates had better live near the Malaria Authority in order to assist him in his inspections or to be despatched wherever he shall direct. The remainder should live at convenient centres. The men had better mostly be Indians or Mauritius-born Indians of the servant class, who are especially apt at the work. The pay of the junior five may be put at Rs.20 a month ; that of the next five at Rs.25 ; of the four senior men at Rs.30 ; and of the head moustiquier at Rs.35. This would stimulate proficiency. Their salaries would therefore amount to Rs.4,560 altogether. There is considerable risk in the occupation—three of our ten men became badly infected before I left the Colony ; they should, therefore, be provided with mosquito nets. Pans for collecting larvæ and travelling expenses are necessary.

(7) *The Malaria Authority* should be an officer who is thoroughly acquainted with the subject of malaria and also of mosquitoes and their habits. He should serve under the Director of the Medical and Health Department. He will require a clerk and office allowance, but should be troubled as little as possible with the correspondence which paralyses so much work ; and an office in his private house would save much time in travelling. He will require full facilities for travelling. All his time should be spent on superintending and organising the general campaign against malaria, but examination of mosquitoes and other necessary microscope work will constitute a part of his duty, so that he will require the necessary microscopes and appliances (this does not mean a large laboratory). Seeing the great importance of the post, I do not think that the salary could well be put at under five hundred rupees a month. Further details of organisation had better be left to the Malaria and Health Department, but I would earnestly beg that the holder of the post, while he should be held

entirely responsible for success, should be disturbed as little as possible in his important task.

Many of the local gangs could with advantage be put under the immediate superintendence of Sanitary Wardens, or Medical Officers, who may be willing to undertake such a duty--which will not be heavy. It is advisable to bring into play as much local interest as possible.

(8) *Tools and implements.*—These must be supplied through the Medical Department, and kept where convenient.

I forbear to give further specification of details, which would only hamper the organisation.

34. **DETAILS OF MAJOR WORKS.**—In reply to my request for information, Government forwarded to me (Colonial Secretary, No. 24/08 of 17/2/08) the excellent minute and annexures of the Hon. M. P. le Juge de Segrais, Director of Public Works and Surveys, which are printed in annexure 4, C of this report. In this the Director gives a rough estimate of the total cost of the major works which may be required throughout the island, amounting to Rs.630,000, with an annual expenditure of Rs.44,300 for maintenance by means of 205 workmen with the necessary number of sirdars. This scheme will serve as a base for future work; but it should be looked upon for the present as an ideal, not to be forgotten, but not to be attempted too soon.

The general principle to be remembered in considering the matter is contained in the words, *minor works before major works.* It would be folly to commit the Colony to a large capital expenditure until the absolute necessity for this becomes quite apparent; and it cannot become apparent unless the minor works and other methods of prevention have been tried for some time. The whole area of the island will then have been studied accurately with regard to breeding places; the working capacities of the gangs will have been gauged; the marshes and streams which cannot be improved by minor works will have become known; the disease will have been attacked everywhere by case reduction as well as by mosquito reduction; and the results will have become apparent. Then, if and where the major works are found to be necessary or economically advisable, they should be carried out. But to rush upon the major works without such preliminary experience would be unwise, except in cases where the necessity for them is already quite obvious. The same idea evidently underlies paragraph 7 of M. le Juge de Segrais' minute. For example, there was no doubt about the propriety of draining the Clairfond marsh. To deal with it effectively by minor works would have cost more than the interest of the capital expended on the major work ; it was situated in an important locality, was causing an immense amount of sickness among both the civil and military population, and was threatening Curepipe with a similar epidemic. On the other hand, the drainage of the marshes of Post of Flacq cannot be recommended with similar cogency. Lastly, we must remember that capital spent means interest lost. The sum of Rs.100,000 would not go far for major works, but the interest of it would support about twenty-four workmen indefinitely. And, moreover, the major work, when completed, would require a certain annual expenditure for maintenance.

I therefore recommend after careful consideration that for the present attention be concentrated on the minor works. There are, however, some major works which, I think, certainly do unquestionably require early execution, namely, the drainage of the marshes of Curepipe, La Louise, Pamplemousses and Centre of Flacq, and the canalisation of the minor streams of Port Louis (section 36).

35. **LEGISLATION AND ADMINISTRATION.**—(1) Obviously the economical working of the scheme suggested above will depend largely on excellence of administration ; and to assist in this, certain small *amendments of the laws* will be useful. I made a careful study of Ordinance No. 32 of 1894-95, which is practically the Health Act in force for Mauritius, and concluded that some additions would facilitate the anti-malaria campaign. These were drafted out and submitted to the Medical and Health Department, and were carefully matured by the Director, the Acting Assistant Director (Dr. Momplé), and the Procureur-General. The resulting draft legislation is printed in annexure 3 of this report, and will, I hope, be further considered by Government.

Every effort should be made to prevent the abuse of the right of appealing against sanitary orders and convictions connected with them (section 24).

(2) There is already a considerable *sanitary staff*, consisting of a Chief Sanitary Officer, three Sanitary Wardens, sixteen Sanitary Inspectors at salaries from Rs.960 to Rs.1,500 a year each, and twenty-two Sanitary Guards at salaries of Rs.360 each, costing Rs.52,740 per annum altogether (Blue Book, 1906). Its duties are multifarious—inspections, conservancy, contraventions, &c.; but it may be able to give assistance to the anti-malaria work, if the Director thinks this possible.

(3) Since the entry of plague in Mauritius in 1899 there has also been a considerable special *plague service*, which has been so successful that only about 5,000 cases have occurred since then, the number being now greatly reduced. The cost of this service is estimated at Rs.168,640 for the year 1907-08 (Estimates). Here again help may be given to the malaria service; while, on the other hand, the latter may also be able to help the former. These matters are not in my province to discuss, and must be left by me to the excellent organising capacities of the Medical and Health Department.

(4) On the 16th January, 1908, I wrote to Government in order to call attention to *leakage from standpipes* which occasionally causes conditions favourable to Anophelines. In replies under letter of the Colonial Secretary No. 493/08 of 22/2/08 and of 17/2/08, it was stated that the defect was due to wear and tear, to thefts and mischievous breakage of taps which the present law does not adequately prevent, and to insufficient funds for repair. At Port Louis the Mayor proposed to increase these funds. At Beau Bassin and Rose Hill the Chairman of the Board made the excellent suggestion that a "fountain keeper" at Rs.18 a month should be appointed to look after the matter, and also drafted legislation on the subject (his letter No. 1,790 of 17/2/08), which I hope Government will consider.

(5) In section 33 (3) I alluded to correspondence on *roadside ditches, drains, and gutters.* It seems possible that the duty of clearing, cleansing, and repairing these could be largely handed over to the malaria gangs, with whose work it is closely connected. The duty now lies in the hands of the Public Works Department, which spends about Rs.6,000 on it; of the Health Department, which allots a small sum; and of the Towns, in which the cost cannot

easily be extricated from that of conservancy. Port Louis puts the figure at about Rs.21,000 a year; Curepipe at Rs.5—600 for cleansing; Quatre Bornes at Rs.442; and Beau Bassin and Rose Hill at Rs.710 for cleansing and repairs. Perhaps the two departments first mentioned might be willing to transfer the money to the malaria service; while the towns could utilise their expenditure under this heading for forming the nucleus of the malaria gangs which I advised in section 33 (4) they should possess.

(6) On the 14th January, 1908, I called the attention of Government to the facts that there are in the Colony many *water-channels* used for conveying water from rivers and springs to plantations and factories, and that they often breed Anophelines; and asked who exactly were the owners, and whether they could not be compelled by law to keep them in order, or to fill up those which have fallen into disuse? Replies were sent to me under letter of the Colonial Secretary, No. 422/08 of 20-2-08. My letter and the reply of the Procureur-General are printed in annexure 2. From the latter it would seem that the channels are owned by private persons who could be compelled, at least after legislation, to do as I suggest.

(7) On the 16th January, 1908, I wrote a similar letter regarding the important subject of *marshes on private property*. In this I asked whether the owners could be forced by law to drain such marshes, or to pay for the drainage of them by Government; especially in view of the fact that such drainage might greatly enhance the value of the property? In reply I was informed (Colonial Secretary, No. 497/08 of 30-1-08) that the question, which presents many difficulties, had already been under consideration; that in the opinion of the Law Officer, marshes could not be held to be nuisances in the statutory sense of the work; that legislation had been proposed, but was not easy to effect; and that H. E. The Governor hopes that my report would assist in finding some practical solution of the difficulty.

The answer seems to me to depend upon the questions (*a*) whether the existence of the marsh is or is not the fault of the owner; and (*b*) whether the removal of it would or would not benefit the general public as well as himself. For instance, if there is in existence a sufficient and practical outfall for the marsh, or other means of dealing with it, in the owner's property, but one which the owner neglects to use, or refuses for his own profit to use ; and if he neglects to render the marsh innocuous by such reasonable minor works as may be recommended by the Medical Department ; and if it is proved by the examination of the spleen-rates of the people living near the marsh, or by other methods, that the marsh is actually causing sickness, or, in the opinion of the Medical Department, is likely to cause sickness ; then, I think, he (the owner) may be forced to do the work. As a matter of fact a marsh in a malarious country is a nuisance, because it is certainly and absolutely a danger to the public health, as known since the time of the ancients, and as recently proved by the case of the Clairfond marsh in Mauritius (addendum 2); and the fact that this is not recognised by law proves only the inefficiency of the latter. If a person can be forced to remove or cleanse a latrine, he ought most certainly be forced to remove or discharge a marsh—and for the same reason.

On the other hand, if the owner of a marsh has done all reasonable minor works to render it innocuous ; if the major work is beyond his means or cannot be carried out on his property ; and if the marsh is not causing, or is not immediately likely to cause, public sickness ; then I doubt whether he can fairly be forced to undertake the expense.

Each case must be judged on its merits ; and in many cases Government would feel it to be more fair to pay at least a part of the expense. But I think that legislation to compel the defaulting owner should certainly be passed.

In the meantime, however, I recommend (as in the previous section) that attention be concentrated on the minor works. It is only after they have failed, that the major works can be definitely demanded.

36. **NOTES ON PREVENTION IN THE TOWNS.**—The scheme advised above is a general one ; but I may add a few notes for the Towns.

(1) *Port Louis.*—Major Fowler and I spent ten days in a close inspection of the capital, which constitutes the most thickly peopled part of the small district of the same name (15 square miles). The population of the whole district has recently been steadily diminishing, as shown at each successive census.

Year	1846	1851	1861	1871	1881	1891	1901
Population	45,212	49,909	74,128	63,015	66,466	62,046	52,740

The decrease commenced after the great epidemic of malaria in 1867, during which year alone one-quarter of the inhabitants died from all causes. It has probably been accelerated by the facilities given by the railway to the wealthier inhabitants to sleep in the cooler areas of Plaines Wilhems, and to visit the town only for business during the daytime.

The death rate of Port Louis has always been in excess of that of the whole island, as shown by the chart in the annual reports of the Registrar-General; has been steadily rising (apparently); and averaged 56·97 or nearly 57·0 per mille during the seven years 1900–06. It rose to 67·9 in 1901 and to 60·4 in 1903. In 1906 it was 105·6 in the Eastern Area of the town.

Out of 2,003 children examined by Dr. Keisler in the schools of Port Louis, 706, or 35·4 per cent. had enlarged spleen early this year. The average spleen of all the children was 2·64 times the normal. These are slightly above the means for the whole island, but school children generally give lower rates than estate children, of whom there are none at Port Louis.

Major Fowler and I, greatly assisted by Dr. Keisler, and three moustiquiers, made a careful search for Anopheline larvæ. The principal breeding places are the uncanilised lengths of the three little streams, the Pouce, La Paix, and Trichinopoli streams which traverse the town proper. The two first of these rise in the hills which surround the small plain in which the town lies. High up, their beds are stony and usually nearly dry except for an occasional pool; but further down there is running water. The Trichinopoli stream apparently commences from the discharge of a water supply pipe. All three when they enter the town are well canalised till they reach the sea. Above the canalisation the water runs through grassy borders and breeds numerous Anophelines (photograph 17). A larger stream, the Latanier river discharges to the east of the town and breeds *A. costalis* plentifully. There are marshes at Fanfaron Bastion (away from many habitations). The insects are also found in the "regards," in ooze from leaking water-pipes, and similar waters; but our men generally searched for them in vain in the numerous and well-made stone gutters which border the streets. There was not much breeding in the Cassis stream; but the larvæ were found here and there in pits, hollows, and channels. On the whole I consider that the uncanalised parts of the four streams first mentioned are responsible for the disease in Port Louis. The spleen rates were high anywhere near them. At Tranquebar, close to pools in the upper part of the Pouce, all out of 32 children suffered—some very severely. Generally, near the canalised part of the streams the town appeared to be more healthy, but of course the insects could wander in from outside—though we never found a single Anopheline while we where at Government House.

The measures which I recommend are :—

(*a*) The spleen census and treatment of children in schools described in sections 28 and 29.

(*b*) House-to-house quinine distribution (section 30).

(*c*) I would strongly urge that an *extensive house-to-house spleen census of children in Port Louis should be undertaken in September, October and November next.* The object of this will be to ascertain exactly which are the most malarious spots, and whether they are contiguous to the uncanalised streams, as I suspect, or to other breeding places, with a view to justifying the major works presently suggested. In 1901 there were 12,876 houses in Port Louis district; too many to examine thoroughly. But certain blocks of houses might be taken in the healthiest part, as round Government House, and the results compared with those obtained at—let us say, (*a*) close to the Pouce at Tranquebar and south-west of the Champ de Mars; (*b*) east and west of Plaine Vert, south of the Market; (*c*) south of the Latanier; and (*d*) near the Cassis streams, &c. I fear that the labour will be considerable; but, if enough children are examined, say over 2,000, the results ought to be striking and useful. I suggest that it be done by two or three medical officers, each working a strip between the streams from the sea upwards towards the source of the former, so that each can make his own comparisons.

(*d*) For *minor works*, rough canalisation of the lesser streams, as frequently shown by me to the Mayor (Dr. Laurent, who has long taken great interest in the work) and as largely tried by Dr. Keisler, should on no account be neglected after and before the rains. I think that the pools then formed fill the town with Anophelines. During the rains the large floods render such work much more difficult. The frequent leakage from water-pipes, and mosquito-breeding in the "regards" and elsewhere must be dealt with rigorously by sufficient gangs.

The Mayor has wisely discouraged too many trees. As he says, "a town is not the place to grow a forest in." At the same time this is a secondary measure, as Anophelines very rarely breed in holes in trees.

(*e*) For *major works*; the Pouce must ultimately be canalised right up to Junction Road Crossing; the La Paix and Trichinopoli streams up to Boulevard Victoria. Before, however, recommending anything like the canalisation of the Latanier, an expensive work, I should like to see more evidence that it really causes much sickness, and that cheaper methods will not succeed in reducing the amount it does cause.

The same thing must be said of the intercepting drains round upper contours rightly commenced some time ago. If other measures fail, they must be proceeded with (on advice by the best engineers).

(2) For *Curepipe* I have nothing to add to the advice given when I was in the Colony—namely to drain the marshes as soon as possible. This can be effected by deepening the bed of the Mesnil; the cost will not be large; and the matter has already been urged by many, including the Town Engineer, M. Hugues. Although there is little endemic malaria in the town, yet Dr. de Chazal's opinion that there is some must be accepted; and though we could find only a few *P. costalis* in the Curepipe marshes, yet they may become much more numerous in the future. The recent outbreak at Clairfond, at the doors of Curepipe, and the case of Cilaos in Réunion, give a warning which it is not wise to ignore. An outbreak at Curepipe will be a most serious affair for the town. Hundreds of the wealthier people and their children would probably become infected; the value of property would fall; and the last stronghold against the disease would be conquered. Cases already occur among the poorer classes to the north, or are immigrating from outside; and a sudden swarming of *P. costalis* might easily occur as the result of a hot summer. The outbreak might be as sudden as disastrous. This is one of the instances in which I think a clear case exists for the major works.

(3) The marsh at La Louise, Quatre Bornes, causes considerable

sickness and ought to be removed as soon as funds allow. The cost is estimated at Rs. 30,000 (annexure 4, 3).

I have no further detail to add regarding the towns, except perhaps a protest against the excessive number of trees at Quatre Bornes and Beau Bassin and Rose Hill. They exhale an enormous amount of damp (as I was informed by M. Koenig and Mr. Walter); they shut out the breeze; and they breed and shelter mosquitoes. It may be a matter of taste; but to me a house in the tropics closed in by too many trees is very unpleasant. Perhaps the best way to encourage a reduction of trees on private properties is to allow the malaria gangs to do the felling in the dry weather when other work is slack, on charge of a small percentage of the wood—or without charge.

37. **THE ANNUAL MALARIA REPORT.**—This should commence with a tabular statement, giving all the details entered in section 21 of this report, not only for the current year, but for past years for comparison. The general remarks by the Malaria Authority should follow, stating totals of malaria statistics, work done, expenditure, and results. The following tables should be added.

Table I.; School Children.—Average total children, children with enlarged spleen, spleen-rate, average spleen, and children treated in each school; the averages being made up from the four quarterly inspections. Similar figures for the previous year should be given for comparison.

Table II.; Estates.—The same items; and also infant spleen-rate and average number of adults under continuous treatment, and remarks regarding works done or required.

Table III.; Towns, Villages and Populous Localities.—Following Dr. Lorans' table (annexure 4 of this report), and giving the number of gangs employed in each place, spleen-rates of local schools and estates, and results.

Table IV.; Major works and their cost.

Table V.; Establishment, salaries, quinine, implements, office and other expenditure.

Such a report will enable Government to judge whether or no value is being received for the money spent.

38. **MISCELLANEOUS SUGGESTIONS.**—(1) *Intercepting drains.*—Since returning to England I have had the advantage of meeting

Dr. Malcolm Watson whose good anti-malaria work is described in section 22. A letter from him, describing several important experiences of his, is given in annexure 1; but he also strongly impressed upon me the advantage of draining small marshes by intercepting, or so called circumvallatory, drains in preference to cutting channels through or across the marsh. The former are both cheaper and more effective.

(2) *Rubble-drains.*—These consist of a channel of the requisite depth cut through or round a marsh and filled up with stones—large stones at the bottom and small ones at top. The water percolates through the stones, and is said to carry away the silt automatically, and the stones prevent the growth of grass and weeds in contact with the water, so that mosquitoes cannot breed in it. They might be tried in convenient localities.

(3) *Stoning irrigation pits and water-channels.*—Such pits are frequently made for storing water for irrigating gardens. There are a number (about 10 pits per acre) close to the prison at Beau Bassin. They cannot be filled up without causing hardship; but they can be cemented, or (a cheaper method) lined from edge to bottom with large stones embedded roughly in the earth. One of Dr. Castel's gangs dealt with a number of pits close to Pleasance Estate in this manner in a few days. The owner can be warned to keep them in order. The same thing can be done for any water-channels which are not apt to be swept by floods. The stones prevent very rapid growth of vegetation on the banks. When the channel is filled with the stones, instead of being only lined by them, we have the rubble drains just referred to.

(4) *Rough canalisation.*—This consists in collecting the stones on each side of a stream, or deepening the bed where necessary, in order to remove marginal pools and vegetation and to give a straight constant flow to the water. Photographs 23–25 well illustrate the kind of work. That on the Mesnil was done before my arrival by the Forest Department, at the instance of the Medical Department. It cost only R.0·37 a running foot for both banks, but remained perfectly good during my stay. Of course lower down the streams floods may carry away such slight work; but it is demanded *at the end of the rainy season* in order to remove the stagnant festering pools which might otherwise breed mosquitoes during the whole of the dry

weather. Experience will show when and how it is best to carry out this measure (see also addendum 3).

(5) *Holes in rocks and trees.*—The fact that Culicines breed in these is frequently cited as a great difficulty in the way of mosquito-reduction. As a matter of fact, nothing is more easy than to deal with such breeding-places. Where the work is called for, the gangs are sent round to fill up the holes with gravel and concrete. For trees it is better to employ boys, who do the work with rapidity.

(6) *Mosquito plants.*—The Culicines breed largely in holes in trees in Mauritius, but they also breed in certain plants. On page 11 of (17) a list of mosquito-breeding plants in Ceylon is given. In Mauritius *Bilbergia splendida*, an introduced kind of flowering pine-apple, breeds large numbers of Stegomyia, and is planted in many gardens. Photograph 19 shows a cartload removed from a single house, the inmates of which said they could not sit in the verandah on account of these insects. This plant ought to be rooted out everywhere at sight. The Traveller's Palm contains water, but on cutting down to it we generally failed in finding larvæ—though these sometimes occur in it. A few larvæ exist in other shrubs, and bamboos—even in sugar canes ; but the important breeding-places are the usual tubs, pots, tins and broken bottles round the houses.

The houses at Vacoa were much infested by Culicines, and we carried on a constant war against them. All we could say was that they were certainly reduced in our house—but by no means banished. The explanation probably is that the adult insects are very long lived (as also observed elsewhere), so that it is long before the old ones die off. Nevertheless I would urge a continuous campaign against them in the towns. The cost is trifling, and the gain to health and comfort likely to be considerable. The work can easily be done by the malaria gangs, or ordinary sanitary service, at convenient times.

(7) *The introduction of Myzomyia rossii.*—When in Mauritius, I suggested the idea that it might be useful to introduce this Indian Anopheline, which does not carry malaria, in the hope that it might crowd out the fatal *P. costalis* in marshes which cannot easily be drained. If this would really happen the boon to the Colony would be great, and would be achieved at small cost. But experiments on the matter are first required, and may perhaps be carried out by the Malaria Authority.

39. **THE GENERAL PLAN OF CAMPAIGN.**—I would urge most strongly that the campaign be not confined to certain localities, but be extended at once to all the more populous parts of the Colony, especially as the estimated cost cannot be considered as being very large. Minor local campaigns will only fritter away considerable sums without producing any marked effect on the immense total of sickness caused by the disease.

The campaign should be commenced generally, simultaneously and vigorously over the whole Island, before the commencement of the malaria season; if possible in September or October next.

The first step, which can be taken without special apparatus in, let us say, September, should consist in the medical examination of as many as possible of the children in the schools and on the estates; the provision of registers; and the continuous and energetic treatment of children suffering from enlargement of the spleen, according to sections 28 and 29. The object of this will be to destroy the parasites in as many as possible of the patients before the advent of the breeding season of the Anophelines. It is important that the treatment should be commenced earliest in the lowest parts of Mauritius, where the malaria season first begins.

At the same time the five Quinine Dispensers should be selected and set at work, according to the suggestions of section 30, in the most malarious places.

While this work is proceeding, the gangs required by section 33 should be organised according to Dr. Lorans' rough estimate (annexure 4, A), and should be pushing the minor works vigorously by not later than November, so as to check the early breeding of Anophelines.

Simultaneously the Immigration Department and the managers of malarious estates should strain every nerve to do the same work. They should be supplied by the Medical Department with a printed plan of campaign and instructions.

The Municipality of Port Louis, the Town Boards, the District Councils, and other bodies, particularly the Société Médical, should be invited to assist.

All medical officers who are willing to help should be asked to do so by watching the distribution of quinine and the work of the gangs.

Meantime, I trust, the necessary funds, with a sufficient margin for extra calls (next section), can be allotted.

The Malaria Authority should be appointed under the Medical Director as soon as possible, for the early organisation of the gangs.

Quinine, and the organisation for making and distributing preparations of it, must be provided perhaps first of all; and implements for all the gangs should be ready by November.

Further details must be left to the Medical Director and the Malaria Authority.

The great strategical object is to deliver as heavy a blow as possible upon the disease at the commencement of the malaria season, in the assurance that every case then cured and every infection then prevented will save many infections later on. It will be most wise, and most economical, to spare no expense in the attainment of this object. The greater the success, the greater will be the reduction of the malaria expenditure in following years.

40. **SUMMARY OF PRINCIPAL RECOMMENDATIONS, AND APPROXIMATE COST.**—The principal *recommendations* are :—

(1) Periodical medical examinations of children in schools and on estates, and the continuous treatment of all of them who are found to be suffering from enlargement of spleen (sections 28, 29).

(2) Continuous house-to-house distribution of quinine, where necessary, by five Quinine Dispensers (section 30); and continuous treatment of fever patients on estates (section 30).

(3) Continuous performance of "minor works," where required, in towns, villages and populous areas, by about 109 malaria gangs, consisting of about three workmen each; and of similar works on estates (section 33).

(4) Employment of fifteen moustiquiers (section 33).

(5) Appointment of a Malaria Authority (section 33).

(6) Execution of "major works" when called for (section 34).

(7) Appointment of a Committee to consider house-protection (section 31).

(8) A special spleen-census for Port Louis (section 36).

(9) An annual malaria report (section 37).

(10) Some legislation (section 35 and addendum 3)

The measures to be adopted over the whole island, and to be started simultaneously, if possible before the commencement of next malaria season (section 39).

The *approximate cost* may be roughly estimated as follows :—

Items.	Rs. per annum.
1. Salary of the Malaria Authority	6,000
2. Salaries of 5 Quinine Dispensers (say)	6,000
3. Salaries of 15 Moustiquiers	4,560
4. Salaries of 109 gangs (327 men)	65,400
5. Cost of quinine (say)	30,000
6. Preparation and dispatch of quinine (say)... ...	3,600
7. Office of Malaria Authority (say)	1,500
8. Implements, &c., for gangs (say, Rs. 50 a gang)...	5,450
9. Travelling expenses for staff (say)...	2,000
10. Margin for possible calls	10,490
Total ...	135,000

This amounts to £9,000 per annum, or about Rs. 0·36 per head of population per annum, and 1·2 % of Revenue.

Notes.—Item 4 is a rough estimate (section 33). The salaries and implements of 13 of the gangs, amounting to Rs. 8,450, ought, I think, to be met by the Towns.

Items 5 *and* 6 may be considerably underestimated.

Item 10 should be large, in order to defray many expenses which may be required at first, especially if a very active campaign is undertaken, as advised.

The cost of the quinine and possibly of the gangs may diminish considerably if the campaign is markedly successful (section 24, 5).

Major Works.—These, requiring capital expenditure roughly estimated by the Public Works Department at Rs. 630,000 for the whole Colony, are advised to be undertaken, in part, only when and where the other measures have failed; but early attention is recommended to be given to the marshes of Curepipe, La Louise, Pamplemousses, and Centre of Flacq, and the streams of Port Louis (annexure 4, C).

ADDENDA.

ADDENDUM I.—THE MOSQUITOES OF MAURITIUS.—M. d'Emmerez de Charmoy has given me a list of Mauritius mosquitoes. They have already been studied in Mauritius by him and M. Daruty de Grandpré (14 and 22). Three new species of Culex were obtained during our stay in the Colony, and have been described for us by M. d'Emmerez but the details are unnecessary for this report, and I have published them separately (21.)

ANOPHELINES.—1. *Pyretophorus costalis* Loew 1866. Proved to be a carrier of malaria in West Africa by myself and colleagues in 1899 (1). *The principal carrier in Mauritius.* Abounds round the coast, but also inland and was found by our moustiquiers at Clairfond Marsh (1 350 feet above sea level), where it has been causing the recent outbreak. A few larvæ collected at Curepipe. Apparently much more scanty on the plateau than *M. Mauritianus.*

Proved to carry malaria in Mauritius by Daruty and d' Emmerez (21). Out of 73 caught at Clairfond and carefully examined during our visit (Daruty, d'Emmerez, Fowler, Ross), 10 or 13·7 per cent. were infected.

Habits already well known. Breeds chiefly in water standing or flowing gently amongst grass and other vegetation and also in bare pools. Caught in houses, verandas, and in the open.

2. *Myzorhynchus mauritianus* d'Emmerez and Daruty 1900. Very common everywhere in Mauritius, especially on the plateau. Abounds at Curepipe. *Apparently does not carry malaria.* Out of 54 fed on malaria patients only one contained the zygotes, and these we considered by their size to have died after penetrating as far as the stomach wall. Until more experiments have been made however, I am not willing to state *definitely* that this species cannot carry malaria under any conditions. All out of 56 caught wild were negative.

3. *Nyssorhynchus maculipalpis* Giles 1902. Not common. A few specimens only caught by Major Fowler at Fanfaron Bastion, Port Louis, and recently at Clairfond.

CULICINAE.—4. *Scutomyia notoscripta* Skuse 1899. The commonest "*Stegomyia*" in Mauritius. Abounds in the shade of woods. Bites in the day time. Breeds in tubs, tins, gutters, cisterns, holes in trees and rocks, in *Bilbergia splendida*, etc.

5. *Stegomyia fasciata* Fabricius 1805. Common near the sea shore, but more scarce in the highest parts of the island.

6. *Culex fatigans* Wiedmann 1828. Very common all over the island.

7. *Culex tigripes* d'Emmerez and Daruty, 1900. One of the largest species known. Common in Mauritius. Does not frequently bite man. Larvæ are cannibals.

8. *Culex annulioris* Theobald 1901. Only one specimen, taken by Colonel Peterkin, R.A.M.C.

9. *Culex arboricolis* n. sp. d'Emmerez de Charmoy (21, 1908). Found in holes in trees at Vacoas, Mauritius. Scarce.

10. *Culex ronaldi* n. sp. d'Emmerez de Charmoy (21, 1908). Larvæ found at Fanfaron Bastion by Major Fowler, but scarce.

11. *Culex fowleri* n. sp. d'Emmerez de Charmoy (21, 1908). From larvæ caught by Major Fowler. Scarce.

I have little to add regarding the insects. The leading facts about the commonest species are already quite familiar, and the habits in general are the same in Mauritius as I have observed them since 1895 to be in many parts of the world (section 2, 3). One fact is worth mentioning. In several parts of India I had observed *Stegomyia* abounding in woods, but had noted that these insects did not seem always to enter houses close to the woods—suggesting that the former may be of a different variety, though possibly of the same species, as those which so frequently persecute the inmates of houses. I observed the same thing in Mauritius. Only a few insects might be in the house at a time when they swarmed in the shade of trees in the garden. It is worth studying whether the house variety does not breed in pots and tubs, etc., while the woodland variety breeds in holes in trees, bamboo stumps, etc. Some further facts are given in the following addenda.

ADDENDUM 2.—THE OUTBREAK AT CLAIRFOND, PHŒNIX.—This epidemic was raging close to the military barracks and to our own house, when we were in Mauritius. It afforded a very good object lesson regarding both the prevalence and the prevention of malaria.

Phœnix is a considerable village situated on the plateau (1,300–1,400 feet above sea level) on the main road from Port Louis to Curepipe, which there runs in a north-westerly and south-easterly direction. To the west of the road and the village there was, until recently, a large marshy area called the Clairfond Marsh, made by a number of springs which spread themselves over a flat area (*vide* map).* The better class houses lie along the road; but numerous huts of Indians (mostly) exist further west, actually among the pools and streamlets of the marsh. Still further west there is a dry open area traversed by the Rivière Sèche, beyond which on a considerable open plain, the well-built barracks of the troops are situated. Further west again there are the villages of Vacoas and La Caverne. To the east of Phœnix there is open ground rising to the estate called Highlands; and to the south the road rises towards Curepipe (1,800 feet).

Until recently, the whole of this area was healthy, in spite of the large marsh; but endemic malaria began to appear in 1903. Dr. de Chazal who has long practised in the neighbourhood has very kindly given me a full history of the epidemic, which I reproduce below.

THE OUTBREAK OF MALARIAL FEVER AT PHŒNIX.

By Dr. de Chazal.

This village was considered healthy until the year 1903, when a small epidemic of malarial fever broke out. I have practised in this District since 1890. Cases of fever among natives had come under my notice from that time; but it was not till the former year that I saw well-to-do people become affected. In my own house, where my people had been settled since 1866, a case of malarial fever, of local origin, had never occurred among any member of my family until 1903, when I first noticed tertian ague and demonstrated the parasites in the blood.

(1) *The presumed cause of the epidemic.*—A part of the "Highlands" Estate, made up of the land now occupied by the Military Government, "Clairfond," and "Mesnil," with their marshy ground, was sold in 1897. The River known under the name of "Rivière Sèche" divides this land into two parts. The Military Government settled to the west of the river, and natives to the east.

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* Page 186.

In July 1898, a regiment of natives from Central Africa was brought to Mauritius. The men were taken to Phœnix as soon as they landed. They were not stationed at Port Louis, so as to avoid contracting fever. The men suffered very little from malarial fever, only three cases of ague and one of remittent fever being recorded among them during that year. This regiment left Mauritius in 1900, and during their stay here they had remained at Phœnix exclusively. In 1899 a Bengal Infantry regiment was introduced in Mauritius and quartered at Port Louis, where the Sepoys suffered so much from malarial fever, that they were brought to Phœnix for a change and placed under canvas on the ground now used for polo practice.

The services of Army Medical Officers not being available in 1898–1899, these two regiments were handed over to me ; I had to attend to the sick and to supply medicines.

The African regiment suffered from influenza in July and August, 1898, and the Indian Sepoys from malarial fever.

The Indians were quartered in Port Louis and the sick brought up to Phœnix for short periods.

In 1902 a second Indian regiment (Rajputs) were brought to Mauritius. The Africans left the island, as already stated, in 1900, the Indians in November, 1906. The sepoys caused a great increase of the Indian civil population at Phœnix, Clairfond and Mesnil villages. Small shops were built to meet the trade opened by the native soldiers. Many new huts were erected for the accommodation of a fairly large population of native dealers who travelled all over the island, to and from Phœnix.

Of the two Indian regiments, one was kept in Port Louis and the other at Phœnix, alternately, for six months at a time.

In order to ascertain if it was the presence of these natives, who settled at Phœnix from the year 1897, that caused an increase of fever in the district, it would be necessary to consult the records of the public dispensaries or the sick rate of the troops quartered at Phœnix camp, but, unfortunately, these records had been kept in such a way that they are not trustworthy until 1906 for the Military Department, and until 1904 for the public dispensaries. All that I can positively state is that I did not notice a marked increase of fever in the district until the year 1903, five years after the arrival of Indian sepoys suffering from malarial infection.

(2.) *The prevalence of fever in this district prior to the epidemic of* 1907.— That fever was prevalent in the district as early as 1892 can be certified by medical practitioners and by consulting the records of the public dispensaries. These records, prior to 1904, indicate the total number of attendances, each attendance being reckoned as a separate case ; *i.e.*, if a patient came to the dispensary three times during the year, three cases of fever were entered in the books, whilst since 1904 if the patient came for the same disease more than once only one case of fever was entered. Only the numbers from 1904 will therefore be given.

The following table shows the gradual increase of the disease in some of the districts from which the patients who attended at one of the dispensaries, that of Vacoas, were drawn.

Years.	Phœnix.	Mesnil.	Eau Coulée.	Caverne.	V. Cantons.	Solferino.	Croisée.	Rainfall.
1904 ...	41	51	67	81	32	12	52	76·46
1905 ...	68	88	71	202	67	55	113	126·86
1906 ...	107	99	73	506	114	90	170	91·53
1907 ...	398	152	113	411	109	154	179	92·00

The information gathered by consulting the Dispensary records are of some value, for they contribute a fair index of the sanitary condition of the district. The numbers given indicate the proportion in which the fever has increased from year to year. The population of these districts can be safely taken as remaining stationary, except that of Phœnix village, which has decreased since the departure of the native regiments in 1906.

(3.) *The course of the epidemic.*—The disease began to make itself very apparent in 1906, although it had already begun to increase in the previous year.

The following table shows the total number of cases of malarial fever at Vacoas Dispensary.

Year.	No. of Cases of Malaria.
1904	346
1905	843
1906	1,147
1907	1,487

It was in November, 1906, that the numbers began really to increase at the Dispensary. In March, 1907, the Government started quinine treatment and prophylaxis at the patients' homes. The dispensary records would have been higher in the latter year if this had not been done. The rainfall, taken within 50 yards of the Mesnil marshes, is given in inches. The returns from the camp apply to European troops.

	1906.			1907.		
	Military.	Phœnix and Mesnil.	Rainfall inches.	Military.	Phœnix and Mesnil.	Rainfall inches.
J. ...	4	10	8·25	4	38	4·13
F. ...	1	17	10·79	2	27	10·30
M. ...	8	31	13·99	11	57	8·00
A. ...	16	23	0·88	13	62	14·34
M ...	9	19	8·26	24	66	7·13
J. ...	7	18	3·70	24	60	10·83
J. ...	5	13	9·47	28	54	2·61
A. ...	2	10	4·12	13	26	0·16
S. ...	3	9	4·61	22	25	4·61
O. ...	3	12	4·88	8	23	4·88
N. ...	6	20	1·10	3	40	1·10
D. ...	2	24	11·50	9	72	11·50
	66	206	91·53	161	550	92·00

(4) *Influence of vicinity of marsh on the causation of fever in neighbouring houses.*—In order to record cases of local infection only those houses are mentioned whose occupants were old settlers in the district and who had not previously suffered from malarial fever. It must be noticed, on referring to the chart which is annexed, that the road leading to Phœnix railway station marks the limit of the Clairfond marshes towards the north. To the south of this road, there are many springs, streams, and marshes scattered over the area called "Clairfond" and "Mesnil."

The first case of fever occurred in January, 1906, in the house marked No. 1 on the chart.

The occupants of No. 2 house were attacked in August.

" " 3 " " November.

" " 4 " " December.

In 1907 the incidence of the disease was as follows :—

The occupants of No.		5	house were affected in		February.
,,	,,	6	,,	,,	March.
,,	,,	7	,,	,,	April.
,,	,,	8	,,	,,	June.
,,	,,	9	,,	,,	September.
,,	,,	10	,,	,,	December.

In 1908 fresh cases occurred.

The occupants of No. 11 house were attacked in January, and those of No. 12 in February.

Up to February 20th, 1908, the following houses had not been affected viz.: those marked Nos. 13 to 26 in the chart.

The European soldiers in the Phœnix camp began to be affected in January, 1906. Some cases even occurred in 1905; but it was not till the month of March, 1906, that the cases became numerous.

These examples demonstrate the following facts :—

(1) That the houses situated nearest the marsh were affected first. Nos. 1, 2, 3, 4, in 1906.

(2) That to the north of the road which marks the limit of the marsh, viz.: that leading to Phœnix Station, some houses were affected much later. No. 7 in April, 1907; No. 8 in September, 1907; No. 9 in December. The other houses situated still further to the north of this road were spared and are still spared up to this day, February 20th, 1908, viz.: houses Nos. 14–19.

(3) That the fever has no tendency up to the present to spread towards the West, along the railway line, beyond the camp, nor towards the North, both these regions being free from marshes or springs. Natives living in these districts are, however, becoming gradually affected. The occupants of the houses mentioned will probably become affected later.

The influence of the vicinity of the marsh in causing fever is thus very apparent—the nearer the house is situated to it, the earlier its occupants contract fever.

These examples also show that the fever spreads slowly but surely to greater distances from the place where it first broke out.

(5) *Blackwater Fever.*—During the epidemic eight cases of Hæmoglobinuria fever were noticed at places marked H. on the chart. These, it should be noticed, all occurred in the immediate vicinity of the Clairfond Marsh, except one case which occurred in a patient who first lived in a house marked No. 3. He suffered so much from fever in this house that he moved to house No. 27 where he was attacked with Hæmoglobinuria fever four weeks later.

These cases show that the type of fever was most severe in the area which is the most marshy; for Hæmoglobinuria is considered, and I think rightly so, as an index of the gravity of the malarial infection.

As a digression, I may mention the following facts concerning these cases of Hæmoglobinuria fever. One case occurred in June, 1907; two cases occurred in July; two cases occurred in September; one case occurred in November; one case occurred in December, 1907; one case occurred in February, 1908.

All these cases got well without taking quinine. This drug was administered in some of the cases only after the blood had disappeared from the urine, after and during treatment by bichloride of calcium.

None of these cases left Phœnix. They got well in the same houses where the disease began. These facts are mentioned because it is believed by some medical men that :—

(1) The disease occurs in the cold weather.

(2) That quinine hypodermically is the best treatment.

(3) That removal to some other place is highly desirable.

(6) *Remarks about Curepipe.*—That malarial fever is prevalent at Curepipe is seen from the records of the Dispensary of that town. The disease shows a marked increase in 1907.

Year.	No. of cases of malarial fever.
1904	473
1905	620
1906	644
1907	1,032*

The patients who attend at this dispensary come from the town itself and from the numerous "free" villages scattered around, for a radius of from half to three miles.

Curepipe attracts a great many people in search of employment, who come there already infected by the malarial parasite; but on making a careful enquiry I had no hesitation in stating that there are a good many cases of local infection

The following table shows the gradual increase in the number of attendances from malarial fever at the Curepipe dispensary and the localities from which these patients come.

Year.	Camp Fouquereaux.	Rivière Sèche.	Trou aux Cerfs.	Botaffical Gardens.	Forest Side.	Old Loretto Convent.	Lower part of Curepipe Road.	Midland and XVIth mile.	Other parts of Curepipe.
1904	20	20	19	12	58	4	45	18	177
1905	16	25	12	16	78	19	55	24	192
1906	21	35	17	17	87	18	111	13	199
1907	101	49	20	50	133	34	114	54	203

DR. DE CHAZAL'S Report ends here.

On our arrival Major Fowler and I, greatly assisted by M. Daruty and M. d'Emmerez, and a number of moustiquiers, made a careful study of the epidemic. Our results were as follows :—

(1) *Spleen-rates.*—These gave most interesting data. We began by examining 163 children collected at Phœnix village, not only from the village, but from some distance outside it, and found that they had an average spleen-rate of 55·3 % and an average spleen of 3·16. Next we made repeated house to house examinations of 339 children living close to the marsh or a little distance from it, and found an average spleen-rate of 71·1 % and an average spleen of 4·12 (Table IV, C.) But the important fact was ascertained that the children living very close to the pools of the marsh had a far higher spleen-rate than those living only a few hundreds of yards away. This confirms Dr. de Chazal's statement based on clinical observations. The spleen-rates, however, give a much more decisive proof of the relation than the clinical observations do, because there is much less statistical error with them, owing to the large number of children examined.

* Much of this was probably due to cases from Phœnix, where there is no dispensary, so that patients often go to Curepipe.—R. ROSS.

Our results are entered in the map in the form of fractions. For example, 3/7 denotes that three out of seven children were found to have enlargement of the spleen. But, owing to the smallness of the map, the fractions are not entered for each house (of which we examined 119), but for clusters of houses. The results however are apparent enough. Near the pools (marked black) the spleen rate is nearly 100%. As we advanced southwards up the slope towards Curepipe the spleen rate fell at once almost to zero, and remained at this all the way there, and in Curepipe itself. At the village of Vacoas and La Caverne (1½ to 2 miles from Phœnix) not a single child out of 104 examined had enlarged spleen ; and on Highlands Estate (1 mile), the ratio was only 3 to 50. The rate is high at Phœnix, to the east of the road ; but this is due to a small marsh in the river Mesnil. Hence this interesting house-to-house spleen census gives a most convincing proof of the law that *malaria and Anophelines abound most only very near to breeding places.*

I do not remember to have read before of the use of the spleen test for obtaining such exact and valuable information. It is evidently capable of similar use elsewhere—wherever we wish to mark down the precise source of the disease ; and I have therefore recommended its employment in Port Louis for determining the exact effect of the streams (section 36).

(2) *The troops attacked.* But this law is only one of averages, and exceptions occur. Just before our arrival the 2nd Battalion of the Loyal North Lancashire Regiment had come to the barracks at Vacoas. They remained well for a few months ; but suddenly at the end of December, 1907, an epidemic of malaria occurred among them. There were 71 cases in January Some women and children were attacked, and there were five deaths and many invalidings. Yet the barracks are half a mile from the marsh. In addition, several residents in neighbouring houses became infected during our stay.

(3) *The diffusion of the Clairfond Anophelines.* In order to study this point, I directed a number of the moustiquiers to search for the Anophelines in the houses at Clairfond marsh and at various distances from it. They used to sit up at night with lanterns, and captured the insects that came to bite them. Many were caught at Clairfond, but very few at any distance ; showing that, as calculated by Professor Karl Pearson and myself, migration to a distance is not great. It was reported that *the migration is greatest on warm still nights*, and least on windy nights—just the opposite to what is generally believed. In fact, cold, rain, and wind seem to make the insects disappear. Very few, and then only *M. mauritianus*, were caught in the barracks before I left ; but it does not follow, because few are caught in a place during the two or three hours when they are being looked for, that many may not visit that place during a longer period. One mosquito a night on the average means 184 during six months ; and the bite of a single infected mosquito means infection.

Many of the troops were possibly not infected in the barracks at all, but while walking about in the evening. The men used frequently to enter or pass Phœnix village. On the other hand, the cases were decidedly more numerous in the barracks nearest to the marsh. Major Fowler has studied this part of the subject more thoroughly.

P. costalis was caught both inside and outside houses, but *M. mauritianus* chiefly outside, in verandas, in woods, under bamboo hedges, and in other sheltered places. Three of our moustiquiers were infected while catching the former. In our own house (number XXIV on the map) we caught only one or two Anophelines (*M. mauritianus*) altogether, showing that very few reach a mile from the marsh.

(4) *Infected mosquitoes at Clairfond.* All efforts to find the parasites in the *M. mauritianus*, either caught wild or fed on malaria patients, failed—with the exception of one insect in which dead zygotes occurred. We were therefore for some time at a loss how to explain the malaria, when suddenly one of our men brought in a single *P. costalis*, which had never hitherto been found so high on the plateau. Both this and the next *P. costalis* caught were found to be infected—thus clearing up the mystery. Subsequently many others, both larvæ and adults, were procured in the marsh. Nevertheless they were always much fewer than *M. mauritianus*—scarcely one to fifty. This shows the absurdity of supposing that the infecting mosquitoes in a locality must be the most numerous ones there.

(5) *The output of mosquitoes from a marsh.* I do not remember any previous efforts to ascertain this point. Accordingly, I stretched an ordinary mosquito net over nine square yards of the Clairfond marsh in the manner shown in photograph 22, and counted the mosquitoes caught within it every day. They were all *M. mauritianus*, no Culicinæ being found; and numbered 30 males and 31 females during 16 days, giving an average of 0·423 mosquitoes per square yard per diem, or 423 for a thousand square yards. Numbers were still hatching out at the end of 16 days. During the day the adult insects took refuge in the grass, from which they had to be beaten out. Many equally simple experiments could be undertaken with much advantage to practical sanitation.

(6) We readily found all species of *the parasites* in the people at Phœnix and neighbouring areas.

(7) Before I arrived, Government had already commenced to drain the marsh, and a further sum of Rs.11,000 was allotted later on. In addition to this, owing to the representations of H.E. the Governor, of General Creagh, C.B., and of Colonel Peterkin, R.A.M.C., the War Office gave a considerable sum for the same purpose, in view of the outbreak among the troops. The marsh was therefore nearly drained by the time I left. In the meantime the Medical Department had employed a Quinine Dispenser for house-to-house distribution (section 30); and the result was that at my departure infected children were becoming markedly more difficult to find. I hear that the improvement has been maintained.

In conclusion, I *strongly recommend* that a second house-to-house spleen census be taken at Phœnix village in next January, in order to compare the results with those given in the accompanying map.

ADDENDUM 3.—THE QUESTION OF THE RIVER RESERVES.— The chief product of Mauritius is sugar. It has been shown by years of observation that the amount produced by her magnificent fields varies as the rainfall multiplied by the number of rainy days. Now it has long been a dogma of forestry that forests tend to increase the rainfall. For this and other reasons, Mauritius possesses a Forest and Gardens Department, costing Rs.142,377 in 1906 (Blue Book).

Although the whole island is well wooded, the true forests exist mostly on the mountains or higher parts of the plateau, where they are carefully guarded by the law. In addition, however, there is an old law which prevents the cutting of trees, without permission of the Forest Department, within a distance of from 10 to 50 feet from the edge of certain parts of rivers and streams. The result is that in most parts of Mauritius, wherever there is a small river or stream, or even a stony channel, there is generally found a strip of thick, and sometimes impenetrable, vegetation, consisting both of large trees and underwood, and extending from the stream to the top of the ravine made by it, in the deep shadow of which the water runs along almost hidden from sight.

These strips of jungle are called the "River Reserves." Recently the question has arisen whether, whatever may be their good effects, their existence is beneficial to the health of the people who live near them. It has been pointed out that nuisances which tend to pollute the streams (which are largely used for drinking) are often committed in the shelter of the wood, and may cause ankylostomiasis; and that the water is further polluted by dead leaves of bamboos and other plants, which lie soaking in the pools. More recently, Dr. Bolton, Medical Officer of the Immigration Department, being directed to report on the cause of the high death rate on certain sugar estates, came to the conclusion that on many it was due chiefly to malaria caused by Anophelines breeding largely in these River Reserves (July, 1906). His reports were forwarded for an expression of opinion to the Société Médicale, which endorsed his views, and advised "la suppression et le maintien de la suppression des réserves forestières le long des rivières dans tout centre de population de la zone malarienne et à 3 et 400 mètres en aval et en amont de ces centres" (August, 1906). The matter was now put before the Woods and Forests Board, which considered it at various meetings for more than a year. During the same time the Director of Forests (Mr. Koenig) wrote reports in which he maintained the utility of the River Reserves, and criticised some of Dr. Bolton's conclusions. Finally H.E. the Governor asked me (Colonial Secretary, No. 9,826/06 of 15/2/08, with correspondence enclosed) for my views on the question.

I have carefully considered this literature, as well as reports by Mr. Thompson (1880) and Mr. Gleadow (1904) on the Forests of Mauritius. I also had opportunities to discuss the whole matter with Dr. Lorans, Mr. Koenig, Dr. Bolton, and many others, and will do my best to throw some light on the controversy.

The first questions which arise relate to matters of fact. (1) *Is it really true that forests increase the rainfall?* In this connection I had the advantage of being able to read in manuscript an able report on the subject by Mr. Walter, of the Observatory. By analysis of a mass of meteorological statistics he concluded that certain large denudations of forest which occurred in the island some decades ago had certainly had a small but definite effect on the rainfall. The total rainfall had not been markedly changed, but there had been an appreciable decrease of the number of rainy days—one of the most important factors in sugar cane cultivation. From another paper of his (and also from other articles I have read) it would seem that trees suck up moisture by their roots and exhale it into the atmosphere by their leaves in large quantities. On calm days this exhaled moisture increases the humidity of the air until saturation and a fall of rain occur—thus explaining the afternoon showers so frequently seen over the land (but not at sea). Hence trees would be, as it were, syphons which tend to draw up water buried in the soil and to distribute some of it over the fields—in other words, valuable irrigators.

But the effect of the whole extensive denudations referred to had not been large. I have unfortunately mislaid my notes on Mr. Walter's report; but if I remember aright there was evidence of only a small percentage of decrease in the number of rainy days. Now the entire extent of River Reserves put together amounts, I believe, only to 2 or 3 % of the total forest in Mauritius. Hence, I presume, the removal of the entire River Reserves would scarcely diminish the number of rainy days by more than a small fraction. Still further, the proportion of River Reserves and other wooded water channels within 400 metres of populous centres must be only a small fraction of the entire River Reserves and other wooded water channels; so that the removal of these parts only, as advised by the Société Médicale, would have (I should think) an absolutely inappreciable effect either on the total rainfall or on the number of rainy days. If the denudation of large areas has had little effect, surely that of a few hundred yards of narrow strips of ground near a few populous centres could have scarcely any at all.

But other benefits are attributed to the Reserves. It is said that they break the force of the wind on the cane fields; and I think that they do—but only to a very small percentage on the average. They prevent the water running away too quickly to sea; they check erosion of the banks by floods and the washing away of the soil by heavy rains. But while admitting these points, we must again remark that it is not proposed to denude all the streams but only small parts of them near "populous centres."

Now let us turn to the other side. (2) *Is it really true that the River Reserves cause malaria?* Dr. Bolton drew his conclusions from a comparison of a number of estates which he divided into two classes, namely, Class A, in which a stream, river, or marsh exists in the vicinity of the Camp, and Class B, in which they do not exist. The death rates for the first half of each of the years 1903, 1904, 1905 tended to be higher in Class A than in Class B; while, taking the average estate death rate for the district as a mean, the death rates of Class A were above it and those of Class B were below it. Unfortunately, owing to large statistical error, death rates are not very reliable quantities for such a comparison. Spleen rates would obviously give much sounder information; and the details for 1907-08 will be found in Table IV, A. These will not necessarily accord with Dr. Bolton's figures, since they were collected two years later, and also because, owing to the confusion of names adopted for some of the estates, I cannot always identify his localities; but they generally support his argument. On averaging the spleen rates for the districts I find as follows:—

	Class A. Av. Spl. R.	Class B. Av. Spl. R.
Pamplemousses	55·7	21·8
Flacq	67·1	53·8
Grand Port	68·8	44·0
Savanne	20·9	27·7

Savanne is the only exception; but the sources of error are so numerous that the figures are worth but little. There may, for instance, be breeding places in Class B not included in those mentioned; while in Class A some of the waters may be too distant to have any great effect.

I trust that the spleen census and the results of the minor works proposed in sections 28 and 33 will definitely clear up the question in a year or two; but at present I cannot say that the River Reserves (or more generally the wooded water channels) have been fully convicted of causing all, or even much of the malaria, near them—at least, by statistical evidence.

Speaking generally, however, they are certainly dangerous. There is no doubt whatever that the Anophelines do breed in the streams; but they breed in water along lengths of grassy margin, and in pools in rocks, &c., not in the trees. I am not certain that the trees affect the question much one way or the other. In fact, as pointed out to me by Mr. Koenig. the shade of large trees is inimical to the growth of grass, which is generally scanty under them—and it is *grass in water* which is the danger. Moreover, I can quite imagine that a thick growth round a stream must make ingress or egress much more difficult for mosquitoes. On the other hand, trees do breed Culicinæ, and shelter all mosquitoes; and our moustiquiers easily captured Anophelines in the Reserves—suggesting that women and children who go to draw water may often become infected there. And the objections to the Reserves on account of nuisances still stand.

Before proceeding to consider recommendations, two more points have to be discussed. (1) It is, I think, perfectly agreed to by both sides in the controversy that the undergrowth in the Reserves is quite unnecessary. Mr. Koenig informed me that his department requires the large trees, not the dense growth of useless bushes under them; and it is precisely this undergrowth which the Health Department objects to. There is therefore no reason whatever why it should be retained. The removal, at least near villages and coolie camps, will give free access to the streams not only to the people but to the malaria gangs. Nothing more is required than what was so excellently done by the Forest Department itself to the Mesnil at Phœnix, as well shown in photograph 25.

The second point is one which I have heard raised, but which, I think, few will assent to. It is that, if they are of use to the planters, the Reserves should be maintained *even if they do cause malaria* From a humanitarian point of view, this proposition is open to strong criticism. It suggests in brief that human life may be exploited in the interests of individuals. But no civilised state can allow such a thing; and the Immigration Department in Mauritius has been expressly constituted to protect the indentured coolies. From a rational economical point of view, however, the proposition is still more unsound. If it could be proved that the small parts of the Reserves near populous centres really add materially to the output of the estates, then something might be said for maintaining them. Even then, however, the question would arise whether the loss to the estates from the malaria would not more than counterbalance the gain from the Reserves. People who urge this proposition seem to have completely forgotten this last item. As Dr. Bolton says (annexure 1), the day's work of a coolie is worth from R 1·25 to R.1·50 to an estate during the season. When 10 % or more of the men are "down with fever," the loss must mount up to hundreds and thousands of rupees to a single malarious estate during the year. Dr. Bolton adds (18/7/06):—"On many estates new immigrants have to be imported to make up for the loss of labour through sickness. They cost Rs.200 each on landing, but in reality a great deal more if the cost of those who desert or die is added to that of those who remain. On some estates more than 25 % of the new immigrants imported within the last three years have deserted. Add to this 5 % of deaths. The remaining 70 out of 100 men therefore cost Rs.20,000, equalling Rs.285·7 per head for five years, or Rs.57·14 per year, or Rs.4·76 per month." He remarks also that numbers of convalescents have to be put to light work, which means that ten men have to do the work of six, and says, "The low price of sugar, the high price of transport, labour, and provisions, leave a very small margin, if any, of profit, so that any economy in the cost of production becomes a matter of serious import." Does anyone suppose that a few hundred yards of jungle planted along a stream is ever likely to compensate a planter for such heavy and constant losses caused by malaria? It therefore seems to me that, if Government is finally driven to decide between River Reserves and malaria sanitation, it would do wisely to clear away the former without much hesitation. For the practical needs of the moment, however, my single *recommendation* is as follows :—

The promotion of a *bill to allow* riverain proprietors to cut down, destroy, or remove any uprooted or dead tree, and also any bush, weed, or noxious growth, found or growing on their property, with proper clauses to notify the Forest Department before this is done, with a view to saving such trees as this department may wish preserved. The bill might be on the lines of the proposed Ordinance of 1905, framed by the Directors of the Forest and Medical Departments, but with the compulsory clauses changed into permissive ones. (I understand that the bill was lost owing to these compulsory clauses.) In sections of the bill the Medical and Health Department might be allowed to do the work after notice. The wood removed might be given to the remover, *i.e.*, the proprietor, the Medical or the Forest Department (if this is possible), whichever does the work. A system must be considered by which the Forest Department will not impede the work either of the owner of the property or of the Medical Department, by delay in specifying or notifying which trees are to be left alone (for example, the trees to be preserved may possibly be marked).

So far as I can see, this bill would meet all the requirements of the case, and would satisfy all parties. The Forest Department admits that it does not wish to retain the worthless growth, and I believe everyone else wishes to get rid of it. Many planters told me that they were only too willing to remove it, but that they were prevented, or hampered, by the laws. If the owner does not wish to do the work, the Medical Department can do it for him. If he refuses permission, I fancy that he could be compelled to give it under the draft legislation in annexure 3—though perhaps a special clause will be required to cover this point. The actual work can be done, where required, by the malaria gangs, especially during the winter months. I would not advise limitation of the bill to any particular localities, *e.g.* those near populous places, unless the Forest Department wishes to preserve undergrowth as well as trees in spots far removed from habitations.

In conclusion I must add that the exact effect of the streams in causing malaria can be ascertained only by watching the results of the minor works and by taking the spleen census frequently, as already recommended. The facts will declare themselves automatically in the course of the work. Here, as elsewhere, labour lights itself.

ADDENDUM 4.—STATISTICAL ERROR. The Poisson formula for statistical error is well known; but it may be advisable to give here an addition made by Professor Karl Pearson, which will be particularly useful for taking spleen rates in villages and towns.

Let N be the total number of children in a locality; n be the number examined, and x be the number with enlarged spleen. Then $\frac{x}{n} \times 100$ will be the spleen rate among the n children examined. But we shall have no right to infer that the same rate will hold for all the N children in the locality Let $e\%$ denote the percentage of error. Then

$$e\% = \frac{200}{n}\sqrt{\frac{2x(n-x)}{n}}\sqrt{1-\frac{n-1}{N-1}}.$$

Thus, when $n = N$, or all the children in the locality are examined, the statistical error vanishes.

For example, let $N = 800$, $n = 200$, and $x = 100$. Then $1 - \frac{n-1}{N-1} =$ about $\frac{3}{4}$; and $\frac{2x(n-x)}{n} = 100$. Hence

$$e\% = 5\sqrt{3} = 8{\cdot}65.$$

So that we can infer that the spleen rate of the total 800 children is between $(50 + 8{\cdot}65)\%$ and $(50 - 8{\cdot}65)\%$; that is, between $58{\cdot}65\%$ and $41{\cdot}35\%$.

The following square roots are useful :—

$\sqrt{2} = 1{\cdot}41$ $\sqrt{3} = 1{\cdot}73$ $\sqrt{5} = 2{\cdot}24$ $\sqrt{6} = 2{\cdot}45$ $\sqrt{7} = 2{\cdot}64$
$\sqrt{8} = 2{\cdot}83$ $\sqrt{10} = 3{\cdot}16$.

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ANNEXURES.

ANNEXURE I.—Extracts from letters by Dr. Bolton to Professor Ross (written by request).

Letter A.

PHŒNIX, *January 3rd*, 1908.

In 1902 I was sent on a special mission to Diego Garcia, one of the numerous atolls forming the Chagos Archipelago.

On my arrival I was told malaria did not exist in the Island—the few cases met with occasionally were among the labourers recruited in Mauritius, where they had contracted the disease.

After careful investigation I failed to discover the least indication of malaria infection among the resident population, *i.e.*, those who had never left the Islands. My next step was to search for Anopheles. In spite of the numerous tanks of stagnant water full of Culex larvæ, I failed to find a single Anopheles. I was bound, therefore, to come to the conclusion that this fact explained the immunity from malaria enjoyed by a certain proportion of the inhabitants. I stayed a month there, so had ample time to search for the fever host.

From Diego I went to Peros Banhos, another atoll 120 miles more to the east. Here again I recorded exactly the same facts.

Having always heard that Rodrigues also was free from malaria I requested my son to investigate the matter. The absence of malaria among the resident population is here again due to the fact that I had occasion to verify last month when I visited the Island, that there are no Anopheles—although other kinds of mosquitoes are plentiful enough and breeding places exist all over the village of Port Mathurin, the capital of the Island.

These facts tend once more to prove the correctness of the Anopheline theory, if any further such proof were necessary.

I need not say that you may make what use of this letter you may wish.

Letter B.

PHŒNIX, *13th March*, 1908.

(1) The loss to agriculture resulting from the yearly outbreak of malaria.

The total Indian population for the whole Island was 263,971 in 1902; in 1907, 100,514 lived on Sugar Estates, viz., 45,526 men, 24,509 women, and 30,479 children. Malaria is rife from February to the end of April—in the most infected locality the sick rate per diem from malaria alone is sometimes as high as 20 % of the total male adult estate population; on some estates it is lower—and on those situated in the district of Moka and the upper parts of Plaines Wilhems still less. An average of 15 % would be very fair for the low-lying districts. If I leave Moka out altogether then the figures stand thus:

Male adult population on estates for the remaining districts, 48,942—say 39,000 daily, average of 15 % = 5,850—say 5,800, multiplied by 90 days = 522,000—say 500,000. The value of a day's work is between Rs. 1·25 and Rs. 1·50, so that the loss to the planters is about Rs. 650,000, and to the Indians at an average of R. 0·25 per diem Rs. 125,000; a grand total therefore of close upon Rs. 800,000. The figures refer only to the adult male population residing on Sugar Estates. There must now be added to this the women and chokras who are regular workers on estates; they also suffer from malaria during the season, and are incapacitated from work for days and even weeks. The number of women on estates is 24,000 odd. If we accept 50 % as a fair figure to represent those working in the fields we obtain a total of about 8,000, and 15 % on 8,000 is 1,200—multiplied by 90 days = 108,000 at Rs. 0·20 = Rs. 21,000. I do not count the chokras nor the loss to the Estate. I find therefore that the loss to the labourers and their wives and children is Rs. 150,000 nearly. Loss to the Estates Rs. 650,000. Total Rs. 800,000.

The Indian population residing outside estates is over 160,000. A large proportion work as day labourers on estates and also on fibre factories, and about 600 adult males in the different docks in town. Thirty thousand adult males, approximately, work as day labourers, earning on an average R. 0·55 per diem—a total of about Rs. 15,000 per day—90 days will represent Rs. 135,000. A loss of 15 % is therefore Rs 20,000. No mention is made of the loss sustained by the blacks who work as day labourers. I have no figures for these. It is no exaggeration therefore to say that the total loss to the labouring classes amounts to quite Rs. 200,000 and to the planters Rs. 650,000, without taking into account extra hospital expenditure, drugs, comforts, &c. All told it would be found that the grand total would come to quite Rs. 900,000. Add to this the expense to Government for the sick treated in the different hospitals and at the dispensaries for malaria and sequelæ during three months, and the respectable sum of Rs. 1,000,000 is attained.

(2.) The next question to deal with is the spleen-rates. There are no schools on the Sugar Estates; but as very few of the children of the indentured coolies attend school there is no danger of any serious overlapping. The Indian boys attending the Government schools belong to the free class of Indians, *i.e.* those who do not live on estates. I am certain the overlapping cannot exceed 0·25 %. This is not, I presume, of sufficient import to affect your statistics.

Letter from Dr. Malcolm Watson to Professor Ross (written by request).*

EASTFIELD, BRIDGE OF ALLAN, 26*th May*, 1908.

On the points on which you ask my opinion, my experience is as follows:—

(1.) The health of the community shows very great improvement within three months of the abolition of the main breeding places, and malaria was found to have practically disappeared within a year at Klang, although all the breeding places had not been satisfactorily drained. Experience has shown that it is sufficient to reduce the number of mosquitoes in order to abolish malaria, although one naturally aims at making the reduction of the mosquitoes as great as possible.†

(2) Drainage undoubtedly reduces the number of Anophelines in an area.

(3) In both Klang and Port Swettenham there was the most convincing proof that there is no dangerous immigration of Anophelines into a drained area from the outside; for both towns, although surrounded by an enormous acreage of breeding places, were when drained themselves freed from malaria. At Port Swettenham the safety zone was certainly less than a quarter of a mile in some places.

* See page 83. † Compare pages 34–36.

(4) Anti-malaria drainage can be effectively carried out with a high rainfall. In Klang the rainfall may reach to over 100″ per annum, and thunderstorms, when two inches fall within an hour, are not uncommon. On such occasions the whole town in submerged.

Further, where this heavy fall occurs on a mangrove swamp, so low lying that it is covered by all spring tides, anti-malaria drainage was found completely successful. Although when a heavy fall occurs at a time when the tidal valves are closed by a full tide the whole land is submerged, the fall of the tide permits the valves to open, and the land is soon dry. No more discouraging outlook for anti-malaria drainage can be imagined than the above, yet the experience of Port Swettenham shows that there is no difficulty whatever in practice.

ANNEXURE 2.—CORRESPONDENCE REGARDING WATER CHANNELS.

From PROFESSOR R. ROSS, BRODICK, VACOAS. *To* THE HONOURABLE THE COLONIAL SECRETARY, MAURITIUS. 14*th January*, 1908.

SIR,

I have observed that there are in the Island many water-channels, apparently made for the purpose of conveying water from rivers or springs to plantations or factories, and also much used by people living near them for obtaining water or washing clothes. These channels are often obstructed by vegetation or silt to such an extent that they cause, or tend to cause, malaria along their course.

I should be much obliged if I could receive, for the purposes of my Report on Malaria, the following details of information regarding these channels :—

1. To whom do they belong—to Government or to the owners of the Estates and Factories which they serve?

2. In the latter case is there any law by which the said owners can be forced to keep them in a sanitary condition, not only within the actual premises of the owners, but also in their entire course, as would seem justifiable owing to the fact that they were originally made for the private purposes of such owners?

3. In the event of there being no law or regulation forcing the owners to keep the channels free from obstruction, thus compelling the Government to do the work for sanitary reasons, is there any means by which the owners can be taxed for the work done on their property? Is there moreover any means by which other persons who use the water can be made to pay for maintaining the channels in good condition?

The same question will also apply to drains made especially for conveying waste and storm water out of Estates, Factories, and private premises.

4. Lastly, in the case of channels or drains which have fallen into disuse or which are persistently neglected by the owners, is there any means by which the latter can be forced to close them or, better, to fill them in?

(Sd.) RONALD ROSS.

No. 422/08.

COLONIAL SECRETARY'S OFFICE, MAURITIUS, 20*th February*, 1908.

SIR,

I am directed by the Governor to acknowledge the receipt of your letter of the 14th ultimo on the subject of the cleansing of water channels, and to transmit herewith copies of the correspondence noted in the margin giving the information asked for therein.

Professor R. Ross, C.B., F.R.S., Brodick Vacoas.

J. MIDDLETON,
Assistant Colonial Secretary.

No. O.L. 165/08.

From The Honourable The Procureur-General *to* The Honourable The Colonial Secretary.

Referring to your letter No. 422/08 of the 27th January last on the subject of the cleansing of water channels, I beg to attach a report from the substitute which affords, I submit, an answer to the questions in the letter from Professor Ross.

(Sd.) A HERCHENRODER,
Procureur-General.

Chambers,
10*th February*, 1908.

1. This matter, I understand, requires speedy attention, as the stay of Professor Ross in this Island is drawing to a close. I shall therefore deal only with salient features, and omit details.

2. "Canals" are the property of (*a*) private owners, *e.g.* most if not all, of the artificial water-courses feeding sugar or aloe fibre factories, or established for the purposes of irrigation; (*b*) corporations, *e.g.* the canals supplying water to the Town of Port Louis; (*c*) communities of riverains *e.g.* the Plaines Wilhems Canal, the Terre Rouge Canal, &c.—I am not quite clear whether there are not also some canals which are the exclusive property of Government; the Director of Public Works and Surveys may give information on this point, which may however, I submit be overlooked, as it does not bear on the more immediate question of legislating, if need be, in order to compel private parties, communities of riverains &c., to take such measures as may prevent the obstructions of canals, and consequently lessen the sources of dissemination of malaria.

3. Private parties are responsible in general for the keeping of their canals in a proper state of maintenance, repair, &c., whether the canals run wholly on lands belonging to such private owners, or partly on such lands, and partly on intermediate lands. (See specially Art. 15 of Ord. No. 33 of 1863.)

4. The same obligation rests on corporations (Ord. No. 35 of 1863, Art. 46; Art. 84, S. iii.).

5. It further extends to communities of riverains whose rights and duties are regulated by Chap. II of Order No. 35 of 1863. Those communities have Syndics (Presidents), and Joint-Syndics (Art. 52 of Ord. No. 35 of 1863) and keepers (Art. 57). An important provision of Chapter II. of the Ordinance is Art. 64, which enacts that every owner of ground through which a canal belonging to a corporation or community of riverains shall pass (Art. 84, S. iii.), shall be bound to keep the canal in its whole course through his property free from obstructions of any kind, including obstruction by plants, branches, roots, &c.

(6) I have, I think, given a complete reply to question No. 1, save on the point of canals which may be the exclusive property of the Crown. Questions No. 2 and No. 3, paragraph 1, are partially answered; the cycle

will, I think, be complete if an enactment is passed on the lines suggested by Professor Ross in another paper, and which we have discussed with the Medical Director. It includes an addition to the definition of a "nuisance," and powers to suppress, within the shortest delay, breeding places for mosquitoes, to incur the necessary expenses, and to charge them against, and recover them from, the parties concerned. The proposed amendments bear specially on Ord. No. 32 of 1894–1895, Art. 29 sqq. and Art. 52 sqq. Canals coming under categories (*a*), (*b*), and (*c*) in paragraph 2 of this report are provided for, and the draft enactment further contemplates measures to be adopted in the case of canals and other "premises" which may happen to be the exclusive property of the Crown.

The projected law on the prevention of malaria will, I believe, meet the second part of Question No. 3, as well as Question No. 4. Drains and channels will, under certain conditions, be treated as "nuisances" under the general law of 1894–95, or they may be dealt with summarily under the proposed enactment.

(Sd.) J. EUG. SERRETT,

8/2/08. *Ag. S.P.G.*

The above shows, I submit, the necessity of considering the present question simultaneously with the one on which Dr. Momplé has conferred with us.

8/2. (Itd.) J.E.S.

ANNEXURE 3.—DRAFT LEGISLATION.

Registered No. D/126/34. MAURITIUS, MEDICAL & HEALTH DEPARTMENT, 11*th February*, 1908.

SIR,

Referring to your letter of the 5th ultimo, I have the honour to transmit for your consideration the enclosed copy of a Draft Ordinance which I think will secure the object aimed at.

I have on the whole followed the lines indicated by you, and in the drawing up of the draft the Acting Assistant Director, who has had particular charge of this work, has been kindly assisted by the Honourable the Procureur-General and his substitute.

The imposition of mininum fines, except under special circumstances, is not allowed by the existing legislation.

As far as manure and useful bodies of water are concerned, it appears to me that private interests will be sufficiently safe-guarded under both the provisions of Regulation No. 198 of 1907 (of which I annex a copy) and those of the Ordinance now proposed.

To Professor R. Ross, C.B., F.R.S., Brodick, Vacoas.

H. LORANS, Director.

ORDINANCE NO. OF 1908.

1. In this Ordinance "owner," "occupier," "premises," "sanitary authority," shall have the same meaning as in Ordinance No. 32 of 1894–95.

2. The following paragraph is added to Article 29 of Ordinance 32 of 1894–95 :—

K. All collections of water, sewage, rubbish, refuse, ordure, or other fluid or solid substances, and all other conditions which permit, or facilitate, or are likely to permit or facilitate, the breeding or multiplication of animal or vegetable parasites of men or domestic animals, or of insects or other agents which are known to carry such parasites, or which may otherwise cause or facilitate the infection of men or domestic animals by such parasites.

3. (*a*) Notwithstanding the above provisions or any of the provisions of Ordinances No. 32 of 1894–95, 21 of 1900, 23 of 1903, 12 of 1889, 31 and 32 of 1895.

It shall be lawful for any Sanitary Authority or any person deputed by him in writing to take immediate steps to destroy mosquito larvæ on any premises where they may be found, and to take such action as may be necessary to render any pools or accumulations of water unfit to be breeding places for mosquitoes.

(*b*) The persons so deputed shall have a right to enter any premises, dwelling houses excepted, between the hours of six in the morning and six in the afternoon.

(*c*) When such pools or accumulations of water lie on premises under the charge of a public body or corporation they shall not be dealt with as above provided, unless due warning has been given in writing to such public body or corporation, and no action has within reasonable delay, not to be less than 24 hours been taken by them. In such cases the expenditure incurred shall be borne by such public body or corporation.

(*d*) Any owner or occupier who shall object to pools and collections of water on his premises being dealt with as above provided, shall within 24 hours submit his reasons to the sanitary authority, who, after inquiry, shall order such action to be taken as he shall consider necessary to meet the provisions of this Ordinance. Should the objections be rejected the measures originally ordered shall be carried out at the expense of the said owner or occupier.

4. It shall not be lawful for any owner or occupier to allow mosquitoes to breed on his premises or to allow the presence on such premises of any receptacle in which water is kept or may collect unless such receptacles are properly protected from access of mosquitoes, or unless the water they may contain is treated in such a way as to prevent the breeding therein of mosquitoes, nor shall such owner or occupier allow on his premises any conditions which may, in any way, be favourable to the breeding of mosquitoes.

5. Trees on all premises shall be at all times kept freely lopped to the satisfaction of the sanitary authority by the owner or occupier, and no trees shall be allowed to grow within 10 feet from any dwelling house. The sanitary authority may, in writing, direct the said owner or occupier to carry out the above provision within a reasonable delay, not to be less than 48 hours, and, in case of non-compliance, the trees shall be lopped or cut down at the expense of the owner or occupier.*

6. It shall be lawful for the Director of the Health Department to make such regulations as may be necessary to carry out the provisions of this Ordinance.

7. It shall be lawful for the Director of the Health Department in any case when the owner or occupier of any premises is liable for the expense of

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* Some specific provision ought to be made to enable the sanitary authority to fill up with concrete, or otherwise to treat, holes and hollows in trees which breed, or are likely to breed, mosquitoes; and also to compel owners to cut insanitary undergrowth (see particularly addendum 3). R. Ross.

any measures carried out on his premises to relieve such owner or occupier from the said expense, if, after inquiry, the Director is satisfied that such owner or occupier is not in a position to incur such expense. In such cases the expenditure shall be borne by Government.

8. Any person acting in breach of Articles 4 and 5, or of the regulations made under Article 6, shall be liable to a fine not exceeding Rs. 100.

9. Expenses incurred by the sanitary authority under paragraphs (*c*) and (*d*) of Article 3, and under Article 5, shall be dealt with in the manner provided by Articles 52 and 53 of Ordinance No. 32 of 1894–95.

10. This Ordinance may be cited as the Malaria Prevention Ordinance.

ANNEXURE 4.—ROUGH ESTIMATES OF WORKMEN AND WORKS, PREPARED:—

(A) BY THE MEDICAL DEPARTMENT.

ESTIMATE OF MALARIA GANGS FOR THE RURAL DISTRICTS.

PAMPLEMOUSSES.

	Gangs of 3 men each.		Gangs of 3 men each.
Villages—		*Populous Places*—	
Pamplemousses ...	1	Riche Terre and Tombeau Bay ...	1
Calebasses	1	Arsenal and Riv. Citrons	1
Terre Rouge ...	1	Ville Bague	1
Pliane des Papayes and vicinity ...	1	Bois Rouge and St. André	1
		Pte. aux Piments Triolet and Trou aux Biches	2
	4		6

Total for District, 10.

RIVIÈRE DU REMPART.

Villages—		*Populous Places*—	
Poudre d'or ...	1	Grand Gaube... ...	1
		Cap Malheureux and Grand Bay... ...	1
		Goodlands	1
		Pte. Lascars and Roche Noire	1
		Riv. du Rempart and Ravin	2
		La Mare and Camp Maçons	1
		Plaine des Roches ...	1
	1		8

Total for District, 9

Flacq.

Villages—	Gangs of 3 men each.	Populous Places—	Gangs of 3 men each.
Centre of Flacq ...	1	Bois d'oiseaux and Plaine Larché ...	1
Post of Flacq ...	1	Bon Accueil and Brisée Verdière	1
St. Julien	1	La Mare and Australia	1
Trou d'Eau Douce	2	Plaine Gersigny and Richelleau	1
Grand River S. East	1	Quatre Cocos... ...	1
Rivière Sèche ...	1	Medine and Mont Ida	2
		3 Ilots and vicinity ...	1
	7		8

Total for District, 15.

Grand Port.

Villages—		Populous Places—	
Mahebourg ...	1	Bois des Amourettes and Coast	2
Rose Belle... ...	1	Cent Gaulettes ...	1
Mare d'Albert ...	1	Mare Chicose ...	1
New Grove... ...	1	Riv. des Créoles and vicinity	1
Escalier	1	Les Mares, Bouchon, &c.	1
Plaine Magnieu ...	1	Mare Tabac	1
Nouvelle France ...	1		
	7		7

Total for District, 14.

Savanne.

Villages—		Populous Places—	
Grand Bois ...	1	Camp Berthaud and Camp Rataud ...	1
Souillac	1	Surinam	1
Chemin Grenier ...	2	Petit Cap	1
Riv. des Anguilles...	1		
Camp Diable ...	1		
	6		3

Total for District, 9.

Plaines Wilhems.

N.B.—Townships to be provided for by Boards.

Villages—		Populous Places—	
Vacoas	2	Beau Bassin (outskirts)	1
Phœnix	1	Mon Roche and vicinity	1
Coromandel ...	1	Stanley	1
		Quatre Bornes (outskirts)	2
		Camp Fouquereaux ...	1
		Solferino	1
		Curepipe (outskirts), N. & S.	2
	4		9

Total for District, 13.

BLACK RIVER.

Villages—	Gangs of 3 men each.	Populous Places—	Gangs of 3 men each.
Petite Rivière ...	1	Pte. Case Noyale ...	1
Bambous	2	Grande Case Noyale and Chamarel	1
		Tamarin and vicinity	1
		Black River	1
		Palma and Pierrefonds	1
		Flic en Flac	1
		Pte. aux Sables ...	1
	3		7

Total for District, 10.

MOKA.

Villages—		Populous Places—	
Moka and St. Pierre	2	Quartier Militaire ...	2
Pailles	1	Camp de Masque ...	1
		Montagne Blanche ...	2
		Beau Bois	1
		Roslyn Cottage and Bois Chéri	1
		Riv. Baptiste	1
		Bocage and Mount Ory	1
	3		9

Total for District, 12.

RECAPITULATION.

Pamplemousses	10
Riv. du Rempart ...	9
Flacq	15
Grand Port	14
Savanne	9
Plaines Wilhems	13
Black River	10
Moka	12
	92
Additional ...	8
	100

EXPENDITURE PER ANNUM.

100 Gangs	60,000
10 Moustiquiers ...	3,000
Extra Urban Port Louis—	
3 Moustiquiers ...	900
4 Gangs	2,400
Implements, Sundries, &c.	13,700
	Rs.80,000

ANNEXURE 4.—B. BY THE IMMIGRATION DEPARTMENT.

COLONIAL SECRETARY'S OFFICE, MAURITIUS, 7 *February*, 1908.

No. 1,117/08.

SIR,

With reference to your letter of the 5th ultimo, I have the honour by direction of the Governor to transmit to you a copy of the report furnished by Dr. Bolton, Medical Officer of the Immigration Department, on the "Major sanitary works of a permanent nature to be undertaken on Estates as part of an anti-malarial campaign."

Professor R. Ross, C.B., F.R.S.,
Brodick, Vacoas.

LÉON KŒNIG,
Asst. Colonial Secretary.

REPORT.—I.—ON MAJOR SANITARY WORKS OF A PERMANENT NATURE TO BE UNDERTAKEN ON ESTATES AS PART OF AN ANTI-MALARIA CAMPAIGN.

Pamplemousses District.

Beau Plan Estate.—The factory and camps of this estate, situated in the flat low-lying part of the district, have in their immediate vicinity a large marsh, resulting from the damming of the discharge canal of all the ponds in the Botanical Gardens. The land all round this marsh is boggy over a considerable area, and contains numberless pools and puddles overgrown with aquatic plants and weeds.

The Malaria Committee have under consideration a scheme for the suppression of this dangerous nuisance.

In my opinion the most important factor operating in producing high malaria prevalence in one part of the district of Pamplemousses is the state of the banks of the river of the same name.

The banks of this water-course are overgrown with a thick jungle, impenetrable in some places and composed of brambles, bamboo, raffia palms and weeds of all kinds. Any number of collections of stagnant water exist on each bank. The roots of trees, stones, aquatic plants and vegetable matter in different stages of decomposition, by impeding the flow of water, help to form collections of stagnant water. This most insanitary condition of things from a general, as well as from a malaria point of view, is the result of "the manner in which the forest laws have been applied," and of the "fanatical reverence for trees which is shown by those in charge of river reserves."

Besides the above obstacles to the flow of water and the resulting nuisances, several dams exist on this river to supply water to Rosalie-Constance, Le Plessis, The Mount, Maison Blanche and l'Espérance Estates and lastly to the Botanical Gardens. Acres of land have thus been submerged, aquatic plants and weeds have grown, water stagnates and mosquitoes abound.

These estates have always given high malaria percentages on the total deaths, 50–60 % being common figures. The camps of these estates have all been built close to the river on account of the water supply.

Anti-malaria measures on a small scale will not be of any use.

Rosalie-Constance, The Mount, Maison Blanche, L'Espérance.—To abate the nuisances existing on these estates will necessitate perhaps alterations in the method adopted in supplying water to the factories of the first two estates; removing some of the dams, cutting down the trees and jungle on the banks of Pamplemousses river, cultivating the land thus reclaimed, training and banking the stream wherever this may be found necessary. But inasmuch as Pamplemousses Village begins immediately after l'Espérance Estate, and as the river flows through part of it, I should say there should be one comprehensive scheme of sanitation embodying the estates mentioned above Pamplemousses Village, including the Botanical Gardens and Beau Plan Estate as far as the Royal Alfred Observatory. Needless to say this calls for the interference of the sanitary engineer.

Rivière du Rempart District.

The coast line of this district being low and flat presents numerous marshes, the most important being at l'Union, Poudre d'Or, Haute Rive and Schoenfeld.

L'Union.—This at one time large estate has been parcelled out, and we have now to deal with a scattered population living in isolated huts, so that I do not advise any major works.

Poudre d'Or.—This estate now forms part of St. Antoine Estate. There is a camp with about three hundred souls. In the vicinity of this camp there is a large marsh which empties itself into the sea by a small stream which skirts Poudre d'Or village. Here again any works to be undertaken should comprise the village as well and must be entrusted to a sanitary engineer.

Schoenfeld.—There is a marsh on this estate which in my opinion is the cause of the high prevalence of malaria. I have not inspected it carefully, so can form no idea of the works which should be undertaken. A careful survey is necessary.

Haute Rive.—Several large marshes overgrown with rushes exist on this estate and a river passes through one of the camps.

I do not think it will be easy to drain all marshes, as the land is very low and there is barely any fall to the sea, which is quite close. A proper survey and plane tabling will have to be made preliminary to any substantial and permanent work.

Flacq District.

There is but one estate in this district where comparatively extensive works will have to be undertaken. Here again, however, as in the case of Pamplemousses, whatever scheme is eventually adopted should comprise Centre of Flacq Village. The estate alluded to above is Constance (d'Arifat).

Constance (d'Arifat)—The portion of this estate where the factory and camps are situated is only a few feet above sea level, very flat and boggy in many places. A sluggish river serpentines through it; the banks are so flat that it often overflows. When the water recedes, part remains behind to stagnate in small pits and hollows, and this occurs under the usual thick impenetrable jungle, the river reserves. Besides this one there is another river which comes from Centre de Flacq Village to meet it. The above description applies equally well to the latter.

Grand Port District.

Union Vale.—This is the only estate in this district where sanitary works of any magnitude are called for. Between the factory and the hospital exists a marsh which should be drained, but as its overflow runs through private property lower down, I am not in a position to judge the magnitude of the works which may be required.

On no estate in the districts of

Savanne,
Plaines Wilhems,
Moka,
and Black River.

are major works necessary in the fight against malaria. Such as may be undertaken will be connected with a general scheme for all villages, townships and hamlets and need not be discussed here.

If the major anti-malaria undertakings are not numerous in connection with estates, the same cannot be said with regard to

II.—MINOR SANITARY WORKS AND MEASURES FORMING PART OF AN ANTI-MALARIA CAMPAIGN ON ESTATES.

There is not a single estate in the island upon which, on close inspection, there is not something to be attempted, something done to drive away the fever carrier.

All the estates of the island were started long before the memorable year 1867, when malaria showed itself in an *epidemic* form. Isolated cases had been met with long before; in fact, from the beginning of Indian immigration into the island. Mauritius then enjoyed a well deserved reputation for its salubrity. The parcelling out of estates had not begun, and the island was not stocked, as it is now, with agglomerations of Indian huts forming hamlets, villages and camps, inhabited by Indo-Creoles and free immigrants who have served their original indenture. The streams, and even rivers of the island, furnished a supply of pure water or water nearly so. Such being the hygienic conditions prevailing before 1867, all Estate Camps were constructed in the vicinity of streams, in view of an easy and abundant water supply.

Alas! how altered the ante-1867 local conditions. What a harrowing picture could a facile pen draw of the present most insanitary conditions to be met with all over the island, from the Morne Brabant in the south to Cap Malheureux in the north, from Port Louis on the west to Trou d'Eau Douce on the east.

Everywhere the same: polluted rivers, foul boggy mosquito-haunted jungles on each side; filth, rank vegetation on the outskirts of villages; and dark, ill-constructed, unventilated tenements; with the ever-present Anopheles Mosquito ready to inoculate the first person who happens to come within the range of his peregrinations.

To facilitate reference, I give a list of all estates where a stream or river plays a by no means unimportant part in the malaria endemicity and periodical outbursts.

Pamplemousses.

Rosalie, The Mount, Rosalie-Constance, Le Plessis (part of The Mount), Maison Blanche (part of Mon Rocher), l'Espérance. All these camps are within mosquito reach of Pamplemousses and have already been considered. At Maison Blanche malaria is at times very bad.

Rivière du Rempart.

Haute Rive is the only estate in this district where there is a stream close enough to the camps to operate against the healthiness of the camps. There are two small ones near the two camps of Ile d'Ambre and a river at Haute Rive. As these camps are, so to speak, within a stone's throw from the sea, the river should be cleaned, all jungle removed and the banks trimmed.

Flacq.

In this district the following have water-courses near their camps. Constance (d'Arifat) has already been dealt with under the heading of Major Works. Argy, Beau Bois (a few huts near the river), I propose to have this small camp removed, Belle-Rive, Belle Vue, Constance (M), Deep River, Olivia, Rich Fund and Union.

Grand Port.

Anse Jonchée, Beau Vallon, Ferney, Joli Bois, Le Vallon, Riche en Eau St. Hubert, Union Park.

On all of these, streams or rivers exist with the usual reserves, which have to be attended to.

Savanne.

In this district there are numerous streams in too close proximity to the camps.

Bel Air, Bel Ombre, St. Aubin, St. Avold, St. Felix, Savannah, Terracine, have all a heavy malaria percentage on total deaths. With exception of St. Avold, they are all situated near the coast; they have no neighbours along the river between them and the sea, so that no possible harm can accrue to any one if the different streams were to dry up after cutting away all the river reserves, a thing I do not anticipate.

Plaines Wilhems.

Bassin, Trianon, and Ebène (part of Stanley) are the only Estates in this district which have filthy streams near the camps.

Moka and Black River.

The first district is the healthiest of the Island, malaria prevalence low. The Malaria Committee had this district under its consideration in 1902, and with most beneficial results. (See my report on Estate Hospitals for the second half of 1902).

In Black River district, Medine Estate has streams near the camp.

I propose now to enumerate the Estates where other measures are called for besides destruction of jungle on river side or concurrently therewith: these consist in filling in pits, draining small marshes or filling in as the case may be, searching for old tins, broken bottles, hollow stumps of trees, collections of stagnant water in factories, boilers, tanks, &c., removal of rank vegetation in the vicinity of camps, and lastly a change in the style of hut adopted on Sugar Estates (sanctioned by law) for the housing of the coolies. The system of having long ranges of huts divided into eight, ten, or more compartments, should be condemned, as they favour infection from one to the other—the partition between being never an efficient protection. To obtain a radical change in this direction, the Labour Law and Camp Regulations will need alteration.

On the following Estates, collections of water represented by small pools and marshes and tanks will call for special attention :

Pamplemousses.

Belle Vue (Harel) ...	...	Tanks, wells, factory.			
Belle Vue S.E. Co. ...		,,	,,	,,	
Mon Piton ...	...	,,	old pits, no factory.		
Mon Rocher ...	...	,,	,,	,,	
Rosalie ...	...	,,	,,	factory.	
Rosalie Constance ...		,,	,,	,,	
Solitude ...	...	,,	,,	,,	canals, small marshes.
Mount ...	...	,,	,,	,,	,,
Maison Blanche ...		Old pond, canal.			
L'Espérance ...	...	Old pits, canal.			

Rivière du Rempart.

ANTOINETTE.—Old drain near Mon Songe Camp. Old disused molass pits in the closed factories of La Lucia and Mon Songe. Pits near manure heaps.

BEAU SÉJOUR.—If the boilers are not emptied after the crop, they should be kept closed to keep out mosquitoes. Tanks and other receptacles for water.

BELLE VUE-L'AMITIÉ.—Old molass pits at L'Amitié. Factory tanks, &c.

BON ESPOIR.—Canal, old factory.

ESPÉRANCE —Cistern at the wall near the hospital, collections of stagnant water.

MON LOISIR (A).—Ponds in yard near camp.

L'UNION (R).—Tanks in yard in vanilla plantation.

LABOURDONNAIS.—About halfway between the factory and the hospital on the right hand side of the road, I have often noticed a collection of water which in the rainy season will persist for weeks. This should not be allowed to continue. At Forbach, an annex of this estate, the cisterns should be carefully watched or properly closed to keep out mosquitoes. The same precautions should be taken at Mapou.

Flacq.

BEAUX CHAMPS.—Part of the camp of this estate has been erected to the leeward and within anopheles range of some boggy lands which are converted into stagnant pools during the rainy season, the period of greatest malaria prevalence. In presence of the high death rates and persistent increasing malaria prevalence, I have recommended the removal of this part of the camp to a healthier locality. This will soon be an accomplished fact.

DEEP RIVER.—The reservoir for supplying the factory of this estate with water is a large pond dug in the earth. The sides are overgrown with brushwood and rank vegetation in which the water stagnates ; although the pond is stocked with some fish, they cannot reach the larvæ of the gnats living among the grass in water barely half an inch deep in certain places. An ordinary road separates this sheet of water from one of the estate camps. The necessity of exploring the pond and clearing and trimming its sides is obvious.

LA GAIETÉ.—Draining and filling in of some small collection of marshes. The factory has been closed for years ; as is usual in such cases, open pans, old tanks and pits are to be found ; as water may stagnate in them, they should be searched for and dealt with.

Grand Port.

The remarks concerning La Gaieté apply also to Anse Jonchée, Ferney, Le Vallon, Virginia, as regards sluggish and stagnant water.

At La Rosa and New Grove, parts of Rose Bell Estate, Anse Jonchée, Savinia (part of La Baraque), Sauveterre, Virginia, the factories have been pulled down ; old pans, cisterns, molass pits, &c., should be carefully investigated and dealt with as circumstances may require.

Savanne.

BENARES.—The land all round the reservoir should be kept free of jungle, any collection of stagnant water suppressed. The canal passing through the camp kept clean, and the sides properly trimmed and freed of grass, &c.

L'Union.—A large depression next to the camp should be carefully watched and no stagnant water allowed in the rainy season.

Savannah.—There is a ditch on one side of the lower camp which is often overgrown with rank vegetation. As there is almost always more or less water in it, it should be kept perfectly clean, the banks properly trimmed, and all obstacles to the flow of water removed.

Terracine.—Canal and ditch to be kept clean. The other estates of this district which I have not mentioned, need no special attention beyond searching for collections of stagnant water in old tins, tanks and cisterns, &c.

Moka.

As I have already observed, the estates of this district being comparatively malaria free, the measures to be adopted need not be specified at length. At Bon Air, however, there is a spring which supplies water to the camp; at one time a marsh had been formed just below the spring and malaria had prevailed extensively. This was suppressed by the Malaria Committee with most marked effect. It should not be allowed to fall into its original state.

Plaines Wilhems.—Black River.

Nothing special to be said of any of the estates of these two districts beyond what I have already written.

Execution and Cost of Major Works.

I am sorry I am not in a position to lay down, even approximately, the cost of some of the works to be executed. Each case must be dealt with separately, and the area to be attacked properly surveyed, levels taken, and the nature of the works to be undertaken specified by a Sanitary Engineer.

I am still of the opinion expressed in my report addressed to the Honourable the Protector of Immigrants, on the 20th of June, 1906, that the so-called "reserves" should be cut down in the lower parts of the island where malaria prevails, the wood given to the riparian proprietors, and the land thus reclaimed cultivated. A very large saving will thus be effected. I have gone fully into this subject in a paper which I read before the "Société Médicale" of this island at a meeting held on the 8th of August, 1906.

Minor Works.

These can easily be undertaken by ordinary labourers under the direction of a trained overseer; the tools required being a measuring tape, a few hoes, pick-axes, crow-bars, and baskets. Each district should have its own gang or gangs distributed over certain areas. I propose to divide each district into sections, each section to be in charge of a patrol composed of:—

One Sanitary Guard at	Rs.35 p. m.
Four labourers at	64 p. m
	Rs.99 p. m

At Rs.35 p. m. the services of an intelligent man able to draw up a report can be secured. All patrols to be under the direction of the Sanitary Warden of the district, and to be allowed to travel free on the railway, and to be entitled to the refund of any travelling expenses where the railway will not be available.

The Sanitary Guard will be bound to send weekly reports to his chief showing the area travelled over, the nature of the nuisances detected, and the measures adopted by him to abate them.

I believe the following scheme should prove satisfactory.

Pamplemousses.

Two sections. Upper and lower. One guard and four men to live at Terre Rouge	Rs.99 p. m.
One guard and two men to live at Plaine des Papayes	67
	Rs.166

The first to patrol as far as the western bank of Pamplemousses River from Rosalie Estate to the sea, and the second over the remainder of the district as far as the boundary of Rivière du Rempart.

Rivière du Rempart.

Two sections. The railway line from Pamplemousses boundary to Poudre d'Or Station and the road leading to the village.

One guard and two labourers to reside at Piton	Rs.67
And the same number at Poudre d'Or Village	67
	Rs.134

Flacq.

One guard and four men at centre of Flacq	Rs.99
One guard and four men at Rivière Sèche	99
	Rs.198

The district to be divided into two sections by the road leading from Camp de Masque Station to Argy and Palmar.

Grand Port.

This district can be divided into two sections by the Main Road from Port Louis as far as the entrance of Plaisance Estate, thence by a straight line to the sea.

One guard and three men to each section Rs.166

One patrol to be stationed at Rose Belle and the second at Mahebourg.

Savanne.

The sinuosities of the Rivière du Bain des Négresses will do very well for the boundary between the two sections of this district.

Each to have one guard and three men living at Chemin Grenier and Rivière des Anguilles Rs.166

Plaines Wilhems.

One guard and three men for Curepipe	Rs.83
One guard and three men for Middle Plaines Wilhems including Vacoa, Phœnix, and marked out by a line drawn from west to east and passing through Phœnix Old Mill to the boundary of Moka	Rs.83

Lower Plaines Wilhems. All that remains of the district below that line.

One guard and two labourers at Rose Hill	Rs.71
One guard and two labourers at Coromandel	71

Moka.

One guard and four men at Pailles	Rs. 99
One man and one labourer to live at Quartier Militaire	Rs. 51

The boundary being a line drawn drawn from the eighth mile post to the mountain and thence to the Piton du Milieu hill.

Black River.

One guard and four labourers to live at Bambous ...	Rs. 99
Total	Rs. 1,287

The above figures may be modified as circumstances may require. It is just possible that after the first year the gangs may be reduced in number owing to permanent works having been executed or to some legislative measure by which the burden of keeping up some of the works may be thrown upon the planters and owners of private property.

Again the distribution of the gangs may later require modification, in which case it will perhaps be possible to have one guard in charge of two patrols.

Major Ross does not say in whose pay the malaria patrols are to be ; from B (a) I should say Government, as these men may be called upon to "distribute quinine" and to report local outbreaks of malaria.

If my surmise is correct, these men ought to suffice for the area allotted to each, as they will have to attend to villages, hamlets, and Indian camps outside Sugar Estates as well as Sugar Estates. Take, for example, the man stationed at Chemin Grenier He will have Souillac and Chemin Grenier villages, Petit Cap, Bassin Blanc, and Riambel hamlets, Surinam Indian village, Ruisseau Michel hamlet, Chamouny, L'Union Bel Air, Terracine, Fontenelle, and Combo estates, with their camps, numbering all together 13. The distance he will have to travel over will be barely 10 square miles, for it must be borne in mind that large areas covered with sugar cane will not require inspection. He will have ample time to peer into every nook and corner in search of mosquito breeding places, and even occasionally take charge of quinine distribution in any particular locality.

On almost all the estates of the island the Dispenser Steward has ample leisure during the day to distribute quinine should such a measure be deemed advisable, and to patrol the camps and surroundings. He could be made to report periodically to the Sanitary Inspector of his district on the number of inspections, the area covered by them, the nuisances detected, the steps taken or recommended by him for the abatement of the same. One man could be told off on each estate to accompany him to perform any little job which he may order. The cost to the estate will be very trifling, about Rs.150 per annum, and the gain ten times that amount.

I beg to suggest the appointment of a medical man of Colonial experience in fighting malaria to take charge of anti-malarial measures and the training of patrols and overseers.

After a year or two he could be replaced by the Sanitary Wardens attached to the Medical and Health Department unless his permanent appointment be considered advisable.

A considerable part of the expenditure to be incurred could be secured by a hut tax, by imposing a licence of Rs. 6 p. a. on each day labourer and by a house tax outside townships where the same is not already levied.

The Indians and creoles in Indian villages, hamlets, and camps outside estates are the principal sufferers from malaria (see what happens at Clairfond), they do not contribute to the revenue, and in case of sickness are a burden on the Colonial finances—gratuitous medical aid.

The total Indian population of the island may be roughly estimated at 280,000 souls. Of these 99,000 reside on Sugar Estates. So that there is a population of 181,000 to be accounted for.

Of these fully 40,000 work as day labourers. A licence of Rs. 6 per annum equal to 2 c. per working day imposed upon every day labourer, Indian and creoles would bring in Rs. 240,000 p. a. at least. And a house and hut tax perhaps considerably more.

(Sd.) JOHN BOLTON,
Medical Officer,
18/1/08. IMMIGRATION DEPARTMENT.

ANNEXURE 4.—C.—BY THE PUBLIC WORKS AND SURVEY DEPARTMENT.

No. 24/08. COLONIAL SECRETARY'S OFFICE, MAURITIUS,
17*th February*, 1908.

SIR,

With reference to that part of your letter dated the 5th January last asking for an estimate of the cost of labour involved in the destruction of breeding places of anophelines, I am directed by the Governor to transmit to you herewith a copy of a minute and annexures from the Director of Public Works and Surveys giving the desired information.

Professor R. Ross, C.B., F.R.S., J. MIDDLETON,
"Brodick," Vacoas. *Assistant Colonial Secretary.*
P.W. 67.

THE HONOURABLE THE COLONIAL SECRETARY.

I have seen Professor on this subject shortly after receiving these papers and have explained to him that to supply to him accurate estimates would take a considerable time, and would mean a very serious expenditure, certainly a good deal more than Rs.300. In fact, it was a practical impossibility to give an accurate estimate within a month's time for instance.

2. Professor Ross informed me that he only wanted a rough estimate for the purposes of his report, and that the details of each individual work might be entered into later on ; that the Medical Director was collecting the information required and would send it on to me as soon as he would get it.

3. On the receipt then of a list of marshes and marshy streams made by the Sanitary Inspectors and controlled by the Sanitary Wardens, I had conferences with Drs. Momplé, Masson, Keisler, and Castel, who kindly had their inspectors in attendance. We discussed together the points in question, and I have thus been able to get at a rough estimate of cost, as per Schedule 1 annexed with fifteen detailed annexures, containing all the information supplied by the Medical Department.

4. I have had the advantage of seeing Professor Ross subsequently, who inspected with me some river diversion drains at Mare aux Vacoas and the water works generally, and I have submitted to him one of the annexures, which appeared to answer his requirements.

5. The total works out at Rs.630,000. Perhaps it would be prudent to add 10 per cent. more making a grand total of Rs.700,000 to cover any works which may have been left out in the lists submitted to me.

Schedule 2 gives the probable cost of Maintenance Works. This can be modified of course after a year's experience, but is not, I think, exaggerating.

6. I may point out that the works to be performed, though costly, are not works of art properly so called. The Engineer's work will come in for very little, as all there is to be done comes to a question of levelling, with perhaps one or two exceptions, as in the case of Beau Plan Marsh, where probably works of art may be required, not to interfere with water rights of riparian owners.

7. So that any one who has some sense and judgment and is active may with the help of one or several Surveyors (as may be necessary) and our technical advice (when required) carry out the works in question. If Government decides to appoint some one to take charge of the malaria works generally, I consider the Officer in question would be the proper person to be entrusted with the execution. He would have the data of the Schedules to serve as a base, and, having only malaria to look after, will far better manage, on account of the time he would give to these drainage works.

8. I am not certain that it would be advisable to go later on to the expense of making exact estimates, as such survey and sounding works cannot but be costly. For instance, supposing a marsh can be drained into a river within a distance of say 1 mile—the following operations would be required. Trial holes within say 100 feet to ascertain the nature of the soil. A contoured survey of the marsh and a levelled section of the proposed drain. When this information has been obtained, quantities can be taken out, priced, and the cost arrived at. But if it is decided to do the whole, it seems to me that further surveys for estimate purposes will be so much less than can be devoted on doing the work itself, as in all probability the gross total arrived at will be correct, though individual items may be under or over estimated.

(Sd.) P. LE J. DE SEGRAIS,
Director of Public Works and Surveys.

15th February, 1908.

SCHEDULE NO. 1 OF PROBABLE COST OF DRAINING MARSHES AND CLEARING AND IMPROVING STREAMS.

No. of Annexure.	District.	Probable cost. Rs.
1	Port Louis ...	21,700
2	Pamplemousses, Northern section ...	87,500
3	Pamplemousses, Southern section ...	20,500
4	Rivière du Rempart ...	33,000
5	Flacq, Northern section ...	64,500
6	,, Southern section ...	17,400
7	Plaines Wilhems, Beau Bassin and Rose Hill section ...	33,500
8	,, ,, Quatre Bornes section ...	54,500
9	,, ,, Vacoas section ...	65,300
10	,, ,, Curepipe section ...	60,000
11	Moka ...	26,000
12	Grand Port, Rose Belle section ...	41,400
13	,, ,, Mahebourg ,, ...	16,500
14	Savanne ...	25,000
15	Black River ...	63,500
		630,300

SCHEDULE NO. 2 OF PROBABLE COST OF ANNUALLY RECURRENT EXPENDITURE FOR MAINTENANCE OF DRAINAGE WORKS WHEN COMPLETED.

No.	District.	Particulars of Labour 300 Working Days.	Probable cost Rs.
1	Port Louis	1 gang of 10 men & 1 sirdar @ 60 cents. @ 1 rupee	2,100
2	Pamplemousses—		
	North	1 " 15 " " "	3,000
	South	1 " 10 " " "	2,100
3	Rivière du Rempart	1 " 10 " " "	2,100
4	Flacq, North ...	2 " 10 " " "	4,200
	South ...	1 " 10 " " "	2,100
5	Plaines Wilhems		
	Beau Bassin and Rose Hill ...	1 " 10 " " "	2,100
	Quatre Bornes ...	1 " 15 " " "	3,000
	Vacoas	2 " 10 " " "	4,200
	Curepipe	1 " 10 " " "	2,100
6	Moka	1 " 15 " " "	3,000
7	Grand Port, Rose Belle	1 " 15 " " "	3,000
	Mahebourg	1 " 10 " " "	2,100
8	Savanne	1 " 15 " " "	3,000
9	Black River ...	2 " 10 " " "	4,200
		205	42,300

DETAILS.

DISTRICT OF PORT LOUIS.

No.	Place.	Description of works required.	Probable cost. Rs.
1	Latanier Stream ...	Cleaning and improving on 2 miles	5,000
2	Terre Rouge River ...	Do.	3,800
3	Ste. Croix Marsh ...	Draining on a length of about ¼ mile	1,200
4	Fanfaron Stream ...	200 feet of drain about required. Concerns the War Department.	
5	La Paix Stream ...	Cleaning and improving on 1 mile	2,500
6	Pouce Stream	Do. ¾ mile	1,800
7	Tranquebar Stream ...	Do. ½ mile	1,200
8	Cassis Stream	Do. 2 miles	5,000
9	St. Louis	Do. ½ mile	1,200
			21,700

DISTRICT OF PAMPLEMOUSSES (Northern Section).

No.	Place	Description of works required.	Probable cost. Rs.
1	Rivière des Pamplemousses ...	Cleaning and improving course of River on 2 miles	5,000
2	Mon Rocher ...	Draining marsh of about 5 acres	5,000
3	Terrain Boulle ...	Draining marsh of about 2 acres	5,000
4	Beau Plan	Draining marsh of about 30 acres with works of art necessary for compensation of water rights	50,000
5	Ruisseau des Citrons	Cleaning and improving stream on 3 miles ...	7,500
6	St. André	Draining marsh	10,000
7	Solitude	Draining marsh	5,000
			87,500

DISTRICT OF PAMPLEMOUSSES (Southern Section).

No.	Place.	Description of works required.	Probable cost. Rs.
1	Rivière Sèche.. ...	Improving and cleaning stream on a length of three miles along Terre Rouge and Riche Terre	7,500
2	River Terre Rouge ...	Improving and cleaning stream near La Briqueterie on about 1 mile	2,500
3	Callebasses	Draining marshy lands by side of main road ...	3,000
4	Do.	Draining marshy lands near the Infirmary	1,000
5	Tombeau Hamlet ...	Draining marshy lands near Tombeau Bridge on about half a mile	2,500
6	Long Mountain ...	Draining of Mare Sanassee	2,000
7	Canton Naney ..	Draining marshy lands	2,000
			20,500

DISTRICT OF RIVIÈRE DU REMPART.

No.	Place.	Description of works required.	Probable cost. Rs.
1	Citronnier river ...	Clearing and improving	2,500
2	Poudre d'Or village ...	Clearing of marsh in neighbourhood	500
3	Schoenfeld estate ...	Clearing of marsh Figette	5,000
4	Ile d'Ambre Hermitage and Pointe Bourrique Hamlets.	Draining of marshes	5,000
5	Ruisseau Chevrettes ...	Clearing and improving on 1 mile	2,500
6	Rivière du Rempart ...	Clearing and improving on 3 miles	7,500
7	Grand Bay, Hamlet ...	Filling ponds	5,000
8	Cap Malheureux ...	Filling ponds	5,000
			33,000

DISTRICT OF FLACQ (Northern Section).

No.	Place.	Description of Works required.	Probable cost. Rs.
1	Centre de Flacq ...	Draining of Marsh	2,500
2	River Croignarde ...	Clearing and improving on about 4 miles	10,000
3	Post of Flacq River ...	,, ,, 2 ,, ...	5,000
4	Rivière Françoise ...	,, ,, 2 ,, ...	5,000
5	Rivière du Poste ...	,, ,, ...	
6	Rivière Cere	,, ,, 3 ,, ...	7,500
7	Ruisseau Sarcelle ...	,, ,, 2 ,, ...	5,000
8	,, Pondard ...	,, ,, 2 ,, ...	5,000
9	,, Cresson ...	,, ,, 1 ,, ...	2,500
10	,, St. Louis ...	,, ,, 1 ,, ...	2,500
11	,, Grande Barbe	,, ,, 1 ,, ...	2,500
12	Mare Jacquot... ...	Draining by about ½ mile of drain	2,500
13	Providence Hamlet	Clearing of ponds averaging 7 acres	3,500
14	Prisee Verdière ...	Filling up of ponds	5,000
15	Riche Mare Hamlet ...	Draining small ponds	1,000
16	Quatre Cocos... ...	Draining of marshes in neighbourhood	5,000
			64,500

DISTRICT OF FLACQ (Southern Section).

No.	Place.	Description of works required.	Probable cost. Rs.
1	Riv. Seche Village ...	Clearing and improving stream	2,500
2	La Lucie	Clearing marsh	500
3	Clemencia	Clearing and improving stream on 1,600 feet ...	800
4	Etoile Estate	,, ,, 3,000 ,, ...	1,500
5	Sebastopol	,, ,, 1,600 ,, ...	800
6	Belle Vue estate ...	Clearing marshes on the estate camp	1,000
7	Montagne Bambous ...	,, and draining	2,000
8	Terrain Dubois ...	Clearing marsh	500
9	Trois Ilots	Clearing and improving stream	2,000
10	Bois d'Oiseaux ...	,, ,, ...	1,000
11	Olivia estate Camp ...	Clearing of marshes	1,000
12	La Nourrice and La Commune	Clearing and improving of streams on 1½ miles ...	3,800
			17,400

DISTRICT OF PLAINES WILHEMS (Beau Bassin and Rose Hill Section).

No.	Place.	Description of works required.	Probable cost. Rs.
1	Plaines Wilhems River	Improving and clearing river on a length of 2 miles	5,000
2	Aliphon's premises, Rose Hill	Getting rid of marshes formed by masonry channel	2,500
3	Collector from Edward VII. Street to Plaines Wilhems River ...	Large repairs to masonry conduits	2,500
4	Corps de Garde Mountain.	Draining marsh on the north and eastern side of the mountain.	5,000
5	Summerfield drain, Beau Bassin.	Repairs to channel and disposal of the water in absorption well.	3,500
6	Beau Bassin, between Allée Mangues and Maingard Street.	Construction of a large open drain in fairly rocky ground on about 5,000 feet.	15,000
			33,500

DISTRICT OF PLAINES WILHEMS (Quatre Bornes Sections).

No.	Place.	Description of works required.	Probable cost. Rs.
1	La Louise	Draining of marshes to discharge at La Fenêtre ...	30,000
2	Plaines Wilhems River	Clearing and improving river on 2 miles	5,000
3	Rivière Sèche, behind Trianon Estate ...	Draining marshes (small)	1,000
4	Beau Sejour	,, ,, ...	1,000
5	Mesnil River	Clearing and improving river from Phœnix Old Mill to junction with Plaines Wilhems River. Length 2 miles	5,000
6	Solferino	Clearing of stream terminating in neighbourhood of Solferino on a length of 3 miles	7,500
7	Papayes River ...	Clearing and improving river on 2 miles	5,000
			54,500

DISTRICT OF PLAINES WILHEMS (Vacoas.)

No.	Place.	Description of works required.	Probable cost. Rs.
1	Clairfond	Draining of marshes, already provided for.	
2	River Plaines Wilhems	Clearing and improving on 2 miles	5,000
3	River Camp Fouqueraux	,, ,, ,, ...	5,000
4	River Terre Rouge ...	,, ,, 1½ miles	3,800
5	Allée Brillant and Camp Fouqueraux	Marshy streams in the neighbourhood of these roads to be drained on a length of about 5,000 feet ...	5,000
6	Phœnix	Marshes caused by War Department Sewerage works. Should be removed by War Department ...	
7	Perichon stream ...	Clearing and improving stream on 1 mile	2,500
8	Papayes River ...	Clearing and improving stream on 1 mile in the neighbourhood of Camp Mapou and Camp Roshe	2,500
9	Rivière du Rempart ...	Clearing and improving on about 25,000 feet ...	12,500
10	Rivers Tatamaka and St. Martin	Clearing and improving on about 30,000 feet ...	15,000
11	La Croisse	Clearing and improving 2 feeders of Rivière du Rempart on 3,000 feet	1,500
12	Mesnil River	Clearing and improving from Allée Brillant to Phœnix Iron Bridge on a length of about 3 miles	7,500
13	Rivière Sèche ...	,, ,, ,, about 2 miles	5,000
			65,300

DISTRICT OF PLAINES WILHEMS (Curepipe Section).

No.	Place.	Description of works required.	Probable cost. Rs.
1	River Mesnil	Draining marshes near Town Hall	4,000
2	Do.	Deepening stream on about 2,500 feet	2,500
3	Do.	Draining marshes on Forest side portion	4,000
4	Do.	Deepening drain along Lees Street	3,000
5	Do.	Improving course of stream from D'Arifat Street to Allée Brillant, about 10,400 feet	5,200
6	Eau Bleue River ...	Improving course of stream on about 9,700 feet and draining marshes connected therewith	4,850
7	Poule d'Eau River ...	Cutting bed of stream on 3,000 feet	3,000
8	Do. ...	Improving course of stream on 12,600 feet ...	6,300
9	Rivière Sèche... ...	Improving course of stream on 34,300 feet as far as Allee Brillant	17,150
10	Do.	Improving course of stream on western side of Curepipe on 5,600 feet	2,800
11	Curepipe generally ...	Draining other small marshes and incidentals, say	7,200
			60,000

DISTRICT OF MOKA.

No.	Place.	Description of works required.	Probable cost. Rs.
1	L'Espérance	Marsh requiring draining about 2 miles of drain ...	5,000
2	Providence Lesur ...	A series of marshes requiring draining on about 2 miles	5,000
3	Montagne Blanche ...	Marshy streams in the hamlet to be cleared of vegetation	1,000
4	Pailles	Two marshy streams requiring clearing and trimming on a length of about 2 miles	5,000
5	La Dagotière	Three marshy streams requiring clearing and trimming on a length of about 2 miles...	5,000
6	Alma Estate	Large marsh to be drained	5,000
			26,000

DISTRICT OF GRAND PORT (Rose Belle Section).

No.	Place.	Description of works required.	Probable cost. Rs.
1	Mare Chicose... ...	Draining of marsh into Ruisseau Tranquille ..	1,000
2	Rose Belle	Marsh on Rose Belle estate to be cleared	1,000
3	Nouvelle France stream	Clearing and improving on about 2 miles	5,000
4	Balisson stream ...	,, ,, ,, 2 ,, ...	5,000
5	Ruisseau Sec and Tributary	,, ,, ,, 2½ ,, ...	6,300
6	Eau Bleue stream ...	,, ,, ,, 2 ,, ...	5,000
7	New Grove	,, ,, ,, 1 ,, ...	2,500
8	River Tabac	,, ,, ,, 2½ ,, ...	6,300
9	Bonne Source ...	,, ,, ,, ½ ,, ...	1,300
10	L'Escalier ...	,, ,, ,, 1 ,, ...	2,500
11	Carreau Esnouf ...	,, ,, ,, 2 ,, ...	5,000
12	Ruisseau Copeau ...	,, ,, ,, 500 feet	500
			41,400

DISTRICT OF GRAND PORT (Mahebourg Section).

No	Place.	Description of works required.	Probable cost. Rs.
1	Mahebourg	Marsh to be filled up	1,000
2	Rivière des Creoles ...	Clearing and improving on 1 mile	2,500
3	Rivière La Chaux. ...	,, ,, ,, ...	2,500
4	Rivière des Délices ...	,, ,, ,, ...	2,500
5	Generally	Clearing and improving sources of streams in the neighbourhood of the following localities:— St. Hubert. Le Vallon. Cent Gaulettes. Beau Vallon Bel Air. Mon Desert. Anse Jonchée. Virginia.	8,000
			16,500

DISTRICT OF SAVANNE.

No.	Place.	Description of works required.	Probable cost. Rs.
1	Camp Rabaud Hamlet	Clearing of marsh	500
2	St. Avolt estate Camp	Clearing and improving stream (Riv. Dragon) on 1,000 feet	500
3	Britannia	Clearing and improving stream (Riv. Dragon) on 1,000 feet	500
4	Rivière des Anguilles village	Clearing and improving River on 2,500 feet ...	1,500
5	Surinam Hamlet ...	Clearing small marsh	500
6	,,	Clearing and improving Riviere la Savanne on 10,000 feet	500
7	Souillac Village ...	Clearing and improving streams Ruisseau Mitchell and others on 2,000 feet	1,500
8	Riambel Hamlet ...	Drying small marshes	1,000
9	Ste. Marie Hamlet ...	Clearing and improving river on 2,000 feet ...	1,000
10	Beau Champ estate Camp	Clearing and improving river on 1,000 feet ...	500
11	Bel Ombre Estate Camp	Draining small marshes	1,500
12	St. Martin Hamlet ...	Marsh to be cleared near Cemetery	4,000
13	Petit Cap Hamlet ...	Clearing and improving Choisy river on 1,000 feet	500
14	Do. ...	Clearing marshes	2,000
15	St. Aubin Estate Camp	Clearing and improving of streams on 2,000 feet ..	1,000
16	District generally ...	Add for other parts	8,000
			25,000

DISTRICT OF BLACK RIVER.

No.	Place.	Description of works required.	Probable cost.
1	Albion	Draining of Marsh	4,000
2	Gros Cailloux ...	Ditto	1,500
3	Mouna	Ditto	3,000
4	La Ferme	Ditto	5,000
5	Flic en Flacq	Clearing and improving marsh	2,000
6	Clarens	Draining of marshes	1,000
7	Tamarin	Improving of marsh, as it may not be drained on account of water rights	5,000
8	Wolmar	A large marshy district covering hundreds of acres. It seems hardly worth while to spend a lot of money for a very thinly populated place. Might cost	30,000
9	Yemen...	Draining small marshes	1,000
10	Black River	Draining a small marsh	1,000
11	District generally ...	Draining other small marshy lands distributed over the district	10,000
			63,500

TABLE I.

GIVING POPULATION, DEATHS, AND DECLARED DEATHS FROM FEVER IN MAURITIUS FROM 1831 TO 1906.

Years.	Population.	Deaths.	Death Rate per 1,000.	Fever Deaths.	Fever Death Rate per 1,000.
1831	92,951	2,495	26·8	—	—
1832	93,038	2,917	31·3	—	—
1833	93,643	2,561	27·4	—	—
1834	93,209	3,417	39·8	—	—
1835	93,631	3,367	36·0	—	—
1836	97,534	3,020	31·0	—	—
1837	103,935	3,862	37·2	—	—
1838	115,110	3,533	30·7	—	—
1839	114,989	4,483	39·0	—	—
1840	115,476	3,464	30·0	—	—
Mean	101,361	3,311	32·9	—	—
1841	114,380	4,750	41·5	—	—
1842	112,242	4,760	42·4	—	—
1843	144,137	4,993	34·6	—	—
1844	149,564	8,737	58·4	—	—
1845	156,967	6,198	39·5	—	—
1846	162,170	5,305	32·7	—	—
1847	162,535	4,764	29·3	—	—
1848	166,529	4,403	26·4	—	—
1849	169,770	5,235	30·8	—	—
1850	176,307	5,547	31·5	—	—
Mean	151,460	5,469	36·7	—	—
1851	184,496	4,890	26·5	—	—
1852	199,158	5,591	28·1	—	—
1853	208,800	6,192	29·6	—	—
1854	212,482	17,978	84·6	—	—
1855	220,238	7,269	33·0	—	—
1856	223,736	11,312	50·6	—	—
1857	234,153	6,107	26·1	—	—
1858	257,736	7,242	28·1	—	—
1859	297,267	9,179	30·9	—	—
1860	309,901	9,805	31·6	—	—
Mean	234,797	8,556	36·9	—	—
1861	324,287	6,854	31·1	—	—
1862	330,575	13,719	41·5	—	—
1863	335,310	11,566	34·8	—	—
1864	341,392	11,649	34·1	5,789	17·4
1865	360,337	12,042	33·4	5,181	14·8
1866	365,051	11,702	32·1	4,913	14·0
1867	332,968	40,114	120·5	31,920	99·5
1868	324,370	18,403	56·7	10,923	34·9
1869	322,892	11,295	35·0	6,330	20·6
1870	328,604	7,423	22·6	3,329	10·6
Mean	336,579	14,476	44·1	9,769	30·3

TABLE I.—*continued.*

Years.	Population.	Deaths.	Death Rate per 1,000.	Fever Deaths.	Fever Death Rate per 1000.
1871	319,470	8,171	25·6	3,578	11·1
1872	325,960	8,745	26·8	4,235	12·8
1873	332,476	11,210	33·7	5,031	15·1
1874	339,806	10,019	29·5	4,024	11·8
1875	345,037	8,584	24·9	4,061	11·7
1876	346,390	9,525	27·5	4,845	14·0
1877	349,060	10,335	29·6	5,787	16·6
1878	355,058	9,649	27·2	5,144	14·5
1879	357,774	11,485	32·1	5,303	14·8
1880	360,328	10,143	28·1	5,173	14·3
Mean	243,135	9,787	28·5	4,718	13·7
1881	359,419	10,746	29·9	5,826	16·2
1882	359,322	12,563	35·0	7,483	20·8
1883	360,221	12,770	35·4	6,741	18·7
1884	368,813	11,247	30·5	6,103	16·5
1885	367,288	12,352	33·6	7,423	20·2
1886	368,145	10,624	28·9	5,839	15·8
1887	368,163	12,690	34·5	7,690	20·8
1888	369,302	11,193	30·3	6,110	16·5
1889	372,664	12,567	33·7	7,338	19·6
1890	370,624	12,781	34·5	7,004	18·8
Mean	366,396	11,953	32·6	6,758	18·4
1891	373,985	10,080	27·2	5,003	13·3
1892	374,079	13,055	38·4	5,598	14·9
1893	371,798	15,307	40·9	6,032	16·2
1894	376,219	10,792	29·0	5,655	14·9
1895	378,041	13,958	37·1	7,509	19·8
1896	374,942	15,843	41·9	8,181	21·8
1897	377,856	11,066	29·5	5,890	15·5
1898	378,872	12,064	31·9	6,507	17·1
1899	379,659	13,222	34·8	4,576	12·0
1900	389,897	13,691	34·8	4,844	12·4
Mean	377,535	12,908	34·5	5,980	15·8
1901	380,212	14,971	40·3	5,612	14·7
1902	383,410	12,716	34·0	4,456	16·6
1903	382,483	15,034	39·9	5,840	15·2
1904	387,395	12,064	32·2	4,333	11·1
1905	386,128	15,379	40·6	6,764	17·5
1906	383,206	15,118	40·0	5,827	15·2
Mean	383,606	14,214	36·0	5,472	14·2

TABLE II.

STATEMENT SHOWING THE DEATHS FROM MALARIA AND FROM ALL CAUSES FOR THE YEARS 1896–1906.

Districts.		1896.	1897.	1898.	1899.	1900.	1901.
Port Louis... ...	Malaria ...	1,565	1,111	1,394	789	601	802
	All causes ...	3,184	2,262	2,699	2,836	1,982	3,002
Pamplemousses ...	Malaria ...	1,302	688	871	616	691	916
	All causes ...	1,966	1,110	1,282	1,319	1,346	1,626
Riv. du Rampart ...	Malaria ...	598	308	378	241	219	299
	All causes ...	1,042	580	674	629	722	839
Flacq	Malaria ...	1,309	982	1,153	1,002	1,112	1,000
	All causes ..	2,065	1,572	1,855	1,670	1,961	1,759
Grand Port ...	Malaria ...	1,007	915	691	625	690	823
	All causes ...	2,234	1,702	1,508	1,492	1,633	1,751
Savanne	Malaria ...	592	491	324	374	437	524
	All causes ...	1,299	974	479	969	992	1,231
Plaines Wilhems ...	Malaria ...	1,012	783	944	346	384	351
	All causes ..	2,292	1,644	1,894	1,810	2,201	2,124
Moka	Malaria ...	393	349	428	231	296	453
	All causes ...	1,197	787	943	915	1,054	1,142
Black River ...	Malaria ...	403	263	324	352	416	442
	All causes ...	564	435	460	508	607	685

Districts.		1902.	1903.	1904.	1905.	1906.
Port Louis... ...	Malaria ...	604	451	378	939	549
	All causes ...	2,543	2,428	2,148	2,926	2,416
Pamplemousses ...	Malaria	812	1,020	820	1,084	985
	All causes ...	1,509	1,636	1,381	1,795	1,734
Riv. du Rampart ...	Malaria ...	243	419	326	498	531
	All causes ...	731	940	748	1,039	1,253
Flacq	Malaria ...	811	1,328	1,047	1,557	1,511
	All causes ...	1,465	2,121	1,721	2,412	2,401
Grand Port ...	Malaria ...	643	1,065	537	1,090	643
	All causes ..	1,538	2,188	1,595	2,204	1,700
Savanne	Malaria ...	368	524	413	545	465
	All causes ...	988	1,124	976	1,212	1,156
Plaines Wilhems ...	Malaria ...	217	273	189	274	292
	All causes ...	1,957	1,950	1,684	1,896	2,240
Moka	Malaria ..	352	369	304	427	479
	All causes ...	986	976	899	1,097	1,236
Black River ...	Malaria ...	406	391	319	350	372
	All causes ...	609	631	556	546	638

TABLE III.

SHOWING THE NUMBER OF PATIENTS WHO HAVE APPLIED FOR TREATMENT AT THE CIVIL HOSPITALS, ASYLUMS, AND DISPENSARIES OF MAURITIUS SINCE 1878 FOR MALARIAL DISEASE.

CASES OF MALARIAL FEVER (1878–1892).

District.	Institution.	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892
Port Louis ...	Civil Hospital			1,462	1,613	1,934	1,531	1,616	3,784	1,652	1,686	1,305	1,641	2,439	?	1,711
„ ...	Prison Hospital	256	?	?	?	?	?	?	?	?	?	?	?	?	?	?
„ ...	Central Dispensary ...	1,467	1,767	748	868	1,725	1,874	1,141	3,258	3,948	1,214	1,649	3,118	4,416	2,326	3,408
„ ...	Eastern Suburb Dispensary															
„ ...	Western „ „													1,772	963	701
Pamplemousses	Long Mountain Hospital ...															
„	„ „ Dispensary ...															
„	Pamplemousses „															
„	Terre Rouge „															701
Rivière du Rempart	Rivière du Rempart Hospital ...					196	202	188	208	234	200	232	188	140	213	204
„ „	„ „ Dispensary ...														187	648
„ „	Grand Bay Dispensary ...															
„ „	Grand Gaube Dispensary															
Flacq ...	Flacq Hospital												345	252	130	357
„ ...	„ Dispensary												383	269	348	?
„ ...	„ Prison Hospital and															
	Dispensary.															
„ ...	Rivière Sèche Dispensary ...															
„ ...	Trou d'Eau Douce Dispensary ...															
Grand Port ...	Grand Port Public Hospital ...					283	285	284	367	412	599	402	553	330	252	359
„ ...	Mahebourg Dispensary ...															
„ ...	Escalier Dispensary ...															
„ ...	Plaine Magnien Dispensary ...															
„ ...	New Grove Dispensary ...															
„ ...	Bois des Amourettes Dispensary															246
Savanne ...	Savanne Public Hospital ...					130	165	77	199	125	148	185	293	278	164	274
„ ...	Souillac Dispensary ...	169	329	514	70	397	294	230	693	542	617	380	499	734	459	314
„ ...	Souillac Prison Hospital and															
	Dispensary.															
„ ...	Rivière des Anguilles Dispensary															
„ ...	Chemin Grenier and Baie du Cap Dispensary.															
Black River ...	Petite Rivière Dispensary ...															
„	Bambous Dispensary															
„	Case Noyale Dispensary... ...															
Moka ...	Moka Hospital									27	99	31	61	50	24	44
„ ...	Saint Pierre Dispensary ...	109	76	84	172	243	135	168	449	227	290	182	141	195	115	207
„ ...	Pailles Dispensary ...															
Plaines Wilhems ...	Barkly Asylum Hospital... ...															520
„ „	„ „ Dispensary ...															235
„ „	Lunatic Asylum Hospital ...	456	220	149	90	179	135	101	83	109	183	108	72	69	55	59
„ „	Government Reformatory Hospital															
„ „	Beau Bassin New Central Prison Hospital.															
„ „	Vacoas Dispensary														198	256
„ „	Curepipe Dispensary															245
		2,457	2,392	2,957	2,813	5,087	4,621	5,805	9,041	7,276	5,036	4,454	7,294	10,944	5,434	10,469

CASES OF MALARIAL FEVER (1893–1907), Annual Means, Total Cases in 1907, Percentage to Totals in 1907.

District.	Institution.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	Annual Means.	Total Cases in 1907.	Percentage to Totals in 1907.
Port Louis ...	Civil Hospital	1,706	1,649	1,667	1,266	1,194	1,616	1,592	1,099	1,124	1,301	1,068	909	1,664	1,134	1,019	1,569	6,355	16
„ ...	Prison Hospital	?	192	?	?	?	550	345	272	?	522	756	530	1,167	2,233	3,254	915	1,009	?
„ ...	Central Dispensary ...	2,934	4,459	4,537	3,778	2,461	2,133	339	582	1,174	1,412	1,017	846	1,638	1,242	1,168	2,156	3,326	35
„ ...	Eastern Suburb Dispensary			443	1,578	2,282	2,817	2,385	349	2,064	3,155	1,415	?	1,423	2,010	3,454	1,948	9,707	35·6
„ ...	Western „ „	979	556	265	989	2,016	2,308	749	1,063	1,806	1,649	1,007	785	1,541	1,141	1,434	1,206	2,874	49·9
Pamplemousses	Long Mountain Hospital ...										168	338	213	182	167	222	215	850	26
„	„ „ Dispensary ...										433	638	568	910	512	494	592	1,284	38·5
„	Pamplemousses „							478	760	1,349	979	668	534	1,089	603	656	791	1,949	33·6
„	Terre Rouge „	874	1,548	?	?	?	?	?	996	766	996	1,185	824	984	692	629	925	1,678	37·5
Rivière du Rempart	Rivière du Rempart Hospital ...	215	235	246	184	197	253	222	182	344	240	249	227	266	178	201	215	1,445	13·9
„ „	„ „ Dispensary ...	362	270	472	433	297	332	148	487	505	257	540	379	477	328	333	381	707	47
„ „	Grand Bay Dispensary ...		549	377	399	258	482	414	518	621	313	607	572	936	740	547	525	1,045	52
„ „	Grand Gaube Dispensary	603	603	593	400	424	828	413	488	1,019	773	626	547	899	732	476	650	1,145	41·5
Flacq ...	Flacq Hospital	272	196	399	201	258	370	274	243	404	338	567	408	446	441	680	341	2,252	30
„ ...	„ Dispensary	50	354	370	359	326	560	548	459	400	314	219	208	285	193	264	328	470	54
„ ...	„ Prison Hospital and														23	17	20	152	11
	Dispensary.														86	183	138		
„ ...	Rivière Sèche Dispensary ...								456	308	369	480	518	717	612	659	515	896	73·7
„ ...	Trou d'Eau Douce Dispensary ...				353	624	644	587	739	734	618	613	510	836	678	?	630	1,412	?
Grand Port ...	Grand Port Public Hospital ...	363	264	459	404	605	408	416	405	525	55	741	203	588	342	506	403	3,069	16·4
„ ...	Mahebourg Dispensary ...	382	459	965	715	895	1,003	738	709	969	504	1,174	635	1,235	1,042	725	810	1,762	41
„ ...	Escalier Dispensary ...				610	1,377	59	882	892	1,006	640	644	516	752	495	386	688	1,206	32
„ ...	Plaine Magnien Dispensary ...								647	771	536	698	497	1,064	614	476	665	1,831	26
„ ...	New Grove Dispensary ...							333	105	321	231	377	316	730	397	363	397	1,459	24·8
„ ...	Bois des Amourettes Dispensary	331	766	647	842	1,006	935	866	829	856	719	900	563	902	551	548	719	1,868	29
Savanne ...	Savanne Public Hospital ...	321	166	182	129	180	137	122	105	305	92	365	223	299	300	376	205	1,310	28
„ ...	Souillac Dispensary ...	394	230	344	194	304	144	200	115	790	298	715	637	525	344	518	399	1,327	39
„ ...	Souillac Prison Hospital and												78	160	105	68	102	260	26
	Dispensary.												41	104	128	131	101		
„ ...	Rivière des Anguilles Dispensary	1,090	1,281	1,112	934	806	579	799	741	882	669	755	689	816	542	624	821	1,249	49·9
„ ...	Chemin Grenier and Baie du Cap Dispensary.	?	?	?	?	573	535	679	846	950	635	1,326	1,033	1,082	674	592	811	1,651	35·8
Black River ...	Petite Rivière Dispensary ...		1,693	1,595	979	643	773	499	513	665	359	444	418	400	438	494	707	1,162	42·5
„	Bambous Dispensary									442	644	665	706	666	545	446	573	1,042	42·8
„	Case Noyale Dispensary... ...									331	307	137	274	314	228	356	281	1,121	31·7
Moka ...	Moka Hospital	40	59	69	39	88	185	129	124	185	173	213	90	190	133	244	108	1,118	21·9
„ ...	Saint Pierre Dispensary ...	186	130	156	139	146	260	147	134	695	344	189	142	339	234	199	208	1,714	10·6
„ ...	Pailles Dispensary ...									865	?	949	1,141	2,042	827	1,112	1,156	1,889	58·8
Plaines Wilhems ...	Barkly Asylum Hospital... ...	613	545	474	518	584	895	555	803	897	467	627	499	851	746	822	651	3,940	20·8
„ „	„ „ Dispensary ...	253	230	327	298	398	512	304	502	488	399	626	497	697	415	443	414	1,587	28
„ „	Lunatic Asylum Hospital ...	80	102	101	102	184	248	141	234	312	129	149	106	164	177	154	146	490	31·4
„ „	Government Reformatory Hospital	247	188	222	177	186	179	95	136	93	59	124	56	98	91	148	140	116	?
„ „	Beau Bassin New Central Prison Hospital.		340	200	390	596	627	339	425	217	319	295	181	299	229	338	342	1,395	24
„ „	Vacoas Dispensary	239	170	310	250	272	361	220	180	166	226	495	350	845	1,150	1,497	421	3,611	40·9
„ „	Curepipe Dispensary	748	827	913	969	1,019	503	352	306	473	480	724	473	621	644	1,032	647	4,322	23·8
		13,282	18,061	17,445	17,629	20,229	21,296	16,340	17,834	24,822	22,222	25,231	19,042	31,223	25,088	28,294	13,464	79,053	35·8

TABLE IV.—A.

SHOWING THE SPLEEN RATES OF CHILDREN ON SUGAR ESTATES AND FACTORIES, 1907-08 (section 20).

District.	Estate.	Acreage.	Altitude (feet).	Population.	Death-rate.	Examiner.	Total Children.	Children Examined.	Spleens. 1	3	6	9	Total with Spleen	Spleen Rate.	Average Spleen.
PAMPLE-MOUSSES.	Beau Plan ...	640	210	949	56·0	Tennant ...	515	268	115	69	50	34	153	57·1	3·5
	Belle Vue (H) ...	1,550	325	1,180	30·4	,, ...	446	376	312	55	9	0	64	17·0	1·4
	Belle Vue S.E. Co.	1,510		776	40·7	,, ...	348	348	315	20	7	6	33	9·5	1·3
	L'Espérance ...	750		242	47·5	,, ...	73	70	22	27	12	9	48	68·6	3·7
	Mont Piton ...			501	25·5	,, ...	300	100	61	20	11	8	39	39·0	2·6
	Mon Rocher ...	1,200	238	429	41·8	,, ...	125	95	50	21	15	9	45	47·4	3·0
	Rosalie	1,200	625	863	31·7	,, ...	379	379	215	61	78	25	164	43·3	3·9
	Rosalie C. ...	992		631	45·8	,, ...	158	100	81	14	5	0	19	19·0	1·5
	Solitude... ...	3,112	90	976	41·8										
	The Mount ...	1,262	400	781	29·9	,, ...	281	261	36	78	113	34	225	86·2	4·8
		—	—	—	37·3		—	1,997	1,207	365	300	125	790	39·6	2·62
RIVIERE DU REMPART.	Antoinette ...	1,900	630	2,096	25·7	Ménagé ..	936	497	458	16	14	9	39	7·8	1·4
	Belle Vue (M) ...	3,652	350	1,618	23·4	,, ...	690	315	228	48	17	22	87	24·4	2·1
	Beau Sejour and M. Choix.	2,530	350	1,572	29·9	,, ...	408	407	202	139	54	12	205	50·3	2·6
	Bon Espoir ...	700	300	513	38·5	,, ...	199	199	139	52	8	0	60	30·1	1·7
	Ile d'Ambre A. E. Co.	2,517	50			,, ...	168	140	21	45	37	37	119	85·0	5·1
	Esperance ...	1,824	172	1,279	35·8	,, ...	498	365	331	26	3	5	34	9·3	1·3
	Labourdonnais ...	2,924	296	1,997	25·8	,, ...	1,010	870	719	97	37	17	151	17·4	1·6
	L'Union (D) ...	1,250	25			Tennant ...	50	32	17	6	3	6	15	46·9	3·3
	L'Union (M) ...	710	157			,, ...	145	96	80	9	5	2	16	16·7	1·6
	Mapou	1,200	200	354	29·3	,, ...	117	105	79	10	6	10	26	24·8	2·2
	Mon Loisir S. E. Co.	500	140	328	27·8	Ménagé ..	384	384	348	9	15	12	36	9·4	1·5
	Mon Loisir (R) ...	1,596	150	1,074	28·4	Tennant ...	94	69	42	14	6	7	27	39·1	2·6
	Mare Sèche ...	1,085	150	219	44·5	,, ...	63	49	20	11	7	11	29	59·2	3·9
	St. Antoine ...	3,200	50	1,507	33·3	Ménagé ...	525	340	251	46	27	16	89	26·2	2·0
	Schoenfeld ...	1,400	200	590	51·9	,, ...	78	77	29	13	22	13	48	62·3	4·1
		—	—	—	30·7		—	3,945	2,964	541	261	179	981	24·6	1·97
FLACQ.	Argy	6,700	240	614											
	Australia ...	479	600	198	31·0?	de la Roche	55	55	9	23	17	6	46	83·7	4·3
	Beau Bois ...	750	450	1,040	18·5	,,	219	102	41	31	25	5	61	59·8	3·2
	Beau Champ ...	2,857	40	2,133	38·3	Lesur ..	823	268	97	126	41	4	171	63·8	2·8
	Beau Vallon ...			135	12·5?	de la Roche	40	25	10	11	4	0	15	60·0	2·6
	Belle Rive ...	1,471	425	562	43·9	Lesur ...	296	99	17	30	30	22	82	82·8	4·9
	Belle Vue (A) and	3,500	400	1,659	32·4?	de la Roche	207	207	78	77	40	12	129	61·3	3·1
	Petite Retraite.		200			,,	228	147	48	58	35	6	99	67·3	3·3
	Bel Etang ...		800			Lesur ...	269	86	23	24	19	20	63	73·3	4·5
	Constance (A) ...	1,521	300	1,321	36·0	de la Roche	419	398	74	112	120	92	324	81·4	4·9
	Constance (M) ...	922	378	937	42·2	,,	248	52	32	12	6	3	21	40·4	2·5
	Carried forward	—	—	—	—		2,804	1,439	429	504	337	170	1,011	—	—

TABLE IV.—A. *(continued.)*

District.	Estate.	Acreage.	Altitude (feet).	Population.	Death-rate.	Examiner.	Total Children.	Children Examined.	Spleens. 1	3	6	9	Total with Spleen	Spleen Rate.	Average Spleen.
	Brought forward	—	—	—	—		2,804	1,439	429	504	337	170	1,011	—	—
FLACQ (*contd.*)	Deep R., La Louise and Sebastopol.	1,947?	300	1,011?	31·5	Lesur ...		253	126	77	35	15	127	50·2	3·2
	La Gaiété ...	1,611	280	1,511	17·5	de la Roche	582	222	82	41	56	43	140	63·1	4·1
	L'Etoile ...	2,670	418	2,245	24·5	Lesur ...	668	201	79	56	56	10	122	60·7	3·3
	L'Unité... ...	1,271	880	806	18·2	de la Roche	216	164	113	25	16	10	51	31·1	2·3
	L'Union ...	945	600	1,059	47·5	,, ...	311	247	200	24	14	9	47	19·0	1·8
	Olivia	1,201	376	614	40·8	Lesur ...	222	94	12	25	35	22	82	87·2	5·2
	Queen Victoria ...	3,100	400	1,949	21·6	de la Roche	626	112	57	37	8	10	55	49·1	2·8
	La Retraite ...	1,475	310	—	33·3?	,,	203	107	54	25	17	11	53	50·4	3·0
	Rich Fund ...	1,324	700	1,304	32·6	,,	435	37	6	11	8	12	31	83·8	5·2
		—	—	—	30·9		6,067	2,876	1,158	825	582	312	1,719	59·6	3·45
GRAND PORT	Anse Jonchée ...	1,609	00	285	43·1										
	Astrœa ..	1,025	600	512	28 4	Chauvin ..	108	59	20	7	20	12	39	66·0	4·6
	Beau Vallon ...	2,769	00–266	1,174	30·9	Guerin ...	454	19	7	5	3	4	12	63·2	4·0
	Cent Gaulettes ...	1,482	400	834	23·5	Senneville...	302	157	53	31	46	27	104	66·2	4·2
	Cluny	2,003	1,000	114											
	Deux Bras ...	1,000	700	1,073	16·4	Chauvin ...	410	210	130	24	39	17	80	38·0	2·8
	Eau Bleu... ...	914	500 to 1,000	330											
	Ferney	3,229	10	1,020	23·3	Guerin ...	286	24	2	8	8	6	22	91·7	5·3
	Gros Bois ...	2,436	560	787	19·9	Chauvin ...	195	85	49	9	16	11	36	42·3	3·2
	Joli Bois	527	750	225	47·4	,,	94	38	34	4	0	0	4	10·6	1·2
	La Baraque ...	1,600	600	1,120	23·2	Senneville	233	233	118	28	55	32	115	49·3	3·5
	Savinia		250			,,	488	447	229	74	95	49	218	48·8	3·2
	Le Vallon ...	4,110	20	1,714	18·1	Guerin ...	442	20	4	5	8	3	16	80·0	4·7
	Mon Désert ...	2,748	200	1,492	31·3	Senneville	446	410	210	91	66	43	200	48·8	3·1
	New Grove ...	—	900	952	20·5	Chauvin ...	111	69	55	2	9	3	14	20·3	2·0
	Plaisance ...	2,000	150	1,231	12·4	Senneville	566	566	359	80	97	30	207	36·6	2·6
	Riche-en-Eau ...	2,000	400	1,740	24·4	,,	474	234	72	49	63	50	162	69·2	4·0
	Rose Belle ...	2,858?	900	876	30·0										
	Sauveterre ...	653	300	458	17·5	,,	124	118	72	20	22	4	46	38·1	2·5
	St. Hubert ...	1,975	650	1,017	29·7	,,	258	242	65	57	70	50	177	73·1	4·6
	Union Park ...	875	1,150	856	13·5	Chauvin ...	310	128	113	2	9	4	15	11·7	1·6
	Union Vale ...	1,588	200	807	38·5	Guerin ...	233	21	5	6	5	5	16	76·2	4·7
	Virginia	1,200	200	353	24·4	,,	102	20	8	2	5	5	12	60·0	4·4
		—	—	—	24·5		—	3,110	1,615	504	636	355	1,495	48·0	3·25
SAVANNE	Beau Champ ...	777	125	505	41·9	Ulcoq ...	187	169	124	20	15	10	45	26·6	2·2
	Bel Air	625	225	541	38·8	,,	175	170	87	41	29	13	83	48·8	2·9
	Bel Ombre ...	2,500	100	1,224	34·8	,,	295	269	177	55	29	8	92	34·2	2·2
	Bénarès	1,812	300	977	36·8	,,	308	180	110	42	10	18	70	38·8	2·5
	Britannia... ...	—	700	1,962	13·7	Chauvin ...	366	312	287	20	5	0	25	8·0	1·2
	Chamouny ..	2,700	450	560	26·3	Ulcoq ...	217	217	208	2	0	7	9	4·1	1·3
	Combo	996	800	577	28·3	,,	165	96	92	3	0	1	4	4·2	1·1
	Carried forward	—	—	—	—		—	1,413	1,085	183	88	57	328	—	—

TABLE IV.—A. *(continued.)*

District.	Estate.	Acreage.	Altitude (feet).	Population.	Death-rate.	Examiner.	Total Children.	Children Examined.	Spleens. 1	3	6	9	Total with Spleen	Spleen Rate.	Average Spleen.
	Brought forward							1,413	1,085	183	88	57	328	—	—
SAVANNE (*contd.*)	Fontenelle ...			344	16·9	Ulcoq ..	86	80	20	11	24	25	60	75·0	5·3
	Riche Bois ...	2,000	750	1,516	16·5	Chauvin ..	429	236	213	11	8	4	23	9·7	1·4
	Riv. des Anguilles	571	125	940	26·6	Senneville	326	268	147	69	33	19	121	45·1	2·7
	Savannah ...	2,530	150	1,756	32·8										
	St. Aubin and Beau Bois.	2,500	300 800	2,774	25·6	Ulcoq ..	455	455	432	15	5	3	23	5·1	1·2
	St. Avold ...			573	27·2	? Chauvin ..	130	127	111	11	5	0	16	12·6	1·4
	St. Felix	730	426	937	46·4	Ulcoq ..	188	188	158	10	20	0	30	15·9	1·6
	Terracine ...	1,100	—	1,011	40·2	,,	200	186	151	24	6	5	35	18·8	1·6
		—	—	—	28·7		—	2,953	2,317	334	189	113	636	21·5	1·85
BLACK RIVER.	Albion	2,000	00	444	29·8	Harel	151	151	37	51	58	5	114	75·5	3·9
	Médine	2,980	150	885	26·7	,,	324	324	201	51	42	30	123	36·9	2·7
	Tamarin	5,894	155	1,530	42·9	,,	400	400	140	90	93	77	260	65·0	4·1
		—	—	—	39·5		—	875	378	192	193	112	497	56·7	3·56
MOKA ..	Alma	3,221	1,460	2,218	19·1	Leclézio ...	604	219	212	2	4	1	7	3·2	1·0
	Bel Etang ...		900	1,304	30·9										
	Bonne Veine	480	1,350	502	13·7	Leclézio ...	174	86	82	1	2	1	4	4·6	1·2
	Côte d'Or ...	1,215	1,200	974	19·5	Clarenc ...	296	181	168	3	4	6	13	18·0	1·4
	Melrose	889	975	540	3·8	Leclézio ...	91	38	38	0	0	0	0	0	0
	Minissy	722	1,140	1,102	21·5	Clarenc ...	230	173	159	3	7	4	14	8·1	1·4
	Mon Désert	2,800	1,320	2,244	13·9	,,	317	260	247	0	2	11	13	5·0	1·3
	Pieter Both ...	2,542	1,320	1,540	24·0	,,	293	186	176	6	3	1	10	5·4	1·2
	Valetta	1,500	1,420	1,367	23·4	,,	483	95	88	3	4	0	7	7·4	1·3
	8 other Estates ...					,,	800	723	704	5	8	6	19	2·6	1·1
		—	—	—	18·7		—	1,961	1,874	23	34	30	87	4·4	1·23
PLAINES WILHEMS	Bagatelle... ...	645	1,330	382	23·9	Harel ...	150	100	93	1	6	0	7	7·0	1·4
	Bassin	3,000	500 to 1,200	631	39·0	,,	173	173	119	15	16	23	54	31·2	2·6
	Henriette ...	3,200	1,486	353	33·1	,,	125	125	120	2	3	0	5	4·0	1·2
	Highlands ...	2,939	1,362	726	25·4	,,	105	105	105	0	0	0	0	0	1·0
	Réunion	848	1,400 to 1,700	512	20·8	,,	222	50	46	0	4	0	4	8·0	1·2
	Stanley and Ebène	1,007	925	655	31·4	Bour ...	—	105	82	10	4	9	23	21·9	2·1
	Trianon	2,600	1,050	1,463	21·3	Vinson ...	533	533	524	5	2	2	9	1·6	1·1
		—	—	—	27·0		—	1,191	1,089	33	35	34	102	8·6	1·43

The death rates given in this table are averages for the two years ending June, 1907, and are taken from the Reports on Estate Hospitals. The acreage, altitude and population were sent to me separately. In both cases, however, I have not always been able to identify the estates given in various papers, owing to confusion in their names. Many of the examiners gave interesting details about imported cases (see section 20, 6), but these could not be inserted in the tables.

TABLE IV.—B.

SHOWING THE SPLEEN RATES OF CHILDREN IN SCHOOLS, 1907-8 (section 20).

District.	School.	Altitude.	Examiner.	Total Children.	Children Examined.	Spleens.					Spleen Rate.	Average Spleens.
						1	3	6	9	Total with Spleen.		
Port Louis (1)	Roche Bois Government ...	0	Keisler ...	120	75	36	15	9	15	39	52·0	3·6
	Vallée des Prêtres... ...	,,	,, ...	39	34	15	5	6	8	19	55·8	4·1
	Total											
(2)	Government Aided, Pamplemousses Road	,,	,, ...	200	165	97	22	16	30	68	41·2	3·2
	Eastern Suburb Government	,,	,, ...	90	51	28	5	6	12	23	45·1	3·7
	,, Girls' ,,	,,	,, ...	85	49	35	8	3	3	14	28·5	2·1
	,, Boys' ,,	,,	,, ...	84	22	11	3	1	7	11	50·0	4·0
	Nicolay Road Aided ...	,,	,, ...	175	104	66	14	9	15	38	36·5	2·9
	Church of Scotland Aided	,,	,, ...	77	35	22	3	3	7	13	37·1	3·2
	Total											
(4)	Filles de Marie Convent ...	,,	,, ...	87	73	39	16	10	8	34	46·5	3·0
	Arsenal St. Aided... ...	,,	,, ...	134	108	62	23	10	13	46	42·5	2·8
	St. Joseph Aided	,,	,, ...	225	160	137	15	5	3	23	14·3	1·5
	Total											
(5)	Training Government ...	,,	,, ...	171	155	105	22	14	14	50	32·2	2·5
	St. Jean Baptiste	,,	,, ...	393	286	195	43	24	24	91	31·8	2·3
	Total											
(6)	Champ de Lort Girls' ...	,,	,, ...	125	60	44	11	5	0	16	26·6	1·8
	,, ,, Boys' ...	,,	,, ...	100	31	20	3	5	3	11	35·4	2·8
	Bon Secours Convent ...	,,	,, ...	137	123	98	10	8	7	25	18·2	1·8
	Immaculée Conception ..	,,	,, ...	120	80	66	8	2	4	14	17·5	1·7
	Total											
(8)	Cassis Road Government	,,	,, ...	203	170	116	30	9	15	54	31·7	2·3
	Cassis St. Joseph	,,	,, ...	100	62	25	13	9	15	37	59·6	4·1
	Signal Mountain	?	,, ...	130	59	33	12	6	8	26	44·0	3·0
	Grand River, N.W. ...	0	,, ...	80	23	7	6	0	10	16	69·5	5·0
	Total											
(?)	Western Suburb Boys' ...	,,	Ross, Fowler	206	78	40	18	19	1	38	48·7	2·8
	Total			—	2,003	1,297	305	179	222	706	35·4	2·64

TABLE IV.—B (*continued*).

District.	School.	Altitude.	Examiner.	Total Children.	Children Examined.	Spleens.					Spleen Rate.	Average Spleens.
						1	3	6	9	Total with Spleen.		
GRAND PORT	Rose Belle Government Boys'.	800	Masson ...	144	121	111	3	5	2	10	8·2	1·4
	Rose Belle Government Girls'.	,,	,, ...	123	101	89	6	3	3	12	11·8	1·5
	Anse Jonchée	0	,, ...	49	29	15	7	4	3	14	48·2	3·0
	Rivière des Créoles ...	,,	,, ...	51	37	16	10	8	3	21	56·7	3·3
	Old Grand Port	,,	,, ...	48	22	11	7	3	1	11	50·0	2·7
	L'Escalier Boys'	?	,, ...	140	100	57	30	6	7	43	43·0	2·8
	,, Girls'	?	,, ...	68	55	32	18	3	2	23	41·8	2·2
	Malakoff R.C.	?	,, ...	49	27	19	4	1	3	8	29·6	2·4
	Plaine Magnien R.C. ...	250	,, ...	104	62	44	12	4	2	18	29·0	2·0
	Mare d'Albert	500	,, ...	125	95	75	9	7	4	20	21·1	2·0
	Nouvelle France	1,500	,, ...		37	35	1	1	0	2	5·4	1·2
	PlaineMagnienGovernment	250	,, ...		61	33	2	14	12	28	45·9	3·8
	Mahebourg Boys' Government.	0	,, ...		119	78	16	15	10	41	34·5	2·6
	Mahebourg Girls' Government.	,,	,, ...		73	51	4	12	6	22	30·1	2·6
	Mahebourg Girls' R.C. ...	,,	,, ...		80	66	2	10	2	14	17·5	1·9
	,, Boys' Aided ...	,,	,, ...		47	25	6	10	6	22	46·8	3·3
	New Grove R.C.	900	,, ...		68	54	2	3	9	14	20·6	2·3
	?	?	,, ...	40	18	2	5	7	4	16	88·9	5·3
	TOTAL			—	1,152	813	144	116	79	339	29·4	2·30
SAVANNE ...	Souillac Convent, Aided ...	0	Masson ...	—	66	37	11	10	8	29	43·9	3·1
	,, Government ...	,,	,, ...	—	86	58	8	12	8	28	32·7	2·6
	Surinam Aided	?	,, ...	—	58	29	4	12	13	29	50·0	3·9
	Chemin Grenier, Government.	?	,, ...	—	79	62	5	8	4	17	21·5	2·0
	Grand Bois	?	,, ...	—	41	40	1	0	0	1	2·4	1·0
	Baie du Cap	0	,, ...	—	59	21	9	8	21	38	67·4	4·8
	Rivière des Anguilles ...	400	Ross, Fowler	—	60	53	5	1	1	7	11·7	1·4
	TOTAL			—	449	300	43	51	55	149	33·2	2·74
BLACK RIVER	Tamarin Bay	0	Masson ...	25	17	1	7	4	5	16	94·1	5·3
	Petite Rivière	250	,, ...	55	29	11	10	7	1	18	62·1	3·2
	Cazela Government ...	350	,, ...	32	19	5	9	3	2	14	73·7	3·6
	Case Noyale	0	,, ...	31	11	3	4	3	1	8	72·7	3·4
	TOTAL			—	76	20	30	17	9	56	73·7	3·85
MOKA ...	Côte d'Or Aided	1,200	Castel ...	35	35	33	1	1	0	2	5·7	1·2
	St. Pierre Convent ...	,,	,, ...	31	31	29	2	0	0	2	6·4	1·1
	Camp Saury R.C. ...	,,	,, ...	41	41	34	6	1	0	7	17·1	1·4
	,, Ch. Eng. ...	,,	,, ...	61	61	45	13	2	1	16	26·2	1·7
	Moka Government ...	,,	,, ...	95	95	68	19	4	4	27	28·4	1·9
	TOTAL			263	263	209	41	8	5	54	20·5	1·61

TABLE IV.—B (*continued*).

District.	School.	Altitude.	Examiner.	Total Children.	Children Examined.	Spleens. 1	3	6	9	Total with Spleen.	Spleen Rate.	Average Spleens.
PLAINES WILHEMS	Brown Sequard St. Curepipe.	1,800	Castel ...	181	181	174	1	2	4	7	3·8	1·2
(1)	Girls' R.C., Curepipe ...	,,	,, ..	151	151	146	4	1	0	5	3·3	1·1
	Boys' ,, ,, ..	,,	,, ...	130	130	123	3	3	1	7	5·4	1·2
	Girls' Government, Curepipe.	,,	,, ...	125	125	123	2	0	0	2	1·6	1·0
	Curepipe Road Aided ...	,,	,, ...	71	71	68	3	0	0	3	4·2	1·1
	Total			658	658	634	13	6	5	24	3·6	1·15
(2)	Camp Fouqueraux S.P.G.	1,450	,, ...	23	23	22	1	0	0	1	4·3	1·1
	,, ,, Government	,,	,, ...	25	25	22	0	0	3	3	12·0	1·9
	Total			48	48	44	1	0	3	4	8·3	1·54
(3)	Camp Mapou, Vacoas ...	1,400	,, ...	31	31	29	1	0	1	2	6·4	1·3
	Glen Park Aided	,,	,, ...	80	80	73	5	2	0	7	8·7	1·2
	La Caverne Aided ...	,,	,, ...	87	87	84	2	1	0	3	3·4	1·1
	Vacoas Road	,,	,, ...	141	141	134	3	3	1	7	4·9	1·2
	Total			339	339	320	11	6	2	19	5·6	1·20
(4)	Phœnix Aided	,,	,, ...	39	39	34	3	2	0	5	12·8	1·4
	St. Paul's Convent ...	,,	Ross, Fowler	109	44	30	7	4	3	14	31·9	2·8
	Phœnix (Police Station) ...	,,	Castel ...	33	33	17	6	2	8	16	48·4	3·6
	Total			—	116	81	16	8	11	35	30·1	2·38
(5)	Quatre Bornes Government	1,050	,, ...	91	91	72	8	6	5	19	20·8	1·9
	Belle Rose Avenue ...	,,	,, ...	55	55	50	5	0	0	5	9·1	1·2
	,, Convent ...	,,	,, ...	40	40	39	0	1	0	1	2·5	1·1
	Total			186	186	161	13	7	5	25	13·4	1·54
(6)	Rose Hill, Labs. St. ...	950	,, ...	65	65	62	3	0	0	3	4·6	1·1
	,, Edward VII. St.	,,	,, ...	55	55	54	1	0	0	1	1·8	1·0
	,, Ch. Eng. Aided	,,	,, ...	70	70	66	3	1	0	4	5·7	1·2
	,, Mahomedan Aided.	,,	,, ...	98	98	97	1	0	0	1	1·0	1·0
	Rose Hill Government ...	,,	,, ...	75	75	72	2	0	1	3	4·0	1·2
	,, St. Enfant Jésus	,,	,, ...	166	166	156	7	3	0	10	6·0	1·2
	,, R.C. Aided ...	,,	,, ...	100	100	96	3	1	0	4	4·0	1·1
	Total			629	629	603	20	5	1	26	4·1	1·12
(7)	Beau Bassin Ch. Eng. ...	750	,, ...	34	34	33	1	0	0	1	2·9	1·1
	,, Convent Ch.	,,	,, ...	58	58	54	3	0	1	4	6·9	1·2
	,, Gustav Colin St.	,,	,, ..	72	72	64	5	1	2	8	11·1	1·4
	,, Girls' and Boys'	,,	,, ...	105	105	100	5	0	0	5	4·7	1·1
	Total			269	269	251	14	1	3	18	6·7	1·22
	TOTAL			—	2,245	2,094	88	33	30	151	6·7	1·26

TABLE IV.—C.

SHOWING THE SPLEEN RATES OF CHILDREN EXAMINED IN VARIOUS LOCALITIES, 1907-8 (section 20).

District.	Locality.	Altitude feet.	Examiner	Children Examined.	Spleens. 1	3	6	9	Total with spleen.	Spleen Rate.	Average Spleen.
Pample-mousses.	Terre Rouge School and Village.	100	Milne.	206	61	59	48	38	145	66·5	4·2?
	Pamplemousses School and Village.	200	"	186	58	18	49	61	128	68·8	5·1
	Calebasses Village	200	"	116	22	26	29	39	94	81·0	5·4
	Belle Vue Harel Estate ...	350	"	100	88	10	2	0	12	12·0	1·3
	Long Mountain School and Village.	500	"	194	82	45	34	33	112	57·7	3·7
Rivière du Rempart.	Poudre d'Or School and Village.	50	"	150	39	34	32	45	111	74·0	4·9
	Riv. du Rempart School and Village.	150	"	208	115	32	37	24	93	44·7	3·1
	L'Espérance Estate	200	"	174	125	28	12	9	49	28·1	2·1
	Beau Séjour Estate	400	"	100	77	8	8	7	23	23·0	2·1
	Mont Piton Camp	650	"	100	65	18	14	3	35	35·0	2·3
Flacq.	Trou d'Eau Douce School and Village.	50	"	185	67	49	42	27	118	63·8	3·8
	Post of Flacq School and Village.	50	"	162	20	31	39	72	142	87·6	6·1
	Constance d'A. Estate ...	100	"	166	7	41	18	100	159	95·7	7·5
	Beau Champ Estate	100	"	202	33	49	50	70	169	83·7	5·5
	Centre of Flacq School and Village.	150	"	237	25	33	86	93	212	89·4	6·2
	Rivière Sèche School and Village.	200	"	202	21	67	46	68	181	89·6	5·8
	Olivia Estate	350	"	113	17	25	36	35	96	84·9	4·7
	St. Julien Village	450	"	150	126	10	5	9	24	16·0	1·8
	Rich Fund Estate	600	"	151	122	15	6	8	29	19·2	8
	Sebastopol Village	650	"	150	117	20	7	6	33	22·0	8
Moka.	Pailles Village	200	"	162	29	34	46	53	133	82·1	6·0
	Montagne Blanche School and Village.	900	"	150	137	8	4	1	13	8·6	1·3
	Sans Souci Estate	950	"	200	178	17	2	3	22	11·0	1·2
	Quartier Militaire Village ..	1,350	"	143	129	8	5	1	14	9·7	1·3
				3,907	1,768	677	657	805	2,139	54·7	3·83
Grand Port.	Nouvelle France Village ...	1,500	Masson ...	61	60	0	1	0	1	1·6	1·1
Pl. Wilhems.	Tintamaree (?)	?	"	47	45	1	0	1	2	4·3	1·2
Black River.	Flic-en-Flac Village	0	"	40	9	6	15	10	31	77·5	5·2
	Bambous School	400	"	73	32	15	14	12	41	56·1	3·8
	Anna Estate	?	"	39	22	7	6	4	17	43·6	2·9
	Carried forward ...			260	168	29	36	27	92		

TABLE IV.—C (*continued*).

District.	Locality.	Altitude feet.	Examiner.	Children Examined.	Spleens. 1	3	6	9	Total with spleen.	Spleen Rate.	Average Spleen.
	Brought forward ...			260	168	29	36	27	92		
PL. WILHEMS.	Phœnix, collected children ...	1,350	Ross, Fowler 27-12-07.	163	74	37	46	6	89	55·3	3·16
	Do. House to House in 119 Houses.	1,350	Ross, Fowler Feb. 1908.	339	98	104	82	55	241	71·1	4·12
	Highlands Estate	1,400	Ross, Fowler 7-12-07.	50	47	1	0	2	3	6·0	1·36
	Phœnix along Curepipe Road	1,450		38	36	2	0	0	2	5 2	1·10
	Le Réduit	—	Ross... ...	58	55	1	1	1	3	5·1	1·26
PORT LOUIS.	Men's Training Government School.	0	Ross, Fowler	169	102	43	17	7	67	39 6	2·34
SAVANNE.	St. Felix Estate	400	,,	30	24	3	1	2	6	20·0	1·9
PAMPLEMOUSSES.	Beau Plan Estate	200	,,	26	4	16	5	1	22	84·6	3·5
				1,133	608	236	188	101	525	46·3	2·96
MISCELLANEOUS	Curepipe	1,800	,,	107	106	—	—	—	1	0·9	—
	Curepipe to Phœnix Road ...	1,700-1,400	,,	130	124	—	—	—	6	4·6	—
	La Caverne	1,350	,,	104	104	—	—	—	0	—	—
	Henrietta	1,600	,,	62	59	—	—	—	3	4·8	—
	Solferino	1,200	,,	51	43	—	—	—	8	15·7	—
	La Louise	1,100	,,	63	51	—	—	—	12	19·0	—
	West of Rose Hill	700	,,	36	30	—	—	—	6	16·6	—
	Moka	1,200	,,	62	59	—	—	—	3	4·8	—
	Camp Fouquereaux	1,450	,,	26	26	—	—	—	0	—	—
	Petite Rivière	200	,,	62	23	—	—	—	39	62·4	—
	Tranquebar	50	,,	32	0	—	—	—	32	100·0	—
	Port Louis	0	,,	41	19	—	—	—	22	53·6	—
	Road to Arsenal	100	,,	109	72	—	—	—	37	33·9	—
				885	716	—	—	—	169	19·0	—

TABLE IV.—D.

SUMMARY OF SPLEEN RATES (section 20).

		Children Examined.	Spleens.					Spleen Rate.	Average Spleen.
			1	3	6	9	Total with spleen.		
ESTATES ...	Pamplemousses ...	1,997	1,207	365	300	125	790	39·6	2 62
	Rivière du Rempart ...	3,945	2,964	541	261	179	981	24·9	1·97
	Flacq ...	2,877	1,158	825	582	312	1,719	59·8	3·45
	Grand Port	3,110	1,615	504	636	355	1,495	48·1	3·26
	Savanne	2,953	2,317	334	189	113	636	21·5	1·85
	Black River	875	378	192	193	112	497	56·8	3·57
	Moka	1,961	1,874	23	34	30	87	4·4	1·23
	Plaines Wilhems ...	1,191	1,089	33	35	34	102	8 6	1·43
	Total	18,909	12,602	2,817	2,230	1,260	6,307	33·35	2·42
SCHOOLS ...	Port Louis	2,003	1,297	305	179	222	706	35·2	2·64
	Grand Port	1,152	813	144	116	79	339	29·4	2·30
	Savanne	449	300	43	51	55	149	33·3	2·74
	Black River	76	20	30	17	9	56	73·4	3·89
	Moka	263	209	41	8	5	54	20·5	1·62
	Plaines Wilhems ...	2,245	2,094	88	33	30	151	6·5	1·26
	Total	6,188	4,733	651	404	400	1,455	23·5	2·05
VARIOUS LOCALITIES.	By Dr. Milne ...	3,907	1,768	677	657	805	2,139	57·7	3·84
	By Masson, Ross, and Fowler.	1,133	608	236	188	101	525	46·3	2·96
	Total	5,040	2,376	913	845	906	2,664	52·9	3 64
	Total	30,137	19,711	4,381	3,479	2,566	10,426	34·6	2·54
MISCELLANEOUS.	Ross and Fowler ...	885	716	—	—	—	169	19·1	—
	Grand Total ...	31,022	20,427	—	—	—	10,595	34·1	—

TABLE IV.—E.

SPLEEN RATE ACCORDING TO ALTITUDE (section 20, 7).

Altitude in Feet.	Children Examined	Spleens.					Spleen Rate.	Average Spleen.
		1	3	6	9	Total with Spleen.		
100	5,210	2,623	1,030	732	734	2,587	49·6	3·20
200	4,843	2,593	813	765	633	2,250	46·4	3·16
300	3,559	2,208	616	457	258	1,351	37·6	2·59
400	2,817	1,432	651	473	262	1,386	49·2	3·01
500	1,246	786	193	177	90	460	36·9	3·48
600	830	518	106	128	78	312	37·5	2·74
700	1,963	1,373	227	235	122	590	30·0	2·27
800	1,398	1,241	80	41	36	157	11·1	1·65
900	624	478	52	48	46	146	23·4	2·14
1,000	972	901	47	11	13	71	7·3	1·26
1,100	782	736	18	9	7	46	5·8	1·14
1,200	858	751	49	28	19	107	12·4	1·28
1,300	130	124	—	—	—	6	4·6	
1,400	1,991	1,556	185	160	90	435	21·8	1·94
1,500	612	586	10	12	4	26	4·2	1·19
1,600	112	105	3	4	0	7	6·2	1·31
1,700	—	—	—	—	—	—	—	—
1,800	765	740	13	6	5	25	3·2	1·13

TABLE IV.—F

SPLEEN RATES COMPARED WITH DEATH RATES BY DISTRICTS (section 20, 8.

Class.	Districts.	Death Rates Average 1905-06.	Spleen Rates.	Average Spleen.
Estates only ...	Pamplemousses	37·3	39·6	2·62
	Rivière du Rempart	30·7	24·6	1·97
	Flacq	30·9	59 6	3·45
	Grand Port	24·5	48·0	3·25
	Savanne	28·7	21·5	1·85
	Black River	39·5	56·7	3·56
	Moka	18·7	4·4	1·23
	Plaines Wilhems	27·0	8·6	1·43
	Average of the above	29·7	32·9	2·42
All Classes.	Port Louis	56·6	35·6	2·66
	Pamplemousses	46·1	45·7	3·04
	Rivière du Rempart	39·7	27·6	2·12
	Flacq	42·4	62·7	3·89
	Grand Port	38·6	42·4	2·97
	Savanne	32·5	23 0	1·96
	Black River	44·2	58·2	3·63
	Moka	31·1	11·2	1·52
	Plaines Wilhems	31·9	14·3	1·61
	Average of the above ...	40·3	35·6	2·60

The death rates for Estates are taken from Table IV. A. Those for all classes from the Registrar General's Report for 1906, page 10, being the rates for 1905 and 1906 averaged.

PLAN OF VACOAS CAMP AND CLAIRFOND MARSHES.

(For Addendum 2.)

1. The fractions (such as 3/7), denote the ratio of the number of children with enlarged spleen (3) to the total number examined (7).

2. The Roman numerals denote the houses referred to in Dr. de Chazal's report, as follows :—

House	I.	Affected	January, 1906.
,,	II.	,,	August, ,,
,,	III.	,,	November, 1906
,,	IV.	,,	December, ,,
,,	V.	,,	February, 1907.
,,	VI.	,,	March, ,,
,,	VII.	,,	April, ,,
,,	VIII.	,,	Servants in June, children in December.
,,	IX.	,,	September, 1907.
,,	X.	,,	December, ,,
,,	XI.	,,	January ,,
,,	XII.	,,	February ,,

Houses XIII. to XXVI. not affected by Malaria.

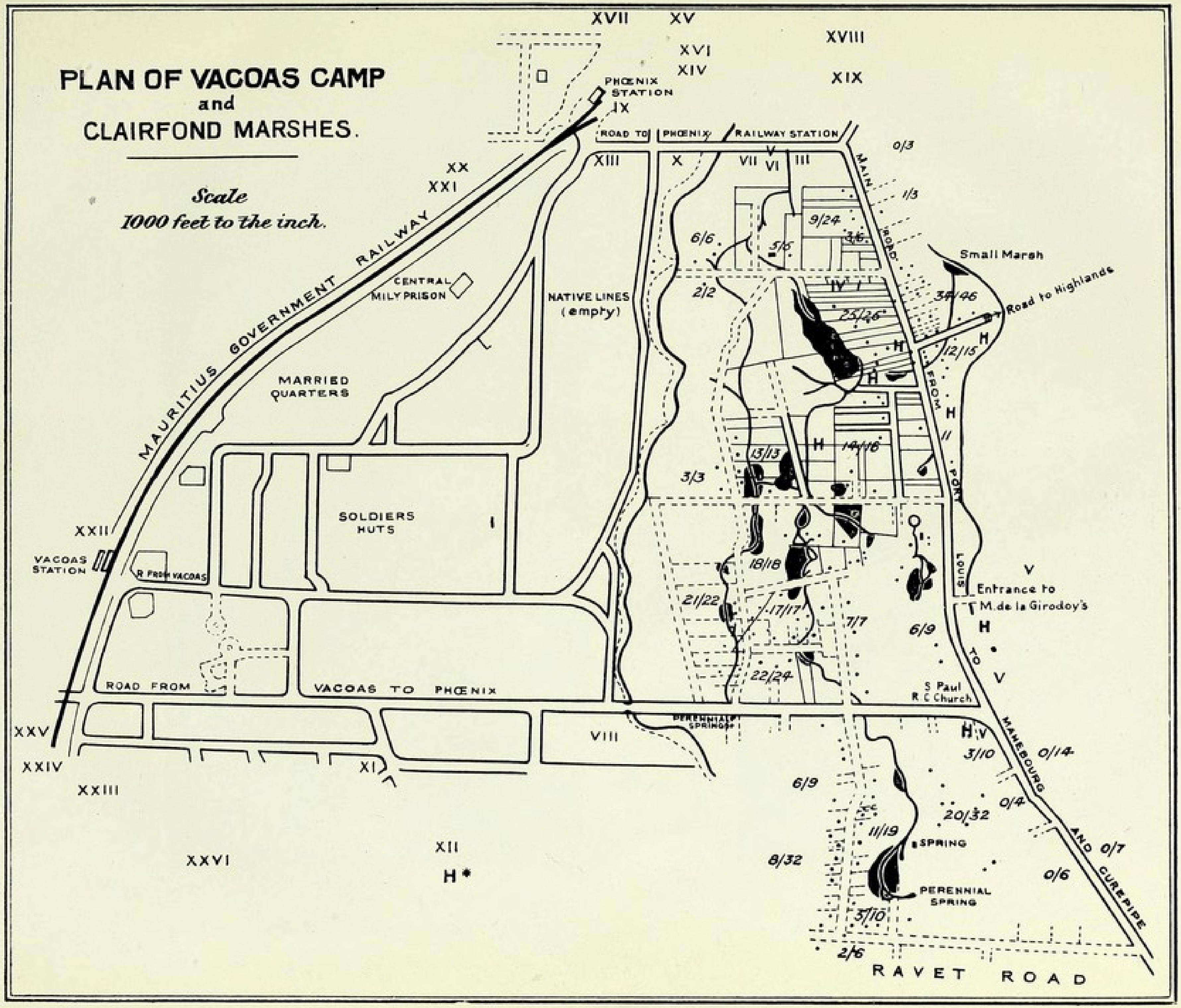
Houses H, where cases of Blackwater fever occurred.

House H*, case of Blackwater had moved in here from House III. four weeks before he was attacked.

3. The marshes are entered in black.

PLAN OF VACOAS CAMP and CLAIRFOND MARSHES.

Scale 1000 feet to the inch.



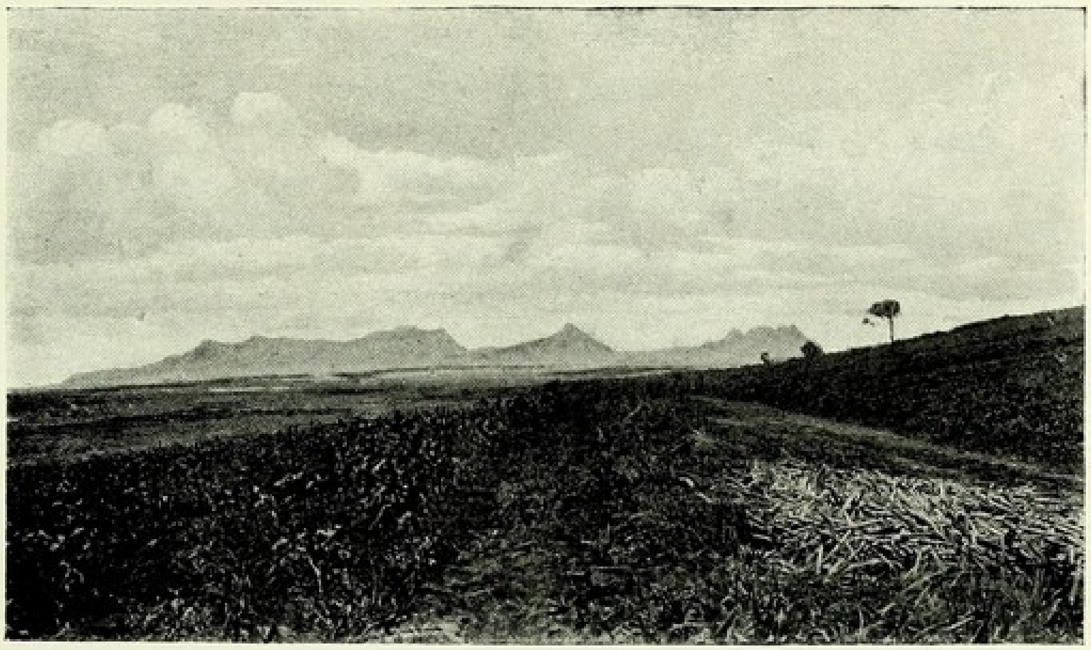


PHOTO. 1.—Plateau of Plaines Wilhems from near Curepipe, looking northward.

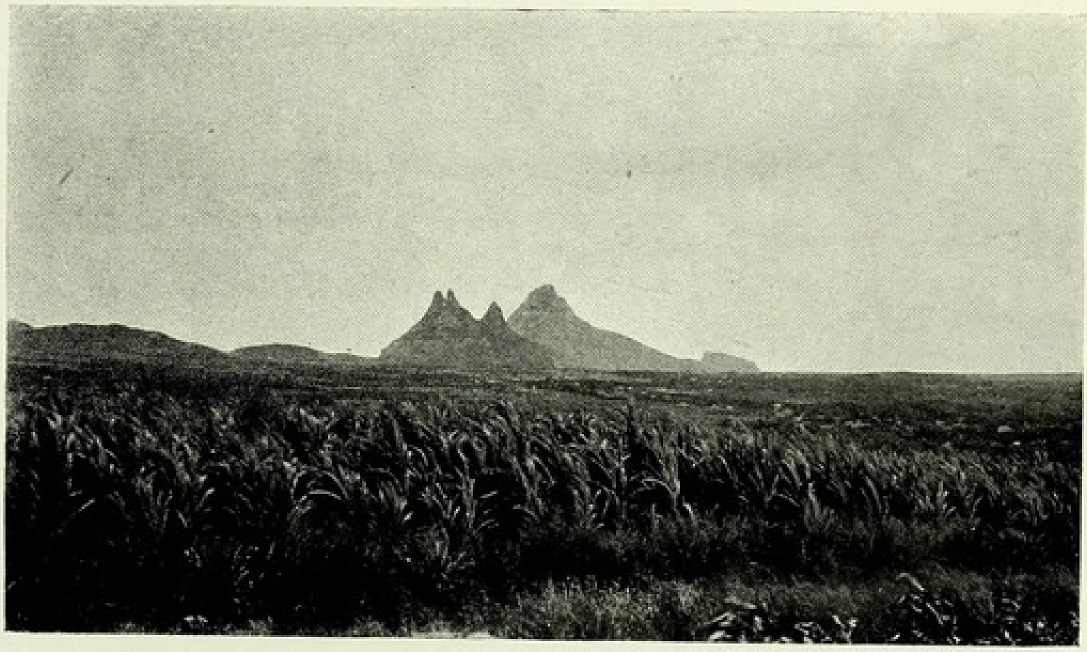


PHOTO. 2.—Plateau of Plaines Wilhems from near Curepipe, looking westward. Cane fields.

PHOTO. 3.—The Black River, near the Coast. By Major Fowler.

PHOTO. 4.—Portion of a Cane-Field.

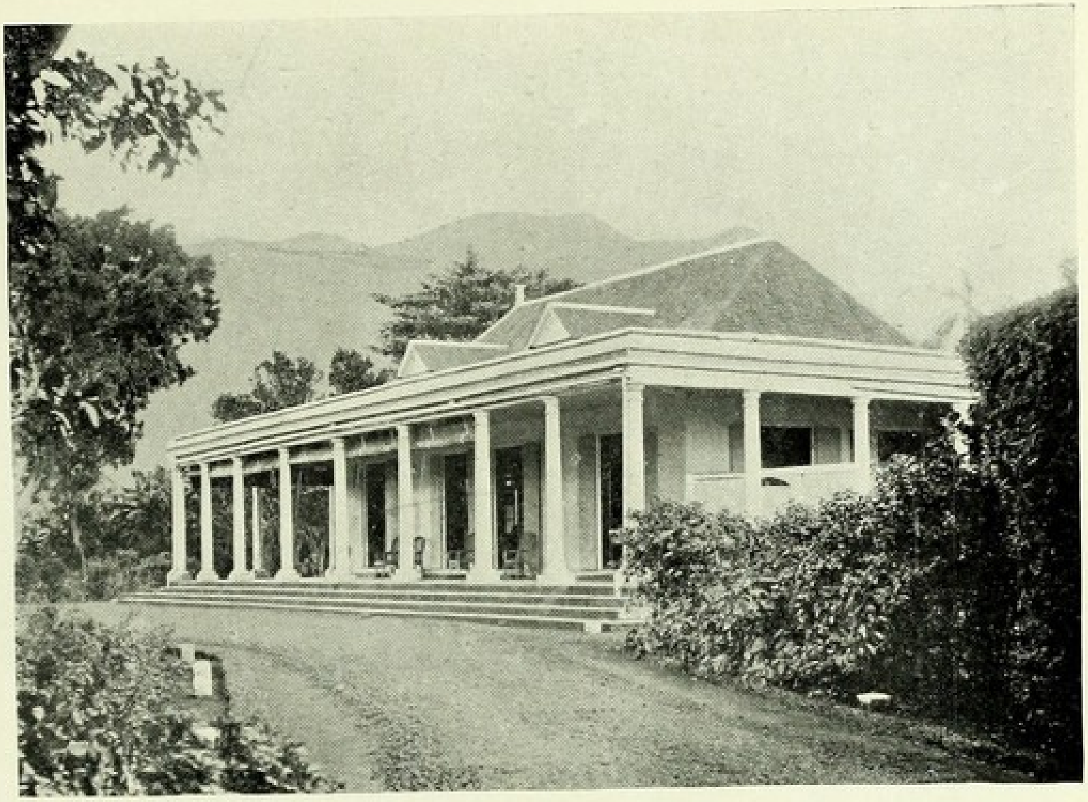


PHOTO. 5.—The Bishop's House at Moka.

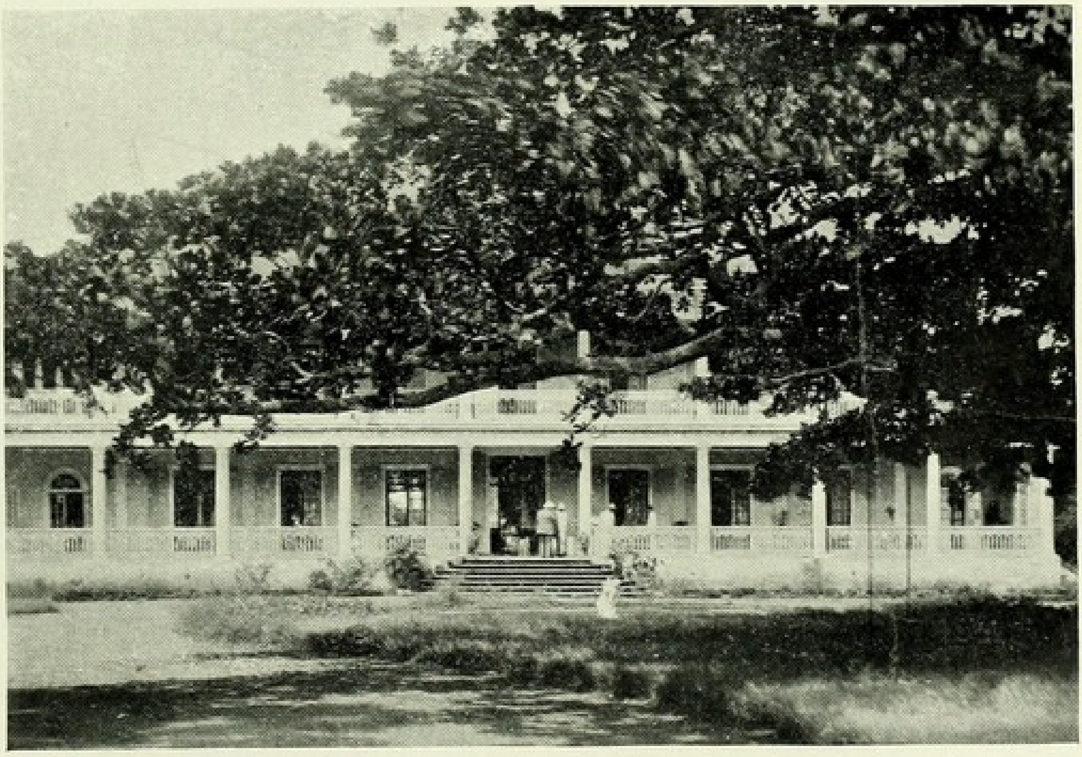


PHOTO. 6.—Labourdonnais House on Estate.

PHOTO. 7.—Middle-class Creole's House at La Caverne.

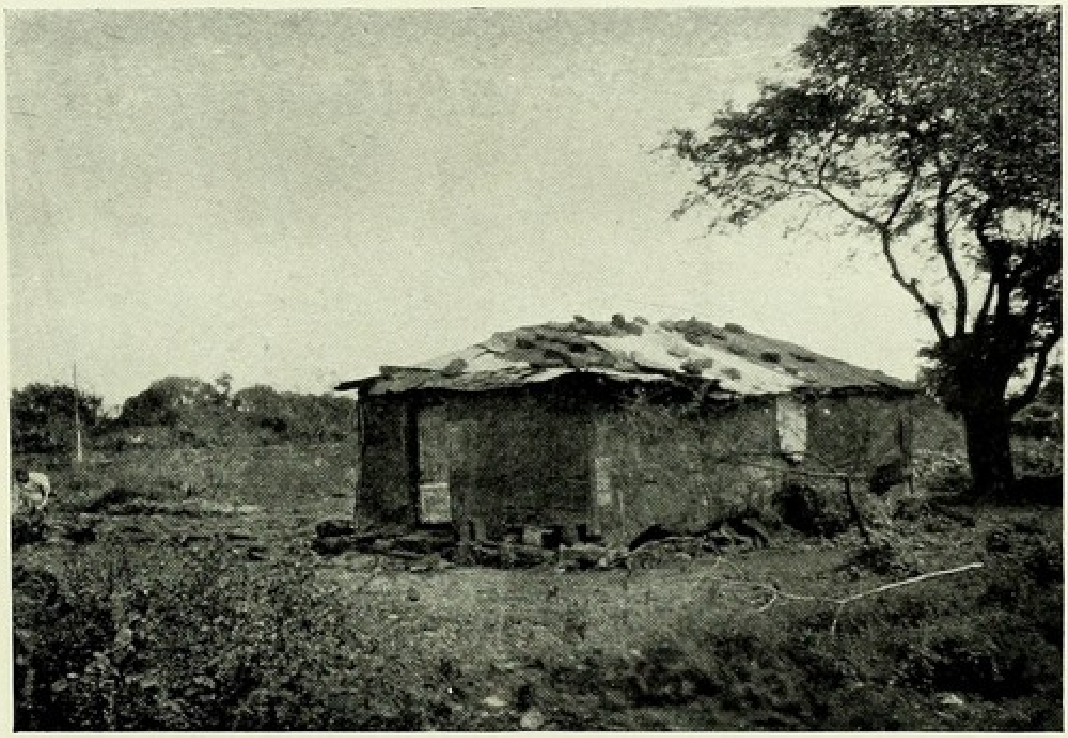


PHOTO. 8.—Shanty at Port Louis, made mostly of old tins.

PHOTO. 9.—Indian's House. By Miss Lane.

PHOTO. 10.—Indian's House near Clairfond Marsh.

PHOTO. 11.—Moustiquiers at work in Marsh at Curepipe.

PHOTO. 12.—Marsh in Wood at Phœnix.

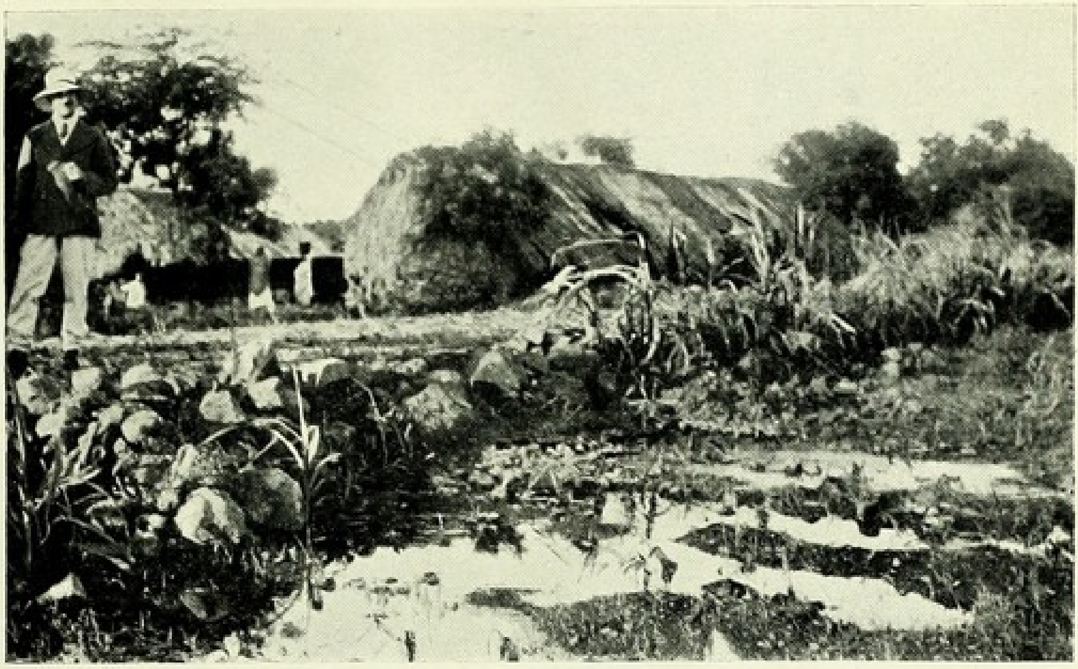


PHOTO. 13.—Marshy condition at Clairfond, made by a Conservancy Road.

PHOTO. 14.—Ornamental Pond in Gardens at Curepipe. Moustiquier at work.

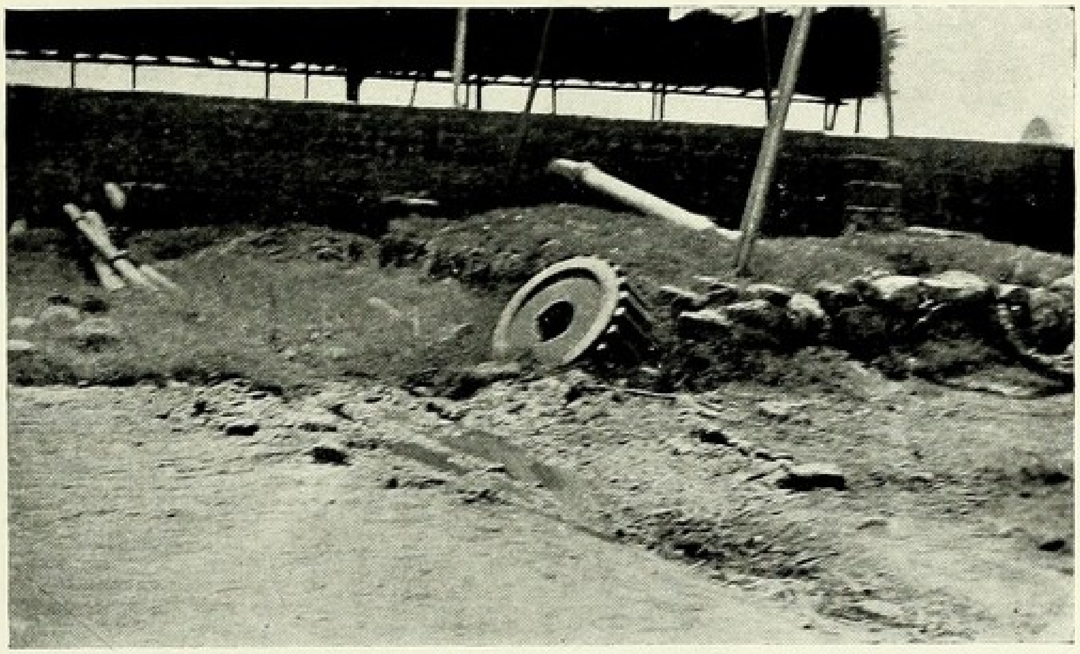


PHOTO. 15.—Anopheline Breeding Pool in discharge from Factory, Esperance Estate.

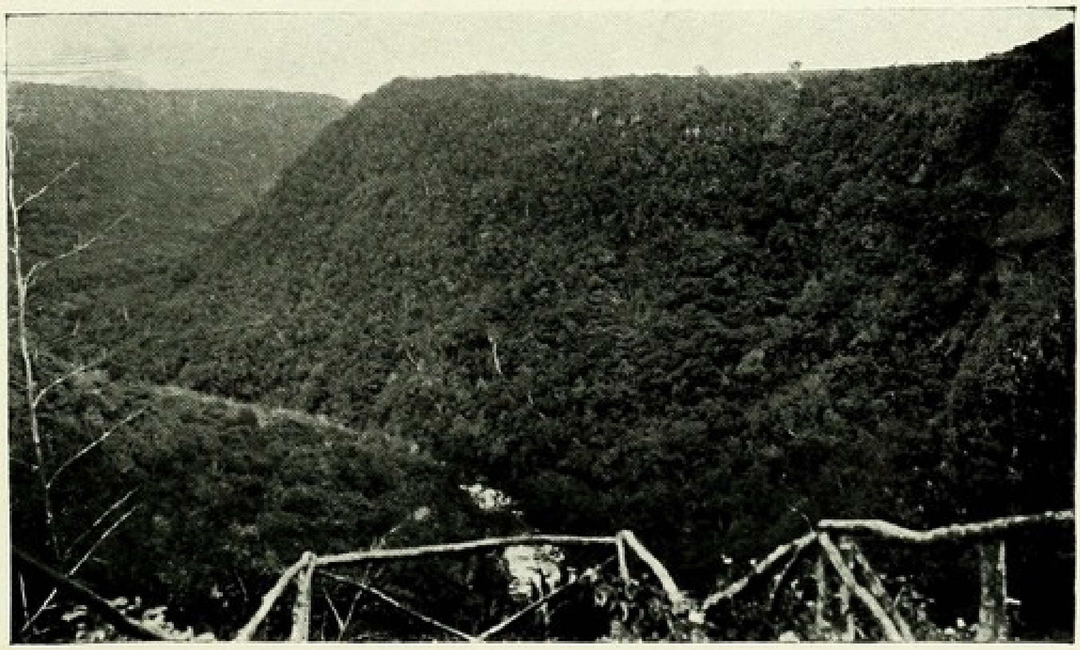


PHOTO. 16.—Densely-wooded Ravine trom Government House Gardens, Le Réduit.

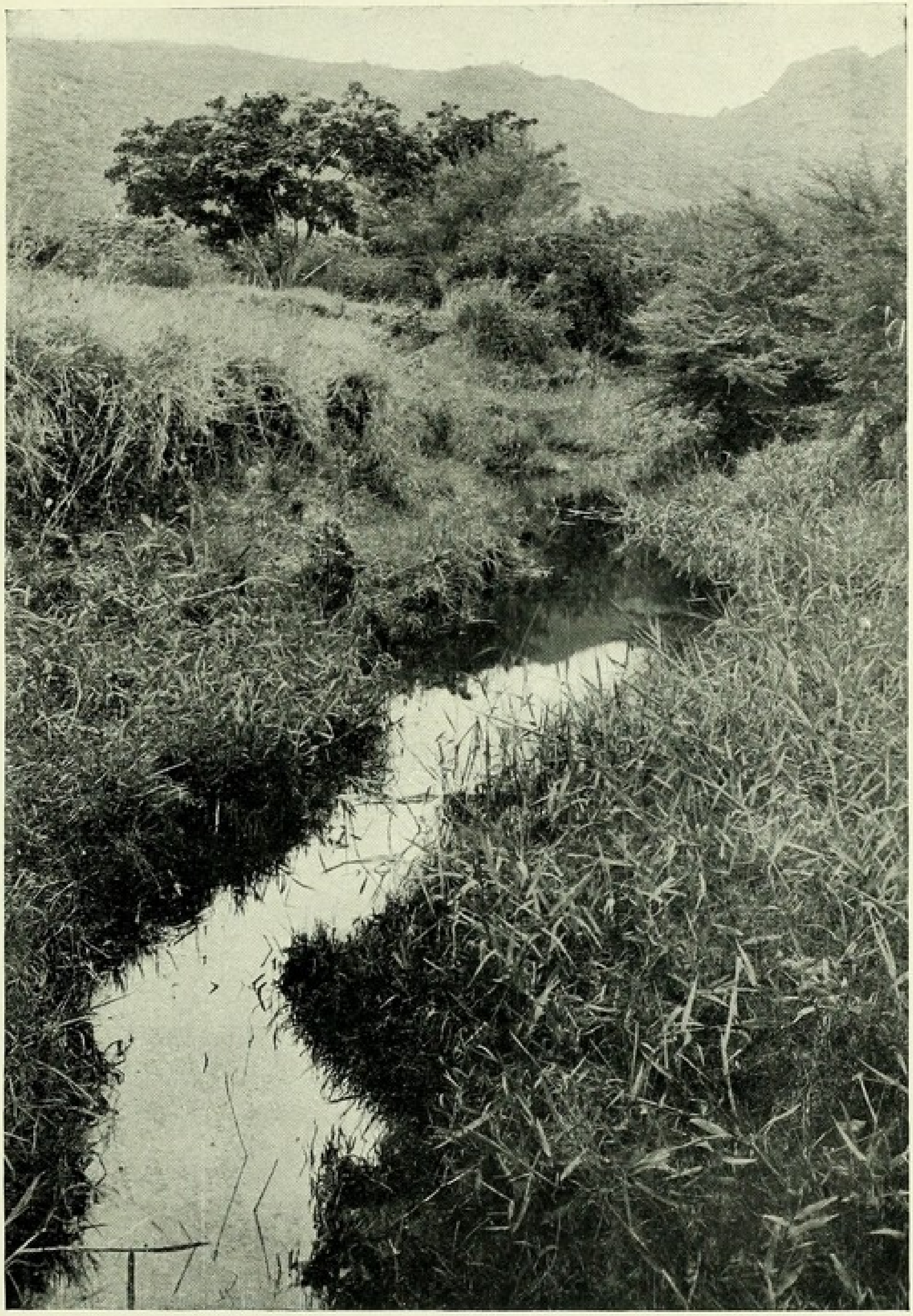


PHOTO. 17.—Anopheline Breeding Place in uncanalised part of La Paix Stream at Port Louis. By Major Fowler.

PHOTO. 18.—Cartload of *Bilbergia* (breeding *Stegomyia*) removed from a single house at Quatre Bornes.

PHOTO. 19.—Travellers' Palms at Mare-aux-Vacoas.

PHOTO. 20.—Tub containing pots filled with rain water and breeding *Stegomyia*.

PHOTO. 21.—Child with enormously enlarged spleen.

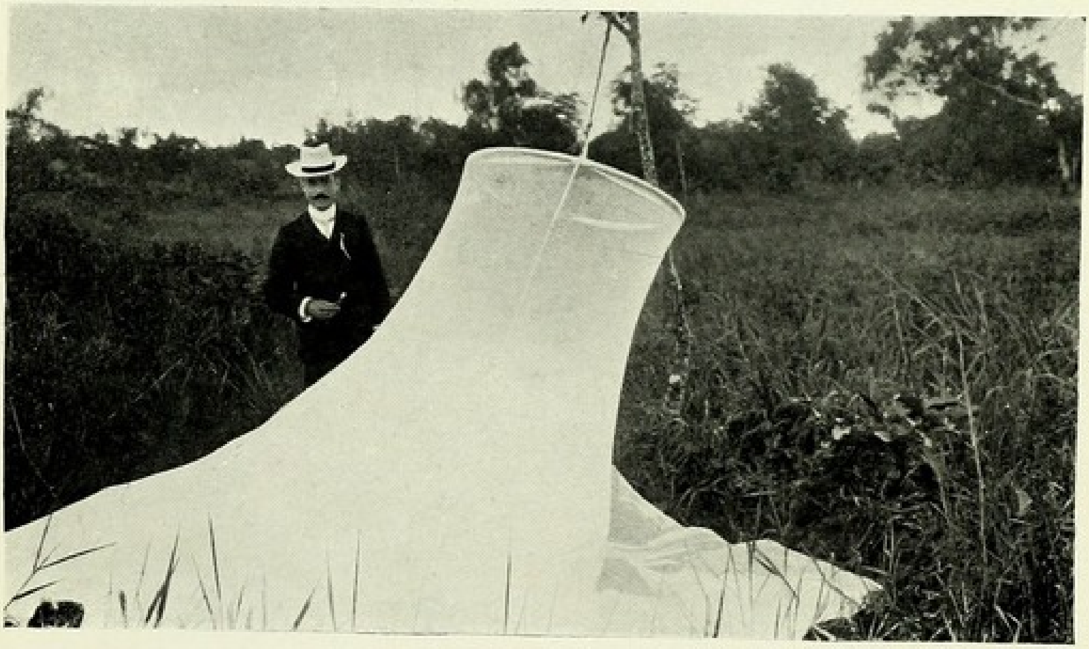


PHOTO. 22.—Net used to estimate number of Anophelines given off by nine square yards of Clairfond Marsh.

PHOTO. 23.—Part of channel at Clairfond Marsh cleared by three men in one day.

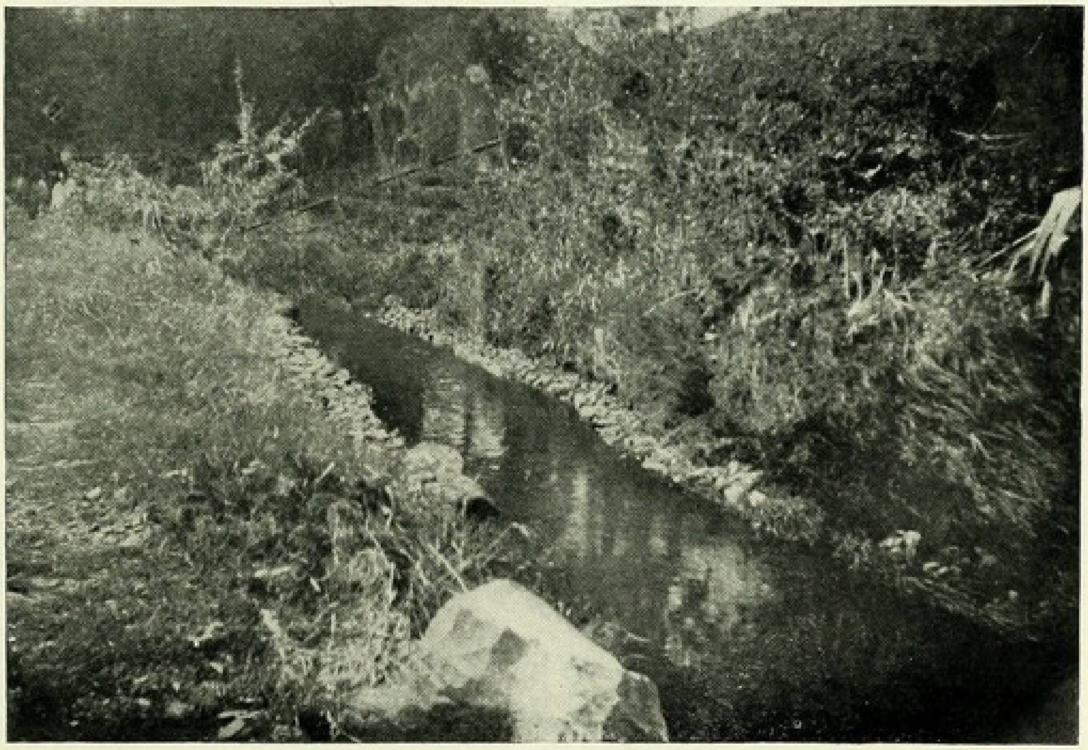


PHOTO. 24.—Rough canalisation of Latanier River, Port Louis.

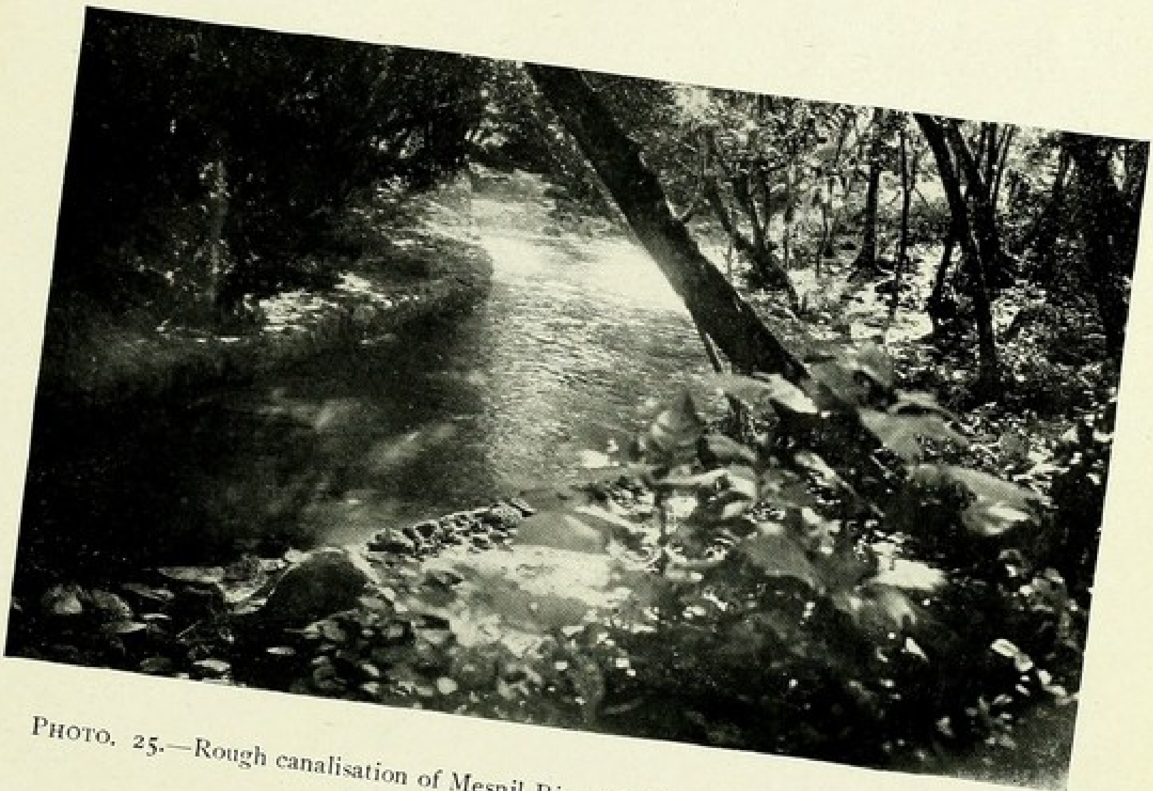


PHOTO. 25.—Rough canalisation of Mesnil River, by Forest Department, at Rs.0·37 a running foot, for both banks.