What provincial and local authorities can do

Since leprosy work falls quite naturally into the sphere of public health and preventive medicine, in most places it would be well for leprosy work to be an activity of the public health authority.

It cannot be too strongly emphasised that what will ultimately do more than anything else to control leprosy is the education of the public to recognise leprosy as a transmissible disease which can be controlled by preventing contact with infective cases. They will then insist on a reasonable degree of isolation of such cases in families, villages, and communities. This public opinion can only be formed as the result of teaching and propaganda, wisely organised and specially planned to reach the particular people whom it is desired to influence. The methods of work which have been found most effective have already been described in this paper. These methods must be modified to meet local conditions. The propaganda work will gain much in effectiveness if based on a study of local conditions affecting leprosy, and also if associated with treatment centres which greatly aid in securing the confidence and co-operation of the people.

The following is an outlined policy for anti-leprosy work. It will be found useful by provincial and state authorities and also by those in charge of district and municipal health work.

1. Organise a leprosy board consisting of official and private individuals in order to stimulate interest and public support for leprosy work.

2. Make anti-leprosy work one of the duties of the public health service and medical service.

3. Appoint a special leprosy officer who has had special training and experience in leprosy work, or else choose a good man to be trained. He should work under the public health authority and his duties will be :—

(*a*) To train doctors and public health workers in anti-leprosy work.

(*b*) Where there is a medical school, to instruct the students in anti-leprosy work.

(*c*) To organise propaganda, survey and treatment work in endemic areas.

(*d*) In highly endemic areas in addition, to establish special treatment centres.

(*e*) To supervise and co-ordinate all anti-leprosy work being done in the province or area.

4. Where the appointment of a special leprosy officer is impossible, to make anti-leprosy work part of the duty of a responsible public-health officer.

5. Make use of the available literature, vernacular pamphlets, lantern slides, posters, etc., in anti-leprosy propaganda.

6. Arrange for a doctor with special training to carry out medical examination for signs

(*Continued at foot of next column*)

A NOTE FROM AN ESTATE MEDICAL PRACTICE IN MALAYA

By B. BARROWMAN, M.B., Ch.B., D.T.M., D.T.H.
Klang, Federated Malay States

THE Malay peninsula projects into the China Sea, and forms the most southerly portion of the continent of Asia. Geographically, it begins at the isthmus of Kra, 10′ N., at a point which is only between 60 and 70 miles wide. From this isthmus the peninsula extends south, with a general inclination eastwards, the most southerly point being Tanjong Bulas 1′ 16 N. A line drawn down the centre of the peninsula gives a length of about 750 miles. The breadth at its widest part, from Dindings to Tanjong Penunjut in Trengganu, is about 200 miles. The peninsula is bounded on the north by Siam, on the south by the island and strait of Singapore, on the east by the China Sea and on the west by the Strait of Malacca.

A range of granite mountains forms a backbone to the peninsula. Smaller ranges run more or less parallel to the main range and there are numerous isolated spurs. The highest peak is 7,186 feet high while the two hill stations are 6,666 feet and 4,280 feet, respectively. The road to the latter, Bukit Fraser, has a general gradient of 1 in 30.

The west coast is covered to a depth of some miles with mangrove swamps, with a few stretches of sandy beach. The force of the north-east monsoon of the China Sea has for the most part kept the east coast free from mangrove. Islands are numerous on both coasts. The peninsula has been described as one huge forest intersected by numberless streams and rivers which form the most lavish water-system in the world.

Over 70 per cent. of Malaya is still virgin forest. This forest is a dense impenetrable mass of tree trunks and creepers. It has been described as so dense that a newspaper cannot be read in its depths at mid-day. Much of it is swamp underfoot to a depth of several feet.

The characteristics of the climate of Malaya are: uniform temperature, high humidity, and copious rainfall. By uniform temperature is meant the absence of extreme variation throughout the year; the actual daily range is large, being from 20 to 25 degrees Fahrenheit. The excessive temperatures of the continental tropical countries are never experienced and an air temperature of 100 degrees Fahrenheit is unknown. The nights are everywhere reasonably cool and oppressive heat rarely prevents refreshing sleep. Hill stations exist where a temperature just 10 degrees Fahrenheit above freezing has been recorded.

There are no real seasons throughout the year, although the greater rainfall is generally experienced between certain months which vary rather with the part of the peninsula. In the west, *e.g.*, Selangor, the wettest months are usually March and April, and October and November. Real droughts are not common and the grass rarely loses its green colour.

The yearly rainfall over the peninsula is high; the station with the lowest record gives an average of

(*Continued from previous column*)

of leprosy among Government employes, employes of industrial concerns, and above all of school children.

7. Arrange for leprosy treatment to be given in all public hospitals and dispensaries.

These measures if carried out efficiently would in time do much to help to bring leprosy under control. The expense of such measures is not great. As far as possible use should be made of existing medical and public health organisations and institutions.

65 inches, and that with the highest 242 inches. Kuala Lumpur for 1931 recorded:

Temperature (mean) Max.	Min.	Humidity (mean) per cent.	Rainfall in inches
90.5	72.7	86	91.79 *

* This is 1.83 below the average for 53 years.

It is rare for three weeks to pass without rain, but the fall is often extremely localised. The writer has in one afternoon during his visiting round seen a golf course so dry that the balls lost themselves in crevices, while an hour later he crossed bridges being repaired from flood damage.

Of the total 3,150 square miles of the state of Selangor about 560 are under cultivation, mostly of rubber and coconuts. On these estates the health and medical service is in the hands of private officers retained by the companies concerned. The position of the government is that of health auditors only.

An attempt was made recently to correlate the work of the government and the private health officers under the Health Boards Enactment. This was an ambitious piece of legislation, but unfortunately its sponsors left the country before it came into full force, and, as a result of unfortunate administration and the efforts of vested interests, the enactment failed and was repealed.

The private health officers are of two kinds:—(a) whole-time officers employed by an estate or group of estates, (b) practitioners having private practices as physicians in the towns, who visit estates as a part-time practice.

The duties of these estate medical officers, or visiting medical practitioners have been defined as follows:—

To advise upon and supervise:

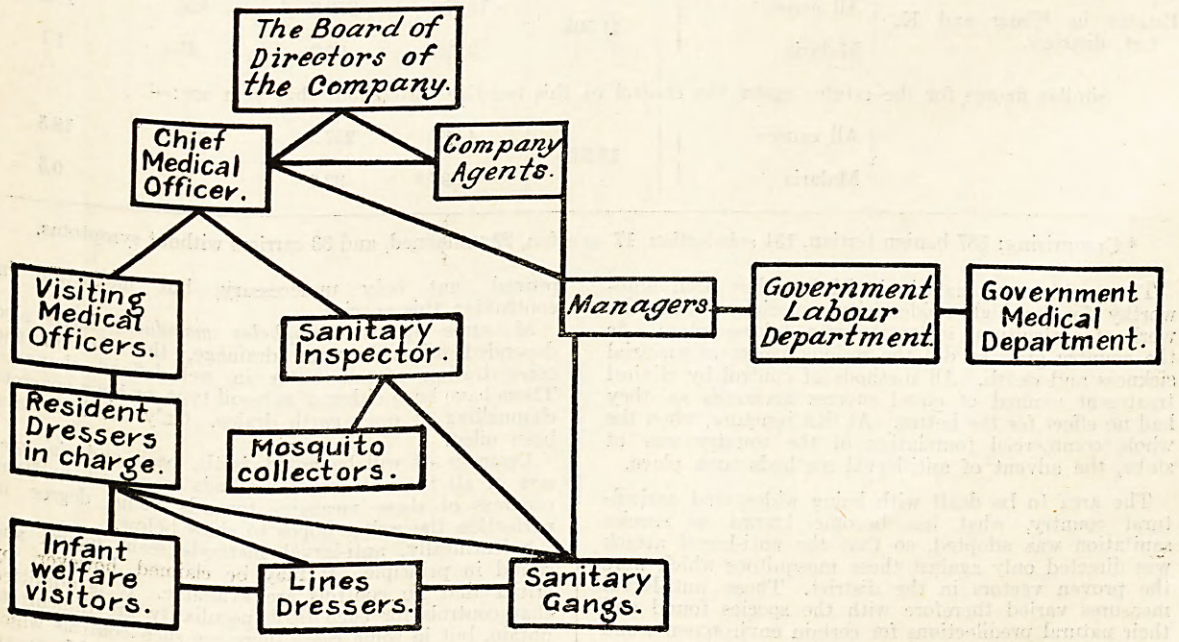
(a) housing accommodation on the estate,
(b) sanitary treatment of housing and surroundings,
(c) scavenging and disposal of refuse and excreta,
(d) water supplies,
(e) anti-malarial and other measures for the prevention and control of disease, including
(f) the treatment of the sick on the estate and in the estate hospital.

It is the writer's object to report on some of the work of his own practice, and to record some of the results obtained, and the following remarks are to be understood as referring to his own practice. They are not necessarily applicable to estates and practices elsewhere in Malaya.

The practice was founded by Sir Malcolm Watson in 1908 when, at the request of a number of estates round Klang, he resigned from government service and concentrated on reducing the terrible economic loss to estates from bad health. The writer has been associated with the practice since 1922, first as assistant and later as principal.

The practice is organised on the principle that the work of the physician and surgeon is part only—albeit a highly specialised part—of the greater whole of the sanitarian. The principal of the practice is the sanitarian while each medical officer has his own district and his own hospitals. These estate hospitals vary in size from 30 to 130 beds, and vary from rather primitive structures of wood to modern concrete buildings with all modern conveniences. In this practice at least, even the most primitive hospital has a microscope which the most junior dresser is trained to use.

At each of these hospitals, which may serve one or more estates, there is an Asiatic in resident charge; his qualification varies from an L.M. & S. on the Indian register, to a local government certificate of competence to assume charge of such hospitals. The estates themselves have lesser-qualified dressers who daily visit the 'lines' of the native labour of one or more estates, supervise the sanitation, treat any minor conditions which need no hospitalisation, and transfer to hospital those requiring admission. The larger estates have also a trained midwife who visits the lines and conducts ante-natal and child welfare work.



The direct relationship of the various members of the health organisation and estate staff may be described diagrammatically as above.

In his annual report for the year 1930 the Principal Medical Officer to Government (1931) gives the number of deaths in the Federated Malay States as 41,594. Of these 16,721 or 40 per cent. were due to fever. The term 'fever' here includes cases of undefined fever as well as cases of microscopically-diagnosed malaria. It is generally considered, however, that the majority of these undefined fevers are of malarial origin. The next highest single cause of death was disease of the respiratory system with 3,183 deaths. Malaria is still therefore the predominating single disability in the country generally, and it is with the control of this disease that this report is concerned.

The following figures are extracted from the official report for 1930. The figures for that year are chosen for quotation as it is for that year that they are published in a form which lends itself to this analysis. In that year too, the Health Boards Enactment had placed all estates, European and Asiatic, under the charge of a medical officer.

TABLE I

Hospital and death rates for 1930

		Population	Hospital admissions	Hospital rate per mille	Deaths	Death rate per mille
All estates of F. M. S. ..	All causes	280,721	84,581	301.3	5,784	20.6
	Malaria		25,744	91.7	782	2.8
Selangor estates ..	All causes	104,474	30,522	292.1	2,155	20.6
	Malaria		8,044	76.9	205	1.9
Estates in Klang and K. Lgt. districts.	All causes	41,505	11,232	270.6	824	19.6
	Malaria		2,725	65.3	45	1.1
Similar figures for the estates under the control of this practice throughout that year are:—						
	All causes	18,398	4,367	237.3	341	18.5
	Malaria		597 *	32.4	10	0.5

* Comprising: 387 benign tertian, 131 sub-tertian, 17 quartan, 29 undefined, and 33 carriers without symptoms.

The problem of malaria in Malaya has been noteworthy for its high epidemicity especially when the work of agricultural expansion was taking place. As the country grew so did the serious aspect of malarial sickness and death. All methods of control by clinical treatment seemed of equal success inasmuch as they had no effect for the better. At this juncture, when the whole commercial foundation of the country was at stake, the advent of anti-larval methods took place.

The area to be dealt with being widespread agricultural country, what has become known as species sanitation was adopted, so that the anti-larval attack was directed only against those mosquitoes which were the proven vectors in the district. These anti-larval measures varied therefore with the species found and their natural predilections for certain environments and conditions, and with the topography of the locality.

The malaria vectors implicated were *Anopheles ludlowi, Anopheles umbrosus* and *Anopheles maculatus.* While admitting the possibility of other species being upon occasion capable of carrying infection, the writer's experience is that, in Malaya, in the absence of these three species, epidemic malaria does not occur.

The earlier work in this practice has been described elsewhere (Watson, 1921), and the methods there given in detail have been followed with but little alteration since that time. In the writer's experience success still invariably follows the proper application of anti-larval methods for the control of malaria, but, except in so far as a record of success of any particular method is of itself evidence in its favour, these notes are not intended as a defence of any one method as opposed to another. They are simply a record of experience of the writer in the field of malaria control.

Anopheles ludlowi, the brackish water breeder is dealt with by bunding and the provision of good drainage through tide gates. This mosquito is, of course, typically found on the coast, but with faulty and leaking bunds and gates, or in their absence, it is surprising how far inland it may be found on flat land. Efficient drainage of this sort, with neither oiling nor any other auxiliary has been found in this practice sufficient to control *A. ludlowi.*

Anopheles umbrosus has been dealt with entirely by concentrating all water, and maintaining it open to the sunlight in clean-cut channels or containers free from all surface vegetation. The application of oil has proved, not only unnecessary, but ineffective in controlling this species.

Measures against *Anopheles maculatus* have also depended primarily upon drainage, that is, on the concentration of all water in well-defined channels. These have been either of sub-soil type, or open concrete channelling or open earth drains. Only the last have been oiled.

Drainage, it will be noted, is the basis and *sine qua non* of all the anti-larval methods employed, and the progress of these measures towards some degree of perfection the writer hopes to show below.

Scientifically, anti-larval methods seem logical and sound in principle. It may be claimed, however, by critics that no controls are available. It is admitted that controls for each little peculiarity are difficult to obtain, but in some cases there are such controls which are considered good enough for the purpose. Moreover, controls due to the removal of anti-larval methods and the re-introduction of these methods in the same locality are available.

The whole subject of anti-larval control in this country has been tried and tested *pari passu* with the progress of knowledge of the subject, until a stage has been reached which, if not of perfection, is at least one of a high degree of success. It is the writer's opinion that, if these methods were pushed to the limit, no economic factor intervening, practical perfection would obtain. To support this contention examples will be given on separate entities and of the factors which counteract actual perfection being obtained. The latter factors will be explained and enumerated first so that a better criticism of the estate results can be made. These factors fall chiefly under the following heads—(*i*) topography, (*ii*) the human element, (*iii*) insufficiency of quarantine or of control over the population (estate immigration and visiting), and (*iv*) the economic factor.

The topographical factor is probably the most insistent counteracting influence. This is best appreciated by a study of the map of the locality. Here we see anti-larval control on small estates more often than not

Map 1

Map of the district. The estates of this practice are shaded and show the large periphery liable to invasion by mosquitoes and malaria.

hedged round by other agricultural land which has no mosquito control in any form. These alien areas are often within mosquito striking distance of the habitations of the controlled labour forces, although to avoid this should be the first step of an anti-malarial policy. This is made apparent when no long view has been taken and temporising measures have prevailed. With foresight and courage most of the heavy initial expenditures on attacks on Nature's strongholds would actually have paid in a short time, but where, for example, the control area round the habitations is insufficient, on account of unwillingness to face initial expenditure, a definite counteracting factor to perfect anti-larval control is present.

Even when more than half mile from housing, these areas still form a source of infection to night visitors. Furthermore, work on an estate often starts in the half light of the morning and workers may be infected while operating near these boundaries. With most estates there is a relatively large boundary line thus adjacent to a non-controlled and endemic area.

The human element in all ventures is apt to fail at times and no less so in any method of malaria control. The carrying out of the various procedures must be definite and exact, and here alone error may occur. Constant care must be as permanent as the structures used, and work put off till to-morrow will surely exact its toll. As the effects of good anti-malarial work can only be seen in a negative light there is a great temptation at times for a worker to allow himself a certain amount of easing up. This negative character of the evidence of the best work in malaria control often, too, tempts the onlooker to consider as the most superfluous, the worker with the greater achievement to his credit.

The total number of cases of malaria treated on Carey Island during the past five years has been 159, or 0.6 per cent. per annum of a population of five thousand persons.

Of these 52 were admitted within 10 days of arrival on the estate, 27 were admitted between 10 and 20 days, 23 were admitted between 20 and 30 days.

Of the remaining cases 17 gave a history of fever elsewhere during the previous six months and 9 during the previous one year. Of the remaining 31 cases 14 had the infection traced to the uncontrolled Sakai reserves on the island. Only 17 cases or 0.6 per cent. per annum remain unaccounted for. These include all parasite carriers who had shown no clinical symptoms, but whose blood had been examined as a routine measure.

If, in order to satisfy the most critical, we accept as imported only those cases detected within ten days of arrival, we have one-third of the cases imported. As communication with Carey Island is by private ferry and costs money, it is clear that this proportion must be very much higher on healthy estates completely surrounded by easily-accessible infected country.

The anti-malarial measures adopted on Carey Island consist of deep drainage and well-constructed and well-supervised tide gates, and the siting of all housing over half a mile from uncontrolled areas. The potential vectors are *A. ludlowi,* and, to a lesser extent, *A. umbrosus.* No oiling has been done on Carey Island, which has over 17,000 acres under cultivation, and the malaria incidence since 1921 has been under one per cent. per annum.

This work on Carey Island was conducted from the opening up of the estate, and has prevented the introduction of epidemic malaria to any important extent to the foreign labour brought to work the estate.

TABLE II

Malaria rates on Carey Island estate

Year	Population	Malaria cases	† Malaria rate per mille	Malaria deaths	* Malaria death rate per mille
1921	4,400	60	13	4	0.9
1922	4,321	26	6	2	0.4
1923	4,424	20	4	1	0.2
1924	4,573	16	3	1	0.2
1925	4,844	15	3	*nil*	*nil*
1926	5,223	24	4	1	0.2
1927	5,651	28	5	*nil*	*nil*
1928	5,197	36	7	1	0.2
1929	5,838	38	7	2	0.3
1930	5,410	32	6	1	0.2
1931	4,989	25	5	*nil*	*nil*

* All cases having parasites in the blood are included, whatever the specific cause of death.

† Includes imported cases. No correction for these cases is made in any of the tables given.

There have been times in the history of every estate when labourers were required in increasing numbers. This immigration, especially in times of exigency, had no effective control. Here a leakage took place and there appeared in the labour force cases of malaria whose infection had been contracted on the unhealthy estates from which they came. No control over the population has ever been effective as regards their habits of wandering from one area to another, whether for one night or for extended periods of time.

The map of the area of this practice clearly indicates the vast opportunities provided for these imported cases, much of it being small detached areas completely surrounded by uncontrolled country where anopheline vectors, high spleen and malaria rates, of anything from 30 per cent. to 100 per cent., abound.

As an example of the extent to which such imported cases can effect the incidence rate in areas under full control the figures of Carey Island estate, where some form of quarantine is possible, are of value.

Several controls are available for the work done. Carey Island is identical in character to, and is situated at the mouth of the same river as, Port Swettenham, and the malaria history of that port is well known to have been so bad that, after it was built, the Government ordered it to be abandoned.

Two areas of uncontrolled Sakai (aboriginal) reserves on the island itself, with their numerous *A. ludlowi* and *A. umbrosus,* and their high malaria endemicity, are further controls for the work on the cultivated portion of the island.

There have too been incidents in the history of the estate which themselves serve as controls. Some years ago 300 coolies left the island and went to an estate in Malacca. Some months later 200 returned, all heavily infected with malaria. No isolation of these reservoirs was attempted yet no infection was passed from them to any other cooly.

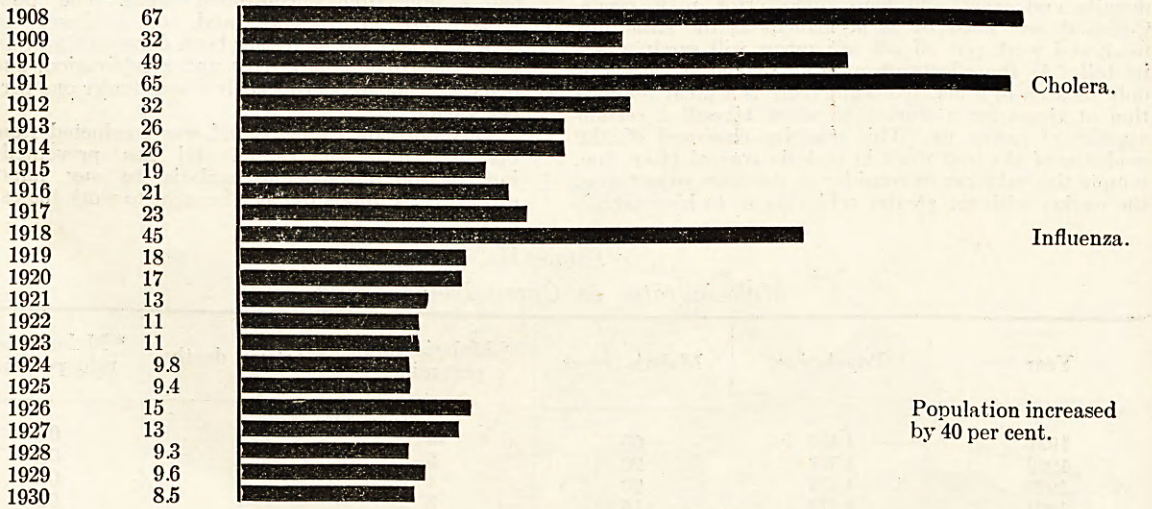
A contrast to this was provided in 1920, when 19 cases of malaria occurred in one division. This outbreak was

traced to a disused well which had been allowed to become overgrown with weeds and in which *A. umbrosus* was found. In 1928 five cases of malaria occurred in coolies who had not left their division. A survey revealed a few *A. ludlowi* in the drain. Further investigation showed a slight undermining of the tide gate controlling the area, which permitted the ingress of salt water.

Over the area of the practice where malaria was already hyper-endemic among the labour forces before work was started the figures of past years are incomplete in some respects, but with every person known to have had malaria more than once in the year, progress is fairly shown by the annual death rates. In the past all statistics were noted for workers only and the death rates of these, from all causes, fell from 67 per mille in 1908 to 8.5 per mille in 1930.

CHART I

Death rates from all causes of estate workers



As the incidence of malaria fell below 100 per cent. this has been recorded separately for the whole population, and over an area of some 130 square miles, of what was at one time as malarious a part as anywhere in the world, the malaria incidence for 1931 was 2.4 per cent.

Now that an incidence rate has been obtained which is no greater than that which might well be caused entirely by imported cases, attention is being directed to the parasite rate as obtained by complete blood surveys using thick blood films, the technique followed being that described by Green (1931).

These have been as yet completed only for a relatively small area. In the case of the estate which produces the highest malaria rate, *viz,* 10.0 per cent. per annum, the parasite rate was 11.3 per cent. When a sufficient length of time for proper observation has elapsed the results of treatment with plasmoquine on these carriers will be reported.

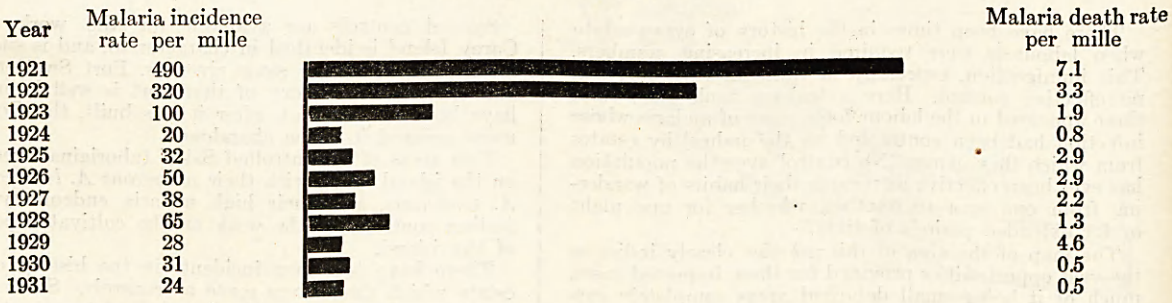
Estate P. in 1930 gave an incidence rate of malaria of 5.3 per cent. of the population per annum. A parasite survey, by the officers of the Institute for Medical Research, of 415 persons gave 32 positive or 7.7 per cent. The hospital books of this estate show that at one time a 'burial gang' drew, almost constantly, overtime pay for their work, and the death rate was for years around 300 per mille per annum. The malaria incidence rate in 1931 was 1.2 per cent.

Chart II shows the malaria incidence and death rates for the entire area of this practice since 1921, while the three following charts show these rates for the *ludlowi, umbrosus* and *maculatus* areas, respectively. Since these areas overlap they have been divided so that the area described as *umbrosus* is composed of those estates where no other vector is found. Where *A. umbrosus* is found in addition to either of the other vectors the estate

CHART II

Rates per mille over the whole practice

Population = 17,000 ± 4,000.



is included in the *ludlowi* or *maculatus* area as the case may be. It is this duplication of species with opposed preferences as to breeding conditions which makes this area so much more difficult to control than those parts where only one vector has to be considered.

In these charts are included in each year all estates, whether under our control throughout the year or only for part of the year.

In the matter of effectiveness and of costs even the old subsoil drainage on this estate more than proved its worth over the fourteen years it remained, as reported by the writer (1932).

In 1926, however, the old piping was replaced. The year 1925 had been a dry one and the roots of the nearby trees had sought out the water in the pipes, which they had partially choked in some places, although this

CHART III

Rates per mille over the 'ludlowi' area

Population = 5,000 ± 600.

Year	Malaria incidence rate per mille	Malaria death rate per mille
1921	13	0.9
1922	6	0.4
1923	4	0.2
1924	3	0.2
1925	3	*nil*
1926	4	0.2
1927	5	*nil*
1928	7	0.2
1929	7	0.3
1930	6	0.2
1931	5	*nil*

CHART IV

Rates per mille over the 'umbrosus' area

Population = 10,000 ± 8,000.

Year	Malaria incidence rate per mille	Malaria death rate per mille
1921	288	10.7
1922	72	3.0
1923	57	3.6
1924	11	0.8
1925	22	2.4
1926	63	7.1
1927	40	2.5
1928	29	0.6
1929	29	0.5
1930	6	*nil*
1931	7	*nil*

CHART V

Rates per mille over the 'maculatus' area

Population = 4,000 ± 2,000.

Year	Malaria incidence rate per mille	Malaria death rate per mille
1921	613	15.9
1922	469	7.6
1923	104	4.4
1924	23	2.0
1925	104	5.3
1926	137	6.6
1927	115	4.9
1928	177	3.6
1929	46	0.6
1930	96	1.7
1931	73	2.8

In combating *A. maculatus* two main methods are employed, *viz*, oiling and subsoil drainage. Shade and other methods are on no estate solely depended upon although they play their part.

Chart VI shows the malaria incidence on estate S. F. which has been subsoil-drained against *A. maculatus*. The pioneer work on this estate is described in full by Watson (1921, chapter XII), but the system as it exists to-day has been considerably modified as a result of the experience gained since that time, both on this estate and elsewhere.

did not become apparent until the excessive rainfall of 1926 when the narrowed pipes were unable to cope with the great amount of water during the floods of that year. Water seeped to the surface and was unfortunately oiled. The result of this oiling was that after the choked pipes had been repaired the oily silt prevented the water reaching, not only the newly-laid pipes but also the unbroken lines. It was therefore decided to relay the entire system. In relaying them the pipes were laid deeper and they are now five feet deep at least, and are laid in loops along the hillfoots

to discharge into open drains on the flatter part of the ravines. These drains are 22 feet wide at top and 2 feet at bottom which is laid with concrete channeling.

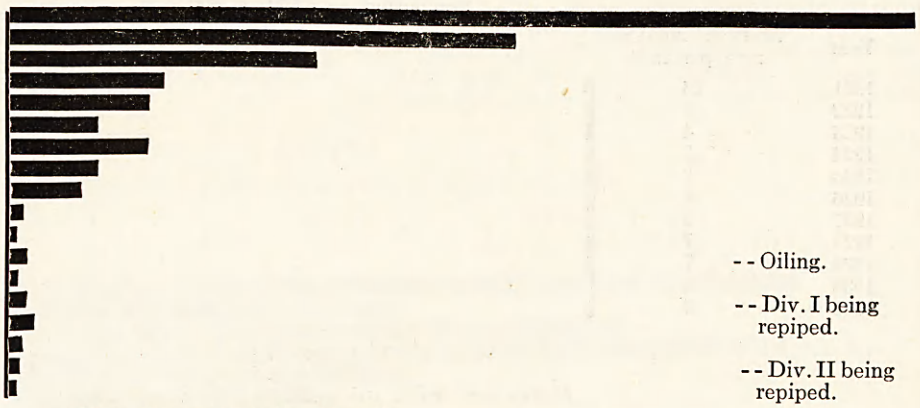
more evident that a malariologist is not merely a physician or an entomologist or a civil engineer, but something of all three.

CHART VI

Rate per mille on subsoil-drained area

Population = 800 ± 250.

Year	Cases	Malaria incidence rate per mille per annum *
1914	6,185	9,389
1915	4,137	5,128
1916	2,491	3,120
1917	1,265	1,619
1918	1,063	1,488
1919	624	750
1920	1,236	1,317
1921	609	769
1922	369	530
1923	56	91
1924	6	14
1925	130	140
1926	86	85
1927	185	153
1928	234	233
1929	36	36
1930	115	131
1931	65	99



* Note change in scale of graph.

The earth sides of the drains are laid with turf and they have stood up excellently to the tremendous scour, even on Seafield estate. Only at their termination have they required repair and there the heavy

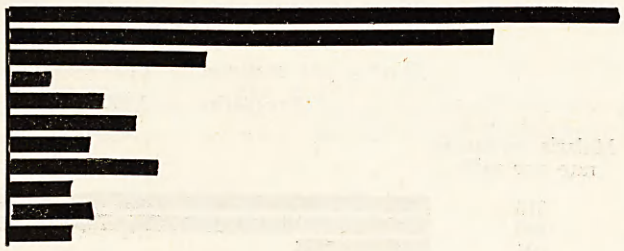
Chart VII shows the figures for these estates where oiling was considered the method of choice. The only method now used of applying the oil is by spraying from a knapsack sprayer by cooly labour.

CHART VII

Rate per mille on oiled area

Population = 2,200 ± 300.

Year	Malaria incidence rate per mille per annum
1921	503
1922	399
1923	154
1924	27
1925	73
1926	89
1927	64
1928	100
1929	53
1930	75
1931	53



concrete inverts have been carried 40 to 50 feet by the scour.

Pipes are still upon occasion choked by roots. No difficulty is experienced in keeping pace with the repairs as oil is now never used over a seepage. Paris green, 5 per cent. in smoke-house dust, spread by hand, has proved satisfactory for this purpose. One ravine has been left under the old system and is being used for certain observations.

The writer's experience of subsoil drainage on estates by some other workers leads him to emphasise that such drainage is not intended to carry off storm water. The ravines must therefore be levelled and graded so as to allow free passage to the open drains of surface water. The application of oil too over subsoil pipes will ruin the piping and only by complete removal of the oily soil and replacement by fresh can this be remedied. As emphasised elsewhere, in this work as in other spheres, multiple control can never be so effective as competent single executive. It is becoming more and

During these years new estates have from time to time been added to the area of the practice. This has tended to cause periodical rises in the incidence rates over the whole. Chart VIII represents the malarial incidence on these estates which first came under our control in 1922, from that year to 1931.

In 1928 the writer noted a comparative ineffectiveness in the anti-malarial oil mixtures which had previously given satisfactory results. These mixtures were being compounded from the same prescription as before, that is, Diesel fuel oil, solar oil and kerosine in certain proportions. These oils remained the same as regards their burning properties but investigation showed a difference in certain other properties. At a meeting of the Malaria Advisory Board to the F. M. S. Government, the writer (1931) drew the attention of the Board to his experiments on the subject of these mixtures, and Corbett and Hodgkin (1931) confirmed, almost entirely, these experiments under full laboratory conditions. These workers minimized the importance of

volatility, but further stressed the importance of surface tension and viscosity.

The writer has conducted further experiments in the field and, although much work is yet to be done before any final conclusions can be justified, the following figures even suggest a range within which these qualities of the oils should fall for successful anti-mosquito spraying in Malaya.

drained areas. Estate K. (chart IX) has been drained with a view to proper oiling, while estate S. N. (chart X) has been oiled as efficiently as possible over simple agricultural drainage. Both estates have a history of malaria rates in the past of around 100 per cent. per month.

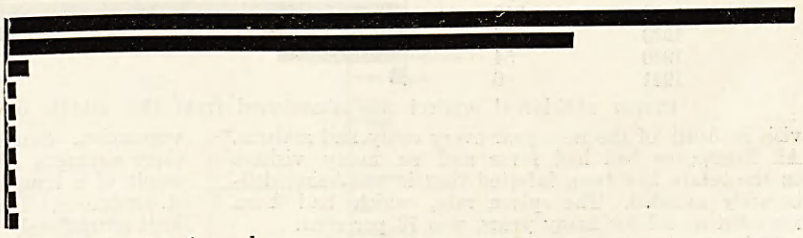
The necessity for constant technical supervision of oiling is well demonstrated in the case of estate H.

CHART VIII

Rates per mille on newly-controlled estates

Population = 500 ± 150.

Year	Cases	Malaria incidence rate per mille per annum *
1922	3,716	5,133
1923	508	1,229
1924	38	111
1925	16	41
1926	20	38
1927	14	22
1928	20	35
1929	8	14
1930	6	12
1931	6	14



* Note change in scale of graph.

The Asiatic Petroleum Company generously supplied samples of their various oils and very kindly undertook the analysis of a number of mixtures of these oils, some of which had been found successful and some unsuccessful for larval control.

The results of the analyses showed that:—

(1) Although the *flash point* of all successful oils fell within the limits of 81° ± 10° C., many unsuccessful oils were also within this range.

(2) The *specific gravity* too showed little relationship to the success, although all successful oils fell within the range 0.870 ± 0.02.

(3) All successful oils had a *viscosity* (Enggler at 30° C.) of 1.4 ± 0.3. Some unsuccessful samples of the lighter oils also came within this range.

On this estate the manager elected on his own responsibility to alter the oiling to some practice of his own.

The average malaria incidence rate per month for the previous two years had been 0.3 per cent. After one month from the initiation of the ineffective oiling this incidence was 3.5 per cent. per month, which was again reduced to 0.1 per cent. per month over the succeeding years by proper oiling.

It is always noticeable that the results following such an outbreak are better than those immediately previous. In other words after a manager has been personally convinced of the necessity of the persistent care in the maintenance of the work, his part of it is done much more thoroughly than when it is done merely because his board tells him to do so.

CHART IX

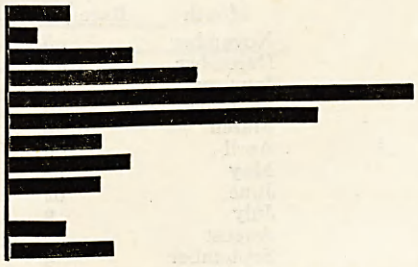
Estate B. K.

Month	Malaria rate per cent.
January	*nil*
February	*nil*
March	*nil*
April	0.2
May	*nil*
June	0.8
July	*nil*
August	*nil*
September	*nil*
October	*nil*
November	*nil*
December	0.2

CHART X

Estate S. N.

Month	Malaria rate per cent.
January	0.4
February	0.2
March	1.2
April	1.8
May	3.5
June	2.8
July	0.8
August	1.0
September	0.8
October	*nil*
November	0.5
December	0.9



(4) All successful oils had an *average volatility* within the range 283° ± 7° C. The unsuccessful oils were all either less than 234 or greater than 325.

(5) All successful oils had a *surface tension* of 32.6 ± 1.1 dynes per cm. No unsuccessful oil came within this range. All unsuccessful oil mixtures tested were greater than 34.2.

It has been said that oiling should be considered as supplementary to drainage as an anti-malarial measure. Proper results cannot be obtained by oiling unless all water to be oiled has been defined, and the two estates, topographically as nearly comparable as possible, whose monthly figures over one year are shown below (charts IX and X) demonstrate the difference which is to be expected between suitably drained and unsuitably

Much the same experience has been had in *umbrosus* country. Some years ago a fairly large area dissociated itself from my practice and, arguing that malaria having been absent for many years, the careful maintenance of the anti-larval drainage was no longer imperative, elected to abandon anti-larval drainage and to maintain only agricultural drainage. As malaria reappeared large quantities of oil were used for spraying without however affecting the increase of malaria.

For four years this policy continued, after which time the area reverted to my control and proper anti-larval methods suitable for the conditions of the area were reinstituted.

During these years the annual incidence of malaria rose from 0.9 per cent. per annum to 31.2 per cent.,

only to fall again to 0.6 per cent. when proper measures were reinstituted (chart XI).

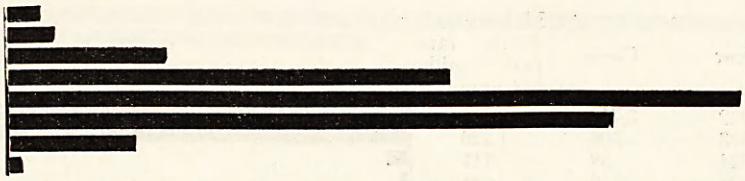
Another recrudescence of malaria in *umbrosus* country occurred in my consultant practice. The estate T. M. had apparently been free from malaria for some thirteen years and had a sharp outbreak in October of one year. Within a month the management gave the malaria incidence as 100 per cent. and at the time of my own visit in April of the next year every cooly had malaria. All Europeans had had fever and so many visitors to the estate had been infected that it was being deliberately avoided. The spleen rate, which had been recorded as *nil* for many years, was 73 per cent.

This case is of interest in more respects than one. The incriminating vector had been considered to be *A. ludlowi* and there is little doubt that this mosquito was associated with the beginning of the epidemic, but on my visit *A. umbrosus* was found breeding in the drains, which in the past had been kept clean-weeded but which for motives of economy were then uncleaned. Some *ludlowi* had been found breeding at 16 chains from the lines and these places had been heavily oiled without however effecting the malaria. At my visit however, they were found breeding at 35 chains from the cooly lines. As this area of breeding had been in existence during the years when there was no malaria I advised reversion to the anti-larval methods against the *A. umbrosus* only. Such control also removed the *A. ludlowi* breeding spots at 16 chains.

This work was commenced in May. Since August of that year, 1931, to date, October 1932, no case of malaria has occurred.

CHART XI

Year	Malaria rate per mille per annum
1924	9
1925	12
1926	74
1927	194
1928	312
1929	265
1930	54
1931	6



Proper anti-larval control was abandoned from the middle of 1925 to the middle of 1929.

An interesting point is that *A. ludlowi* are still breeding in their usual profusion at a 35 chain radius and for some miles beyond. In view of the suggestion of a longer range of flight of this mosquito this is of interest and fails to support the theory. There is ample fresh water around the lines and adjoining their brackish breeding places.

I recall another case which fails to support this suggestion regarding the flight range of *A. ludlowi*. An epidemic of malaria had occurred in a township which had extended its boundary to within a few hundred yards of the uncontrolled area in which were *A. ludlowi* in their customary abundance. I had advised the extension of the control to the full half mile but this was done only to the quarter-mile limit. This proved successful although *A. ludlowi* continued to breed at this radius and for some miles beyond. No other vector was implicated in this epidemic.

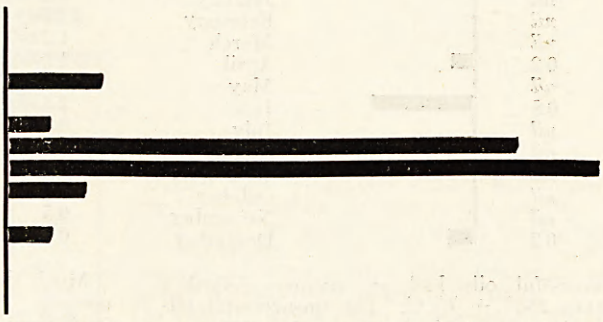
The measures against *A. umbrosus* elsewhere also remain unchanged, *viz*, the concentration of all water in sunlit or flowing channels kept free from all surface vegetation. Small epidemics have occurred (*e.g.*, five cases among a labour force of 174 on estate C.) as a result of a long drought providing breeding places for *A. umbrosus*. The drains and wells on the estate were kept scrupulously clean on their sides, but some vegetation existed on the bottom. With water some feet deep in the drains this was of no importance, but as the drought continued the drain became merely a series of small pools shaded by this growth. *A. umbrosus* was found breeding in these pools within 40 yards of the rooms used by the five cases of malaria; one of these patients possessed a vegetable garden at the jungle edge half a mile distant, and he is presumed to have imported the parasite.

Other recrudescences of malaria from this vector have occurred. On estate B. the management closed an outlet drain to the north of the estate in the month of November. A new outlet was provided farther south, but the smaller drains were not regarded and were left to silt up. Water therefore lay in them and soon became shaded by grass. *A. umbrosus* reappeared in them and, as the estate is frequently visited by outsiders, reservoirs were readily available. The malaria incidence is shown in chart XII. The outlet was reopened in the month of June and *A. umbrosus* disappeared along with the malaria.

CHART XII

Malaria incidence rate per mille on estate 'B'

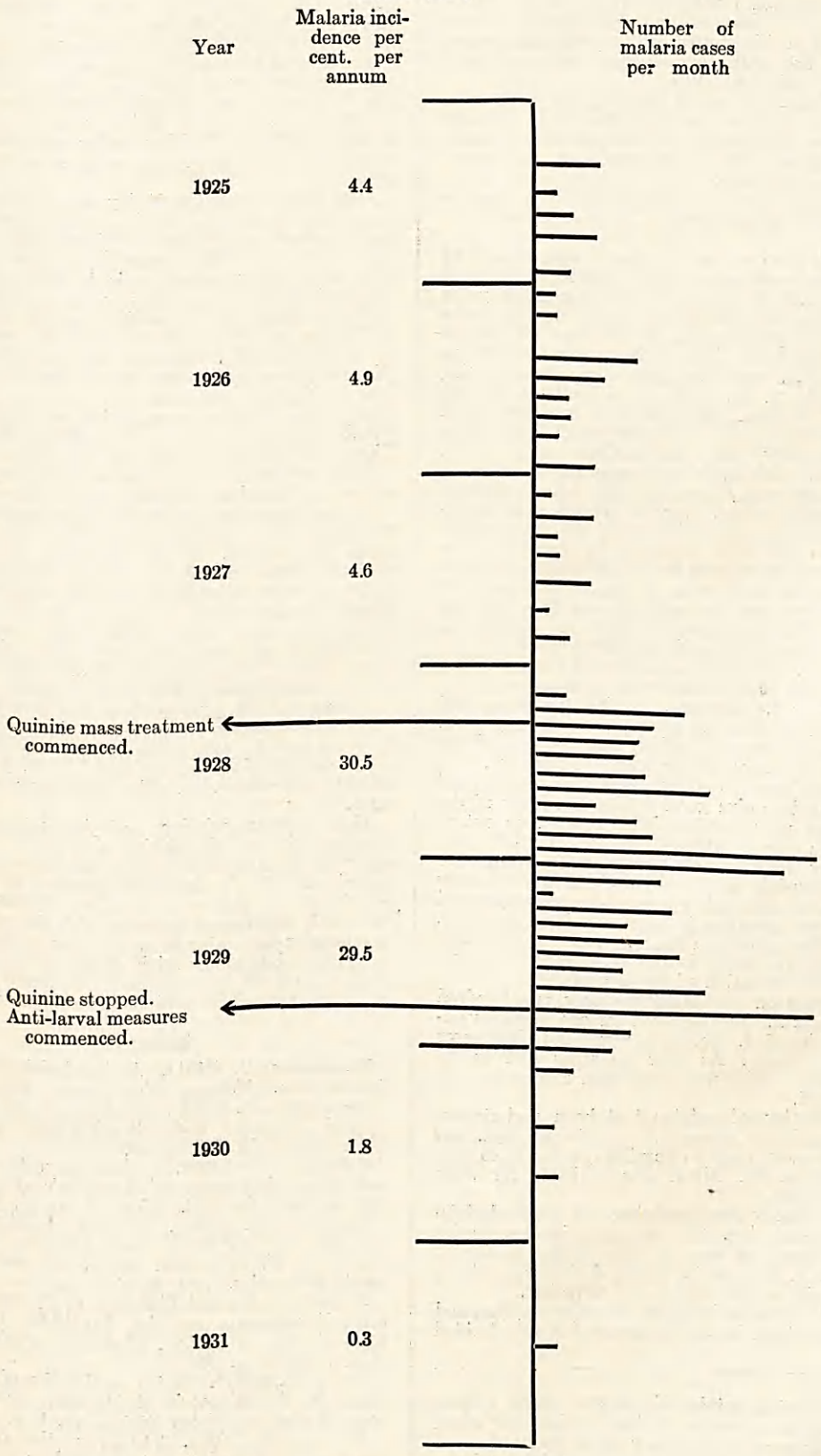
Month	Rate per mille
November	*nil*
December	*nil*
January	*nil*
February	10
March	*nil*
April	5
May	52
June	62
July	9
August	*nil*
September	4
October	*nil*
November	*nil*
December	*nil*



These results have all depended upon anti-larval methods of control, but the writer does not wish to appear to deprecate the use of chemo-prophylaxis in its proper place. The judicious combination of both clinical and anti-larval methods will no doubt take us further with more ease than either alone, but it is surely the chemo-prophylactic measures which must be supplementary to established anti-larval methods and not *vice versa*.

While of opinion that chemo-prophylaxis may keep the death rate of a small population within reasonable

CHART XIII


Year
Malaria incidence per cent. per annum
Number of malaria cases per month
1925
4.4
1926
4.9
1927
4.6
Quinine mass treatment commenced.
1928
30.5
1929
29.5
Quinine stopped. Anti-larval measures commenced.
1930
1.8
1931
0.3

bounds, or even control the malarial incidence in a small and isolated community, the writer cannot believe that it can ever be successfully applicable to labour forces generally in this country with populations around one thousand and with the constant changes which occur in their individual units.

The writer has made use of chemo-prophylaxis upon occasion and in at least one case has had apparent absolute success in the control of malaria with plasmoquine and quinine. The circumstances of that estate were however exceptional.

In 1928 an experiment was started with drug prophylaxis on an estate which, however, it was impossible to complete.

The estate is situated on the edge of *maculatus* land and extends into *umbrosus* country. Anti-larval control on the flat land had been maintained for many years but *A. maculatus* had never been found on the estate till 1927. This is explained by the fact that the adjoining land on the hilly side of the estate had been controlled and *A. maculatus* had never jumped this barrage to settle on the small area of hillfoot seepage on the estate. In June 1927 however it was first found there. No measures were taken, by intent, and it was not until February 1928 that malaria appeared in epidemic form. This took place one month after a considerable number of the coolies had visited a festival at a neighbouring estate. For 19 months mass treatment with quinine was tried with no success (see footnote).* It had been intended to continue this treatment for two years, this being about the time after which a tentative conclusion of the effectiveness of chemo-prophylaxis can be justified, and then to use plasmoquine. The management however refused to allow further experiment and anti-larval methods had to be instituted. The figures in chart XIII show that during the years 1924 to 1927 the average monthly malaria rate was 0.3 per cent. During the years 1928 and 1929 when quinine was given it was 2.5 per cent. Since anti-larval measures (oiling) have been used the rate as was to be expected has been 0.02 per cent.

In the case referred to above where plasmoquine and quinine appeared to give good results, the locus of the experiment was a small estate being opened up out of a block virgin jungle situated on the foothills and surrounded by impenetrable forest and swamp. No position for housing was possible which would allow of even a quarter mile radius for anti-larval control and *A. umbrosus* was breeding in unusually large numbers. *A. maculatus* had also been found. Adult *A. umbrosus* can still always be found in the temporary hutments erected for the population of 140 persons.

Since its inception the estate has been one hundred per cent. malarious. Visitors even for one night invariably returned infected. Severe cerebral and blackwater cases were frequent. As new planting had to be undertaken new coolies were employed and every one became infected.

Mass distribution of quinine had been undertaken, but in spite of it the spleen rate was 82 per cent. and the stream of severe cases to hospital continued, so that only one-third of the labour was available for work at any given time.

In January 1931 it was decided to try mass administration of plasmoquine. The estate is in the district under the direct charge of the senior assistant, Dr. Lawrence A. Watson to whom, during the writer's leave, all details of the experiment were left.

Owing to the extreme isolation of the estate, personal supervision could not be undertaken and it was decided to distribute the drug in small doses combined with quinine in capsule. To reduce liability of error administration was effected at each of two musters in the day, on the principle of 'no capsule—no pay'.

The dose of plasmoquine was small but the treatment was continued for 21 days, the dosage being: quinine bihydrochloride, gr. 7½ with plasmoquine gr. 1/15 (0.004 gm.) twice daily. This treatment was first given in February, 1931. Neither during nor after this treatment has there been any case of clinical malaria whatever.

After three months the 21-day programme of the same doses was repeated. Another three months later a 14-day course of quinine bihydrochloride gr. 7½ with plasmoquine gm. 0.005 twice daily was given. This programme was repeated again in three months time, and again in February, May and August 1932.

Not a single case of clinical malaria has occurred during the twenty months following the first treatment in February, 1931, although in September, 1931, a parasite survey, using thin blood films showed 26 per cent. to harbour parasites.

In August 1932 an examination was made of thick blood films from every cooly resident on the estate. These now numbered only 48. Of these 48 persons 2 only, or 4.16 per cent., showed parasites. Both were subtertian infections although they had had no fever.

At varying periods during the experiment coolies were transferred to a healthy estate where they were kept under observation. In all, the after history of 42 persons was thus recorded:—Of these, 39.5 per cent. were found to harbour parasites on their transfer and were given a 14-day course of quinine gr. 7½ with plasmoquine gm. 0.01 twice daily. There remained still infected 18 per cent. and these were given another similar course. Unfortunately all of them left the estate before further observation could be made.

Among the 42 persons thus transferred from the experimental estate there were 4 double infections of *P. vivax* and *P. falciparum*. After one course of treatment the *P. vivax* in one and the *P. falciparum* in another had cleared up. The other two were free from both.

The small population and its extreme isolation together with its diminishing numbers is felt to have contributed an essential factor to the success of this experiment. It is intended shortly to double the population on the estate and Dr. Watson will report the whole experiment together with the results of this immigration at a later date. As soon as the population is again stabilised the high dosage of quinine will be reduced and an attempt made to assess the relative value of the quinine and the plasmoquine.

* In administering quinine the writer selects a dose equal to 1½ grains per stone of body weight per diem. For mass treatment an arbitrary adult daily dose of 10 grains was usually selected for a Tamil labour force, and this given to every worker and dependent on the estate. The dose was adjusted for children and infants were given euquinine in condensed milk.

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