REPORT ON THE SIXTH INTERNATIONAL COURSE IN MALARIOLOGY, 1939.

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Shortly after arrival in Malaya and while visiting a containment in the course of erection I was asked for advice on the subsoil drainage of the area, on the ideal level of a system of invert drains and on the installation of a tidal gate. Although I had been lucky enough to attend a course of instruction given at the Malaria Institute of India at Karnal in 1929 I had no experience, nor even a vague knowledge, of the way in which these problems should be tackled. Similar difficulties awaited me in the outlying districts where the garrison has been rapidly increased, where fresh buildings are being put up every day, and where large areas are being used by troops for war purposes, manoeuvres, and for what might now be called permanent accommodation. It was with great relief, therefore, that I embarked on an anti-malarial course—the Sixth International Course in Malariology run by the League of Nations Eastern Bureau, Singapore.

I shall try to give a short description of the course, and then endeavour to point out some of the lessons which I learnt, and which I trust will be learnt by other officers of the R.A.M.C. and R.E. who attend future courses.

I was unlucky in being unable to attend the first half of this course which was based on the Institute for Medical Research, Kuala Lumpur, and which embraced the study of practical entomology, haematology, protozoology and chemotherapy, together with some practical demonstrations on anti-malaria work in rubber estates and jungle and tidal areas in the State of Selangor.
The second part of the course was based on the College of Medicine, Singapore, and consisted of a study of epidemiology and immunity, clinical malaria and pathology, control methods and special studies.

A considerable part of this course was devoted to practical demonstrations and during the first week of the course was attended by engineers from all over the Far East and one representative from the Royal Engineers, stationed in Malaya Command.

The problems which present themselves in Malaya to one responsible for malaria control are mainly two, namely, the control of malaria carrying anophelles in the hilly country and the foothills and the control of malaria carrying anophelles in the tidal and swampy areas, and the whole course was organized to give the delegates an outline of the main principles which rule and guide the practical methods which have been brought to such a pitch of perfection by workers in Malaya.

Colonel Covell, Director of the Malaria Institute in India, gave us a series of lectures in Epidemiology, and I can only say that, as a result of the instruction given in these lectures, even the most stupid of us was able to see the way in which any question of malaria control must be approached. His lectures were illustrated by most interesting facts, statistics, graphs and photographs from India, and the warning he gave us that we must not be optimistic because our control succeeds for one or two years was a most timely one. As he said, the outbreak of an epidemic leads to the initiation of control methods during the years immediately following it when the incidence of the disease would show a progressive fall even if no preventive measures were adopted. Undue credit may then be given to the effects of the campaign and a false sense of security may be engendered which would be rudely upset when the next epidemic arose.

He gave us a complete picture of the necessity for possessing a thorough knowledge of the various factors which influence the spread of the disease and for measuring the amount of malaria in the area under investigation before planning methods of malaria control.

Spleen surveys, theories of the spleen rate, parasite surveys and the infant malaria index were all gone into in a thorough fashion. Epidemic and endemic malaria were explained to us and the problems connected therewith. Perhaps one of his most interesting lectures was that on immunity and the work done in the last ten years on the difference in strains and the difference in man's reaction to them, and the consequent change in our outlook on malaria. It is particularly pertinent to examine this problem closely in Malaya where we have infected Indian troops coming to live and work under conditions which expose them to fresh infections with Malayan strains. Personally, the transition from acute infestation to immune infestation was a revelation to me, and will be of considerable help in assessing the likelihood of Indian troops carrying an acute infection with them from India to Malaya; and the fact that this immunity is maintained only by constant reinfection and superinfection and is comparatively
quickly lost by sojourn in non-malarious areas, should be noted by any health officer in Malaya.

**Clinical Malaria.**

Clinical malaria and pathology were dealt with by Professor R. B. Hawes of the College of Medicine, at the Tan Tock Seng Hospital, and his series of lectures and demonstrations on the many malaria cases which come from outlying islands around Singapore, which are not malaria controlled, was most refreshing. He gave us a complete picture of the disease in all its manifestations, a most valuable dissertation on the biochemical changes which the parasite brings about in the human being and a most interesting disquisition on the various treatments or combinations of treatment which are at one’s disposal to-day. To me his method of treating a severely infected and collapsed case by intravenous injections of quinine sulphate 10 grains, calcium chloride 5 grains, adrenaline 10 minims, and 3 per cent saline, to one pint was quite new, and the saline to counteract the excess potassium in the system seemed to be the most logical method of treatment. It has proved extremely successful in the Tan Tock Seng Hospital and their mortality rate in these severe cases has fallen from 14 to 3 per cent.

Other useful lessons learnt were:

(1) The test for the presence of atebrin in urine, which will show a lively yellow fluorescence when atebrin is present in the original urine in so minute a quantity as 1 : 100,000. Traces of reactions are recognizable in still higher dilutions.

The technique is as follows:—

(a) To 10 c.c. of urine in a test tube add 1 c.c. of a saturated solution of potassium carbonate. (b) Add 1 c.c. of amyl alcohol to this alkalized urine. (c) Thoroughly shake and put aside for a few minutes to allow the alcohol to separate. The alcohol layer contains most of the atebrin, and if the drug was originally present in a concentration of over 1 : 1,000 the yellow coloration of the atebrin can be easily recognized by the naked eye. If the naked eye test is negative the urine is examined by ultra-violet light when the lively yellow fluorescence mentioned above can be seen.

(2) A description of the vital staining of malaria parasites. The best results, he told us, were given by a saturated solution of brilliant cresyl blue in sterile physiological saline. A small drop of this—2 c.mm.—is placed on a slide and a glass cover on which a drop of blood has been placed is dropped on the stain. The preparation is ringed and is ready for examination at once, as staining of the parasite is almost instantaneous. The parasites remain alive for upwards of two hours on the warm stage. It seems that the method will be useful for the study of the relation of the parasite to the reticulocyte and of the action of the drugs.

**Malaria Control.**

Control methods occupied the greatest proportion of our time during the period and particularly in the first week when we had the novel experi-
ence of being accompanied by engineers. The difference in approach to problems of malaria control between doctors and engineers was very manifest, and the somewhat inhuman attitude of those who consider that "progress" is shown solely by the building of roads and railways, and not by the happiness of the inhabitants, was rather a shock to the doctors whose more human method of approach seems such a reasonable one. The experience, however, of listening to and, at times, combating the opinions of the engineers, was most valuable and enabled the delegates to the course to appreciate the difficulties that must be overcome when trying to initiate a scheme for the control of malaria.

Our chief instructor was Dr. J. W. Scharff, Chief Health Officer, Singapore, and from the outset his wonderful energy, vigorous personality and remarkable enthusiasm permeated the whole course. He showed us that continuity of policy, persistence and tireless energy in addition to adequate knowledge and receptive brain are necessary to maintain effective malaria control. As I state above, the chief problems which we meet with in this country are two, namely, the control of anopheles in the hills and foothills—rocky ground with outcrops of granite is met with all over Malaya—and control of anopheles in the tidal and swamp areas.

PERMANENT WORK—CONCRETE DRAINS, ETC.

We were first of all shown in the museum and on the demonstration ground outside it various kinds of permanent work which experience has taught are the most effective in draining the storm surface and subsoil water of this country. We were shown examples of well made subsoil drains, badly made subsoil drains, and useless subsoil drains. We were shown how to make concrete, how to test it and how to use concrete in making invert drains, channels and the like. We were shown the common faults perpetrated by unskilled people who do not realize that when dealing with the wily mosquito, strict attention to detail is essential, and that a series of drains well laid with an even gradient, of good material, can be a grave danger if speckled with weepholes badly made, or not made at all, which collect and hold water and, with encouragement, breed Anopheles maculatus. I was particularly struck by the necessity for having a thorough knowledge of the elementary principles that govern the laying of drains, the use of boning rods and bench sites, the great appreciation of gradients, and the measures that have to be taken to prevent these extensive concrete channels from being washed away by the heavy storms which are such a common feature of this climate.

The use of grass and turf to strengthen these concrete banks, the use of cement slabs anchored every ten yards by a cube of stone which acts as a key, and a storm water ledge of 3¾ inches of concreting which binds the invert to the cement slab, were practical considerations the adequate appreciation of which would save the War Department many hundreds of pounds.
Invert drain, Singapore. Note 1—Working weepholes; 2—Inverts left with open points.

Laying an invert. Note 1—Angle of slabs; 2—Open joints between slabs and inverts; 3—Sand base on which inverts are laid; 4—Keyslabs.

Laying subsoil drains. Note 1—Depth; 2—Collar of properly puddled clay; 3—Top soil first on pipes.
Shortly after I arrived here I was taken out to a new cantonment to see 400 yards of concrete channel which had been washed away in a torrential rainstorm on the previous day. Before I had been on this course it would have been quite idle to ask me what measures should be taken to deal with the situation and when they should be taken. After the course it was quite obvious to me what steps should be taken and when they should be taken. This is entirely due first of all to the demonstrations given to us by Dr. Scharff at the museum, and later demonstrations when he showed us the work he was doing around Bukit Timah Hill and elsewhere on Singapore island. We were taken by the Deputy Health Officer of Singapore Municipality to the Singapore Waterworks at Gunong Pulai in the State of Johore where Dr. Hunter, formerly Chief Medical Officer, Singapore Municipality, had achieved almost complete malaria control in an area where such control was considered by many to be almost impossible.

The problems dealt with at Gunong Pulai are very much akin to those which present themselves to us at Pengerang. Here is the same hilly country, the geology of which is complex almost beyond belief. Layers of clay, laterite, granite and sand are intermingled in the most astonishing fashion, and between these layers water shows itself on the sites of steep hills in the midst of large boulders, or as an oozy marsh in the foothills. The Municipality of Singapore, seeing the necessity of complete malaria control if their large engineering project was to be successful, were willing to expend 10 per cent of the capital outlay on malaria control, and this realization of the necessity to spend money was a primary factor in the success of the venture.

Unfortunately, our commitments at Pengerang are such as to render the cost of similar methods to those adopted at Gunong Pulai out of the question, but it was an experience which showed us how to deal with some of the more dangerous breeding places and gave us fresh ideas about work close to camps in Pengerang and in some out-stations in Penang.

Natural Methods of Control.

Dr. Nicholas, Health Officer, Province Wellesley, took us for instruction in natural methods of mosquito control. We were shown how to stone-pack hilly streams, and this seemed a very adequate attempt to deal cheaply with problems like those in Pengerang when other methods are out of the question. The dangers to be guarded against were carefully explained to us.

The method is as follows:—First of all the stream is cleaned and cleared of debris leaving a channel about 3 feet deep and anything from 18 inches to 5 or 6 feet wide. Large stones are then chosen to form a channel—one stone at each side and one on top to prevent smaller stones and debris from blocking the channel up. On this rough primary channel large stones are laid. On top of these smaller stones and above them smaller stones again and, finally, either a mosaic of large stones or an earthen plat-
form underlaid with twigs on top of which turfs are placed. When the slope is very steep and the flow of water in storm time liable to be very heavy retaining walls should be built, i.e. the stones in the drains should be cemented together every 10 or 12 yards in order to hold up the smaller stones and prevent the whole drain being swept to the bottom of the hill.

We were then shown examples of fascine drainage and the principles of this were again explained to us by Dr. Nicholas. The drains are made as follows:

First of all young saplings are laid lengthwise in the drain to a level of 6 to 8 inches above the normal flow. Secondly, twigs are laid crosswise over the drain and, finally, grass evenly cut is laid across the sticks in bundles, the cut end of the grass facing upstream, and the whole laid in the manner of tiles laid on a roof. The whole, after settling down, i.e. after about a week, can be covered with earth and turfed over. We saw drains laid in this fashion which were still working well three years after they had been laid. Their action is twofold. The drain is covered in and cannot act as a breeding place and if a portion of a drain remains uncovered the mass of rotting vegetation alters the composition of the water so that Anopheles maculatus is unlikely to be able to use it as a breeding place. These drains are unsuitable for hilly country, but are excellent in the plains.

Other methods of natural control were explained to us by Dr. Scharff, and perhaps one of the most interesting was that exemplified in the Botanical Gardens in Singapore, where the weekly changing of 6 inches to 2 feet in the level of the water has had the extraordinary effect of completely inhibiting breeding of mosquito larvae in any part of the large lake which is a marked feature of these gardens. More important, perhaps, was the method which he first described and then showed us, of making the use
of the tide in lands near the shore where *A. sundaicus* is a constant danger. The careful appreciation of levels and of the rise of the tide, the difference between spring tides and ordinary tides, the meaning of the terms "high neap tide" and "low neap tide," "high spring tide" and "low spring tide," the various types of tide gates and how they are used, were all points that are of the greatest importance to us in dealing with drainage in North Cantonment, Pulau Tekong and in Penang. As in all the schemes of drainage which were shown and explained to us, the most important point was to start at the outlet. The outlet must be as low as possible, and from there on there must be as few open drains as possible, and as few subsoil drains as are necessary, and the level of these tidal drains is not a matter of luck in taking the lowest point in the existing ditch. Tides must be noted over a considerable period in each place, because the rise and fall of the tide differs materially in this country over comparatively short distances, and the rise in the spring tides is so great that every drainage scheme which involves a tidal area must take note of it.

In two of the areas which were shown to us it was made quite clear that a mangrove swamp rendered dangerous by clearing needed comparatively inexpensive treatment to ensure that the area was washed by the tide every day and therefore made quite uninhabitable to *A. sundaicus*, which only breeds in fairly brackish water the salinity of which is slight.

Colonel Covell gave us a most interesting lecture on the control of the breeding of mosquito larvae by the breeding of larva-eating fishes, and it would seem that one fish, the common name of which is "millions," and whose proper name is "*gambusia*" is the only effective larvicide.

**Larvicides.**

We were then given a lecture on larvicides by Dr. Scharff and a demonstration in the field. It was quite plain from the experiences quoted by Dr. Scharff from all over Malaya that Paris green is of little value in this country for two main reasons:

1. Rain is so prevalent that the Paris green is washed down to the bottom of any ponds, streams or marshes, and therefore becomes ineffective in a short time.

2. The diluting material for Paris green is hard to come by as road dust is very uncommon and the soap-stone which is the best medium for the dilution of Paris green has to be imported from Calcutta. The expense is therefore very considerable.

It has been found that oil is the best larvicide and the two chief petroleum companies, the Asiatic Petroleum Company and the Standard Oil Company of New York, have each produced an excellent anti-malaria oil. The first-mentioned company has published the prescription for its larvicidal oil and the many experiments which have been made to find an oil with the maximum toxicity, maximum spreading power, and minimum evaporation. A most interesting demonstration was given by an official
of the Asiatic Petroleum Company showing the toxic effect of volatile hydrocarbons of all classes on mosquito larvae, and the spreading powers of oil on water, with the surface tension figures for spreading and non-spreading oils, the power of evaporation of high and low vapour pressure liquids, and of blended oils.

The result of their experiment, namely the oil called "mariol," was shown to us, and its effect on larvae in vitro was seen on the screen and under the microscope. Dr. Scharff then showed us the way in which he considers oil should be spread, preferably by sprayers, and he recommended the "Four Oaks" Spray as one of the most suitable. He showed us the various ways in which oil was wasted and the toxic effect on grass and herbage and plant life of all kinds which any oil has. The effect of the Standard Oil Company’s product was seen by us later and the difference in toxicity between the products of the two companies was negligible. The Standard Oil Company do not publish the prescription of their product.

During all the foregoing lectures, demonstrations and experiments, we worked in company with the engineers but, in the second week, the medical delegates were working by themselves and our lectures embraced more work on malaria control with particular reference to its cost, the economics of the problem, and the methods by which it should be made more acceptable to the general public.

Further lectures in epidemiology were given by Colonel Covell in amplification of what he had said during the previous week and, finally, we were given two most interesting lectures by Professor B. A. R. Gater of the College of Medicine. These lectures were on special entomology, and his explanation of the necessity for exactitude in nomenclature was of great value. His description of the more recent work in identifying and classifying anopheles mosquitoes was remarkably useful to one who had not kept in complete touch with the literature of the subject during the last ten years.

We left Singapore for the remainder of our course which consisted of further demonstrations and lectures by Dr. D. W. G. Faris and his Sanitary Engineer, Mr. Villiers, in Penang, with a solid groundwork on the principles of malaria control and the practical measures dependent on these principles. We were filled with a profound admiration for the energy, enthusiasm and brilliance of our instructors.

Penang.

The four days that followed in Penang were of particular interest to me as the lectures we were given and the demonstrations to us largely concerned the military area on that island where the local health authorities, namely our two instructors and others, have taken over malaria control on our behalf and have achieved complete mastery. On our first day we were shown a waterfall area, stone packing most successfully done, and a number of flushes, automatic and hand-worked. This use of flushing streams as an anti-malaria measure was first brought to notice in the Sudan, but has been brought to perfection in this hilly island where its use has saved many
thousands of pounds in draining streams and, when carefully worked and equally carefully managed and inspected, it has proved itself completely successful. There are many types of automatic sluices but one type in the simple form of a U-tube flush seems to be the most successful yet devised.

On the second day we were shown the advances which have been made in the control of malaria in rural areas by the people themselves. Natural methods such as fascine drainage, earth bund sluices, stone packing and coconut husk packing of drains, and similar cheap and satisfactory, if not foolproof, methods of larval control were shown us. The most interesting feature was the malaria consciousness of the villagers, their pride in the work they had done themselves, and the much increased prosperity which is the result of their freedom from disease and better drained land.

The following day we went to Butterworth and were shown the Butterworth drainage scheme, which deals with a low-lying area in which *A. barbirostris* seems to be the principal carrier of malaria—an unusual experience for Malaya, which in fact is the only place where this anopheles is the chief source of trouble.

Finally, on the last day, we travelled to the Dublin Estate, Kedah, where the estate medical officer, Dr. Wallace, has been carrying out valuable experiments in malaria prophylaxis with atebrin. He has ceased to attempt any malaria control by oiling and uses atebrin, 0.4 gramme per adult per
week, with relative doses for children, as the sole means of combating malaria. I examined 150 children and found not one with an enlarged spleen though the larvae of *A. maculatus* were to be found in streams all about us. That this was not entirely due to my lack of skill in palpating spleens was borne out by the fact that three other delegates skilled in the art were also unable to find any enlarged spleens amongst the children.

This method and its results are the subject of several articles published by Dr. Wallace in the *Malayan Medical Journal*. It is a method not applicable to our troops except under conditions of mobile warfare in heavily infected areas, and the effect of this dosage of atebrin on fair-skinned people working in the sun requires further investigation.

In this last part of the course the enthusiasm and energy of Dr. Faris of Penang, Dr. Nicholas of Province Wellesley, and Dr. Wallace of Kedah, were equal to that of anyone we met in Singapore and seem to be natural to health workers in Malaya.

This paper is a short if rather confused description of a most excellent course, the value of which should be inestimable to anyone who is attempting to control malaria in any part of the world, and without which no hygiene officer in Malaya can attempt to do anti-malaria work with any degree of success.

It would now perhaps be as well to summarize the lessons learned which are:

(i) The importance of drainage, the principles of it and the best methods of lowering the water table of the land in such a way as to exclude breeding places for anopheles mosquitoes.

(ii) The energy, persistence and attention to detail required from the medical officer in charge of health measures.

(iii) The bionomics of the more important malaria carrying anopheline mosquitoes in Malaya.

(iv) The economic factors in malaria control.

(v) The modern methods of controlling and treating malaria in Malaya.

In addition to the knowledge and experience gained it was delightful to come into contact with so many highly skilled and enthusiastic workers who were willing to put themselves at one’s disposal, and the contacts made have proved invaluable since the course and will, I am sure, be no less valuable during the ensuing years.

Seeing that so many of our problems are man-made and the result of thoughtless work on the part of engineers and contractors, it seems a pity that only one engineer officer could be allowed to attend the course, a course that would have been of immense interest and importance to any officer employed in constructive works in the tropics.

Finally, I only hope that if these courses are held in future years opportunity will be given to R.A.M.C. officers to benefit by them and to get an insight into the problems involved in the control and treatment of malaria which should be invaluable to the Service.