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The Control of Urban Malaria (Kuala Lumpur)

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THE PRACTICAL APPLICATION OF ANTI-MALARIAL MEASURES ON MALAYAN ESTATES.

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In approaching the problem of the control of malaria on rubber estates in this country, four points present themselves for consideration—

1. The species of malaria vectors.
2. The nature of their breeding places.
3. The system of anti-malarial organisation.
4. The types of anti-malarial measures.

1.—THE MALARIA VECTORS.

Although Gater, in his book "Aids to the Identification of Anopheline Imagines" published in 1935, records 41 species and sub-species of *Anopheles* in Malaya, only five of these are well-recognised malaria carriers. They are *A. maculatus*, *A. umbrosus*, *A. novumbrosus*, *A. sundaeicus* and *A. barbirostris*. Others have from time to time been incriminated, but in general they have proved of minor importance.

2.—THEIR BREEDING PLACES.

These five species have each certain distinctive breeding characteristics, a knowledge of which is a guide to the appropriate measures for their control.

(a) *Anopheles maculatus*—This species is known as the sunlit stream and seepage breeder. It is, so far as the majority of rubber estates in hilly land are concerned, Public Enemy No. 1. Now, although sunlit streams and seepages may be regarded as its optimum habitat they form but half the story of the possible breeding places this most adaptable malaria carrier can make use of. During the past four years much new agricultural activity has taken place all over the Peninsula in the form of replanting, and in spite of extensive and well-organised anti-malarial control of ravine, swamp and seepage areas, there have been widespread outbreaks of malaria.

It follows that some new factor has been introduced which favoured the breeding of this malaria vector. This factor is now recognised to be new only in the degree it has afforded "maculatus" extended opportunity for breeding. It was long ago known that "maculatus" could breed in standing water if associated with recent disturbance of the earth and exposed to a few hours sunshine each day. Prior to the extensive replanting programmes which commenced in 1936, such standing water as was provided by earth wells, silt pits, isolation drains, cattle hoof marks in wet grass, etc., were all recognised as possible "maculatus" breeding places. Replanting introduced three new factors, each of which produced conditions tending to favour the breeding of "maculatus" to an extent not hitherto anticipated. Those in charge of anti-malarial organisations on estates were caught unawares and although the location of the breeding places was early defined, it took three years to persuade the planting community of the facts and to obtain co-operation in combating these new sources of potential danger to the health of the community. The factors referred to are—

(a) The formation of holes following the removal of old rubber tree roots.
(b) The digging of replanting holes which were left open for two or three months to weather the soil.

(c) The construction of terraces on hilly land for the purpose of contour planting (a measure to minimise soil erosion).

Wherever the soil contains a preponderance of clay these measures may result in holes capable of holding water which, under the conditions of replanting, is naturally associated with considerable disturbance of the soil and is exposed to the sun all day long. Under these circumstances "maculatus" finds many happy breeding grounds.

To impress upon you the serious breeding potentialities arising from these agricultural sources, I will describe what happens on a hypothetical 100 acres of replanting.

The old tree stance of such an area may be taken at 70 trees to the acre. When these are felled and the old roots removed, the 100 acres is left pitted with 7,000 holes about 2 feet in depth and 3 feet wide. In between the rows of these holes the replanting holes are made, 2 feet square and $2\frac{1}{2}$ feet deep, to the number 140 holes to the acre, or 14,000 holes in the 100 acres. Thus there are 21,000 possible water-holding holes the earth of which has recently been turned, and which are exposed to the full blast of the sun.

It is obvious that all these holes will not hold water, but if, say, two per cent. of them do so, and only a couple of dozen of these become breeding places of *A. maculatus*, there will thereby be liberated a sufficient army of anopheline vectors to give rise to a serious outbreak of malaria. I have known several hundred "maculatus" larve to be collected from a few such old tree holes during a single survey. To these artificially made breeding places must be added the terraces which are necessary on hilly and undulating land to prevent wash. They are from 4 to 6 feet wide, constructed on the contour, and are made to slope backwards. There are often 25 chains of terraces to the acre, i.e., 30 miles to the 100 acres. Between the terraces cover crops are grown which, within a year or so, spread over the terraces and cover drains, holes, contour drains, etc., making it very difficult to spot standing water, but covering it insufficiently densely to prevent breeding. The danger of such measures giving rise to concentrated breeding places of *A. maculatus* is very obvious. Larval surveys have confirmed the fact and the widespread outbreaks of malaria that have startled the country since the commencement of replanting in 1936 prove the case. Thus I would repeat that so far as rubber estates, particularly those on hilly land, are concerned, "maculatus" is Public Enemy No. 1.

(b) Other Vectors.—Since to-day I am speaking not of antimalarial measures in general but of my own experiences in the control of malaria on estates in the State of Negri Sembilan, and since *A. umbrosus*, *A. novumbrosus*, *A. sundicus* and *A. barbirostris* have not besmirched their family escutcheons by seriously marauding the districts I work in, I shall, so far as they are concerned, limit my remarks to general observations.

*Anopheles umbrosus* and *novumbrosus* are shade breeders with a predilection for jungle-covered swamps where the soil is of a peaty nature such as so often is the case in the flat coastal areas. The shade does not need to be so heavy as the term "jungle-covered" would seem to indicate. Even where the
jungle has been felled and replaced by light secondary growth; these shade breeders may reappear if the type of earth is suitable and the water lies in stagnant pools or drains. *Anopheles sundaiicus* is a brackish water addict and is consequently only found within tidal areas. It made dark history in the early days of the development of Port Swettenham where Dr., now Sir Malcolm Watson gained one of his early battles against malaria. This *Anopheles* is not known in Negri Sembilan. I, therefore, have no experience in dealing with it.

*Anopheles barbirostris* is a pool breeder which, in the past few years, has gained notoriety in Perak and Selangor. It is partial to pools such as over-grown borrow pits and mining holes containing coarse vegetation. I recently found it breeding in a half empty fish pond, the bottom of which was covered with coarse grass and aquatic vegetation.

3.—THE ANTI-MALARIAL ORGANISATION.

The system of anti-malarial organisation which I practice is divisible into three sections—

(a) To define the area to be protected.

(b) To ascertain the breeding places of anopheles vectors within the area.

(c) To establish an organised system of weekly records of anti-malaria work done.

For the purpose of the practical application of anti-malarial measures in this country, it has for many years been agreed that the anopheles vectors concerned normally have an effective flight range that does not exceed about half-a-mile. Unfortunately, however, observations made in 1937 and 1938 by Dr. W. E. Holmes showed that under the conditions introduced by replanting "maculatus" can cover about three times that distance in sufficient numbers to cause a serious outbreak of malaria. Still, for the purpose of this lecture I shall work on the half-mile limit which suffices under ordinary circumstances.

(a)—DEFINITION OF THE AREA.

The first step in the initiation of an anti-malarial organisation on rubber estates is to obtain a survey plan showing the disposition of the ravines and the location of the habitations to be protected. On such a plan a primary circle is marked having a radius of half-a-mile, the centre being at the main group of dwellings to be protected, usually the labourers' lines. Secondary segments are then taken from such places as European and subordinate staff bungalows—which are usually situated at a distance of ten or twenty chains from the lines and consequently require observation of ravines, etc., for a corresponding distance beyond the limit of the primary circle. In this way the area to be organised is defined and the ravines and swamps lying therein can be readily traced and marked out in the field.

Each half-mile circle encloses 500 acres which, in the average hill-land estate, contains four miles of streams, ravines and swampy areas. By the time the main stream or ravine has been drained and the seepages have been collected in narrow intercepting drains, the four miles of drains will have extended to something in the region of twelve miles. If such a control area encloses broad valleys, many miles of agricultural drains will also have to be supervised and maintained by the anti-malarial organisation.
(b).—**The Larval Survey.**

The second step is to make a detailed survey for *Anopheles* larvae of all streams, seepages, pools, etc., within the defined area. Such a survey, if made between March and the beginning of June, will give a reliable general idea of the malarial potentiality of the area. I have mentioned the period March/June because this is the most active breeding season of *A. maculatus*, the chief malaria carrier on hilly rubber estates. There is a second period extending from October to December when a recrudescence of breeding often occurs, but which, probably owing to the heavier rains of that season, is only infrequently accompanied by much malaria.

Although the periods mentioned make what may be regarded as a picture of cause and effect, namely, the active breeding of "maculatus" and outbreaks of malaria, such periods should not be regarded as definite limitations to the breeding of this mosquito. Considerable variations both in the breeding and in the incidence of malaria mark the history of this country. The factors which favour such variability are as follows—

(i) **Seasonal breeding habits.**

(ii) **Meteorological conditions.**

(iii) **Agricultural and other activities causing disturbance of the soil.**

(i)—**Seasonal Breeding.**

The underlying biological factors which make for seasonal breeding in a country so well rained upon and consequently full of breeding opportunities in streams, swamps, seepages and pools all the year round, have not, so far as I know, been completely explained. The fact, however, remains that April/June and to a less degree October/December, in the foot-hill districts, show regularly recurring outbreaks of malaria.

(ii)—**Meteorological Conditions.**

There is an annual rainfall in this country of over 100 inches. Although October/December are distinctly the wettest months, periods of heavy rain may occur at any time throughout the year. When this occurs, flat and swampy land may be stimulated into short-time breeding activity. If such wet periods coincide with agricultural works such as felling of *blukar* or jungle, the making of holes preparatory to planting, etc., it behoves the malarialogist to be very watchful if an outbreak of malaria is to be avoided.

(c).—**The Survey Organisation.**

Because of this variability in the breeding of "maculatus" it will be obvious that an occasional larval survey will not give a true idea of the malarial potentiality of an area requiring control. For this reason I organised, many years ago, a system of weekly larval surveys on all the estates under my supervision. Only in this way can one keep oneself reasonably well informed of the disposition, strength and activity of the enemy. The larval surveyor thereby becomes the scout of the organisation whose duty it is to bring in early information of impending enemy attacks.

Again, if the hospital is situated within the malarious area, as is usually the case, a regular early morning examination of the mosquito nets forms a most useful check on the efficiency
of the anti-malarial work. In like manner, if there are Chinese "linos" or kongsies within the protected area, examination of their nets at frequent intervals will serve the same purpose.

In order to give precision to these weekly larval surveys it is necessary to organise a system of recording the results. To this end the ravines should be divided into sections, and lettered and numbered for reference. Such divisions are of an arbitrary nature. No specific distances are taken, but the natural divisions due to branching of the streams are made use of. These divisions are first made on the survey plan. Then a record of the letters and numbers corresponding to the divisions is made on monthly sheets. Two sheets are used; one to record when surveys are made and the results obtained, and the other to show when the sections are oiled and the amount of oil used.

In the ravines, boards are erected corresponding to the divisions marked on the plan, and are lettered and numbered. In this way it is easy for anyone sent to make a check survey to know where he is and to make an accurate control examination.

Further, from such weekly survey records a monthly summary is compiled, and at the end of the year these results are recorded on a separate sheet. In this manner a picture is gradually built up showing those ravines that are regular breeding places, and those that breed only occasionally or not at all. Such a table is of great practical use in estimating when the oiling measures should be increased and when economies can be safely introduced. This system also illustrates the seasonal breeding waves and the influence of extraneous agricultural works associated with replanting upon the variability of Anopheles breeding. For estate anti-malarial control, where every possible economy which does not conflict with efficiency has to be constantly kept in mind, the regular weekly larval survey system will be found to be the key to the situation.

4.—ANTI-MALARIAL CONTROL MEASURES.

Since "maculatus" is the chief vector on my estates I shall speak only regarding the methods used to control this species.

There are two principal methods, in wide general use, which can be depended upon to give satisfactory results. They are—

(a) by placing all visible water in pipes underground, as in subsoil draining,

(b) by open earth drains and the use of larvicides, such as prepared oil mixtures, Paris Green, etc.

(a)—SUBSOIL DRAINAGE.

This method involves too high a capital expenditure to be considered to-day an economically practical means of control suitable for use on estates. It is the ideal method for urban areas where the population is concentrated and consequently the cost per head shows up at a reasonable figure. But on estates where the population per acre is small, the cost per head for subsoiling all ravines in the 500 acres or more of the health circle, takes on a different complexion. Moreover, the cost of a subsoil scheme is not limited to the initial cost of construction: the work must be maintained. The annual cost of this is reckoned at 5 per cent. of the cost of construction. For this amount alone, without locking up the initial capital, open drainage and oiling measures can be carried out on the average estate, and reliable control thereby ensured. Again, by the open drain method there is no sacrifice of arable land, in fact land
is often reclaimed and afterwards planted. Whereas, when a ravine is subsoil-drained, planting must be restricted to a distance of 80 feet from the nearest pipes.

(b)—Open Drains and Oiling.

The construction of open earth drains and the spraying of oil at weekly intervals are the usual combined methods of control of "maculatus" in use on estates. They give eminently satisfactory results if carefully organised and supervised. They should be supported by the system of weekly larval surveys previously mentioned.

Construction of Open Drains.

Appropriate drainage is the first and most important measure of attack on the stronghold of "maculatus". If correctly designed and carefully constructed, drainage alone will reduce the malarial potentiality of an area by some 75 per cent. Given an average type of clay soil, the construction of effective anti-malarial drains is by no means a difficult undertaking. The following three principles will be a useful guide—

(a) Don’t be deceived by surface water.
(b) Intercept the seepages.
(c) Make the drains narrow and deep.

Where malaria is hyper-endemic, an estate medical practitioner finds his time occupied more with field work than with the dispensing of physic. He must have a reasonable knowledge of local malarial entomology, an interest in drainage construction, and be able to organise oiling and other larvicidal measures.

To this end he should hold himself responsible for the construction and upkeep of all ravine, seepage and swamp drainage work. To act merely as adviser on anti-malarial requirements, and leave the construction to the manager of the estate, is to invite divergence of views and variations in methods which too frequently result in disappointment. This is so because managers see but a limited variety of swamps and types of soil. Their opinions upon drainage are based on traditional ideas of size of drains, 2 feet x 1 foot or 4 feet x 2 feet or even larger being considered necessary from an agricultural point of view to dry up an area effectively. These opinions arise from lack of experience in judging between swampiness due to a high water table and that due to collected surface water lying on a heavy clay soil. On undulating land in the foot-hill districts there is usually little difficulty in finding a sufficient fall to construct a reasonably well graded drain sufficiently narrow and deep to carry off the normal flow of water at a speed that will effectively prevent the breeding of Anopheles larvae. It is therefore desirable that the estate medical practitioner should have his own anti-malarial gang: a lines "dresser" and two coolies are usually sufficient. They can be put on to such work as the medical practitioner considers necessary and can be instructed to carry out the work in the manner he thinks best. Conflict of views can thereby be largely avoided and increased flexibility of action gained. This freedom of action is most important when an outbreak of malaria threatens.

Ravines.

The word "ravine" is widely used in this country to mean any form of water course in undulating or hill land. Any valley, small or large, steep or shallow, is thus loosely referred to as a
"ravine". Any flat water-logged area, such as is often found towards the foot of the undulations or hills, forming the outlet of a stream, or marking the junction of two streams, is referred to as "swamp". Even in hilly places where the valleys have become blocked with silt, or, as frequently happens, where the road or railway culverts are placed too high to allow of proper drainage, the resulting collections of water are called swamps.

The so-called "ravines" vary greatly in steepness and width. The ground forming the sides and base of the valleys also shows many types of soil: the soil most favourable to good drainage work is one containing a high proportion of clay. The average laterite soil of this country is of this nature. Several types of earth, however, may be encountered even in one ravine. Patches of white kaolin clay, gravel or outcrops of rock are frequently met with, while, in the flat areas, sand is the cause of many difficulties in drain construction.

**Ravine Drainage.**

The purpose of the drainage of ravines is to give ready exit to surface water, and to control flowing water and seepages.

Assuming a ravine of moderate proportions in width and gradient and free from vegetation, drainage calls for no particular skill so long as the three principles mentioned previously are kept in mind. In organising such work the chief difficulty in dealing with the main stream is to decide how wide and deep to make the drain. On inspection it will probably be found the stream takes many bends, either because of undulations in the land forming the base of the valley, or because trees have fallen across and dammed the ravine. Consequently the flow of water will vary frequently, now fast through narrow passages, now slow through pools or flat swampy patches. There is little wonder if the inexperienced maker of drains, after seeing much water held up in pools and flat areas, concludes that a wide drain will be necessary for satisfactory drainage.

However, as I said before, don't be deceived by surface water. It is the flowing water with which the drain is primarily being constructed to deal. There is a simple way of deciding the size of drain necessary to carry off the normal flow of the stream. It is as follows: examine one of the narrow parts where the stream is flowing at a reasonable speed. Measure its width and depth. Say, for example, it measures 2 feet wide and 3 inches deep. The simple sum of 24 x 8 inches equals 72 square inches and represents the section of the flowing water. Obviously a drain measuring 9 inches wide by 8 inches deep would carry off the same amount of water and therefore a drain 9 x 18 inches would have a free margin of 10 inches depth to spare for light rain. A drain of this type conforms to the third principle in being narrow and deep. I would here give a frequently required warning. Don't worry about storm water. There is plenty of room above the drain level for any degree of storm water. It is only on flat land that heavy rain tends to lie about long enough for breeding. The drainage of true swamps is a special subject calling for collaboration with the engineer specialist. Figure 1 shows a jungle swamp after felling and burning; Figure 2 the same swamp drained by a 9 x 24 inch drain.
DRAINAGE OF BLUKAR-COVERED RAVINES.

A blukar-covered ravine is one which, after the felling of the original jungle, has been allowed to revert to secondary growth of any type of vegetation that can find a footing. A high percentage of the ravines in hilly land districts are in this condition. So long as the cover is of good growth A. maculatus does not breed. They are, however, most dangerous potential sources of unexpected outbreaks of malaria. Trees falling across them, cattle wandering into them and natives making footpaths through them may damage the shade and give rise to breeding places.

For the most part such overgrown ravines are artificial swamps due to collections of spring and seepage water dammed by spongy masses of low growing vegetation and the trunks of fallen jungle trees. The water has no chance of a proper flow through the mass, and the base of the ravine, being usually of heavy clay, prevents percolation to lower levels.

The treatment of such a swamp is comparatively easy provided it is tackled with patience and good sense. The water, being mainly collected surface water, even though it may be a couple of feet deep in places, will run off if given a reasonable chance to do so.

The first step is to have the line of the proposed drain marked out. A little experience is necessary to do this sort of work in a ravine covered with trees, grasses and creepers through which one cannot see more than a few yards ahead. In the narrower ravines it is usually possible to cut the drain straight through the centre of the ravine. But if the ravine is, say, two or three chains or more wide it will be necessary to cut "rentices" across it at intervals of a few chains in order to get an idea of the lie of the land, the nature of obstructions and the amount of flowing water.

Having decided the line along which the drain can be most easily constructed, and having calculated the size of the drain required by the method previously described, cut a narrow "rentice" or path, through the blukar (secondary growth) and remove all trees, bushes and obstructions along the line of the proposed drain. In cutting paths for such purposes inside swampy ravines, it is necessary to keep them as narrow as possible so that as little sunlight as possible can enter, otherwise "maculatus" will soon establish breeding places. It might well be asked why not fell all the blukar first so that the line of the drain can be easily seen: this is one of the most frequent mistakes made by the agriculturist. Such felled blukar has to lie for several weeks to dry before it can be cut and piled ready for burning. During this time it is impossible to get in and efficiently oil the area. Thus "maculatus" has an excellent opportunity to establish breeding places and usually makes the most of it. Only by draining a blukar-covered swamp before felling can A. maculatus breeding be controlled.

It is my practice to put in two coolies armed only with parangas—heavy knives—after cutting the necessary "rentice" and marking out the line of the drain. They are instructed to follow the line of the cleared "rentice" and to cut through the grass and roots which form the base of such swamps and lift the mass out with their hands. The sides of the channel thus formed are soft and collapsible. It may therefore be necessary to keep a labourer going over the line every few days, pressing the