injection, while one case—the most serious of all that we had—received five injections.

Formula:—

Iodum	.. 1 drm.
Pot. Iodide	.. 1 drm.
Aq. distillata	.. 5 ozs. 2 drms.

The iodine is dissolved in the solution of potassium iodide in distilled water, previously prepared.

Roughly, 20 minims of the above solution contains ½ grain of iodine.

Initial dose. 20 minims (½ grain iodine).

Second and subsequent doses. 40 minims (1 grain iodine).

THE MOSQUITO FACTOR IN THE MALARIA OF ASSAM TEA GARDENS.

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Introduction.

The main object in here reproducing this paper which was read before the Assam Branch of the British Medical Association at its Jorhat Meeting on March 2nd, 1925, is to publish it with the illustrations which were given by lantern and to correct a few minor misapprehensions thereanent which have arisen.

The subject was the conclusions arrived at from a mosquito malaria survey of the tea gardens of Assam which the Endowment Fund of the School of Tropical Medicine was enabled to finance by the generous help of the Indian Tea Association. Further study of the detailed observations which have only recently been concluded may of course oblige us to modify the opinions expressed here, but in the meantime they are submitted for "necessary action."

I wish to repeat here that I owe a great deal to Lieutenant-Colonel J. W. D. Megaw, I.M.S., Director of the School of Tropical Medicine, for his sympathetic administration of the work undertaken, and to the officers and members of the Indian Tea Association for their help in every way. The work would have been impossible had it not been for the acceptance of the spirit of the scheme by the Medical Officers of the tea estates, for they placed all information at my disposal and every possible facility for collecting the data which I required.

The Advantages of a Survey.

While a malaria-prevention campaign without a previous survey can indeed be carried out by employing certain measures which are of general application, a survey has three advantages, enabling one to (1) find out if a healthy site be available; (2) localise the area in which prophylactic measures should be taken; and (3) choose the most appropriate measures to deal with the situation. The last item is very important because some anti-malarial methods not being of general application might, if tried without knowing what situation is being dealt with, cause worse trouble. Take for instance, open earth-drainage; one drains a swamp and eradicates the species *umbrosus,* one drains another and introduces *maculatus* or *funestus.* In this connection Boyd says "all anopheline mosquitos are not carriers of the malaria parasites, and gross variations with regard to breeding habits are found among the different species of anophelines. Thus, it often happens that in a mosquito-infected district where malaria is occurring, only a small portion of the total mosquitos are of the carrier type, and these may have quite specialised breeding habits, so that *general measures of mosquito destruction might miss them altogether.* The first essential in any district is, therefore, to make a critical survey to ascertain what mosquitos are carrying the parasite and what their breeding habits are; after which, if feasible, steps *specifically directed* against the *carrier species* may be undertaken. To illustrate the diversity of breeding habits the following instances may be quoted:—*Anopheles maculipennis,* a well-known carrier, breeds chiefly in swamps and marshes and does not breed in running water, so that it can be attacked by draining the swamp. Conversely, *A. maculatus,* which gave rise to much trouble in the Federated Malay States, breeds in running water. Other things being equal, therefore, draining by open drains (the usual method) would not abolish but rather encourage the breeding of this species. Yet another, *A. stephensi,* is almost exclusively a well-breeder and can only be countered by screening or oiling the responsible wells. It can thus be seen that haphazard measures are almost bound to involve a waste of time and money, and may even render the last state of affairs worse than the first by taking away conditions under which harmless mosquitos were breeding and replacing them by others suitable to the propagation of carrier species" (1924).

On the same subject Sir Ronald Ross at a meeting of the Royal Society of Tropical Medicine (1924) stated how different species of mosquitos must be dealt with in different ways. He said "We must deal with each species on its merits"; to which dictum Major Austin agreed, and Dr. Balfour and Major Austin both were of the opinion that it was necessary to make careful biological investigations before starting upon any anti-malarial campaign. Watson (1924) in this connection said, "Let me candidly admit that for some years we cleaned up the ravines in our hill-land in Malaya making the malaria worse. We had to adopt an entirely different method. Let me remind you too that in 1901 when the Federated Malay States Government gave me the money to clean up Klang, Dr. Braddon applied for money to clean Seremban, a town on the main range. Presumably he would have felled jungle and "trained" streams, and would have caused a big outburst of malaria in, at that time, a healthy

town. Had that occurred I can imagine the progress of malaria prevention in the Federated Malay States would have been seriously retarded as it has been in India by the experiment done in Mian Mir."

The fact that Watson started to preach this doctrine of the specific prevention of malaria in 1911 and that it is still necessary in 1925 for the Society of Tropical Medicine to reiterate it seems rather lamentable.

It will, however, be seen how important it is to do a preliminary survey. As Dr. Murphy of Sylhet has said very concisely " to obtain the most successful results with the most economical expenditure it is necessary that a preliminary detailed survey should be carried out."

Previous Surveys in Assam.

From time to time other surveys than that which is the subject of the present paper have been conducted in Assam. Not all of them have been in tea-garden tracts, but I have included a consideration of some of them in this paper because of the general similarity of the terrain described with that of the tea gardens.

These surveys have been made at Lumding Junction by many medical officers in co-operation, the report being published by Lieutenant-Colonel T. C. McCombie Young, I.M.S. (1921); at Nalbari, Kamrup District, reported by Lieutenant-Colonel S. R. Christophers, I.M.S. (1922), Lieutenant-Colonel McCombie Young I.M.S., and and Captain B. S. Challam (1923); at Pasighat by Lieutenant-Colonel McCombie Young, I.M.S. (1921); and lastly, at Doom Dooma by Sir Malcolm Watson (1924). An analysis of these reports has been made in conjunction with the data collected in my survey and details will be noticed below.

The Mosquitos of Assam.

Of the 42 known Indian and Malayan anophelines 15 have been found in Assam and of these 6, because of what is known of their activities elsewhere, must be on their face value suspected and will be the only ones considered here; with regard to some of the others, however, a mental reservation might be held pending further information.

The six are:—*umbrosus, jeyporiensis, aconitus, funestus,* culicifacies,* and *maculatus.*

A. umbrosus.

This species was one of those responsible for so much trouble in Malaya before Watson showed how to deal with it. We now know it is very easy to tackle; rough open earth-drainage, even through the jungle, is sufficient to eradicate it. It lives in pools or swamps in the jungle or in densely-shaded places, so that by merely cutting down the shade one becomes rid of it.

* *A. funestus* = *minimus* and *listoni.*

As it can be so harmful, the question arises as to the place it takes in the malaria problem in Assam.

I have caught it in several places in Assam jungles, for instance, in the swampy ground under jungle near to Lokra in the Balipara Frontier Tract, (fig. 1), and I have no reason to suppose it is not to be found in all similar situations.

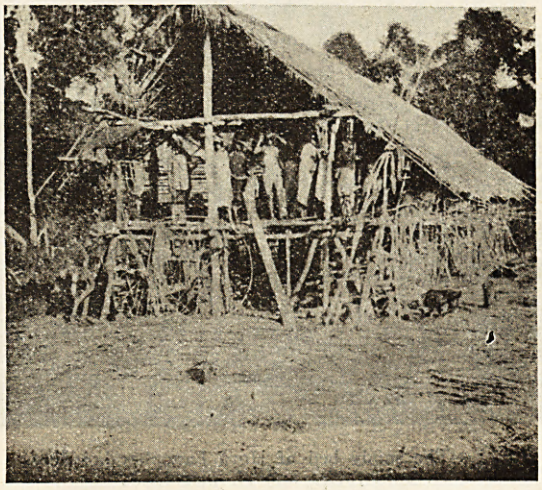

Fig. 1.—Daphla chang in the jungle near Lokra.

But does it do any harm? I agree with Watson that in gardens which are well cleared such as in the Doom Dooma district the species is perhaps of no importance, nevertheless it is significant that of the estates along the Dibru or similar rivers, which he mentions as being so malarious, some are opposite the Dibru Forest Reserve. The evidence of the seasonal incidence of malaria in the gardens is also compatible with this being at least partly due to *umbrosus,* for being a swamp breeder it is probably much increased in numbers during the rains, when malaria is also more prevalent.

At Pasighat which Lieutenant-Colonel McCombie Young, I.M.S., surveyed, *umbrosus* was not incriminated but I am inclined to think on reading his description of the terrain that *umbrosus* may have been partly to blame. It seems to me significant that great improvement in health followed cutting down a belt of jungle 300 yards from the lines.

Then one must note too that at Lumding Junction where all anophelines except some breeding in the bed of a river have been got rid of and the spleen-index reduced from about 80 to 30 per cent., a community of sweepers living near the jungle boundary still have a high malaria-rate and a splenic-index of about 90, so Dr. Leitch tells me.

As a final point I would cite the ill reputation for " fever " that the Nambur Forest has for officers on tour.

In general I would give my opinion that any undrained jungle in relation to tea gardens should be considered dangerous until it has been proved not to be so.

A. MACULATUS.

McCombie Young in his Pasighat survey determined that *maculatus* was the cause of most, if not all, of the trouble. At Lumding, where it was found breeding in the sandy bed of the considerable river the Horu Langpher (fig. 2),

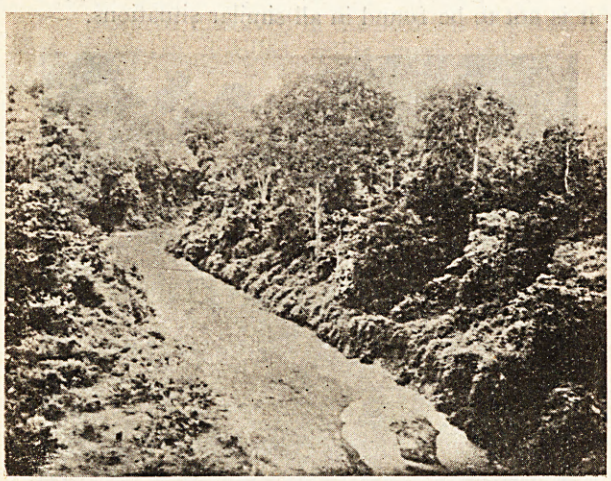

FIG. 2.—The sandy bed of Horu Langpher breeding *A. culicifacies* and *A. maculatus*.

it was not incriminated to the same extent by James, Young, and Fry; and as subsequent anti-malarial measures seem to have eradicated the other species one may conclude that *maculatus*, which still breeds in the bed of the river, is probably responsible for the spleen-index of about 30 per cent. which persists. I am indebted to Drs. Weldon and Leitch for my data.

Challam at Nalbari, in 1920, found no *maculatus;* in 1921, during October and November, a few; and in 1922, after April, some more. He concluded nevertheless that they were not the source of much malaria, in which view McCombie Young concurred. On the other hand, *maculatus* was one of the species which Watson considered to be a dangerous factor in the Doom Dooma gardens. He found it abundantly in January.

I did not find *maculatus* myself very often, only 17 times out of a total of 2,774 catches of all species, and of those most were found in hill-side streams where one would expect the species; however, the paucity of my catch is not surprising when one considers the general lack of suitable breeding places for it in most tea gardens. *A. maculatus* is essentially a stream breeder (fig. 3), or a drain breeder, so that where drains hold spring-water they may be dangerous; it is not a swamp breeder. Watson says, *A. maculatus* lives in the purest water, so it is found in hill-streams, springs at the foot of the hills and banks, and in *bhils*. It is never found out in large flat *pathars* (rice-fields) away from hills, but in narrow valleys in the hills; it may be found in the small *pottahs* or areas which are irrigated by clean water. It is highly sensitive to pollution, or its food is, for even daily washing of clothes at the head of a small valley will drive the insect from the main stream."

With regard to Watson's conclusion that the species must be regarded as one of the chief causes of malaria in the Doom Dooma gardens, it must be remembered that he found it in the months January to March, and as this is not the malaria season its connection with *maculatus* must still be proved. No observer has yet reported it during the malaria season.

Watson says, and I agree, that the species is to be found breeding in pools in the beds of big rivers like the Brahmaputra, but that "big rivers as a rule are not associated with malaria": which proves that the mere fact of finding *maculatus* in any place is not evidence of any connection with malaria there.

The species having such a liking for seepage water is an additional argument against it being very prevalent in Assam or causing much trouble, for the land is generally low-lying and there is not much seepage; what there is will be found

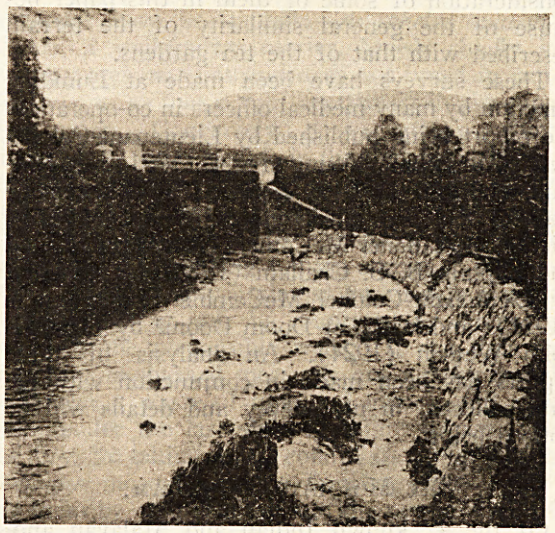

FIG. 3.—*Maculatus* is a stream-breeder.

where the land is more hilly as in Cachar (fig. 4). In such places, in my opinion, it is more likely that *maculatus* is doing harm, although I found no direct evidence of it.

A. CULICIFACIES.

This species has been reported in the Nalbari and in the Lumding survey. At Nalbari it was found in June breeding scantily in rain pools in paddy-fields, but not much importance was ascribed to it. At Lumding it was found by Weldon in large numbers in a tank as well as in pools in the bed of the big river and much of the malaria was put down to it. Unfortunately the season during which it was found breeding was not mentioned.

Watson caught none of the species but in his conclusions thinks that perhaps it is of some importance.

Likewise, during my three months preliminary survey of the tea gardens in 1923, I found none. However there is no inherent improbability that *culicifacies* is a factor in tea-garden malaria. Watson and I caught none because we tried at the wrong season (October to March). The species is a pool breeder like *umbrosus,* so it should be looked for at the advent of the rains

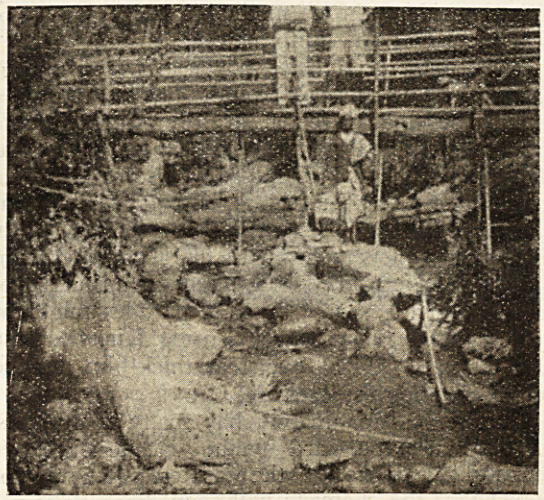

FIG. 4.—*A. Maculatus* will be found where land is more hilly, as in Cachar.

when the malaria season is starting. It is a clean water breeder; seepage or fresh water pools in the beds of streams or drains in the uplands or where subsoil drainage is good are its natural habitat. It would not be found on low-lying lands like the *pathar* level, hence a place like Dibrugarh is not malarious. Drainage eradicates it as it cannot breed in running water.

A. JEYPORIENSIS.

This species, in the light of our present knowledge, need not be seriously considered.

I only found it on one occasion in South Sylhet; Dr. Meek has since sent (from Cachar) a number of specimens caught in August, but as no one during the previous surveys has reported it, it cannot be of any great epidemiological importance.

A. FUNESTUS (MINIMUS) AND A. ACONITUS.

I will deal with these two species together as they are closely related. It is not usual to find them on the *pathar* level; their habitat lies in streamlets of running water edged with grass, (figs. 5-7). The larvæ have the thorax particularly well developed, which enables one to distinguish them from most other anophelines with the naked eye. Watson says they are found in the clearest water, e.g., "in the *bhils.*"

McCombie Young in the Lumding survey and Challam and McCombie Young at Nalbari decided that in these places *funestus* was the chief carrier, while Watson in Doom Dooma concluded that it was of the greatest danger to the tea gardens; he found it in abundance and of adult anophelines caught in houses 45 per cent. were of this species.

FIG. 5.—Streams breeding *A. funestus.*

FIG. 6.—Streams breeding *A. funestus.*

FIG. 7.—Streams breeding *A. funestus.*

I found 136 breeding places out of 1,730 during September to November, 1923, *umbrosus* being the next among the malaria carriers with 29. The species was not found in comparatively non-malarious localities.

It is generally agreed then that this is an enemy of the first importance and this is equivalent to saying that the *streams and irrigating channels of the rice-fields are culpable* (figs. 8, 9).

FIG. 8.—The irrigating channel of a rice-field.

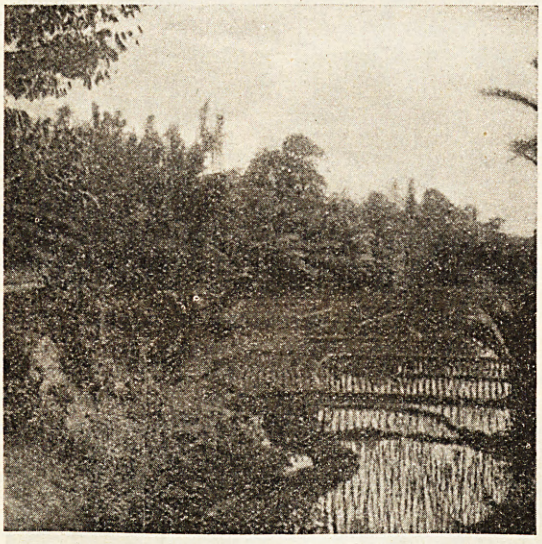

FIG. 9.—Rice-fields irrigated by a side channel, which harboured *A. aconitus*.

CONCLUSIONS REGARDING THE RELATIVE IMPORTANCE OF THE SPECIES.

Of the known malaria carriers which occur in Assam I have concluded then that *funestus* and *aconitus*, represented in the paddy-fields, are very dangerous; that probably during the rains *culicifacies* breeding in pools of pure water is also of danger; that *maculatus* breeding in spring-water cannot on present evidence be incriminated with doing much harm; that *umbrosus* lurks in all undrained jungle which should be viewed with great suspicion; and that *jeyporiensis* takes no important part in the causation of the disease.

MOSQUITO CONTROL.

MEASURES NOT DEPENDENT UPON A MOSQUITO MALARIA SURVEY.

On the subject of mosquito control one may first consider those methods which are not dependent on a mosquito survey.

Sterilising the blood of the carriers of the parasite.—The carriers from whom the mosquito mainly becomes infected are the children, and every effort, I suggest, should be made to treat such children with quinine so as to prevent them infecting the mosquito. A similar principle is observed in the practice of protecting from mosquitos all persons with parasites in their blood, for instance, in screened hospitals or segregating the sick. Parasite parades might be held regularly, once a week, using Knowles' and Das Gupta's (1924) excellent thick-film method for discovering the parasite.

Quinine* unfortunately has many limitations, of which the outward symbol is the excessive malarial incidence of the estates. It is to be hoped that the chemists will soon discover something as effective for the malaria plasmodium as trypan-blue is for *Piroplasma canis*.

Protection from the bite of the insect.—For the European some protection is afforded by the use of mosquito boots and the European in Assam is to be congratulated on his general attention to such matters; but this does not protect other parts than the ankles. For this reason, I strongly recommend the use of mosquito-proofed houses or at any rate proofed dining-room and lounge. *And it is to my mind more important than anything else that clubs should be thus protected.* Nobody who has not lived in a screened house can appreciate its comfort (fig. 10). One objection that is often made against it, is that it is impossibly stifling in the hot weather. Certainly that is so if the screening is fixed, but if it is made to be opened up from sunrise to sundown, my experience is that it does not make the air appreciably hotter.

This measure is of course only applicable to the staff of the estates though I wonder if it would not repay the Companies to give their labour cheap and strong bed nets, starting with those who would apply for them. We all know how the cooly will get under a net except for his feet, but even then his chance of infection is much lessened (and his feet ought to be horny enough to look after themselves).

GENERAL METHODS OF MOSQUITO CONTROL WHICH ARE NOT DEPENDENT ON THE SPECIES OF MOSQUITO PRESENT.

1. *Water-tidiness.*—When any species' breeding-place is "tidied-up" (fig. 11) it is rendered

*I will deal in another place with the so-called quinine prophylaxis.

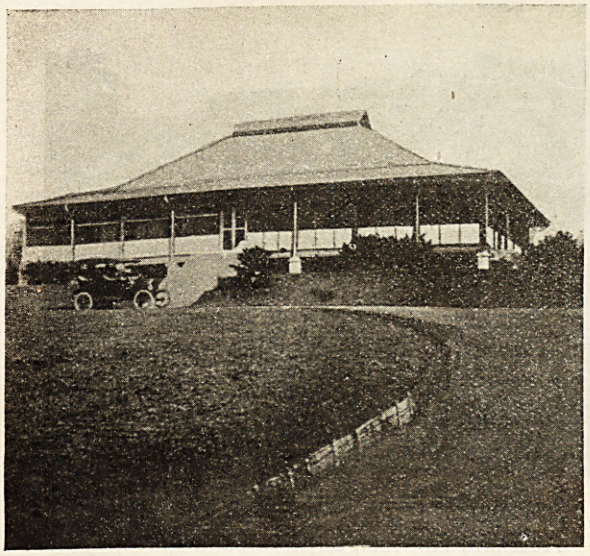

FIG. 10.—A mosquito-proofed bungalow.

FIG. 11.—Water-tidiness, clean-weeding paddy.

less suitable for the life of the mosquito because its protection and food is removed. In pools and ditches of slowly-running water this implies the clearing out of as much debris and foreign matter as possible, also the oiling and burning of all plant life; in streamlets it implies the keeping of the banks and edges clear of vegetation or facing them with concrete (fig. 12) or steps, and "training" or deepening the water-channel to such an extent that plants cannot grow.

Water-tidiness has been the *raison d'être* of the drains put in at Lumding where the old earth drains have been lined with a concrete invert constructed of reinforced concrete and deep enough to carry off the normal drainage and the banks above the drains have been shaped and smoothed down and curved.

FIG. 12.—Water-tidiness, concreting the bed of a hill-stream.

For water-tidiness a mosquito gang under an overseer should be employed.

2. *Subsoil drainage and filling.*—Subsoil drainage will not be discussed here as in Assam it is not "practical politics." Another general measure is filling, but this is expensive. The tank at Lumding was filled. The principle is the same as subsoil drainage, that is, the water is kept underground. In Orissa I have seen shallow natural nullahs, which are prolific breeding-places of certain malaria-carrying anophelines, filled in by the natives to level up the land for rice cultivation; an instance of economics and sanitation going hand in hand.

MOSQUITO CONTROL *vis-à-vis* CERTAIN SPECIES.

There are certain methods of mosquito control which are dependent on the species present.

1. *Open earth-drainage.*—Open drainage implies the confining of all masses of water within regular channels and a fall provided in order to enable the water to run away. There are, however, certain situations where such a scheme is impossible.

Drainage, strange as it may seem, does not appear on the schedule of "measures of general application." Three of the malaria-carriers prevalent in Assam,—*A. maculatus, funestus,* and *aconitus*—are stream breeders, the two latter fast-stream breeders, so what one does by confining collections of water into regular channels is to increase the pace or flow of the water and therefore make it easier for *maculatus, funestus* and *aconitus* to breed. Watson in 1911 demonstrated this; he drained his swamps, whereupon *maculatus*—which is not a swamp breeder—obtained a habitat to its liking and malaria was increased by the measures taken.* And there is no *a priori*

* Incidentally this example may dispose of the ridiculous hypothesis that a species of mosquito driven out of one type of habitat will establish itself in another.

reason to suppose that what happened in Malaya would not happen in Assam, or an even worse thing because here the species *funestus* is so prolific, while it is altogether absent in Malaya. There is no doubt whatever that it is chiefly in the drains dug by the native cultivators for irrigating purposes that *funestus* and *aconitus* are principally found.

There is, however, the possibility that the reduction of the area of water in a *bhil* may countervail the factor just mentioned and the sum-total of *funestus* output might be reduced: drainage systems are now being used with this idea by Watson to control *maculatus* and *funestus* in the Doom Dooma gardens.

2. *Oiling.*—This measure might be considered of general application except for the fact that in fast-running streams the film tends to flow away and collect in midstream so that its influence soon dies away on the grassy borders where *funestus** and *aconitus* are found.

The utility of oiling is really in inverse proportion to the rapidity of exchange of water in any breeding-place whether that exchange is due to surface water running away or is due to spring-water.

In streams I feel that the cost of this measure is out of proportion to the results and if water-tidiness is resorted to the same results would be much cheaper.

When one comes to consider the pool breeders there can be no doubt of the efficacy of oiling. *A. umbrosus* is essentially a pool breeder, as is *culicifacies;* so is *maculatus* if the pool is of spring-water.

In all such places oiling would be very effective, though in great swamps it is impracticable and they must be drained first. For oiling constant supervision is needed and the cost of the organisation would be high even in Assam in spite of (1) the proximity of the Assam oil-fields and (2) the discovery of the use of castor-oil for aiding the spreading qualities. Oiling has been discarded by the Corporation of Calcutta because of the human equation. Moreover where there is any rice cultivation oiling cannot be used.

Larvacides, which may be considered here, are mostly dangerous and possess no advantages over oil. But Balfour recommends for undrainable swamps a "marine soap" manufactured in Marseilles.

3. *Flooding.*—More might be made of this measure. The practice is to throw a dam across a valley when the effect is to create a large body of deep comparatively still water where swamps or running streams existed before (fig. 13).

Danger may ensue at a later stage when silting takes place to such an extent that water plants may take root, or when there is a mass of certain floating water plants. Moreover, seepage below the dam may be a source of danger.

*A. *funestus* lives at the edge of really fast-running streams while *maculatus* lives in little pockets or bays.

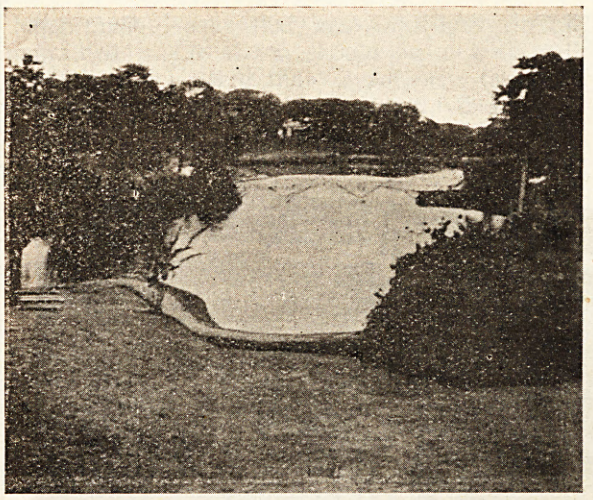

FIG. 13.—"Drowning" a dangerous ravine (Shillong).

At a still later stage the embankment may hold up a solid mass of silt over which the original flow is distributed if it is not retained beneath the surface (fig. 14).

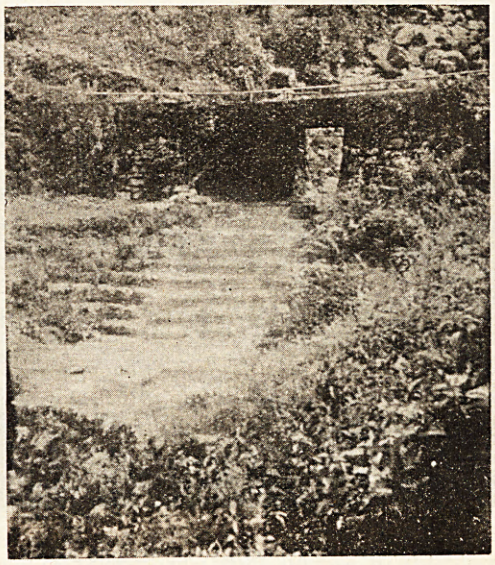

FIG. 14.—At the bottom of the steps is a bed silt held up by a stonework dam.

4. *Jungle-growing.*—This measure is of limited application as there is the danger of *umbrosus* behind it. In Malaya, in parts of the country where *umbrosus* is not found, among the inland hills, where are situated most of the rubber estates, it is the best method of preventing malaria (fig. 15) and it is now, I believe, the law that a permit must be obtained from the Health Department before any jungle is cut. With regard to the "coastal hills," where *umbrosus* is found, I suggested in an unpublished report to the Government of the Federated Malay States (1916) that the *umbrosus* and *maculatus* danger could both be averted by digging drains through the jungle, the only alternative being subsoil drainage which is very expensive.

In Assam I have no reason to suppose that the same procedure would not be perfectly effective, i.e., filling up the "*hulas*" and "*kals*" with

FIG. 15.—The best way of preventing malaria, jungle-growing.

jungle after draining them and then neither *umbrosus, maculatus* nor *funestus* could breed. Of course rice cultivation would be precluded by this measure.

5. *Jungle-clearing.*—This measure should certainly be resorted to where, after the land is cleared, *culicifacies* and *funestus* will not breed. If this would take place the health would probably become worse. Presumably Dibrugarh and certain tea gardens on the so-called *pathar* level were malarious when they were under jungle, but they have been cleared and drained for settlement or planting and are now comparatively healthy. This is what happened in Malaya where Watson had such great success with his early efforts in 1901.

That completes the summary of the more important operations that can be undertaken in a mosquito-control campaign.

Measures of general application:—

1. Therapy.
2. Protection from the insect.
3. Water-tidiness.
4. Subsoil drainage and filling.

Measures that depend on the findings of a mosquito survey:—

1. Open earth-drainage.
2. Oiling and larvacides.
3. Flooding.
4. Jungle-growing.
5. Jungle-clearing.

SUMMARY.

Reviewing the opinions expressed above, one might say that screening houses and especially clubs is very desirable and that an organised attempt at sterilising the blood of the children should be made.

While with regard to other measures, except in places on the '*pathar* level' where clearing jungle should be all that is necessary, one is confronted by something of a jigsaw puzzle which is complicated by the fact that oiling, jungle-growing and flooding are incompatible with rice-growing.

If rice-growing need not be considered then the situation can easily be dealt with by draining and oiling combined, flooding, or by jungle-growing combined with draining.

On the other hand, the only preventive measures compatible with rice cultivation which may be successful are the general measures (except subsoil drainage); none of the special measures given above would be applicable.

The bed-rock alternative is, therefore, which is preferable, the rice cultivation and only perhaps a mitigation of the malarial prevalence, or the rice given up and a non-malarious labour force. I expect many estate managers would say "let us be content with trying to mitigate our condition by means of the general methods." On the other hand, Crawford says "some discipline there must be on every garden in the interests of health."

But the planter must clearly see that if he wishes to control his malaria either on economic or humanitarian grounds he has got to interfere with his rice cultivation.

This rice cultivation seems to be something of a fetish, for in "Castes and Tribes of India" published by the Indian Tea Association, one reads the following passage:—"Facilities for the acquisition of land have in the past been held out as decided attractions to estates which are in the position to grant holdings, either free or at a nominal rent, to the permanent labour force. This factor still, undoubtedly, carries great weight with potential emigrants, but at the same time many instances could be cited, particularly in Upper Assam where *khet* land has never been available, yet labour continues to flock to the estates in all seasons. It might be argued that such concerns are in this fortunate position owing to their strong connections in the recruiting districts, but when we consider the favourable economic conditions that have obtained in the districts during the last three seasons and the fact that sirdars of other estates, having the attraction of *khet* land to offer, have also been endeavouring to recruit, but with comparatively indifferent success, we are forced to the conclusion that the attractiveness of an estate lies, not so much in the offer of material amenities but in a feeling of confidence and faith in the management, in brief, the personality of the Manager."

I have myself seen that many of the gardens in the Doom Dooma District have no *dhan-khet* land and yet the Doom Dooma gardens must procure coolies, for are they not veritable El Dorados? The coolies there seem to be content with patches of *aushdhan* and vegetable gardens, not to mention churches and hospitals with bed

sheets. I ask whether all gardens cannot get on as well as the Doom Dooma gardens, and if not why not?

Doubtless there is no answer, but at the same time let me, for the sake of argument, accept the deep-seated feeling that exists in the matter and see whether anything can be done to cope with the difficulty. The following suggestions might be made:—

(1) That coolies be given their *dhan-khet* at some distance from the lines and the intervening land not rice-cultivated, and the lines concentrated so as to reduce the total non-cultivated area. I am told that the coolie likes to see his rice growing under his very nose, but on the other hand a prominent planter of the Jorhat District, in response to a demand from me that the planter himself should put up suggestions as to how the difficulty should be met, informed me that coolies would be quite content to have their *khets* some distance away. This view seems borne out by the fact that coolies will sometimes leave their *khets* and *bustees* for long periods to work on estates, only returning for the harvest.

If the lines then be concentrated on one side and *dhan-khet* parcelled out to the coolies as far away as possible, the intervening area can be treated to the special measures which are necessary, either flooding, jungle-growing, or draining and oiling.

(2) If that suggestion be not liked another to be submitted is based on our knowledge that it is the small *hulas* which are particularly dangerous, therefore, I would ask that the cultivation of small *hulas* only be given up and if that be not admitted, that at least the very dangerous irrigating channels may be dealt with in accordance with the general principles laid down, though I am afraid the results would be but meagre.

We have now seen whatever is strong or weak in the position, if mosquito control is aimed at. In general, I do not agree with Boyd, who has written:—"The simplicity of the theory, i.e., mosquito control, is too often outshone by the complications encountered in its practice. The problem bristles with difficulties which may be so great as to throw the matter out of court on the ground of impracticability."

It is, I hold, a fact that the problem, in no place where there has been a will to succeed, has presented insuperable difficulties, the only real difficulty having been the finding of money.

Non-Mosquito-Control Measures.

1. *Quinine prophylaxis.*—One must now consider whether that famous prophylactic measure—quinine administration—would be preferable, i.e., quinine given to the whole labour force to prevent their becoming infected by mosquitos. The problem has been analysed by Dr. Hermitte in an address to the Assam branch of the British Medical Association. He came to the conclusion that quinine prophylaxis is efficacious and recommended two doses a night to ensure perfect results as quinine is excreted 8 hours after its ingestion but that only one dose would do a lot of good. On the other hand Dr. Forsyth in his carefully-controlled experiment at Kacharigaon found that with such a system as one would use in ordinary practice it produced no good results.

Hermitte did not mention the very carefully conducted experiments conducted by army officers at Salonika during the war. I think that if British army officers with highly disciplined troops under war conditions came to an adverse conclusion in the matter, their opinion should be regarded as final. Watson's opinion is that for prophylaxis no amount of quinine is of any avail to stamp out the disease. Malaria will not be eradicated unless some medicine vastly more effective than quinine is discovered or mosquitos are destroyed.

In general, therefore, it may be concluded that quinine prophylaxis does not offer sufficient inducement to us to use it rather than mosquito control.

2. *Site selection.*—Site selection is an important rival to mosquito control, but it is expensive. It requires a careful malaria and mosquito survey and a careful calculation as to whether the cost of moving houses, lines, etc., to a new site would be less than mosquito control measures. Certainly, however, when new habitations are being built one should choose the site most carefully and the medical officer should be the first and last man consulted.

Summary.

When comparing the possibilities of mosquito control measures with others, one may summarise therefore that, except for site selection, mosquito control is best. Bassett Smith thinks that the method of destroying the mosquito carrier is evidently a practicable one but that it demands a large amount of co-operation on the part of those whose land is concerned. With intense optimism much can be done. Watson, however, states more forcibly that nothing but mosquito control can give the desired results.

Accessory Measures.

There are certain measures which are quite ineffective in themselves as anti-malarial agencies, but which nevertheless are very important in the general campaign.

1. *Education and propaganda.*—Education and propaganda amongst the directors, the shareholders and the coolies is required.

The cooly, I believe, on some gardens is treated to a cinema show and perhaps he could be "got at" in this way by suitable propaganda.

As for the managers and directors, they have only to be shown reasonably and lucidly what has been accomplished elsewhere to be ready to furnish the sinews of war. In fact they seem to want usually very poor arguments to persuade them to pay up. They are, of course, nervous lest experiments should be conducted and prove costly failures, for unfortunately money spent

on the prevention of malaria has not always been repaid. One way of reassuring them would be, I think, for the Assam branch of the British Medical Association to proceed by resolution from time to time on agreed-upon measures which may be confidently recommended to the public. One resolution for instance might be that in the future lay-out of a garden the medical officer should be consulted; the present lay-out of some gardens showing the necessity for such a proposal. I am sure the directorates would feel that such a proceeding protects them from faddists. I could cite an instance myself of how the executive in Malaya was let down by a highly placed medical officer who thinking, *qua* the lady-novelists, that mangrove forest was deadly got money for cutting it down. He acted in quite good faith, but we now know that such a measure converts a healthy place into an unhealthy one.

We therefore have to educate the people who provide the money. Watson has said that most of his life he had spent in fighting the men who were preventing him from fighting the mosquito. I am very glad to see that something more than virtue has now been his reward.

It now therefore only remains for the directors to vote a large sum of money for propaganda among themselves.

2. *Financing anti-malarial measures.*—I am very strongly of the opinion, which I see has also been expressed by Watson, that the cost of anti-malarial work should not effect the commission of the staff of an estate. If it is made to do so, the practice will act like a dead weight on all the efforts of those who are trying to do some good.

3. *Technical education of the Doctor Babu.*—I think it is an excellent idea that prompts Dr. Hermitte with the sanction of his directors, Messrs. Williamson, Magor & Co., Ltd., to send his doctor babus in a never-ending stream to the School of Tropical Medicine in Calcutta. Every doctor babu ought to have a microscope and know how to use it. If he went to the School of Tropical Medicine he would learn microscopical technique and how to identify mosquitos and parasites.

The school short course is admirably adapted to meet the needs of the tea estates doctor babus; and I am sure that the Director will give the fullest consideration to any suggestions which may be made by the Assam branch of the British Medical Association for making it even more suitable.

4. *Research.*—This must of necessity be largely left to institutions equipped for the purpose. One research suggested above was the looking for chemical compounds which would be better than quinine for clearing the blood of the parasite. The School of Tropical Medicine fulfils such a function and as it is largely dependent on public contributions, it is to be hoped that these will not be stinted.

Conclusion.

I have now surveyed the main points in the malaria problem in the Assam tea gardens and I hope I may have carried the reader with me in my argument.

If we are agreed, it is not likely that the planter will lag behind. His chief problem now seems to be the procuring of sufficient labour. As Crawford says, "To get, and still more to keep, labour is becoming yearly a more and more vital factor." Tea has to compete with the industrial concerns and also with plantations in other countries—Ceylon, Malaya, etc. In the competition Crawford says "The comparative attraction of particular estates will exercise an increasing influence on the labour supply"; the healthiness of a place "where the water is good" is undoubtedly such an attraction. I have myself seen how easy it has been for the healthy rubber plantations in the Federated Malay States to obtain coolies as compared with the unhealthy estates. While coolies on the healthy coast land were getting from 24 to 30 cents a days those in the malarious uplands took 60 to 80 cents.

Countries like Malaya and Ceylon have certainly paid more attention to sanitation than has India in general, so they have obtained a lead in the race which should now be reduced by Assam. It does seem lamentable that a quarter of a century after Watson started his work in Malayan plantations that a start has only just been made in Assam. All the more credit to the Associated Doom Dooma Companies and to Messrs. Duncan Bros. for being the first to make a move.

A development of the labour situation has come about during a generation of planting in that it is now seen that a sufficient labour force may perhaps be brought up on an estate. There is a growing labour force of 1,000 children, aged from 2 to 10 years, on Alinugger Estate in Sylhet. But this is a healthy estate and I doubt whether that would be possible in a highly malarious locality. As Watson says, "Quite apart from the sickness among the men, the women are concerned with the sickness and loss of their children, and where the greatest primal instinct—the maternal instinct—is thwarted, there can be no rest or stability among a people. Loss of, and sickness amongst, children unsettle the women; they blame the water, the food, the air, ghosts, spirits and other more or less real or imaginary causes. They instinctively seek to flee from the place, and what the woman thinks to-day, the man thinks to-morrow. They hear rumours and reports of healthier places and better pay, and as Mr. Ramsden told me, coolies leave here to seek employment elsewhere, but few or none come up here from lower down the valley. On the other hand, if her children are well and healthy a woman is generally loath to move, as she fears for her children in a strange place."

I conclude by saying myself that the motto for the combat should be "save the women and children."

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THE TREATMENT OF MALARIA WITH PERACRINA 303.

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THE MAKERS' ADVERTISEMENTS.

THE Haco Company of Berne, the manufacturers of Peracrina 303, have been kind enough to furnish me with a supply of this preparation for the treatment of persons suffering from malaria. They have sent me, in addition, a number of letters and pamphlets describing Peracrina and its employment in the treatment of malaria. Among these pamphlets were the "Therapeutic News" edited by the Haco Company and a report by Dr. J. Walker on the treatment of malaria with Peracrina, which was published originally in the *Archiv für Schiffs- und Tropen-Hygiene.*

The following information was contained in the pamphlets:—When Dr. Walker went out to the famine districts of the Volga, with the Swiss Red-Cross, the Haco Company gave him a supply of Peracrina to be used as an intestinal antiseptic. It did not prove to be of value for this purpose but to the surprise of the physicians attached to the expedition "it was found to be at least equal to quinine in the treatment of malaria."

The makers describe Peracrina 303 as "the chemical compound of an acridine dye stuff with a specific albuminate prepared according to a patented process. It is made up in sugar-coated pills each containing 7.7 grains." The dose recommended is eight pills per diem for children between nine and sixteen years of age, and twelve pills a day for adults; but it is added that "small doses of Peracrina have worked with great success, very serious cases of adults and older children have been cured by doses of two to four pills." It is recommended that the pills be taken before meals at the rate of two pills at a time. The Haco Company advertise that Peracrina does not speedily reduce high temperature, but, if systematically employed, it cures malaria completely and permanently. A complete course of treatment lasts from three weeks up to three months, for it must be continued for a fortnight after an examination for plasmodia in the thick blood film has given a negative result. .....It is sometimes observed that during the first three weeks of treatment, the blood test shows an increase of plasmodia and during the same period the temperature has a tendency to rise occasionally. These symptoms need not cause anxiety.....The Haco Company, Ltd. are willing to give to every physician the opportunity of judging for himself.....Upon receipt of a money-order for two pounds, 400 Peracrina pills in two registered sample-packages will be sent to you. They should be sufficient for the treatment of an average test case of chronic malaria."

Dr. J. Walker claims to have treated seventy-two cases successfully with Peracrina, and, as illustrations, he reproduces the clinical histories of three cases, namely, Dollimanowa, Peredumowa and Assuna.

Case 1.—Dollimanowa. A case of acute benign tertian malaria. Peracrina was administered from the outset, and the treatment was continued for more than three months. The patient had six paroxysms in the first fortnight, the last was on the fourteenth day. She had no more fever during the rest of the time she was kept under observation, but malarial parasites were found at each of twenty-one examinations made during the first eighty-six days of treatment; the last occasion on which they were found being the eighty-sixth day. During the next eighteen days three examinations were made with negative results.

Case 2.—Peredumowa. A case of chronic benign tertian malaria. This patient had occasional attacks of fever up to the sixteenth day of treatment. The blood was examined twenty-nine times during the first two months, with positive results on twenty-one occasions. Schizonts were found on the sixty-second day of treatment. No parasites were found during the next fifteen days.

Case 3.—Assuna. A case of mixed tertian malaria. The patient had occasional attacks of fever up to the forty-ninth day of treatment. The blood was examined twenty-six times during the first eighty days, with twenty positive results. Trophozoites were present on the seventy-eighth day. Three negative examinations were made during the next thirteen days.

A CRITICISM OF THE ADVERTISEMENTS.

(1) *The composition of Peracrina* 303.—The makers state that Peracrina is a chemical compound of acriflavine with a specific albuminate. The pills which I received from them consist of a soft, brown, granular substance enclosed in a brown, sugary coating. When some of the granular substance was put into water, it did not