Instructions for the prevention of malarial fever : for the use of residents in malarious places / [Ronald Ross].

LIVERPOOL SCHOOL OF TROPICAL MEDICINE

Instructions for the Prevention of Malarial Fever

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by Sir Ronald Ross ?

LIVERPOOL SCHOOL OF TROPICAL DISEASES. MEMOIR I.

INSTRUCTIONS

FOR THE

PREVENTION OF MALARIAL FEVER

FOR THE USE OF RESIDENTS IN
MALARIOUS PLACES

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INSTRUCTIONS FOR THE PREVENTION OF MALARIAL FEVER.

1. The Nature of the Disease.—Malarial Fever or Ague is caused by certain minute parasites which live in the corpuscles of the blood, and are called *Hæmamœbidæ*.

In order to produce an attack of fever, about 250,000,000 at least of the parasites must be present in the body; while in severe cases there may be as many as a billion or more. If they are present in sufficient numbers, they can easily be found by the aid of a strong microscope in a small drop of blood drawn from the patient by pricking his skin with a needle. Sometimes however, when the patient is not actually getting fever, they may exist in such small numbers that they cannot be readily detected in this manner.

The sudden rises of temperature which occur in this disease, and which are often accompanied by shivering (ague), are due to the parasites scattering their spores in the blood-fluid. The parasites grow up together and scatter their spores, or "eggs," simultaneously; and it is at the moment when they do so that the shivering or rise of temperature begins. The spores then occupy fresh blood-corpuscles; when the fever gradually ceases and sweating comes on. After one, two, or three days, a fresh attack of fever occurs, owing to the fact that another batch of parasites, many millions in number, have reached maturity and have scattered their spores.

After a variable number of such attacks, the parasites may largely decrease in number, when the patient loses his fever for a time and feels better. At any moment, however, the number

of parasites may increase again, either spontaneously or because the patient has exposed himself to the sun, or to chill, fatigue, and so on. Such relapses may occur even many years after the patient has left the malarious locality where he acquired the original infection—as, for instance, after his return from Africa to England. Between the relapses the parasites continue to live in him in comparatively small numbers; but, of course, after they have once become quite extinct, no relapses will occur—unless as the result of a fresh infection.

Besides fever, the parasites often cause other symptoms, such as enlargement of the spleen, anæmia, and darkening of the skin.

Quinine kills the parasites.

2. How Parasites in general Live.—Men, animals, or plants in which parasites live are called their *hosts*. All parasites or their eggs pass, in some way or other, from one host to another—that is, from an infected man, animal, or plant, to a healthy one. Parasites have many different and, so to speak, ingenious ways for effecting this transference. A large number of them employ *a second species of animal* as a go-between. Thus *tape-worms* and the worms which cause *trichinosis* live a part of their lives in swine as well as in men. Swine eat human offal, and men eat swine; and these parasites thus transfer themselves alternately from the one to the other. Insects are often employed in this manner. Thus dogs often have a minute worm in the blood which enters the dog's flea, and returns to the same or another dog when this flea happens to be swallowed. Again, *guinea-worm* is carried by a water-insect; and the worm which causes *elephantiasis* is carried by mosquitoes. We know also two important diseases of cattle, called *Tsetse-fly disease* and *Texas tick-fever*, which are carried, one by the Tsetse-fly and

the other by the cattle-tick. The fact is that these suctorial insects give great facilities to parasites for passing from one host to another.

Like other parasites, the parasites which cause malarial fever must pass from one host to another—that is, must manage somehow or other to enter fresh persons to live in. Long ago it was thought likely that they too are carried by insects; and this has now been definitely proved to be the case.

3. How we get Malarial Fever.—It has been stated that the malaria parasites, the *Hæmamœbidæ*, are easily detected by the microscope; in fact they have a very distinctive appearance. If, now, we allow mosquitoes of the kind called *Anopheles* to bite persons infected with malaria parasites, and if we then dissect these mosquitoes, we shall easily be able to find the parasites growing also in the mosquitoes. If, on the other hand, we allow a hundred, or two hundred, or a thousand, of the same kind of mosquitoes to bite healthy persons, we shall find nothing like the parasites in them.

It is easy to watch the development of the parasites in the *Anopheles* by dissecting the latter at various intervals after they have been fed. The parasites are of course sucked into the insect's stomach. From this they burrow into its body-tissues, in which they live for a week or more, and grow rapidly. On reaching maturity they produce a swarm of young, which, most remarkable to relate, enter the *poison or salivary gland* of the insect. Everyone knows the itching caused by the bite of mosquitoes. This is due to a minute drop of an irritating fluid which is injected by the insect into the wound made by its proboscis. The irritating fluid comes from the salivary gland just mentioned, and may also contain the young of the malaria parasites. Hence these young must be injected into

the wound made by the mosquito's proboscis, just as a bacteriologist injects bacteria by means of a syringe into a rabbit for experiment. When so injected, the young of the malaria parasite set up infection.

That this is the case has been absolutely proved by a number of experiments made in India and Italy, and there is no doubt about it. Healthy men are attacked with malarial fever after being bitten by infected *Anopheles*.

These investigations have been repeated and confirmed by many men of the highest scientific ability ; and are accepted as true by the leading experts on malaria.

It has thus been proved that malarial fever, like all other parasitic diseases, is really a *catching complaint* ; that is, it is communicable from the sick to the healthy by the agency of mosquitoes of the kind called *Anopheles*. These mosquitoes bite a patient suffering from malarial fever, and after a week or more convey the parasites into healthy persons by their bite.

4. Some Obscure Points explained.—Of course it is only the *first infection* of a patient which is caused in this manner. As already mentioned, after he is once infected he may suffer from relapses for years—relapses which have nothing to do with mosquitoes. People who are ignorant of this often doubt the facts given above, because they find that they still get fever in places—such as England—where there are no mosquitoes.

Other objectors point out that mosquitoes exist where there is no malaria. They forget that only *mosquitoes of a certain kind* carry malaria (so far as is known at present). The harmless kinds of mosquitoes may therefore abound in a place without affecting the argument. Others say that malaria exists where there are no mosquitoes. Not a single instance

of this has yet been recorded after sufficient investigation. A third class of objectors say that they have become infected without being bitten by mosquitoes. But it is certain that one can be bitten without knowing it, or observing any mark afterwards—especially if one is bitten during sleep; while it is easy to overlook the presence of *Anopheles* altogether.

But it may now be asked, If malarial fever is only carried from man to man by mosquitoes, how comes it that the disease is connected, as we know so well it is, with stagnant water, rainfall, or disturbed soil? The answer is a very interesting one. It is because the *Anopheles* do not breed in vessels of water, tubs, and so on, in which the ordinary kinds of mosquitoes breed, but as a rule only in *stagnant puddles of water on the ground*. Such puddles most commonly exist in low-lying flat localities, especially where the ground tends to be marshy, and, of course, during continuous rains. They also accumulate in places where the ground has been excavated, embanked, or trenched. Hence it is easy to see how the idea that malaria rises from marshes got about; and, of course, people formerly tried to explain the facts by the supposition that malaria is a miasm or mist which rises from damp soil. There is, however, no longer any reason at all for believing in malarial mists, and so on. The germs of malaria themselves do not rise from the soil. It is the *carriers* of the germs, the *Anopheles*, that do so—or rather, that rise from pools of water on the ground.

This fact also explains why draining the soil so often removes malaria—because it drains away the breeding-pools of *Anopheles*.

One other question requires mention. It is often thought that malarial fever may be acquired by travellers in uninhabited places. In such cases it is possible that the *Anopheles* may

convey the parasites from lower animals ; and in fact monkeys, bats, and birds are known to have parasites closely like the parasites of malaria in men, and belonging to the same zoological family, the *Hæmamœbidæ*. It is open to doubt, however, whether infection can really be acquired in uninhabited places ; although, of course, relapses often occur to travellers in such places as elsewhere.

It is right to state that we cannot yet say with absolute certainty that infection is produced *only* by mosquitoes, but there are numerous reasons for doubting the existence of any other route for infection ; while, at all events, the mosquito theory will help us to prevent a great deal of fever.

5. Facts about Mosquitoes.—Mosquitoes are zoologically the same as gnats.

They do not originate from grass and trees, as some people think ; but from those little wriggling brown creatures—called *wigglers*—which are found so commonly in tubs of water, and wriggle to the bottom on being disturbed. These creatures are the *larvæ* from which mosquitoes develop, just as butterflies develop from caterpillars.

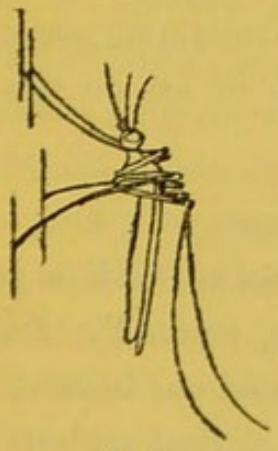
The larvæ *must* live in water. They take about a week to grow from the egg to the chrysalis stage, called the *pupa*. The pupa lives for one or two days, also in water ; and then the adult winged insect rises from it and flies away.

The adult mosquitoes do not live only for one day, as people think. They may live for *months*, and have been kept alive in glass tubes for ten weeks. In Italy they can hibernate all through the winter. They feed on fruit, birds, animals, as well as on men ; but only the females suck blood, the males living on fruit, and possibly leaves. After feeding on a man or animal, the female generally sleeps gorged all day on the wall of

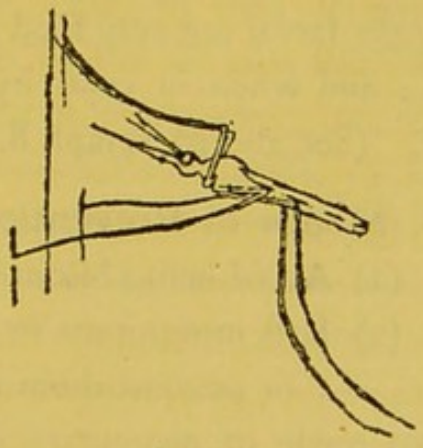
a room or other place. Every few days she has to fly back to the water where she lived as a larva, or to some other suitable spot, to lay her eggs; and returns afterwards, probably to the place where she first obtained food. Hence mosquitoes which feed on human beings generally breed in water *close to houses.*

Gnats and mosquitoes are scientifically known as *Culicidæ.* We already know some 200 species. These are divided into several groups called genera. The commonest genera are called *Culex* and *Anopheles;* and it is important to know how to distinguish between them, because *Anopheles* carry malaria, while *Culex* appear to be harmless. This can be done by anyone at a glance.

Anopheles have a slim, elegant body, shaped like that of a humming-bird moth; a small head, and a long, thick proboscis. When seated on a wall the axis of the body is almost at right angles to the wall; and they generally have spotted wings. *Culex* have a coarser body, with a thick *thorax* or chest, and a thin proboscis. When seated on a wall the tail hangs downward, or even points a little toward the wall; and the wings are generally quite plain. The following drawing shows the characteristic attitudes adopted by these two kinds of insects when seated. Observe also that the wings of the *Anopheles* are spotted along the front edge.



Culex.



Anopheles.

The larvæ of the two kinds are equally different from each other. Those of *Culex* float when at rest on the surface of the water, suspended by their tails, and with their heads hanging downward; and when disturbed they wriggle at once to the bottom. But those of *Anopheles* float flat on the surface of the water, like sticks; and when disturbed, wriggle *on the surface* with a backward *skating* movement. Then the larvæ of *Culex* are found almost entirely in *artificial* collections of water, such as tubs, pots, broken bottles, cisterns, and drains; while those of *Anopheles* prefer *natural* collections of water, chiefly rain-water puddles which do not dry up too quickly, which do not contain small fish, and which are not liable to be scoured out by heavy rain; and may also be found sometimes in small ponds and submerged rice fields.

With a little practice anyone can learn to distinguish between these kinds of mosquitoes at sight. It is interesting to keep the larvæ in bottles half full of water; they soon hatch into adults. The adult winged insects can easily be caught alive when seated asleep on a wall, by placing the mouth of a bottle *slowly* over them; and if a little water be put in the bottle they will soon lay their eggs in it.

Males can be distinguished from females by their possessing feathery *antennæ* on their heads. It should be added that *Anopheles* larvæ are very fond of puddles containing green water weed; and when in captivity require to be fed on this green weed. (See also paragraph 8.)

6. Modes of Prevention.—We must

(1) Avoid being bitten by mosquitoes as much as possible.

(2) Kill mosquitoes or their larvæ, especially *Anopheles*; or prevent them breeding round our houses.

No mode of preventive inoculation against malaria is yet known.

7. **How to Avoid being Bitten.**—Unfortunately this is not always possible, but a careful person can certainly avoid being bitten to a very large extent; and the less one is bitten the smaller are the chances of infection.

Mosquito nettings on the bed should invariably be used in all malarious countries, even when night punkahs are available, and during the hottest weather. They are often employed in a very unintelligent manner. French nets and nets hung from rings should be avoided, because they fall round the bed in heavy folds, which are hot and close. The nets should be square, should be hung inside a framework, tucked carefully under the mattress all round, and stretched tight so as to allow air to pass through easily. The roof should be made of netting like the rest of the net, and not of longcloth. No rents, holes, or apertures should be allowed, and the net should never hang loosely round the bed down to the floor; because mosquitoes can find their way through the smallest opening. The mesh may be large, except when sand-flies are present, because mosquitoes cannot get through ordinary meshes. The hands and feet are often bitten by being thrust against the net during sleep; this can be prevented by having a loose frill or valance sewn on the net a foot above the mattress and also tucked under it. Where punkahs are available they should swing above the mosquito net. Nets should be generally used for afternoon sleep as well as at night. On getting into bed, one should slip inside the net as carefully as possible, in order to avoid giving ingress to mosquitoes as well. If mosquitoes are found inside the net next morning, it is due only to carelessness. Servants should be instructed to let down the nets before dark, and to tuck them carefully under the mattress. Close attention to these details will save much sickness.

Punkahs should be employed as much as possible, as they are in India. *Anopheles* often bite in the day time, but are kept off by the use of punkahs. Flannel socks, in preference to cotton ones, preserve the ankles. Oil of lavender and some patent medicines are often recommended for keeping off the insects; but are not to be implicitly trusted.

Numbers of people fancy that mosquitoes will not bite them. The truth generally is that they do not feel the bites, to which some individuals are very callous. Such fancies seldom stand the test of experiment, and persons who entertain them are often the victims of chronic malaria.

Care in the exercise of these precautions should be redoubled in houses where *Anopheles* are present; and also by travellers when they are obliged to sleep in hotels, rest-houses, or the houses of natives, where old infected mosquitoes may often abound.

Patients suffering from fever, or who have lately suffered from fever, should always remember that they are capable of spreading the disease to others through the agency of mosquitoes, and are even capable of *reinfecting themselves* through the same agency. They cannot therefore be too careful to avoid being bitten. This fact should also be remembered by those who live in the same house with patients, and are therefore especially liable to catch the disease from them.

8. How to Destroy Mosquitoes.—These precautions against being bitten should always be taken in malarious places; but at the same time people should try to rid their houses of mosquitoes as much as possible; and experience shows that this can generally be done to a very large extent in most places by the exercise of a little care and common-sense. The fact is

that the presence of many mosquitoes in a house is generally a sign of slovenly housekeeping, just as the presence of other vermin is, and is almost always due to the stupidity or laziness of the inmates.

It has been mentioned (paragraph 5) that, as a rule, man-eating mosquitoes like to breed close to houses, and that *Culex* larvæ live in *vessels* of water, and *Anopheles* larvæ in *pools*. The first thing to do is to search carefully in and round the house for vessels and pools of water; and if there are many mosquitoes in the house, we may be almost sure that we shall presently find their larvæ somewhere close by. Thus *Culex* larvæ swarm in any old tub or pot of water; in broken bottles, old gourds, flower-pots, cisterns, garden fountains, and even in buckets of water kept for cooling soda-water or washing plates; or in those small tins of water placed beneath the feet of tables and meat-safes to keep ants away. They may also swarm in drains and small ditches. To find the larvæ, all that a person has to do is to go and look for them in places like these; he is sure to come across them almost immediately, and will recognise them at once from the descriptions in paragraph 5. [We often find little red, worm-like creatures mixed with the mosquito larvæ; these are not mosquito larvæ, but the larvæ of *midges*.]

To find *Anopheles* larvæ we must generally go further afield. Small pools on the ground containing green water-weed, especially rain-water puddles by the side of roads and paths, are their favourite haunts; but they may also be found in puddles on the surface of roads, or in hollows in rocks, in old wells, in drains, in small ponds and rice-fields, or even in "sloppy" ground amongst grass, or round stables or cattle byres. To find them we must simply *go and look for them*; and this should always be done if adult *Anopheles* are seen in the house, or even if they are not actually seen but if fresh

cases of malaria are occurring close by. Stables and servants' go-downs are very favourite haunts for adult *Anopheles*.

Now in order to kill mosquitoes wholesale, it is necessary only to destroy their larvæ. This is generally a very easy matter, especially in regard to *Culex*. We have only to go round the premises at least once a week and to *empty out all pots and vessels containing stagnant water*, and also *to brush out with a broom all puddles containing larvæ*. As the larvæ take about a week to mature, this procedure will generally be enough to keep the insects away; but, at the same time, it is necessary to *prevent water collecting anywhere near the house*. These duties should be attended to by reliable persons, and *should not be left to native servants*.

If mosquitoes are numerous in a house, they will generally be found to be *breeding just outside the windows*. Hence people can generally keep their houses comparatively free of these pests simply by *attending to their own premises*. It often happens in towns, however, where houses are crowded together, that a neighbour is so obliging as to breed thousands of mosquitoes daily for the supply of the adjacent dwellings. In such cases a copy of this pamphlet may be sent him, with any remarks which may be considered suitable; and if he does not attend to these, the local municipality may be referred to.

Generally speaking, great stupidity is shown in towns in warm countries with regard to the absence of all check to the breeding of mosquitoes. Prominent citizens should lay the matter strongly before municipalities; and all municipalities should employ at least one special agent for the destruction and prevention of mosquitoes.

But while small collections of water can easily be emptied out or brushed away, it is often more difficult, perhaps sometimes impossible, to deal with the larger collections of water in which

mosquitoes, especially the dangerous ones, breed. In such cases the following measures are to be used :—

(1) All useless collections of water in which mosquitoes breed should be filled up or drained away, if this can be done at a reasonable cost.

(2) If this cannot be done, recourse must be had to the *habitual* use of *culicicides*.

It is unnecessary to discuss methods of draining or filling up stagnant pools; but the subject of culicicides requires close attention. The simplest culicicide is *oil*—especially kerosene oil (paraffin). This, if sprinkled on the surface of water, produces a fine film, which destroys the larvæ by choking their air-tubes, or perhaps by annulling the surface-tension of the water. But the film must spread all over the surface of the water, and must last for at least half an hour. The oil can be best applied by "painting" the pool with a rag fixed on a stick and first dipped in a pot of oil ; in this manner numbers of pools can be dealt with in five minutes at the expense of very little oil.

Perhaps more permanent oils than kerosene would be more permanently effective. Fresh tar dropped in a puddle makes a film like that of oil, and has been favourably reported on. Quicklime has been suggested ; and all these should certainly be tried. But the ideal culicicide still remains to be discovered. It should be some cheap solid substance or powder, which, even when in very small quantity, kills larvæ without injuring higher animals, and which dissolves so slowly in water that it will render a pool uninhabitable for larvæ for a long time.

Whatever fugitive culicicide is used, it must be used at least once a week. Cisterns and wells of drinking-water should be kept covered in as much as possible.

It is sometimes impossible to find the breeding-pools of *Anopheles*, even where the adults are numerous in a house. This is especially the case when there is much rank vegetation round the house. Here much good can be done simply by killing the adult insects as they sleep on the walls during the day time. Fly-flappers should be used; it is dangerous to kill mosquitoes with the hands, because the insects sometimes contain parasites which cause elephantiasis.

9. Houses for Europeans in the Tropics.—These should, if possible, be built on high or sloping ground, and far from *Anopheles* pools. They should not be crowded together. They should be distant from native quarters. Each should be surrounded by a large open compound, from which all rank vegetation should be cleared away. In damp, malarious places they should be built of two storeys. Trees should not be allowed very near the house. The premises should be kept entirely free of stagnant surface-water. Wells should be kept covered. Flowers should not be placed in pots in the verandah.

10. Malaria on Ships.—*Anopheles* often come on board ships from the shore in large numbers, and may then live on board for weeks. They may bring the infection with them when they arrive; but it is more probable that they spread the infection from sick men or coolies already on board the ship. The following measures should be adopted:—

(1) Sick coolies should be banished.

(2) Sick men should sleep in mosquito-nets, even for weeks after they have recovered from the actual fever.

(3) Every day men should be sent round the ship, especially into the sleeping cabins and crew's quarters, to kill all the mosquitoes they can find.