MALARIA AND THE ARMY

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INTRODUCTION

Great reductions in the strength of the Armed Forces have taken place during the past two years and further reductions are anticipated. It is, therefore, as important now as ever it was during the war to conserve the health of the troops and to keep at a minimum the amount of preventable sickness if the best use is to be made of the available military man-power.

In the tropics and sub-tropics malaria is one of the chief causes of admission to hospital. The curtailment of this wastage is the responsibility of every officer and man. The Medical Services by education in the preservation and advancement of health can show the way to attain this objective. By the institution and supervision of malaria control measures they can make the way easier, but in every case final success will depend upon individual effort.

During World War II the conquest of malaria was an essential preliminary to the defeat of the enemy in certain theatres of military operations. So great was the necessity to protect the troops from the ravages of the disease that highly elaborate and comprehensive anti-malarial organizations, modified to deal with the malaria problems and the type of warfare peculiar to the terrain concerned, were instituted in the various commands affected. The highly trained scientific and technical staffs belonging to these organizations were available, not only to advise unit and formation commanders concerning the malaria situation, but also to initiate, carry out and supervise the multiplicity of schemes aimed to reduce to negligible proportions the malarial hazards confronting the troops. Labour, equipment, and supplies on a scale never before thought of in the military control of malaria were mobilized to fight the disease. The discoveries by teams of specially employed research workers in this country and in the U.S.A. were made available and applied to the conditions in the field as soon as their efficacy was determined. Thanks to the many concerned malaria was overcome for the time being and the way to victory was made easier.

Since the end of the war the anti-malarial organization has been dissolved. Malaria laboratories and control units have been disbanded. The medical responsibility for malaria prevention now rests directly, as it did before 1939, on the hygiene authorities and on whatever assistance they can call upon in the malarious stations overseas.

Unlike yellow fever, the other important mosquito-borne disease, in which one inoculation of a potent vaccine will give complete protection for four years
and in many cases renders other means of prevention unnecessary, no such simple single method has yet been discovered for the control of the protozoal infections. The discovery of the newer insecticides and synthetic drugs, although making certain lines of approach to malaria prevention more successful, has not simplified the way to malaria eradication. The time-consuming and laborious methods of survey and control used by Ross and the pioneers who followed him are just as essential to-day if malaria is to be controlled scientifically and economically.

In order, therefore, to meet our present malarial commitments, the high standard of malaria control achieved during the war years must be maintained. It is the purpose of this paper to give an outline of the means at our disposal whereby this objective may be attained.

The principles of military malaria prevention and their practical application are described. The duties of the various medical officers, who may be immediately concerned when malaria is prevalent, are mentioned in brief. A scheme is set out which may serve as a guide to assist those who may be concerned with the management of an outbreak of malaria. For the sake of completeness two appendices, referring to entomological methods and office organization, are included. The subject is viewed chiefly from the angle of the Deputy Assistant Director of Hygiene (D.A.D.H.) because in the absence of a malariologist or a station anti-malaria officer, he will be directly concerned whenever an outbreak of malaria occurs. It will then be his duty to visit the locality, inquire into the causes and advise as to preventive measures [1]. A brief account of the transmission of malaria is included in the next section in order that certain points in the text may be made clearer.

THE TRANSMISSION OF MALARIA

In order that malaria may occur there must be a reservoir of the parasite, a carrier, and a susceptible individual. This is the chain of infection.

The reservoir consists of humans with the sexual stages of the parasite circulating in the peripheral blood. In stations overseas the local inhabitants, and especially the small children, constitute the main reservoir.

The carrier is a female anopheline mosquito which has access to the human reservoir. She must be a species which will feed readily on humans and one in which the parasite will develop. Local conditions must be such that she can multiply readily and live long enough for the parasite to go through all its stages in the mosquito. The temperature range must be suitable for the parasite.

The susceptible individual is a person who is not resistant to infection. To contract malaria he must be bitten by an infected mosquito.

THE PRINCIPLES OF MALARIA PREVENTION

A. The Military Aspect

The approach to the problem of malaria prevention in the Army is simplified in that the population concerned is basically fit, more subject and accustomed to discipline, and, except when military families have to be considered, is composed of a limited age range. In addition, accurate morbidity statistics
are obtainable which enable the effects of any control measures to be promptly determined.

There are certain disadvantages. A military population is not always static. In many cases anti-malaria measures must be maintained when the troops are in transit. They often have to be instituted at short notice and be of a temporary nature. Small scattered groups or detachments, whose protection is as vital as that of the main body, may have to be considered. Under these conditions and on active service more reliance has to be placed on individual cooperation than would be necessary or practical among a civil population.

B. The Army Policy

The prevention of malaria in the Army can be based upon three considerations in the following order of importance:

1. Freedom from Infection: Troops and their families must not be permitted to become infected if at all possible. This is the ideal at which to aim and is prevention in its purest sense. It includes the avoidance of malarious areas, the establishment of control measures before the risk is encountered, and the education of all in the methods of personal hygiene.

2. Eradication of the malarious focus: Circumstances may be such that malaria is taking a toll of the military man-power and undermining the health of the troops and their families. Steps must now be taken to remove the source of the infection by the prompt institution of control measures.

3. Maintenance of efficiency: When for military or other reasons the above conditions are impracticable and infection cannot otherwise be prevented, the use of drugs, to prevent the disease or to maintain it at a subclinical level, may have to be employed.

C. The Means of Prevention

Malaria can be transmitted successfully under conditions in which the many aetiological factors vary in character from place to place. In prevention, therefore, no hard and fast rules can be laid down which will apply to each and every problem. Before any plan to combat malaria can be put into force, a survey of the malaria situation is essential in order to determine the most appropriate line of action. A malaria survey is always the first step to be taken in any campaign against malaria [2], and for this reason is included in the following classification of the means at our disposal for the prevention of the disease: (a) Survey; (b) Control of the mosquito; (c) Control of the parasite; (d) Control of the human factor.

(a) Survey.—A malaria survey is an examination of all the ascertainable factors likely to determine the occurrence, spread, and effects of the disease in a given community. The thoroughness with which this can be done will depend chiefly on the military situation, the size of the area, and on the time, staff, equipment and laboratory facilities available. It is convenient to consider a malaria survey as consisting of two parts:
(1) A general investigation which will of itself yield information of considerable value. It must be carried out in every malaria survey and is always a necessary preliminary to further investigation. The methods employed are those that fall within the scope of every hygienist. They include the usual methods of investigating an infectious disease as well as the application thereto of the more widely known facts of malaria transmission such as the average duration of the incubation period, the broad outlines of the life-cycle of the mosquito, and the fact that the risk of infection is usually greatest during the hours of darkness.

(2) A special investigation is necessary to determine the finer epidemiological points which may have an important bearing on the prevention and control of the disease. It is also necessary whenever it is intended to take offensive action against the mosquito in order that the most suitable anti-mosquito measures may be applied when and where they are likely to do most damage. For a special investigation a highly trained and well-equipped staff is essential as special methods of procedure and technique may have to be employed. A special investigation may be required to consider:

(i) The identification of the various mosquitoes in an area. The determination of the chief vector by dissection and precipitin tests and its precise habits in all its stages.
(ii) The determination of the intensity of malaria in an area. The presence or absence of immunity in the local population. The study of the effects of the disease on social, economic and other human conditions in so far as they affect the Army.
(iii) The elucidation of facts outside the scope of a general investigation.

The part played by a special investigation in the institution of a general anti-mosquito campaign is described in Appendix I.

(b) The Control of the Mosquito.—In an anti-malaria campaign, measures directed towards the breaking of the mosquito link in the chain of infection are those likely to be accompanied by the most success [3], and for this reason will be discussed in detail.

These measures may be classified as offensive or defensive depending on whether they are concerned with the liquidation of the mosquito or her exclusion from a human blood meal. In theory, the prosecution of one or other course should result in the disappearance of the disease, but in practice this is rarely possible and one approach has to be supplemented by the other.

The conquest of malaria in Brazil in 1940 is the only record in history where vigorous anti-mosquito measures brought about the eradication of the disease by the total extermination of the vector, Anopheles gambiae [4].

Wherever malaria is prevalent the vector population must invariably be large [5]. Protection against the bites of mosquitoes to the exclusion of all other measures will not result in freedom from the disease [6], especially where the number of persons at risk is large.

On the other hand, the complete annihilation of an anopheline population is never a practical proposition from the military point of view. The best that
can be expected is a diminution in the numbers of mosquitoes to such a low level that the risk of infection will be reduced accordingly. Superimposed protective or defensive measures ought then to be sufficient to keep the incidence at a minimum.

In the Army, malaria prevention depends chiefly on the combination of these two means of mosquito control—the proportion contributed by each depending on military circumstances.

In Table I are set out only those measures which have been found most useful in military practice and are of general application. A fuller description is given below.

**TABLE I.—Mosquito Control. (1) Offensive Measures**

A. Measures directed against the adult stages of the mosquito.
   (a) Immediate Killing.
   (b) Delayed Killing.

B. Measures directed against the aquatic stages of the mosquito.
   (a) Temporary measures.
      (i) Oiling.
      (ii) Dusting.
   (b) Permanent measures.
      (i) Filling-in.
      (ii) Drainage.
      (iii) Clearing.

(2) Defensive Measures

A. Those for which the individual soldier is responsible.
   (i) Nets.
   (ii) Clothing.
   (iii) Repellents.

B. Those for which the military authorities are responsible.
   (i) Siting.
   (ii) Screening.

Measures directed against the adult stages of the mosquito consist chiefly in the use of insecticidal solutions in the form of a spray. The habits of the mosquito attacked must be understood so that the spray may be applied where it is likely to be most effective. In all cases not only must the area to be protected be treated, but also, where possible, the zone outside to a depth equal to the effective flight range of the particular mosquito concerned. In some cases where the vector is a strong flier, or where the military units are greatly dispersed, this zone might cover 9 or 10 square miles.

For immediate killing a fine spray containing substances, such as the pyrethrins, which are rapidly toxic to mosquitoes, is used. The spray is delivered in the form of a fine mist.

The best results have been obtained against the domestic species of mosquitoes in their daytime shelters such as barrack rooms, native houses and tents. This is one of the most successful means of cutting short an outbreak of malaria [7]. It is also employed in malaria control schemes before the other methods of mosquito destruction have had time to become effective. It is the method used in the disinsectization of aircraft, motor vehicles and railway trains which may import mosquitoes from malarious areas.
Delayed killing: The scope of spray killing has been extended by the introduction of DDT and Gammexane. Mosquitoes landing on surfaces treated with these substances are killed in a short time. The surfaces retain their lethal effects for many months. It is thus possible to treat the daytime shelters of the wild species as well as all other surfaces, both indoors and outdoors, where mosquitoes may rest for even a brief period. The effect of such sprays depend, among other things, on the species of mosquito concerned, on the strength of the solution as well as the solvent used, on the character of the surface treated, and on the local climatic conditions. Much work remains to be done before the best methods of use of these substances can be stated, but the present use of 5 per cent solution of DDT in kerosene, despite its obvious disadvantages such as fire, has proved to be an inestimable boon to the Army in malarious areas.

Temporary measures directed against the aquatic stages of the mosquito are concerned chiefly with the destruction of larvæ and pupæ by the application of chemical substances to the surfaces of breeding places. To be effective, treatment must be carried out at least once a week and, as in the case of spray killing, must be extended beyond the limits of the area to be protected.

A suitable oil applied as a fine spray forms a film on the surface of water which kills larvæ and pupæ by suffocation and poisoning. Oiling is indicated for all collections of water which are free from vegetation and are not used for drinking purposes. The most suitable means of application is by a knapsack sprayer, but for small collections of water oil may be applied by means of a brush.

Dusting may be used where oiling is contra-indicated, as, for example, in the case of reservoirs, wells and cisterns. It is indicated for the treatment of collections of water where there is vertical vegetation, such as grass, reeds, and rice, which would prevent oil from spreading. In the case of rice fields, dusting is particularly recommended as oil has a deleterious effect on vegetation. The dust most commonly used is paris green (a double salt of copper containing arsenic) which floats on the surface of the breeding place in the form of fine particles and poisons larvæ by ingestion. For use it is diluted with some inert substance which will also float, such as powdered road dust, or charcoal. It is applied in the form of a fine cloud by means of a rotary blower. In the strengths commonly used (1 part paris green to 19 parts of diluent) it does not render the water poisonous to man.

Permanent measures directed against the aquatic stages are concerned with the complete removal of mosquito breeding grounds. This may not be possible in every case and all that may be achieved is the reduction in the size and number of breeding places to such an extent that temporary measures require less labour and materials. The initial cost of permanent measures is usually high but once established recurrent expenditure is low. Permanent measures, in spite of being so called, usually require periodic attention.

The chief indications for anti-malarial drainage are the removal of seepages and the reduction in the amount of surface water. All drainage schemes require engineering advice and supervision, but medical surveillance is always neces-
sary to ensure that drains are constructed and maintained in such a manner that mosquito breeding is not encouraged.

The filling-in of breeding places is an obvious means of control but one which entails much labour. It is an important anti-malarial measure in countries such as tropical Africa, where the chief vector is a rain-water breeder. In these countries it is the only satisfactory method for dealing with small holes in the ground, such as footprints and car tracks in which prolific breeding may occur.

The clearing of jungle, bush or vegetation by exposing breeding places to the sun is indicated in countries where the malarial mosquitoes are shade-loving species. Care must be taken that a sunlight breeder does not become established. Clearing also helps to dry up small breeding places and make them more accessible for temporary treatment.

Defensive measures, properly carried out, in the presence of an effective anti-adult and anti-aquatic campaign, will reduce the likelihood of contracting malaria to negligible proportions.

Mosquito nets are the most valuable of these measures. They protect the sleeper during the hours when most malarial mosquitoes are active.

The next most valuable defensive measure is the use of anti-mosquito clothing during the hours of darkness when one is not in bed. Such clothing consists of a shirt buttoned at the neck and wrists, and long trousers with gaiters or mosquito boots. The surface on which a mosquito can feed is thus reduced enormously.

The exposed parts of the body such as the face, ears, neck, and hands are protected by the application of chemical substances, known as repellents, which deter mosquitoes. Di-methyl phthalate is one of the newer repellents and under adverse conditions such as severe sweating will give a very high degree of protection from mosquito bites for at least ninety minutes. Repellents are specially indicated in intensely malarious areas and for the use of personnel doing duty at night such as guards, telephonists, and drivers. Repellent solution should be taken inside one's mosquito net in case one has to get out of bed before dawn.

A big advance in malariology was the use during the war of veils, gauntlets and oversocks made of 3/8-inch netting and impregnated with di-methyl phthalate. The netting was carried in a wallet of absorbent material which was impregnated with repellent once a week. Such netting when worn over the head, hands, forearms and feet, when the boots were removed, will repel mosquitoes throughout the night and for at least seventy-two hours [8]. The size of the mesh was such that skin ventilation, visibility and hearing were hardly affected and yet a mosquito could not land on the skin without coming in contact with the impregnated netting. Troops on active service were thus able to sleep at night with safety and unencumbered by the ordinary mosquito net. This should prove a valuable means of protection for those travelling in trains at night through malarious areas.

Sites for camps should be situated as far as possible from obvious mosquito breeding places and from places they are likely to frequent such as houses and
native villages. The ground selected should have good natural drainage in order to limit the necessity for subsequent anti-aquatic measures.

The screening of windows, doors and all other apertures in barracks, canteens, messes and family quarters with wire gauze which will prevent the entry of mosquitoes is recommended for all permanent buildings in malarious countries. Life indoors is made less tedious by obviating the necessity for anti-mosquito clothing and the periodic application of repellents.

(c) The Control of the Parasite.—Suppressive treatment is so far the only method by which malaria has been controlled successfully by the use of drugs. It may be defined as the prevention of the development of symptoms by the continued administration of drugs. Military control by this means has been put on a sound basis by the work of Brigadier Hamilton Fairley [9]. He showed that the administration of 0.1 gramme of mepacrine for fourteen days before entering a malarious area and during the whole period of exposure would prevent the development of symptoms even though the persons concerned were harbouring the parasites. If this treatment was continued for a further four weeks after the cessation of exposure, all malignant tertian infections incurred would be completely cured, but benign tertian infections would eventually manifest themselves. Under similar regimes of mepacrine treatment in the Italian [10], Burman [11] and Far Eastern [12, 13] Campaigns, the forces concerned maintained themselves in the field with a very low malarial attack incidence, in spite of the lack or incompleteness of other anti-malarial measures.

There are few uses for suppressive treatment in the peacetime Army. In most military stations anti-mosquito measures should be sufficient to keep the incidence of the disease at a minimum. Only in training should its use normally be necessary.

Suppressive treatment with mepacrine has many disadvantages. An enormous amount of administration, organization and individual supervision is required to ensure that the drug is taken daily by all concerned. If suppressive treatment breaks down there is the difficulty of tracing the source of the infection on account of the inability to determine accurately the time of infection. Toxic reactions occur and though relatively uncommon give rise to greater concern in a peacetime station, where troops families might have to be considered. Finally suppressive therapy may not be sufficient to control the disease in every case as Hamilton Fairley has recently shown that certain strains of the parasite may show resistance to mepacrine [14].

Paludrine, discovered in 1944 by Curd, Davy and Rose [15], appears to have many advantages over mepacrine in the control of malaria. The researches of Maegraith et al. [16] and of Hamilton Fairley [17] show that it is less toxic than mepacrine and that single weekly doses will suppress the malignant and benign tertian forms of malaria. Paludrine has also been shown by these workers to be a causal prophylactic in the case of malignant tertian malaria, that is, it will destroy the earlier forms of the parasite in man and prevent the disease becoming established. This would be of great use in areas where malignant tertian malaria prevails were it not for the fact that the other forms of malaria are also invariably present though to a lesser extent. Too much optimism should
not be directed towards this new drug until the results of further field trials are available. The possibility of the malarial parasites becoming drug resistant cannot yet be excluded and also the suppressive effects at the extremes of age have yet to be demonstrated.

(d) The Control of the Human Factor.—In the Army and especially under field conditions the control of the mosquito and the parasite is not sufficient to prevent malaria unless supported by personal and unit effort [18].

Personal Effort: The success of individual defensive measures against the mosquito and of suppressive treatment depends upon the co-operation of all ranks. The first will fail unless the equipment provided is properly used and the other will break down if there is unwillingness to take the tablets. MacKeith [19], looking at the problem from the psychological aspect, lays down four methods of approach, namely:

1. Discipline, by the enforcement of a rigid system of definite instructions.
2. Habit, by the daily observance of malarial instructions and by associating them with other important military duties.
3. Example given by higher ranks; and
4. Persuasion in the form of lectures, cinema films, posters, etc.

Unit Effort: In addition to their obligations as individuals, officers and N.C.O.s should realize that the preservation of health and the prevention of disease in the unit is their responsibility [20, 21] and not that of the medical authorities. They must, therefore, be aware of the seriousness of malaria, its manner of spread, and the means of prevention if they are to comply with Regulations. By example and vigilance they must ensure that the men under their command carry out whatever anti-malaria instructions are in force. Advice should be sought from the Regimental Medical Officer and the unit should be guided by him in all health matters and at all times. In mosquito control schemes supervised by the medical authorities, the unit must remember that they have a share in the work (see Appendix I).

The methods by which the medical authorities may obtain the desired co-operation outlined above are those of health education modified to suit the particular malaria problem. The more important of these methods are as follows:

1. The training of officers and men in malaria prevention by attendance at practical courses in Army Schools of Hygiene.
2. Lectures by medical officers especially when malaria is prevalent. Interest should be stimulated by describing the local anti-malaria scheme.
3. Frequent routine inspections of units by medical officers in order to encourage the maintenance of a high standard of anti-malaria discipline.
4. The use of educational films and leaflets pertaining to malaria.
5. The use of propaganda. MacKeith, quoted above, draws attention
to the value of symbolization followed by appeal to the emotions in the use of posters.

(6) Periodic Hygiene Exhibitions to include displays of local malaria interest. These proved most popular among the troops of the Eighth Army in Italy [22].

THE PRACTICAL APPLICATION
A. Medical Responsibilities

Medical Officers in General.—Medical officers who are members of sitting boards or reconnaissance parties must always give priority to malaria in affected areas. An outbreak of malaria can be prevented by good site selection. If malaria-free site cannot be found insistance upon the institution of a general anti-mosquito campaign (Appendix I), well in advance of occupation, will do much to prevent the occurrence of the disease [23].

The Regimental Medical Officer.—When an outbreak of malaria occurs the R.M.O. can play a very important part in limiting the spread of the disease and preventing further cases occurring. From his clinical experience and local knowledge, he will be one of the first to suspect the presence of malaria. While recent movements are still fresh in the patients' minds he will be able to ascertain where the infection occurred (when there are several cases of malaria the source of the infection can often be determined fairly accurately without necessarily knowing the species of the parasite responsible) and the personal precautions taken by the victims at the time. The R.M.O. will then be in a position to advise his Commanding Officer to arrange for the place of infection to be avoided if it is outside unit lines. He can arrange for personal measures to be enforced where they have failed. By lectures and talks he can keep the troops aware of the presence of malaria and of the means of prevention. By informing the D.A.D.H. he can bring early notice of the presence of the disease to the attention of the medical authorities.

Medical Officer in Charge of Wards.—Medical officers doing duty in medical wards of hospitals can assist greatly in bringing the disease under control. They can determine accurately the source of infection by the laboratory diagnosis of the type of malaria, by their knowledge of the characteristics of the local parasites, by excluding the possibility of a relapse and from a detailed medical history of the patients. This information must be submitted immediately to the A.D.M.S. (Assistant Director of Medical Services) from whom it will be passed to the D.A.D.H. [24].

Deputy Directors of Hygiène.—In a country where malaria is prevalent the D.A.D.H. is required to know the distribution of malaria throughout his area, the incidence of malaria in the military population, the location and extent of any outbreak of the disease, the effectiveness and state of any existing control measures, and in a seasonal station the approximate date of the onset of the epidemic period and the extent of the disease in the civil population.

This information is required not only to keep the Area Commander and higher formations aware of the malaria situation, but in order that prompt action may be taken to stop an outbreak. It will also enable instructions to be
issued and control measures to be instituted well in advance of the malaria season. This information can be obtained from the weekly hospital returns, the notifications of infectious diseases submitted by the medical officers making the diagnosis, entomological data, personal observations made during the inspection of units and of anti-malarial control schemes, meteorological reports, and reports and returns relating to previous years. A scheme for enabling the D.A.D.H. to make an appreciation of the malaria situation is given in Appendix II.

B. Routine Procedure

From the information given above it is necessary for the D.A.D.H. to determine if the source of the outbreak is within his area or outside. If without, then all that is necessary is to inform the other authorities concerned. If within the area it is necessary to determine whether the source is in civil or military territory. If the former the local authority should be informed and if possible the locality concerned should be put out of bounds to all ranks. On the other hand if the source is in the military zone, the establishment concerned must be visited and a general investigation carried out.

The military importance of the location should be ascertained and the severity of the outbreak determined. Existing anti-malaria measures should be inspected. A brief survey of the locality both inside and outside the military lines should be made. The presence of potential mosquito breeding places and the proximity of native villages should be noted. The possibility of instituting active anti-mosquito measures should be estimated if they are not already in existence.

As a result of the findings made during the above investigation it will usually be possible to tender advice to the military authorities along one of the following lines:

1. The removal of the unit concerned to a healthier place if the military situation permits.
2. The remedying of defects observed in the existing anti-malarial scheme.
3. The establishment as indicated below of anti-malarial measures if not already in existence.

C. Anti-malarial Measures and Their Indications

1. If the outbreak is a small one and the cases are mild, individual defensive measures against the mosquito should be recommended. If possible all living quarters should be screened. If the vector is known and is a domestic species, spraying to produce the immediate killing of adult mosquitoes should be carried out in all living quarters and native houses within flight range.

2. If at the end of a period equal to the incubation period of local infection, there is no improvement in the malaria situation, then existing defensive measures should be supplemented by a general anti-mosquito campaign as described in Appendix I in so far as local circumstances permit.
(3) Suppressive treatment is indicated if military man-power is scarce, hospital facilities are wanting, and the risk of a breakdown in the other anti-malarial measures cannot be afforded.

**Discussion**

The material means, such as equipment, supplies of insecticides, and casual labour will generally be available wherever the Army is serving. Failure of, or a breakdown in, the anti-malarial plan will in most areas be due to the inadequacy of human co-operation, either on the part of those who are to be protected or on account of medical inertia.

The remedy for the former cause has been discussed already. The latter depends on the training of all medical officers, not only at the Army Medical College and the Army School of Hygiene as is done at present, but in their stations overseas when they are in immediate contact with the actual problem. Regimental medical officers must realize that the prompt tracking down of the source of an infection is just as important, as far as the health and the morale of the unit is concerned, as the speedy admission of the patient to hospital. Medical officers in hospitals should realize that their responsibility is not confined to the diagnosis and treatment of the illness. The patient's history should mean more than an account of his symptoms before admission to hospital. It is the important clue which enables the medical administration to pin-point the source of the infection and put into operation the machinery of prevention and control. The D.A.D.H., even in the absence of sickness, must maintain a state of constant watchfulness. By means of his own observations, the various records and other information at his disposal, he should keep a metaphorical finger on the malarial pulse of his area, ready at the slightest alteration in its character to take the appropriate action.

The present Army organization may be quite adequate as a short-term policy, but future needs must be given consideration. One of the functions of the Army in times of peace is to provide an efficient and elastic nucleus capable of expansion and rapid modification so that it may be prepared if the world is ever again plunged into war. That this applies as much to the anti-malarial organization as to the other branches of the medical services was demonstrated in World War II when in India the pre-war anti-malarial schemes and the plans produced during the early years of the war were insufficient to cope with the enormous expansion of the Indian Army and its responsibilities under active operations [25].

Malariology is a highly specialized subject and requires the whole-time study and attention of those concerned with even the smallest outbreak. The peacetime anti-malarial organization of the Army should, therefore, consist of a framework that, though self-contained, will not be independent but will work alongside the existing hygiene organization at every level in the chain of command. In this way it will be possible to produce an anti-malarial plan than can be co-ordinated with the general hygiene policy and so avoid much of the overlapping and many of the errors of the past. With one body concerned with malaria only, it will be possible to provide the time and personnel
to use to the best advantage the valuable war experience and the recent development in this sphere of medical science, as well as supplying the means necessary to direct and carry out further research into the malarial problem affecting the fighting forces.

CONCLUSIONS

(1) An account is given of the methods of malaria control most commonly used in the Army.

(2) A scheme is described whereby these methods may be applied to a particular malaria problem.

(3) The importance of medical cooperation is stressed.

(4) The necessity for an anti-malarial organization is stated.

REFERENCES

[1] Regulations for the Medical Services of the Army, para. 43, 1948. H.M.S.O.
[20] King's Regulations, 1940, para. 80, H.M.S.O.
[21] Field Service Regulations, 1930, 1, 238, sec. 145, para. 1, H.M.S.O.
[24] Regulations for the Medical Services of the Army, para. 596, 1938, H.M.S.O.

APPENDIX I.—A GENERAL ANTI-MOSQUITO CAMPAIGN

A general anti-mosquito campaign consists of a special investigation into the habits of the local vector followed by the necessary control measures. Personnel trained in malaria survey and control methods are required and should have skilled supervision. The methods described here are the minimum consistent with satisfactory results.

(A) Special Investigation

A large-scale map of the area to be protected and the surrounding country for at least a mile beyond is required. The map should include the location of all sleeping and living quarters within the area to be protected (protected zone) (fig. 1). Assuming
the effective flight range of the mosquito to be a half-mile, the limits of an area a half-mile beyond the boundary of the protected zone should be drawn on the map. This line bounds the limital zone. Similarly an extra-limital zone should be mapped out again a half-mile in depth.

All breeding places within the limital and protected zones should be entered on the map. They should be searched for anopheline larvae which should be forwarded in labelled specimen tubes to an entomological laboratory for identification. A record of the location of larvae should be kept.

Places where adult mosquitoes are likely to frequent should be entered on the map as routine collecting stations. These should be selected in the centre of the zone and at intervals around the periphery of the protected, limital and extra-limital zones (fig. 1). The collecting stations should be numbered consecutively and should not be included in any routine adult-spraying programme which may be in force. A daily record should be kept of the number of adult anophelines found in each collecting stations and samples should be forwarded in Barraud's cages [1] to the laboratory for identification and dissection.

FIG. 1.—Diagram of Survey Scheme. (Adult collecting stations entered as a dot.)

The results of the above investigation should provide information regarding the amount of breeding taking place, and whether the larvae found are recognized vectors. The adult catches should corroborate these findings. If none of the larvae were vector species, the search for breeding places will have to be intensified or extended. A possible clue may be provided by the disposition of the collecting stations in which the greatest numbers of adults were caught.

(B) Mosquito Control

Offensive control measures against the mosquitoes should first of all be of a temporary nature. If successful results are obtained more permanent measures may be considered.

The whole area within the limital boundary should be divided into five sectors (fig. 2). Each sector should include at least two collecting stations and the boundaries should be made to correspond with features such as roads, streams or railways to facilitate easy recognition by the labour parties.

All the actual breeding places within one sector are treated each day, with the result that the whole area is covered within a week. An adult spraying campaign should
follow a similar routine but should not include the collecting stations which are retained for the purpose of checking.

In military control schemes it is usual for the limital zone to be the responsibility of the hygiene authorities, the protected area being treated by the unit concerned but under skilled supervision.

![Diagram of a control scheme showing the treated area divided into Sectors. (Adult collecting stations entered as a dot.)](image)

FIG. 2.—Diagram of a control scheme showing the treated area divided into Sectors. (Adult collecting stations entered as a dot.)

Apart from hospital admissions the efficiency of a scheme such as the above can be determined from records of the total daily or weekly catches made in collecting stations. In a successful control, catches made within the protected area should be negligible whereas those made outside should remain high. The extra-limital collecting stations also prevent false credit being given to the effect of the control scheme, when, for example, the total catches commence to fall towards the end of the malaria season.

REFERENCE


APPENDIX II.—THE APPRECIATION OF THE MALARIA SITUATION

A scheme on the following lines may assist the D.A.D.H. in complying with the requirements stated above. The following records should be maintained in his office:

1. A large-scale map of the area. When the source of an outbreak of malaria is located the place is flagged. Every case of malaria attributed to that source is marked by a pin with a coloured head. This is a useful way of demonstrating the extent and seriousness of malaria in the area.

2. A chart giving a list of the sources of infection to which outbreaks have been traced. The weekly total of cases attributed to each source should be entered. This enables the effect of anti-malarial measures to be determined.

3. Graphs or record of accurate statistics, viz. weekly hospital returns, to show the weekly or monthly admissions of malaria to hospital for:
   (i) The whole area.
   (ii) Each station in area.
   (iii) Individual units.
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For (i) and (ii) a rate based on the number of cases per 1,000 of the military population should be worked out. These returns and rates are required to provide material for reports which may have to be submitted.

(4) Entomological data, if available, in the form of the results of weekly adult catches made in mosquito-collecting stations (see Appendix I).

(5) Meteorological data:
(a) Rainfall: A chart or graph showing the daily or weekly totals for the various stations in the area. This is often a most useful way of forecasting an increase in the malaria incidence. In some countries an increase in the rainfall during the rainy season is followed in four to six weeks by a rise in the number of cases. In the Punjab it is possible to make a preliminary forecast as least three months in advance [1].
(b) Temperature (maximum and minimum) and relative humidity should be entered daily on a graph. Horizontal lines drawn across the graph showing the optimum relative humidity and the optimum range of temperature for the prevalent parasite and the particular vector will enable one to determine whether or not transmission is occurring and the date of its onset.

(6) Military and civilian malaria returns and meteorological data from previous years will provide valuable information regarding the trend of malaria in the area.

REFERENCE