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THE PLACE OF ENTOMOLOGY IN MALARIA ERADICATION¹

INTRODUCTION

In most of the national malaria eradication programmes the chief method of attack upon Plasmodium is indirect: it is conducted by means of an attack upon the mosquito vector, in such a way as to eradicate the disease. Only under exceptional conditions, where the vector clearly is not amenable to control, is reliance shifted and placed mainly on direct attack by means of curative and prophylactic drugs.

Vector mosquitos may be attacked in their resting-places or in their breeding-places. Attack upon resting adults is nearly always the preferred method, because it is easier and cheaper to apply total coverage to the house-walls and ceilings than to the breeding-waters, and for the former purpose persistent contact-insecticides are available. Moreover, imagicidal attack reduces not merely the numbers of the vector but the average age of the females that bite man. Even if the man-biting ratio (the number of Anopheles bites per inhabitant per night) remains high during the vector's most prolific breeding season, transmission may be reduced to the minimum because no vector mosquito is old enough to be infective.

The expectation of adult life is usually shortened by the direct lethal effect of residual insecticide, sprayed periodically in all the buildings which are habitual major resting-places of the vector. An insecticide may, however, act rather as an irritant or a repellent, driving the mosquitos out of their favoured haunts. Diversion of this kind may result in their early death from unfavourable climatic conditions or other hazards. Failing that, it may cause the mosquitos to feed less frequently on man and more frequently on animals, reducing the probability of transmission perhaps to an insignificant level. Yet in other

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instances the presence of an irritant substance on the walls may mean failure to interrupt transmission.

PROBLEMS DEMANDING ENTOMOLOGICAL STUDY

Entomological work is generally needed in any malaria eradication scheme to help in answering the following questions:

In the Preparatory Phase

1. What anophelines definitely transmit malaria in the area of the project, and what others must be treated as suspected vectors? Against what species must any spraying programme be directed?

2. Over what areas are confirmed and/or possible vector species present, under conditions which suggest a danger of malaria transmission? What geographical coverage with insecticide is recommended?

3. Through what season are their numbers and activity such that transmission might occur? During which months must vector-control be maintained?

4. Do the habits of the vectors suggest that the spraying of buildings with a residual insecticide will provide effective vector-control? If so, which rooms or parts of rooms (if any) may be left untreated? If house-spraying does not appear to promise success, what other methods should be tried?

5. What is the baseline of susceptibility (LC_{50} and LC_{100}) of each vector to DDT and to dieldrin? Is there evidence that resistance might develop in certain populations following the use of one or other insecticide? What insecticide is recommended?

6. Have the proposed insecticides a good persistence on the surfaces where the vector mosquitos chiefly rest, or is the potency of deposits rapidly lost? What formulation, dosage and frequency of spraying are recommended?

In the Attack Phase

7. Is the chosen method of attack succeeding? Can the entomologist provide evidence that malaria transmission has been or is being interrupted? What is the degree of vector-control achieved?

8. For how long does each cycle of spraying ensure the interruption of transmission? Could any change of spraying policy increase the economic efficiency of the attack?

9. Is failure of vector-control, though not yet a fact, foreseeable by reason of evidence that insecticide resistance is appearing in vector populations? Is there hope of averting failure, short of changing the insecticide?

10. Is there a general or are there local failures in vector-control? What are the causes of failure and what remedy is recommended?

In the Consolidation Phase

11. What entomological conditions in each detected focus of malaria have led (or might lead) to cases of transmission in the area?

12. What vector-control measures (if any) should be taken to supplement the use of drugs in eliminating the focus?

It is evident that the problems demanding entomological study are not marginal ones but are directly related to the methodology of malaria eradication. The entomologist, therefore, should be a member of the general staff directing the campaign, since hardly one important problem can be effectively tackled in default of evidence which he must supply.

CHOICE OF ENTOMOLOGICAL AIMS AND TECHNIQUES

Many field techniques are used in studying the bionomics and the ecology of mosquitos. Some aspects of these studies are irrelevant to the task of vector-control, and irrelevant therefore to malaria eradication. They must be excluded from the work of the malaria eradication entomologist (however interesting he might find them). He has plenty of relevant duties to perform.

The choice of techniques must depend on the choice of entomological aims, and the latter hinge on the questions confronting the eradication campaign as a whole.

These questions have been listed above. In the schedule that follows an attempt has been made to set down the entomological aims that are normally relevant to an eradication campaign at each stage, and to suggest the techniques of study which, used in judicious combination, may serve each entomological aim. Here we would emphasize two points: first, that the entomologist on the spot must exercise constant good judgement in directing the efforts of himself and his assistants. A technique should never be continued by rote, whether because it is easy, familiar, or standardized in a test kit or by traditional practice. Always its use should be re-examined in the light of the short-term and long-term needs of the eradication campaign. And secondly, while any one technique may serve several aims, each aim usually demands the use of two or more techniques in combination. Entomologists sometimes fail to perceive this, and omit some vital factor from their work. As an example of the importance of combining techniques we may draw attention to aim number 5 in the schedule, "To assess the response of vectors to the presence of residual deposits". No fewer than eleven techniques are listed opposite this aim. It is not suggested that every one of these must needs be employed in every project. But it is considered that a combination of at least three measurements - the man-biting ratio, the house-entry survival rate¹ and the multiparity rate - can tell us, far better than any one technique used alone, whether transmission can occur.

A prominent feature of the schedule is the large number of changes which the entomologist must observe and measure, consequent upon the application (and the subsequent wearing off and covering over) of residual insecticide. Changes cannot be measured without a "baseline" - a notable instance being the measurement of susceptibility in the vectors. In former times the baseline measurements could usually be made in parallel with those of change, by studies performed in a "check area" close to the area of vector-control. Under nation-wide coverage this is no longer possible, and any baselines not established before the first attack will

¹ The "house-entry survival rate" means the proportion of females of the vector species which, after visiting a given sprayed room, escape from it in viable condition and might therefore survive to bite again.

SCHEDULE OF AIMS AND TECHNIQUES

Entomological aim
related to vector
control

Techniques related to each aim

Preparatory Phase

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|---|---|
| 1. To determine the vector species and their efficiencies | a. Analysis of taxonomic units
b. Sporozoite rates
c. Man-biting ratios (per night per inhabitant)
d. Resting-densities and ratios (per house, per inhabitant)
e. Human blood ratios ¹
f. Nulliparity and multiparity rates ² |
| 2. To map the distribution of vectors and their reproductive activity | a. Distribution survey (adults and larvae)
b. Seasonal survey of feeding, oviposition and diapause
c. Effective flight ranges |
| 3. To estimate their amenability to imaginal vector control | a. Choice of daytime resting-shelters, surfaces and positions
b. Feeding and night resting-habits (indoors and outdoors)
c. Bio-assay of experimental deposits on the resting-surfaces
d. Susceptibility to insecticides (LC ₅₀ 's, adult and larval)
e. Detection of factors for resistance in vector populations (LC ₁₀₀ 's)
f. Irritability to insecticides |
| 4. To estimate the possibility of economic vector elimination by attacking the larvae | a. Survey of breeding-places
b. Seasonal incidence of breeding
c. Applicability of persistent insecticides to breeding-places
d. Applicability of permanent anti-larval measures (in special cases) |

¹ This term expresses the percentage of a vector's bloodmeals taken on man in relation to the total number of bloodmeals.

² "Multiparity rate" is here adopted to signify the proportion of females which have reached an epidemiologically dangerous age. It may not be determinable under conditions of gonotrophic dissociation. If the multiparity rate cannot be measured, measurement of the nulliparity rate can be used instead (5,f).

Attack Phase

5. To assess the response of vectors to the presence of residual deposits
- a. Decrease in man-biting ratios
 - b. Decrease in indoor-resting densities
 - c. Survival rates after house-entry (using outlet traps)
 - d. Deviation to new shelters or resting-positions
 - e. Deviation to animal hosts (decrease of human blood ratios)
 - f. Decrease in multiparity rates²
 - g. Decrease in infection rates (in areas of high endemicity)
 - h. Appearance of resistant individuals in vector populations
 - i. Increase in insecticide tolerance levels of whole populations
 - j. Increase in irritability levels
 - k. Absence of larvae from breeding places
6. To assess persistence of available residual deposits (also quality of spraying)
- a. Changes in house-entry survival rates (in wild or released mosquitos)
 - b. Increase in bio-assay survival rates
 - c. Recovery in multiparity rates
 - d. Checking of susceptibility levels
 - e. Recovery of indoor-resting densities

Consolidation Phase

7. To advise on vector-control policy in residual foci of malaria
- a. Resting-densities and ratios
 - b. Insecticide-susceptibility checking

remain unknown quantities. Hence the importance of starting entomological work early on in the preparatory phase of the campaign, and of completing in that phase adequate baseline measurements of the various kinds indicated.

STATUS OF THE ENTOMOLOGIST

Certain hard necessities spring to the mind upon a perusal of the schedule. In the first place the entomologist in malaria eradication needs to be a highly trained and competent specialist, showing initiative, judgement and analytical capacity. Secondly, he must be wholly orientated to the malaria eradication campaign, posing and seeking to solve the most relevant problems at every stage. Thirdly, his is no part-time job: to attain the objectives set out, even with

² See footnote on preceding page

moderate efficiency and in a project of limited size, he and his assistants will require to give absolute priority to the demands of their work and to be supported by the maximum resources that can be made available.

Less than half the technical work of the entomologist can be done in a central laboratory, necessary though that be. The field is the true scene of many of his operations. Furthermore, a great part of the field work must be performed at night, and to obtain from subordinate personnel (such as entomology technicians) consistent and conscientious work the entomologist should consider the best way of obtaining a satisfactory and reliable response. This might mean using persuasion to instil enthusiasm, or giving a financial reward.

SUPPORTING-TASKS OF THE ENTOMOLOGIST

It might be thought that the schedule of aims and methods, added to frequent consultation with the campaign director, would keep the malaria eradication entomologist sufficiently busy. Yet what has been mentioned constitutes by no means the whole of his duties, but only, so to speak, their "business end". A number of supporting-tasks, essential to the success of the operational methods, must be performed, and they will weigh heavily upon the entomologist who finds himself to be the first or the only one assigned to work in an eradication scheme. Two tasks will be mentioned briefly in conclusion.

Reference has been made to the central laboratory. This is used for taxonomic work, dissection work and susceptibility tests. An insectary is also required, both for breeding colonies of mosquitos (to provide a constant supply of specimens for various tests) and for holding tested batches to observe the rates of survival. The establishing and equipping of both these units is not seldom an onerous task in the early stages. For much of the entomologist's field work a mobile laboratory (in the form of a closed van or a trailer fitted for the purpose) would perhaps be of special value.

A further inescapable task is to conduct training. Almost every malaria eradication entomologist faces the need to train both graduate and auxiliary

personnel in the course of his work. This is because the strategy and the tempo of malaria eradication are something new, something to which few persons are attuned when they first enter the project. Many have to be induced to discard the more leisurely habits and methods adopted in the days of malaria control, which are unhelpful for malaria eradication. In many malarious countries no biologist has as yet made medical entomology his speciality; far less has anyone specialized still further, by concentrating on the entomological work in malaria eradication. The first in the field in this specialization is then a visitor to the country, probably an official of an international agency who will remain for a limited period only. In order to accomplish the work at all he will be obliged to train, as he goes along, cadres of field technicians, supervisors, mosquito scouts and laboratory technicians. And it will be his concern, if not his duty, afterwards to leave in his place well-qualified persons dedicated to carrying on the work of malaria eradication entomology in their own country.