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An international vector control programme *

by

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The programme being conducted by the World Health Organization (WHO) on Vector Biology and Control is multi-disciplinary in nature and is concerned with all aspects of the control of vectors of diseases of man. Some of the main elements of the programme are described below.

Ecology.

The lack of accurate and quantitative information on ecology represents a serious obstacle in the control or eradication of many of the vectors of diseases of man. It prevents full use being made of currently available control techniques and the exploitation of new procedures such as genetical manipulation. It places in jeopardy our ability to deal with a series of new problems arising from urbanization and the large-scale agricultural and development programs being undertaken by Governments in many parts of the world. Great dams are being built, artificial lakes are being created, and vast tracts of virgin land are being irrigated and occupied by man. In addition, a lack of accurate ecological information on disease vectors hampers the development of effective epidemiological surveillance on a global scale.

In the light of these facts, WHO has expanded its programme on ecology extensively during the past three years. The Filariasis Research Unit in Rangoon has almost completed a study on the ecology of *Culex fatigans* (= *quinquefasciatus*) which has led to the development of control procedures which will be referred to later. The *Aedes* Research Unit in Bangkok is now in the second year of work on the ecology, biology and control of *Aedes aegypti* and *Aedes albopictus*. A research unit will be established in 1968 in Dar-es-Salaam to study the ecology of the vectors of yellow fever in East Africa ; and observations on the ecology of *Ae. aegypti* are being carried out in West Africa in collaboration with a WHO International Reference Center. A long-term programme on all aspects of the ecology of reduviid bugs has been started. A research unit to study the vectors of Japanese encephalitis will be established in Korea in 1969 ;

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a similar unit will be located in Taiwan in 1970. Research on the ecology and biology of anopheline mosquitoes is being intensified, particularly in the research units being conducted by WHO in Kaduna, Nigeria and Kisumu, Kenya.

As part of a long-term programme on epidemiological surveillance, information is being collected on the distribution, density, resistance levels, and behaviour of a number of vectors of public health importance. The most important of these are *Ae. aegypti* and *Ae. albopictus* in countries in South-East Asia and the Western Pacific where hemorrhagic fever is a potential danger. Mapping of the distribution of ticks has been started, and this will be extended to other species as resources permit.

WHO is participating in United Nations Development Programs in which large alterations to the environment are being brought about, and it is encouraging to see the extent to which ecology has been accepted as an integral part of many of these operations.

Development of new insecticides.

The coordinated programme for the evaluation and testing of new insecticides was initiated by the Organization in 1960. This programme has now the collaboration of almost 50 manufacturing organizations and involves nine collaborating laboratories and a number of WHO research units. Compounds introduced into the scheme are subjected to a series of seven stages of evaluation ; each succeeding stage requires a compound to meet more exacting criteria of its ability to perform safely and satisfactorily in the practical control of various species.

Stage I screens the effectiveness of all new compounds submitted from the manufacturers and other sources of mosquito adults and larvae, and houseflies. In these tests both resistant and susceptible insects are used. Three laboratories evaluate the compounds which have been shown to be promising at Stage I on many more species and strains of insects. These tests are carried out both in the laboratory (Stage II) and under simulated field conditions (Stage III), and determine the effectiveness of the material on a series of susceptible and resistant insects. In these stages both the intrinsic toxicity of the new insecticide and the efficacy of the formulation is determined.

Subsequent to these three stages, additional investigations are performed. These include observations on body lice, houseflies, bedbugs, fleas, blackflies, ticks, reduviid bugs, and a variety of mosquito species, the most important of which are anophelines, *C. fatigans,* and *Ae. aegypti.* More than 1,400 compounds have been introduced into the scheme since its inception and new candidate insecticides are received at the rate of approximately 200 per year.

The evaluation of chemosterilants is included in the scheme.

Increasing attention is being given to the development of new rodenticides because of the increasing importance of rat infestations, not only from the point of view of disease transmission but also because of the urgency to protect food under storage.

Field evaluation of new insecticides.

WHO maintains two research units on anophelines. One of these (*Anopheles* Control Research Unit No. 1) is situated in Kaduna, Northern Nigeria, and performs Stage IV and V investigations. Stage IV involves the application of the insecticides to occupied huts ; at Stage V evaluation is performed at the village level. It is on the basis of the results of the Stage V trials that recommendations can be made regarding the probable operational value of the insecticide against anophelines. A larger-scale trial is subsequently required to demonstrate the persistence and overall effect of the material ; that the insecticide can be produced in a stable formulation by the manufacturer in large

quantities ; that it can be applied easily, and that it is safe to handle. This type of investigation, which is categorized as Stage VI, is carried out by a second *Anopheles* control research unit (*Anopheles* Control Research Unit No. II). During 1967 and 1968, this unit evaluated OMS 33 (Arprocarb-Baygon : 0-isopropoxyphenyl methylcarbamate) in Iran and Northern Nigeria. All the trials in the programme are performed under medical supervision, and tests are carried out to determine cholinesterase inhibition and presence of metabolites in urine of exposed persons.

The trials in Iran indicated that OMS 33 can provide good control of DDT- and dieldrin-resistant *Anopheles stephensi* in mud huts for 3-4 months and of *Anopheles dthali* for more than 2 months. Under conditions prevailing in Northern Nigeria, satisfactory control of *Anopheles gambiae* and *Anopheles funestus* was achieved for 3-4 months. The effectiveness of this insecticide appears to be enhanced where villages are compact, probably due to an air-borne phase which kills the vectors at some distance from the sprayed surfaces for periods of up to 6 months. The *Anopheles* control research unit No. II which has been in Iran will be situated in Kisumu, Kenya from 1968 onwards. Confirmation of these findings on OMS 33 was obtained by the Pan American Health Organization/WHO Insecticide Team working in El Salvador.

Observations on the safety of the compound have established that precautions only moderately stricter than those generally used for applying DDT are required. Protective measures are based essentially on the observation of good hygiene.

WHO has had a Filariasis Research Unit in Rangoon since 1962. An experimental field trial was initiated in 1966 embracing an area of approximately 2 square miles of the city. Fenthion was used as a larvicide at a target dose of 1 ppm. These operations reduced the mosquito population in the treated area to a very low level. During the period of highest mosquito production it has been reduced approximately 98 percent compared with an untreated control area. This level has been maintained for a period of almost three years without the emergence of resistance.

The *Aedes* Research Unit, situated in Bangkok, is in the process of evaluating Abate under the experimental conditions that exist in that city. It is hoped that the techniques developed by this unit will be applicable to other urban communities in South-East Asia and the Western Pacific areas where hemorrhagic fever is an important public health problem. The unit is also carrying out observations on the possible use of the ultra-low-volume application of malathion from the air as a means of reducing *Ae. aegypti* densities rapidly, particularly in emergency situations. The results obtained from these trials using single-engined aircraft show that the technique has considerable promise.

The evaluation of new compounds at Stages IV and V against other insects of public health importance is done by WHO International Reference Centers or under special arrangements with Governments.

Insecticide resistance.

The main elements of the programme being conducted by WHO on this subject are to act as a depository for information on resistance from all sources and to undertake a subsequent analysis and distribution ; to promote, stimulate, and coordinate research on all facets of the problems including physiology, biochemistry, and genetics ; to promote the development of standard test methods for detecting resistance, and to perform global surveys on vector species of public health importance. In the past 10 years, more than 5,000 test kits have been distributed to workers and institutes throughout the world, and a reference laboratory performs resistance tests on eggs of *Ae. aegypti* collected in the field.

The number of species now involved, the number of insecticides used, and the number of countries providing information on resistance have increased to the point that it has become essential to analyze by computer the information now available to the

Organization. Information emanating from these analyses is included in the Information Circular on Insecticide Resistance, Insect Behaviour and Vector Genetics issued by WHO. On the basis of this growing programme, it is hoped that in the future it will be possible to forecast the trend of development of resistance in the majority of species and to formulate effective countermeasures.

Genetics.

The Organization is coordinating research on genetics by providing material and financial support to collaborating laboratories, particularly those working on the spectrum of cross resistance and the speed of development of resistance to different groups of compounds. A programme on the mapping of chromosomes of anophelines has been initiated, and surveys on the majority of the species of the American and European continents have been completed.

Standardized strains of insects are maintained in International Reference Centers. Among these are insecticide-reference and marker strains of houseflies, inbred insecticide-reference and marker strains of the *Culex* complex, and marker strains of *Ae. aegypti* and some anopheline species. These strains are provided to laboratories by the Organization without charge.

The Organization also maintains a Vector Genetics Information Service, the aim of which is to provide at periodic intervals stock lists of vector species, technical and research notes, bibliographies of both published and unpublished works, and directories of workers engaged in this field of research.

Genetic and biological control.

WHO is placing considerable emphasis on the exploitation of genetical manipulation for the control of vectors of public health importance. A successful experiment using cytoplasmic incompatibility for the control of *Culex fatigans* has been completed in a village near Rangoon, Burma. A synthesized strain designated D_1 was used. In the trial in Burma 5,000 D_1 males were released every day. Within 3 months no *C. fatigans* could be found in the area. It is now planned to continue the work on this technique on a larger scale in India. An experiment has been carried out in West Africa using hybrid sterility as a means of bringing about control of *Anopheles gambiae*. This has been only partially successful.

WHO is performing a global survey for candidate biological control agents, material being sent to the International Reference Center at Columbus, Ohio, in a specially designed collecting kit issued by the Organization. To date almost 1,000 kits have been distributed. Particular attention is being given to the discovery of organisms that might be used in blackfly control ; basic studies on the problem are being performed in a collaborating laboratory in Prague and field trials with suitable material are planned for Africa. Work is being performed with predator fish in Rangoon and in Taiwan. Developmental work on the mass rearing of *Coelomomyces stegomyiae* is being done following the successful introduction of this fungus into the Tokelau Islands for the control of *Aedes polynesiensis*.

Safe use of pesticides.

The Organization's programme on the safe use of pesticides to man is concerned essentially with investigations into the mode of action of newly developed compounds, routes of absorption into the body, the establishment of inherent toxicity of the different

compounds to man development of methods for determining degrees of absorption, with particular attention to techniques for determining cholinesterase depression, the use of antidotes, and the establishment of appropriate and practical precautionary measures. This work also embraces careful investigations on all persons exposed to newly developed insecticides during the field trials on news compounds.

Increasing attention is being given to the measures for the prevention of contamination of food by pesticides during transportation ; a number of outbreaks of poisoning due to this have been investigated in the past year.

Application and dispersal of pesticides.

Considerable progress has been made during the past 20 years on the development of reliable and safe application and dispersal of pesticides. WHO has published an illustrated manual on equipment dealing with the major items used in public health programmes. This volume is being kept up to date. Attention is also given to the equipment used for the application of molluscicides in order to reduce waste, regulate dosage, and avoid contamination of the environment. Special attention is being paid to the development of equipment for the application of pesticides from the air. WHO in collaboration with the USPHS, has also given much attention to the development of suitable apparatus for the disinsection of aircraft.

Specifications of pesticides.

An important factor in the development of a new insecticide is the establishment of a specification for the active material and formulations based on it. A manual, « Specifications for Pesticides used in Public Health », which was first published soon after WHO's inception, has had an important influence on the quality of materials used in operational programs. It is kept under review by the Expert Committee on Insecticides, and a new edition was published early in 1968.

Services to research.

The Organization provides services to research in a number of ways. Information Circulars on Resistance, Genetics, Ecology, Vector Control, and Toxicology are issued regularly. Standard strains of insects are provided to collaborating laboratories. Financial aid is provided to laboratories working on problems of particular importance to WHO. Standard insecticides and radio isotope-labelled chemicals are provided in special circumstances. Exchanges of scientific workers and visits by highly specialized consultants to collaborating laboratories are arranged.

Future development.

It will be important in future years to place emphasis on improving the effectiveness of vector control methods and extending control measures to vector species now posing threats to public health. Efforts will have to be intensified in determining the extent and nature of resistance, finding suitable and safe alternative insecticides and developing procedures for handling and applying these safely. Parallel to this knowledge on the ecology of the vector will be increasingly important, particularly if integrated

control becomes a reality. An increased knowledge of the genetics of vectors will be necessary not only to obtain better results with techniques currently in use but also in the development of genetic manipulation as a practical means of vector control.

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