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ABSTRACT OF PAPERS

Symposium on
VECTOR CONTROL AND THE
RECRUDESCENCE OF VECTOR-BORNE DISEASES
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Most regions of the Americas have experienced epidemics caused by arboviruses. The recrudescences in the past 20 years illustrated that these events usually were extensions from basic cycles and were unanticipated. Over 100 arboviruses are reported from the Americas, but only a few are known to cause epidemics and these are usually mosquito-borne.

The principal epidemics in North America were caused by St. Louis encephalitis, Western equine encephalomyelitis, Eastern equine encephalomyelitis, or California encephalitis virus. The first three agents also occur in but have not caused widespread epidemics in Central and South America or the Caribbean.

Epizootics of Venezuelan equine encephalitis have occurred over much of Central and South America and with some extension northward. In some instances there were associated epidemics in man.

Conditions that cause encephalitis viruses to extend from their basic cycles in wildlife to destructive epizootics and epidemics are the subject for major current research.

Dengue fevers had seemed to disappear from the Americas by the late 1950's under the impact of Aedes aegypti control and eradication programs. We assumed that endemic or epidemic cycles could not continue. However, dengues have resurged and repeated epidemics have swept the Caribbean and coastal Venezuela since 1962. Dengue fever now appears to be endemic in the Caribbean.
The sylvan cycle of yellow fever virus persists over a large area of South America. Twenty years ago it extended through Central America. If the virus was introduced into areas where dengue occurs or into certain other A. aegypti-infested port cities, it could lead to a recrudescence of urban-epidemic yellow fever and that would represent a health and economic catastrophe.

Viruses of less concern but associated with epidemics include California encephalitis, Oropouche, Mayaro, and Uruma. We must expect these and other arboviruses to emerge increasingly as agents of human disease.
RECENT EPIDEMICS OF YELLOW FEVER IN AFRICA

P. Brès
Virus Diseases
World Health Organization
Geneva, Switzerland

Epidemics of urban yellow fever have been known on the west coast of Africa for at least two centuries, and in the 1930's it was understood that the disease was also endemic far inland between the tropics.

In the 1940's, two main events occurred. The first was a massive outbreak in the Nuba mountains (formerly a "silent area") in which it appeared that Aedes vittatus had probably played as important a role as Aedes aegypti in man-to-man transmission. Another was the beginning of a regular vaccination program in French-speaking West and Equatorial Africa, which progressively brought about the disappearance of yellow fever in these areas. In the early 1950's, yellow fever was receding and interest in it decreased.

In 1958, the virus became active in Central and East Africa and in the Democratic Republic of Congo, then in Sudan in 1959, and Ethiopia in 1960-1962, which was the most dramatic epidemic which ever occurred in Africa. Yellow fever again struck Ethiopia in 1966 in the Rift Valley, an important passageway.

In 1964, yellow fever reappeared offensively in West Africa, beginning with six cases in Portuguese Guinea, followed in 1965 by an outbreak in Senegal, the victims of which were mostly children under ten years of age while older people were still protected by previous vaccination campaigns. In 1969, five countries in West Africa were stricken and Ghana, Upper Volta, and Nigeria suffered the most.
Though many cases go on occurring undiagnosed in Africa, the recrudescence of epidemics since 1958, both in East and West Africa, is threatening the further spread of the disease, strengthened by recent modifications of ecology in the developing countries. The densities of \textit{A. aegypti} are increasing in urban and rural centers, but, even if they could be reduced by better control, a problem will persist with non-domestic \textit{A. aegypti} and other species that are able to transmit yellow fever from monkey to man and also from man to man as, for example, \textit{A. vittatus, A. africanus, A. simpsoni, A. luteocephalus}, which have played an important role in the recent large outbreaks.
In several countries that have malaria eradication programs, a recrudescence of the disease has been observed in recent years. Such circumstances have produced a rather widespread pessimism concerning the possibility of the total elimination of malaria, particularly in tropical areas.

These programs that are successful only in those regions where transmission is interrupted by indoor residual insecticide spraying have found many obstacles in practice, most of which are caused by failures in strategy, financing, planning, and in administration or operations, and in problems connected with the biology of the vector. The recrudescences of malaria that have occurred are mostly due to one or several of these factors.

The main failure in the strategy responsible for recrudescences occurs in the consolidation phase of the program, when, according to the policy adopted, cessation of spraying takes place in the presence of a small remaining reservoir of plasmodia. Early withdrawal of the insecticide in formerly hyperendemic zones in the tropics before the total disappearance of parasites or in areas of high potentiality for transmission submitted to the continuous importation of cases has in many instances resulted in recrudescences, some of them very severe.

Lack of adequate financing particularly in the last stages of the program has been rather frequently another cause of deterioration. Many countries did not evaluate the true meaning of malaria as a main cause of death and disease, did not allot to the eradication program the correct proportion of the budget, and relied too much on outside help.
The planning of operations without taking into consideration the contingencies common to biological phenomena has also been a cause of recession. When setbacks have appeared, the application of adequate measures has not been possible due to the absence of facilities not contemplated in the plan.

Faults in administration or in operations are well known and easy to recognize. One wonders how progress is made when they are present and, therefore, under these conditions it should not be surprising to find increments of the infection.

The cyclic increases of malaria prevalence that have a periodicity of around five years are another factor that has to be taken into consideration. They are due to a rise in the density of the vectors and to an expansion of their geographical distribution probably connected with periodic changes in the food-chain of the larval populations similar to the changes that have been found among other animals. In many countries of the Western Hemisphere, in the pre-DDT times, epidemic peaks were reached mainly in the years ending in 0 or 1, or in 5 or 6. This phenomenon may explain many of the recrudescences observed in 1970 in several areas.
Eradication or control of vector populations has been attempted by chemical, biological, and genetical methods. Chemical control has been the practice most widely applied and studied, and to it three broad classes of response can be recognized. The first response - continued susceptibility with no apparent change in behavior - is likely to become more and more uncommon as the duration of exposure to insecticides lengthens. The second - physiological resistance with no apparent change in behavior - is a common response, which can be measured accurately in the laboratory. The third - continued susceptibility with a change in behavior enabling the vectors to avoid the lethal effects of the insecticide - is, owing to the difficulty of measuring components of behavior, less well documented, though it may occur more commonly than is realized.

Since biological and genetical control methods have, as yet, been used only to a limited extent, vector response is less well defined, but it can be assumed that, given time, resistance and behavior changes will evolve. Since responses can not be compared until they can be measured, a clear definition is required of the parameters to be measured in biological and genetical control programs. In the case of mosquitoes, for example, account will need to be taken of the response of larvae and pupae to biological control agents, and hence of the production of adults from "infected" larval habitats.

The response to control measures of other components in an ecosystem has been less widely studied. In some programs changes in arthropod and vertebrate populations have been observed, some advantageous
to man, others detrimental. It is not possible to predict all the "side-effects" of eradication and control measures, but chemical measures, since they are less specific in their action than biological or genetical methods, are considered the most likely to provoke an undesired response in an ecosystem.
ALTERNATIVE METHODS OF VECTOR CONTROL

A. W. A. Brown
Vector Biology and Control
World Health Organization
Geneva, Switzerland

The only alternative to the insecticidal method of mosquito control that has so far gained any practical standing is the use of larvivorous fish, mainly *Gambusia affinis* and *Poecilia (Lebistes) reticulata*. These are proving effective against malaria vectors in Iran and encephalitis vectors in California and New Mexico. The use of these and other larvivorous species may be combined with chemical larvicide applications as in Hawaii.

Other biological-control agents that show promise for development include: (1) predacious *Toxorhynchites* mosquitoes; (2) the nematode *Reesimermis (Romanomermis) nielseni*; and (3) the protozoan *Nosema stegomyiae*; these are likely to undergo thorough field trial. Among the newly discovered entomoviruses, a nuclear polyhedrosis virus (NPV) and a pox-type virus are the most promising. Although *Coelomomyces stegomyiae* gave good results against *Aedes polynesiensis* on a Pacific atoll, further field experimentation on fungi of this genus still await more precise knowledge on the conditions governing its sporulation and infectivity. It is probable that all these biological agents will require continuous or inundative releases to be really effective.

Among methods of genetical control, the use of radiosterilized males has proved disappointing against *Anopheles* and *Aedes*, but quite promising against *Culex*. Chemosterilized males treated as pupae with thiotepa have given complete control of *C. quinquefasciatus* on a Florida key. Males of a strain of this mosquito species to whose sperm the target population was cytoplasmically incompatible have obtained eradication in a Burmese village. Sterile male hybrids between two relatives of *An. gambiae* have
given fair results against *An. gambiae* in a West African village. It is considered that the most promising genetical-control agents are strains bearing chromosomal translocations originally produced by X-ray treatment because, since their effect continues through succeeding generations, results might be obtained with fewer releases than are necessary in the sterile-male techniques; translocated strains are now available in *C. fatigans* for trial in India, in *A. aegypti* for trial in Kenya and India, and in *C. tritaeniorhynchus*. 
There are many ways, some well-known, by which human behavior encourages infectious and other diseases (witness the expression "man-made malaria"). Some of these and a number of other factors interfere with programs of vector control. One must consider separately the distinct interacting groups of people involved: those who are only politically involved; those who plan and make decisions but are remote from the individuals directly affected; those scientist-administrators who organize and direct the control or eradication program; those who carry out practical measures in the field and come into contact with the people; those who are to be protected by the program; and those who are affected by the measures as distinct from the protective effects of the program. The basic human frailties involved are ignorance (culpable or otherwise), inadequate training and understanding, misperception, inappropriate attitudes, intolerance for either old or new ideas, unrealistic or inappropriate priority- or value-systems, loss of alertness in long-term routines, timidity or cowardice when firm action is needed, and fear (of demotion, of power-groups, of loss of favor, of loss of revenue, or of effects on tourism). These result in incompetent procedures, rejection or suppression of evidence, concealment of facts, opposition, bribery, undue haste under political or bureaucratic pressure, bureaucratic inertia, and having political decisions override sensible caution or scientific data or the lack of enough data for realistic planning. Examples of these are given so that appropriate lessons can be drawn, but there are obvious diplomatic difficulties in advertizing blunders without causing offense. Even so, news reporters could do much good by bringing facts out into the open: that would add a new and salutary fear, the fear of exposure.